

Delphi 5 Developer's Guide

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SAMS

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Foreword

I started work at Borland in the summer of 1985. I came to work here to be a part of the new generation of programming tools (the UCSD Pascal System and command line tools just weren't enough), to help improve the process of programming (maybe even leaving a little more time for our families and friends), and finally, to help enrich the lives of programmers (myself included). Turbo Pascal 1.0 changed the face of programming tools forever. It set the standard in 1983.

Delphi also changed the face of programming once again. Delphi 1.0 focused on making object-oriented programming, Windows programming, and database programming easier. Later versions of Delphi focused on easing the pain of writing Internet and distributed applications. Although we've added a host of features to our products over the years and written pages of documentation and megabytes of online help, there's still more information, knowledge, and advice that is required for developers to complete successful projects.

Delphi 5—"Sixteen Years in the Making" the headline might read. Not this book, but the product. Sixteen years, you might ask? It's been approximately sixteen years since the first Turbo Pascal version appeared in November 1983. By Internet standards, that amount of time would easily overflow an Int64. Delphi 5 is the next great version to arrive.

Actually, it is the 13th version of our compiler. You don't believe me? Just run `DCC32.EXE` from the command line (we used to say DOS prompt), and you'll see the compiler version number and command line parameter help text output. It takes a lot of engineers, testers, documentors, authors, fans, friends, and relatives to produce a product. It takes a special breed of writers to be able to write a book about Delphi.

What does it take to write a developer's guide? The simple answer is "a lot." How can I define a lot? I can't—it's impossible to define. Instead of a definition, I can only offer a few bits of information to help in forming the definition, a "recipe" if you will:

"Davey Hackers Quick 'n Easy Writer's Recipe"

Delphi 5 Developer's Guide

Ingredients:

- Delphi 5 (Standard, Professional, or Enterprise edition)
- Two 150-pound professional strength book authors
- 1000's of tablespoons of words
- 1000's of cups of source code

Decades of helpings of experience (including years working on Delphi)
Handfuls of wisdom
Hours of hacking
Weeks of debugging
Quarts and quarts of fluids (my choice would be Diet Pepsi)
Hundreds of hours of sleep

Preparation:

Preheat your PC to 110 volts (220 volts for most developers outside the US).

Apply heat to the developers.

To your hard drive, mix in the Delphi 5 field test versions, all the text, and source code ingredients.

Stir in the years of experience, hours of hacking, weeks of debugging, handfuls of wisdom, and quarts of fluids.

Drain off the hours of sleep.

Let the remaining ingredients stand at room temperature for a while.

Yield:

One *Delphi 5 Developer's Guide* by Steve Teixeira and Xavier Pacheco.

Variations:

Substitute your favorite choice of fluids—water, juice, coffee, and so forth.

To quote a famous comedienne, “All seriousness aside.” I’ve known Steve Teixeira (some call him T-Rex) and Xavier Pacheco (some call him just X) for years as friends, fellow employees, speakers at our annual developer’s conference, and as members of the Borland community.

Previous editions of their Developer’s Guides have been received enthusiastically by Delphi developers around the world. Here now is the latest version ready for everyone to enjoy.

Have fun, and learn a lot. Here’s hoping all of your Delphi projects are enjoyable, successful, and rewarding.

David Intersimone, “David I”
Vice President, Developer Relations
Inprise Corporation

About the Author

Steve Teixeira is the vice president of Software Development at DeVries Data Systems, a Silicon Valley–based consulting firm specializing in Borland/Inprise solutions. Previously, Steve was a research and development software engineer at Inprise Corporation, where he helped design and build Borland Delphi and Borland C++Builder. Steve is also a columnist for *The Delphi Magazine*, a professional consultant and trainer, and an internationally known speaker. Steve lives in Saratoga, California with his wife and son.

Xavier Pacheco is the President and Chief Consultant for Xapware Technologies, Inc., a Colorado Springs–based consulting/training firm. Xavier frequently speaks at industry conferences and is a contributing author for Delphi periodicals. He is an internationally known Delphi consultant and trainer and a member of Borland’s select group of support volunteers—TeamB. Xavier enjoys spending time with his wife, Anne, and his daughter, Amanda. Xavier and Anne live in Colorado with their German shepherds, Rocky and Shasta.

Dedication

Xavier's Dedication

For Anne

Steve's Dedication

For Helen and Cooper

Acknowledgments

We need to thank those without whose help this book would never have been written. In addition to our thanks, we also want to point out that any errors or omissions you find in the book in spite of everyone's efforts are our own.

We'd first like to thank our technical reviewers and good friends, Lance Bullock, Chris Hesik, and Ellie Peters. The ideal technical reviewer is both bright and detail-oriented, and we were fortunate enough to get three individuals who meet those qualifications in spades! These folks did a great job on a very tight schedule, and we're forever grateful for their efforts.

Next, gargantuan thanks to our contributing authors, who lent their superior software development and writing skills to making *Delphi 5 Developer's Guide* better than it could have been otherwise. MIDAS guru Dan Miser pitched in by writing the excellent Chapter 32, "MIDAS Development." Lance Bullock, to whom we offer double the normal dose of gratitude, managed to squeeze writing Chapter 27, "CORBA Development with Delphi," in among his duties as a technical reviewer. Finally, Web wizard Nick Hodges (TSmiley inventor) is back in this edition of the book in Chapter 31, "Internet-Enabling Your Applications with WebBroker."

Thanks to David Intersimone, who managed to find the time to write the foreword for this book despite his busy schedule.

While writing *Delphi 5 Developer's Guide*, we received advice or tips from a number of our friends and coworkers. These people include Alain "Lino" Tadros, Roland Bouchereau, Charlie Calvert, Josh Dahlby, David Sampson, Jason Sprenger, Scott Frolich, Jeff Peters, Greg de Vries, Mark Duncan, Anders Ohlsson, David Streever, Rich Jones, and others too numerous to mention.

Finally, thanks to the gang at Sams: Shelley Johnston, Gus Miklos, Dan Scherf, and the zillions of behind-the-scenes people that we never meet but without whose help this book would not be a reality.

Special Thanks from Xavier

I can never be thankful enough for God's abundant blessings, the greatest of which is His Son, Jesus—my Savior. I thank God for my wife Anne, whose love, patience, and understanding I will always need. Thank you Anne, for your support and encouragement and mostly for your prayers and commitment to our Holy Father. I am thankful for my daughter Amanda, and the joy she brings. Amanda, you are truly a blessing to my life.

Special Thanks from Steve

I'd like to thank my family, especially Helen, who is always reminding me of what is important and helping me work through the tough spots, and Cooper, who provides complete clarity when I view the world through his eyes.

Tell Us What You Think!

As the reader of this book, *you* are our most important critic and commentator. We value your opinion and want to know what we're doing right, what we could do better, what areas you'd like to see us publish in, and any other words of wisdom you're willing to pass our way.

I welcome your comments. You can fax, email, or write me directly to let me know what you did or didn't like about this book—as well as what we can do to make our books stronger.

Please note that I cannot help you with technical problems related to the topic of this book and that, due to the high volume of mail I receive, I might not be able to reply to every message.

When you write, please be sure to include this book's title and author as well as your name and phone or fax number. I will carefully review your comments and share them with the authors and editors who worked on the book.

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Introduction

Can you believe that it's been nearly five years since we began work on the first edition of *Delphi Developer's Guide*? At the time, we were just a couple of developers working in Borland's languages support department looking for a new software challenge. We had an idea for a book that made a point of avoiding things you could learn in the product documentation in favor of showing proper coding practices and a few cool techniques. We also figured our experience in developer support would enable us to answer developer's questions before they were even asked. We pitched the idea to Sams, and they loved it. Then began the many grueling months of manuscript development, programming, late nights, programming, and maybe a few deadlines missed (because we were so busy programming). Finally, the book was finished.

Our expectations were modest. At first, we were just hoping we would break even. However, after several months of robust sales, we thought that our concept of a no-nonsense developer's guide was just what the doctor (or in this case, the *developer*) ordered. Our feelings were legitimized when you, the reader, voted *Delphi Developer's Guide* to the Delphi Informant Reader's Choice award for best Delphi book.

I think our publisher slipped something into the water, because we couldn't stop writing. We released *Delphi 2 Developer's Guide* the next year, completed a manuscript for *Delphi 3 Developer's Guide* (which was unfortunately never published) the following year, and published *Delphi 4 Developer's Guide* the year after that, for which we were again honored with the Delphi Informant Reader's Choice award for best Delphi book. What you have in your hands is our latest work, *Delphi 5 Developer's Guide*, and we think you'll find it an even more valuable resource than any previous edition.

Currently, Steve is the vice president of Software Development at DeVries Data Systems, a Silicon Valley-based consulting firm that specializes in Borland solutions, and Xavier runs his own Delphi consulting and training firm, XAPWARE Technologies Inc. We feel that our unique combination of experience "in the trenches" in Borland's developer support and R&D departments combined with our real-world experience as developers and inside knowledge of the Delphi product all add up to one darn good Delphi book.

Simply stated, if you want to develop applications in Delphi, this is the book for you. Our goal is not just to show you how to develop applications using Delphi but rather how to develop applications the right way. Delphi is a very unique tool that enables you to drastically reduce the time it takes to develop applications while still offering a level of performance that meets or exceeds that of most C++ compilers on the market. This book shows you how to get the best of these two worlds by demonstrating effective use of Delphi's design-time environment and proper techniques for code reuse and by showing you how to write good, clean, efficient code.

This book is divided into five parts. Part I, “Essentials for Rapid Development,” provides you with a strong foundation in the important aspects of Delphi and Win32 programming. Part II, “Advanced Techniques,” builds upon this foundation by helping you build small but useful applications and utilities that help to expand your knowledge of more in-depth programming topics. Part III, “Component-Based Development,” discusses VCL component development and development using COM. Part IV, “Database Development,” takes you through database development in Delphi, from local tables through SQL databases and multitier solutions. Part V, “Rapid Database Application Development,” brings together much of what you learned in the previous parts in order to build larger-scale real-world applications.

Chapters on the CD

No doubt you’ve seen the table of contents by now, and you may have noticed that there are several chapters that appear only on the CD and are not in the printed book. The reason for this is simple: We wrote more material than could be bound into a single book. Faced with this problem, we had several choices. We could split *Delphi 5 Developer's Guide* into two books, but we chose not to do that primarily because it would be more expensive for readers to obtain the material. Another option was to leave out some chapters entirely, but we felt that doing so would create some obvious gaping holes in the book’s coverage. The choice we made, of course, was to put some chapters on the CD. This allowed us to balance the forces of coverage, convenience, and cost. It’s important to remember that the chapters on the CD are not “extras” but are a full-fledged part of the book. They were written, reviewed, and edited with the same care and close attention to detail as the rest of the book.

Who Should Read This Book

As the title of this book states, this book is for developers. So, if you’re a developer and you use Delphi, you should have this book. In particular, however, this book is aimed at three groups of people:

- Delphi developers who are looking to take their craft to the next level.
- Experienced Pascal, BASIC, or C/C++ programmers who are looking to hit the ground running with Delphi.
- Programmers who are looking to get the most out of Delphi by leveraging the Win32 API and using some of Delphi’s less obvious features.

Conventions Used in This Book

The following typographic conventions are used in this book:

- Code lines, commands, statements, variables, program output, and any text you see on the screen appears in a `computer` typeface.
- Anything that you type appears in a **bold computer** typeface.
- Placeholders in syntax descriptions appear in an *italic computer* typeface. Replace the placeholder with the actual filename, parameter, or whatever element it represents.
- *Italics* highlight technical terms when they first appear in the text and sometimes are used to emphasize important points.
- Procedures and functions are indicated by opening and closing parentheses after the procedure or function name. Although this is not standard Pascal syntax, it helps to differentiate them from properties, variables, and types.

Within each chapter you'll encounter several Notes, Tips, and Cautions that help to highlight the important points and aid you in steering clear of the pitfalls.

You will find all the source code and project files on the CD accompanying this book, as well as source samples that we could not fit in the book itself. Also, take a look at the components and tools in the directory \THRDPRTY, where you'll find some powerful trial versions of third-party components.

Updates to This Book

Updates, extras, and errata information for this book are available via the Web. Visit <http://www.xapware.com/ddg> for the latest news.

Getting Started

People sometimes ask us what drives us to continue to write Delphi books. It's hard to explain, but whenever we meet with other developers and see their obviously well-used, bookmarked, ratty-looking copy of *Delphi Developer's Guide*, it somehow makes it worthwhile.

Now it's time to relax and have some fun programming with Delphi. We'll start slow but progress into the more advanced topics at a quick but comfortable pace. Before you know it, you'll have the knowledge and technique required to truly be called a Delphi guru.

Essentials for Rapid Development

PART

I

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Windows Programming in Delphi 5

CHAPTER

1

IN THIS CHAPTER

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- What's So Great About Events, Anyway? 27
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This chapter is intended to provide you with a high-level overview of Delphi, including history, feature sets, how Delphi fits into the world of Windows development, and general tidbits of information you need to know to be a Delphi developer. And just to get your technical juices flowing, this chapter also discusses the need-to-know features of the Delphi IDE, pointing out some of those hard-to-find features that even seasoned Delphi developers may not know about. This chapter isn't about providing an education on the very basics of how one develops software in Delphi. We figure you spent good money on this book to learn new and interesting things—not to read a rehash of content you can already find in Borland's documentation. True to that, our mission is to deliver the goods: to show you the power features of this product and ultimately how to employ those features to build commercial-quality software. Hopefully, our backgrounds and experience with the tool will enable us to provide you with some interesting and useful insights along the way. We feel that experienced and new Delphi developers alike will benefit from this chapter (and this book!), as long as new developers understand that this isn't ground zero for a Delphi developer. Start with the Borland documentation and simple examples. Once you've got the hang of how the IDE works and the general flow of application development, welcome aboard and enjoy the ride!

The Delphi Product Family

Delphi 5 comes in three flavors designed to fit a variety of needs: Delphi 5 Standard, Delphi 5 Professional, and Delphi 5 Enterprise. Each of these versions is targeted at a different type of developer.

Delphi 5 Standard is the entry-level version. It provides everything you need to start writing applications with Delphi, and it's ideal for hobbyists and students who want to break into Delphi programming on a budget. This version includes the following features:

- Optimizing 32-bit Object Pascal compiler.
- Visual Component Library (VCL), which includes over 85 components standard on the Component Palette.
- *Package* support, which enables you to create small executables and component libraries.
- An IDE that includes an editor, debugger, form designer, and a host of productivity features. The form designer supports visual form inheritance and linking.
- Delphi 1, which is included for 16-bit Windows development.
- Full support for Win32 API, including COM, GDI, DirectX, multithreading, and various Microsoft and third-party software development kits (SDKs).

Delphi 5 Professional is intended for use by professional developers who don't require client/server features. If you're a professional developer building and deploying applications or Delphi components, this product is designed for you. The Professional edition includes everything in the Standard edition, plus the following:

- More than 150 VCL components on the Component Palette
- Database support, including data-aware VCL controls, the Borland Database Engine (BDE) 5.0, BDE drivers for local tables, a virtual dataset architecture that enables you to incorporate other database engines into VCL, the Database Explorer tool, a data repository, ODBC support, and InterBase Express native InterBase components
- Wizards for creating COM components, such as ActiveX controls, ActiveForms, Automation servers, and property pages
- The QuickReports reporting tool for integrating custom reports into your applications
- The TeeChart graphing and charting components for data visualization
- A single-user Local InterBase Server (LIBS), which enables you to do SQL-based client/server development without being connected to a network
- The Web Deployment feature for easy distribution of ActiveX content via the Web
- The InstallSHIELD Express application-deployment tool
- The OpenTools API for developing components that integrate tightly within the Delphi environment as well as an interface for PVCS version control
- WebBroker and FastNet Wizards and components for developing applications for the Internet
- Source code for the VCL, runtime library (RTL), and property editors
- The WinSight32 tool for browsing window and message information

Delphi 5 Enterprise is targeted toward high-end and corporate client/server developers. If you're developing applications that communicate with SQL database servers, this edition contains all the tools necessary to take you through the client/server application development cycle. The Enterprise version includes everything included in the other two Delphi editions, plus the following:

- Over 200 VCL components on the Component Palette
- Multitier Distributed Application Services (MIDAS) support and development license, providing an unprecedented level of ease for multitier application development
- CORBA support, including version 3.32 of the VisiBroker ORB
- InternetExpress XML components
- TeamSource source control software, which enables team development and supports various versioning engines (ZIP and PVCS included)
- Native Microsoft SQL Server 7 support
- Advance support for Oracle8, including abstract data type fields
- Direct support for ActiveX Data Objects (ADO)

- DecisionCube components, which provide visual, multidimensional analysis of data (includes source)
- SQL Links BDE drivers for InterBase, Oracle, Microsoft SQL Server, Sybase, Informix, and DB2 database servers as well as a license for unlimited redistribution of these drivers
- SQL Database Explorer, which enables you to browse and edit server-specific metadata
- SQL Builder graphic query-building tool
- SQL Monitor, which enables you to view SQL communications to and from the server so that you can debug and fine-tune your SQL application performance
- Data Pump Expert for rapid upsizing
- A five-user InterBase for Windows NT license

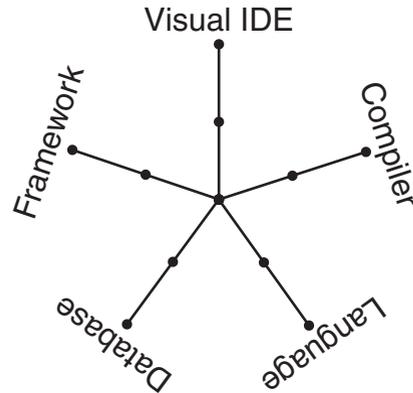
Delphi: What and Why

We're often asked questions such as "What makes Delphi so good?" and "Why should I choose Delphi over Tool X?" Over the years, we've developed two answers to these types of questions: a long answer and a short answer. The short answer is *productivity*. Using Delphi is simply the most productive way we've found to build applications for Windows. Of course, there are those (bosses and perspective clients) for whom the short answer will not suffice, so then we must break out the long answer. The long answer describes the combined qualities that make Delphi so productive. We boil down the productivity of software development tools into a pentagon of five important attributes:

- The quality of the visual development environment
- The speediness of the compiler versus the efficiency of the compiled code
- The power of the programming language versus its complexity
- The flexibility and scalability of the database architecture
- The design and usage patterns enforced by the framework

Although there are admittedly many other factors involved, such as deployment issues, documentation, third-party support, and so on, we've found this simple model to be quite accurate in explaining to folks why we choose Delphi. Some of these categories also involve some amount of subjectivity, but that's the point; how productive are *you* with a particular tool? By rating a tool on a scale of 1 to 5 for each attribute and plotting each on an axis of the graph shown in Figure 1.1, the end result will be a pentagon. The greater the surface area of this pentagon, the more productive the tool.

We won't tell you what we came up with when we used this formula—that's for you to decide! Let's take a deeper look at each of these attributes and how they apply to Delphi and how they compare with other Windows development tools.



1

WINDOWS
PROGRAMMING IN
DELPHI 5**FIGURE 1.1***The development tool productivity graph.*

The Quality of the Visual Development Environment

The visual development environment can generally be divided into three constituent components: the editor, the debugger, and the form designer. Like most modern rapid application development (RAD) tools, these three components work in harmony as you design an application. While you're working in the form designer, Delphi is generating code behind the scenes for the components you drop and manipulate on forms. You can add additional code in the editor to define application behavior, and you can debug your application from the same editor by setting breakpoints, watches, and so on.

Delphi's editor is generally on par with those of other tools. The CodeInsight technologies, which save you a lot of typing, are probably the best around. They're based on compiler information, rather than type library info like Visual Basic, and are therefore able to help in a wider variety of situations. Although the Delphi editor sports some good configuration options, I would rate Visual Studio's editor as more configurable.

In version 5, Delphi's debugger has finally caught up with the debugger featured in Visual Studio, with advanced features such as remote debugging, process attachment, DLL and package debugging, automatic local watches, and a CPU window. Delphi also has some nice IDE support for debugging by allowing windows to be placed and docked where you like during debugging and enabling that state to be saved as a named desktop setting. One very nice debugger feature that's commonplace in interpreted environments such as Visual Basic and some Java tools is the ability to change code to modify application behavior while the application is being debugged. Unfortunately, this type of feature is much more difficult to accomplish when compiling to native code and is therefore unsupported by Delphi.

A form designer is usually a feature unique to RAD tools, such as Delphi, Visual Basic, C++Builder, and PowerBuilder. More classical development environments, such as Visual C++ and Borland C++, typically provide dialog editors, but those tend not to be as integrated into the development workflow as a form designer. Based on the productivity graph from Figure 1.1, you can see that the lack of a form designer really has a negative effect on the overall productivity of the tool for application development. Over the years, Delphi and Visual Basic have engaged in a sort of tug-of-war of form designer features, with each new version surpassing the other in functionality. One trait of Delphi's form designer that sets it apart from others is the fact that Delphi is built on top of a true object-oriented framework. Given that, changes you make to base classes will propagate up to any ancestor classes. A key feature that leverages this trait is *visual form inheritance* (VFI). VFI enables you to dynamically descend from any of the other forms in your project or in the Gallery. What's more, changes made to the base form from which you descend will cascade and reflect in its descendants. You'll find more information on this important feature in Chapter 4, "Application Frameworks and Design Concepts."

The Speediness of the Compiler Versus the Efficiency of the Compiled Code

A speedy compile enables you to develop software incrementally, thus making frequent changes to your source code, recompiling, testing, changing, recompiling, testing again, and so forth a very efficient development cycle. When compilation speed is slower, developers are forced to make source changes in batch, making multiple modifications prior to compiling and adapting to a less efficient development cycle. The advantage of runtime efficiency is self-evident; faster runtime execution and smaller binaries are always good.

Perhaps the best-known feature of the Pascal compiler upon which Delphi is based is that it's fast. In fact, it's probably the fastest high-level language native code compiler for Windows. C++, which has traditionally been dog-slow in terms of compile speed, has made great strides in recent years with incremental linking and various caching strategies found in Visual C++ and C++Builder in particular. Still, even these C++ compilers are typically several times slower than Delphi's compiler.

Does all this compile-time speed mean a tradeoff in runtime efficiency? The answer is, of course, no. Delphi shares the compiler back end with the C++Builder compiler, so the efficiency of the generated code is on par with that of a very good C++ compiler. In the latest reliable benchmarks, Visual C++ actually rated tops in speed and size efficiency in many cases, thanks to some very nice optimizations. Although these small advantages are unnoticeable for general application development, they may make a difference if you're writing computation-intensive code.

Visual Basic is a little unique with regard to compiler technology. During development, VB operates in an interpreted mode and is quite responsive. When you wish to deploy, you can invoke the VB compiler to generate the EXE. This compiler is fairly poky and its speed efficiency rates well behind Delphi and C++ tools.

Java is another interesting case. Top Java-based tools such as JBuilder and Visual J++ boast compile times approaching that of Delphi. Runtime speed efficiency, however, often leaves something to be desired, because Java is an interpreted language. Although Java continues to make steady improvements, runtime speed in most cases is far behind that of Delphi and C++.

The Power of the Programming Language Versus Its Complexity

Power and complexity are very much in the eye of the beholder, and this particular category has served as the guidon for many an online flame war. What's easy to one person might be difficult to another, and what's limiting to one may be considered elegant by yet another. Therefore, the following is based on the authors' experience and personal preferences.

Assembly is the ultimate power language. There's very little you can't do. However, writing even the simplest Windows application in assembly is an arduous and error-prone venture. Not only that, but it's sometimes near impossible to maintain an assembly code base in a team environment for any length of time. As code passes from one owner to the next to the next, design ideas and intents become more and more cloudy, until the code starts to look more like Sanskrit than a computer language. Therefore, we would score assembly very low in this category because, although powerful, assembly language is too complex for nearly all application development chores.

C++ is another extremely powerful language. With the aid of really potent features such as pre-processor macros, templates, operator overloading, and more, you can very nearly design your own language within C++. If the vast array of features at your disposal are used judiciously, you can develop very clear and maintainable code. The problem, however, is that many developers can't resist overusing these features, and it's quite easy to create truly horrible code. In fact, it's easier to write bad C++ code than good because the language doesn't lend itself toward good design—it's up to the developer.

Two languages that we feel are very similar in that they strike a very good balance between complexity and power are Object Pascal and Java. Both take the approach of limiting available features in an effort to enforce logical design on the developer. For example, both avoid the very object-oriented but easy-to-abuse notion of multiple inheritance in favor of enabling a class to implement multiple interfaces. Both lack the nifty but dangerous feature of operator overloading. Also, both make source files first-class citizens in the language rather than a detail to be dealt with by the linker. What's more, both languages take advantage of power features

that add the most bang for the buck, such as exception handling, Runtime Type Information (RTTI), and native memory-managed strings. Not coincidentally, both languages were not written by committee but rather nurtured by an individual or small group within a single organization with a common understanding of what the language should be.

Visual Basic started life as a language designed to be easy enough for programming beginners to pick up quickly (hence the name). However, as language features were added to address shortcomings over the years, Visual Basic has become more and more complex. In an effort to hide the details from developers, Visual Basic still maintains some walls that must be navigated around in order to build complex projects.

The Flexibility and Scalability of the Database Architecture

Because of Borland's lack of a database agenda, Delphi maintains what we feel to be one of the most flexible database architectures of any tool. Out of the box, the BDE works great and performs well for most applications against a wide range of local, client/server, and ODBC database platforms. If you're not happy with that, you can eschew the BDE in favor of the new native ADO components. If ADO isn't your scene, you can write your own data-access class by leveraging the abstract dataset architecture or purchase a third-party dataset solution. Furthermore, MIDAS makes it easy to logically or physically divide, into multiple tiers, access to any of these data sources.

Microsoft tools logically tend to focus on Microsoft's own databases and data-access solutions, be they ODBC, OLE DB, or others.

The Design and Usage Patterns Enforced by the Framework

This is the magic bullet, the holy grail of software design that other tools seem to be missing. All other things being equal, VCL is the most important part of Delphi. The ability to manipulate components at design time, design components, and inherit behavior from other components using object-oriented (OO) techniques is a critical ingredient to Delphi's level of productivity. When writing VCL components, you can't help but employ solid OO design methodologies in many cases. By contrast, other component-based frameworks are often too rigid or too complicated. ActiveX controls, for example, provide many of the same design-time benefits of VCL controls, but there's no way to inherit from an ActiveX control to create a new class with some different behaviors. Traditional class frameworks, such as OWL and MFC, typically require you to have a great deal of internal framework knowledge in order to be productive, and they're hampered by a lack of RAD tool-like design-time support. One tool in the landscape that matches features with VCL in this manner is Visual J++'s Windows Foundation

Classes (WFC). However, at the time of this writing, the future of Visual J++ is unclear due to a pending lawsuit brought on by Sun Microsystems over Java issues.

A Little History

Delphi is, at heart, a Pascal compiler. Delphi 5 is the next step in the evolution of the same Pascal compiler that Borland has been developing since Anders Hejlsberg wrote the first Turbo Pascal compiler more than 15 years ago. Pascal programmers throughout the years have enjoyed the stability, grace, and, of course, the compile speed that Turbo Pascal offers. Delphi 5 is no exception—its compiler is the synthesis of more than a decade of compiler experience and a state-of-the-art 32-bit optimizing compiler. Although the capabilities of the compiler have grown considerably over the years, the speed of the compiler has remarkably diminished only slightly. What's more, the stability of the Delphi compiler continues to be a yardstick by which others are measured.

Now it's time for a little walk down memory lane, as we look at each of the versions of Delphi and a little of the historical context surrounding each product's release.

Delphi 1

In the early days of DOS, programmers had a choice between productive-but-slow BASIC and efficient-but-complex assembly language. Turbo Pascal, which offered the simplicity of a structured language and the performance of a real compiler, bridged that gap. Windows 3.1 programmers faced a similar choice—a choice between a powerful-yet-unwieldy language such as C++ and an easy-to-use-but-limiting language such as Visual Basic. Delphi 1 answered that call by offering a radically different approach to Windows development: visual development, compiled executables, DLLs, databases, you name it—a visual environment without limits. Delphi 1 was the first Windows development tool to combine a visual development environment, an optimizing native-code compiler, and a scalable database access engine. It defined the phrase *rapid application development* (RAD).

The combination of compiler, RAD tool, and fast database access was too compelling for scads of VB developers, and Delphi won many converts. Also, many Turbo Pascal developers reinvented their careers by transitioning to this slick, new tool. Word got out that Object Pascal wasn't the same as that language they made us use in college that made us feel like we were programming with one hand behind our backs, and many more developers came to Delphi to take advantage of the robust design patterns encouraged by the language and the tool. The Visual Basic team at Microsoft, lacking serious competition before Delphi, was caught totally unprepared. Slow, fat, and dumb, Visual Basic 3 was arguably no match for Delphi 1.

The year was 1995. Borland was appealing a huge lawsuit loss to Lotus for infringing on the 1-2-3 “look and feel” with Quattro. Borland was also taking lumps from Microsoft for trying to play in the application space with Microsoft. Borland got out of the application business by selling the Quattro business to Novell and targeting dBASE and Paradox to database developers, as opposed to casual users. While Borland was playing in the applications market, Microsoft had quietly leveraged its platform business to take away from Borland a vast share of the Windows developer tools market. Newly refocused on its core competency of developer tools, Borland was looking to do some damage with Delphi and a new release of Borland C++.

Delphi 2

A year later, Delphi 2 provided all these same benefits under the modern 32-bit operating systems of Windows 95 and Windows NT. Additionally, Delphi 2 extended productivity with additional features and functionality not found in version 1, such as a 32-bit compiler that produces faster applications, an enhanced and extended object library, revamped database support, improved string handling, OLE support, Visual Form Inheritance, and compatibility with 16-bit Delphi projects. Delphi 2 became the yardstick by which all other RAD tools are measured.

The year was 1996, and the most important Windows platform release since 3.0—32-bit Windows 95—had just happened in the latter part of the previous year. Borland was eager to make Delphi the preeminent development tool for that platform. An interesting historical note is that Delphi 2 was originally going to be called *Delphi32*, to underscore the fact that it was designed for 32-bit Windows. However, the product name was changed before release to Delphi 2 to illustrate that Delphi was a mature product and avoid what is known in the software business as the “1.0 blues.”

Microsoft attempted to counter with Visual Basic 4, but it was plagued by poor performance, lack of 16-to-32-bit portability, and key design flaws. Still, there’s an impressive number of developers who continued to use Visual Basic for whatever the reason. Borland also longed to see Delphi penetrate the high-end client/server market occupied by tools such as PowerBuilder, but this version didn’t yet have the muscle necessary to unseat such products from their corporate perches.

The corporate strategy at this time was undeniably to focus on corporate customers. The decision to change direction in this way was no doubt fueled by the diminishing market relevance of dBASE and Paradox, and the dwindling revenues realized in the C++ market also aided this decision. In order to help jumpstart that effort to take on the enterprises, Borland made the mistake of acquiring Open Environment Corporation, a middleware company with basically two products: an outmoded DCE-based middleware that you might call an ancestor of CORBA and a proprietary technology for distributed OLE about to be ushered into obsolescence by DCOM.

Delphi 3

During the development of Delphi 1, the Delphi development team was preoccupied with simply creating and releasing a groundbreaking development tool. For Delphi 2, the development team had its hands full primarily with the tasks of moving to 32 bit (while maintaining almost complete backward compatibility) and adding new database and client/server features needed by corporate IT. While Delphi 3 was being created, the development team had the opportunity to expand the tool set to provide an extraordinary level of breadth and depth for solutions to some of the sticky problems faced by Windows developers. In particular, Delphi 3 made it easy to use the notoriously complicated technologies of COM and ActiveX, World Wide Web application development, “thin client” applications, and multitier databases architectures. Delphi 3’s Code Insight helped to make the actual code-writing process a bit easier, although for the most part, the basic methodology for writing Delphi applications was the same as in Delphi 1.

This was 1997, and the competition was doing some interesting things. On the low end, Microsoft finally started to get something right with Visual Basic 5, which included a compiler to address long-standing performance problems, good COM/ActiveX support, and some key new platform features. On the high-end, Delphi was now successfully unseating products such as PowerBuilder and Forte in corporations.

Delphi lost a key member of the team during the Delphi 3 development cycle when Anders Hejlsberg, the Chief Architect, decided to move on and took a position with Microsoft Corporation. The team didn’t lose a beat, however, because Chuck Jazdzewski, long time co-architect was able to step into the head role. The corporation also lost Chief Technical Officer Paul Gross around this time, also to Microsoft, although that loss was arguably more of a public relations problem than an impact on the day-to-day software development business.

Delphi 4

Delphi 4 focused on making Delphi development easier. The Module Explorer was introduced in Delphi, and it enabled you to browse and edit units from a convenient graphical interface. New code navigation and class completion features enabled you to focus on the meat of your applications with a minimum of busy work. The IDE was redesigned with dockable toolbars and windows to make your development more convenient, and the debugger was greatly improved. Delphi 4 extended the product’s reach into the enterprise with outstanding multitier support using technologies such as MIDAS, DCOM, MTS, and CORBA.

This was 1998, and Delphi had effectively secured its position relative to the competition. The front lines had stabilized somewhat, although Delphi continued to slowly gain market share. CORBA was the industry buzz, and Delphi had it and the competition did not. There was a bit of a down-side to Delphi 4 as well: After enjoying several years of being the most stable development tool on the market, Delphi 4 had earned a reputation among long-time Delphi users for not living up to the very high standard for solid engineering and stability.

The release of Delphi 4 followed the acquisition of Visigenic, one of the CORBA industry leaders. Borland, now called *Inprise* after making the questionable decision to change the company's name to better penetrate the enterprise, was in a position to lead the industry to new ground by integrating its tools with the CORBA technology. To really win, CORBA needed to be made as easy as COM or Internet development had been made in past versions of Borland tools. However, for various reasons, the integration wasn't as full as it should have been, and the CORBA-development tool integration was destined to play a bit part in the overall software-development picture.

Delphi 5

Delphi 5 moves ahead on a few of fronts: First, Delphi 5 continues what Delphi 4 started by adding many more features to make easy those tasks that traditionally take time, hopefully enabling you to concentrate more on what you want to write and less on how to write it. These new productivity features include further IDE and debugger enhancements, TeamSource team development software, and translation tools. Second, Delphi 5 contains a host of new features aimed squarely at making Internet development easier. These new Internet features include the Active Server Object Wizard for ASP creation, the InternetExpress components for XML support, and new MIDAS features, making it a very versatile data platform for the Internet. Finally, Borland built time into the schedule to deliver the most important feature of all for Delphi 5: stability. Like fine wine, you cannot rush great software, and Borland waited until Delphi 5 was ready before letting it out the door.

Delphi 5 was released in the latter half of 1999. Delphi continues to penetrate the enterprise, while Visual Basic continues to serve as competition on the low end. However, the battle lines still appear stable. Inprise had the good sense to bring back the Borland name, much to the delight of long-time customers. The executive offices went through some turbulent times, with the company divisionalized between tools and middleware, the abrupt departure of CEO Del Yocam, and the hiring of Internet-savvy CEO Dale Fuller. Fuller has refocused the company back on software developers, and the products appear as good as ever. Here's to hoping that Inprise is finally back on the right track.

The Future?

Although the history of the product is important, perhaps more important is what lies ahead in Delphi's future. Using history as a guide, we can divine with good probability that Delphi will remain a great way to develop Windows applications for a long time to come. I think the real question is whether we'll ever see Delphi versions that target platforms other than Win32. Based on the information coming out of Borland, it certainly seems that this is certainly something that occupies their minds. At the Borland Conference in 1998, Delphi Chief Architect Chuck Jazdzewski demonstrated a version of the Delphi compiler that generated Java byte-code, which could theoretically target any computer equipped with a Java Virtual Machine.

Although there are obvious technical hurdles with such a technology, and it still remains to be seen whether the Delphi for Java technology will ever make it into a product, it affirms the notion that moving Delphi to other platforms is a part of the game plan. More recently, at the Borland Conference in 1999, CEO Dale Fuller let slip at the opening keynote that there are plans in the works to produce a version of Delphi targeted toward the Linux platform.

The Delphi IDE

Just to make sure we're all on the same page with regard to terminology, Figure 1.2 shows the Delphi IDE and calls attention to its major constituents: the main window, the Component Palette, the toolbars, the Form Designer, the Code Editor, the Object Inspector, and the Code Explorer.

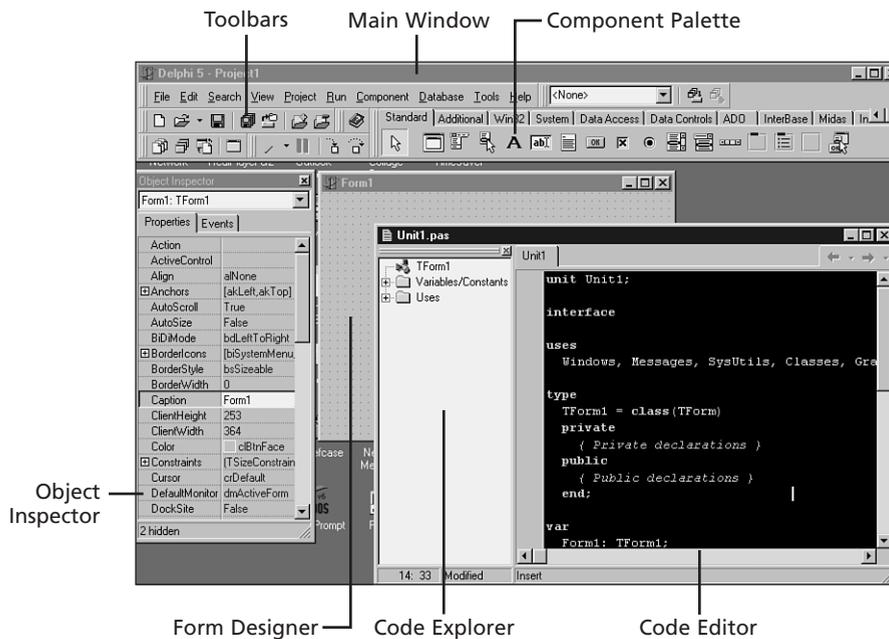


FIGURE 1.2

The Delphi 5 IDE.

The Main Window

Think of the *main window* as the control center for the Delphi IDE. The main window has all the standard functionality of the main window of any other Windows program. It consists of three parts: the main menu, the toolbars, and the Component Palette.

The Main Menu

As in any Windows program, you go to the main menu when you need to open and save files, invoke wizards, view other windows, modify options, and so on. Each item on the main menu can also be invoked via a button on a toolbar.

The Delphi Toolbars

The toolbars enable single-click access to some operation found on the main menu of the IDE, such as opening a file or building a project. Notice that each of the buttons on the toolbars offer a *tooltip* that contain a description of the function of a particular button. Not including the Component Palette, there are five separate toolbars in the IDE: Debug, Desktops, Standard, View, and Custom. Figure 1.2 shows the default button configuration for these toolbars, but you can add or remove buttons by selecting Customize from the local menu on a toolbar. Figure 1.3 shows the Customize toolbar dialog box. You add buttons by dragging them from this dialog box and drop them on any toolbar. To remove a button, drag it off the toolbar.

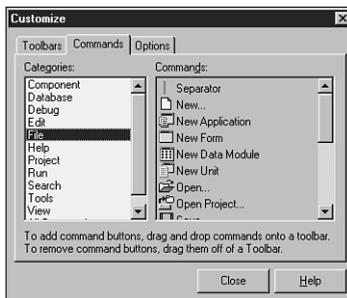


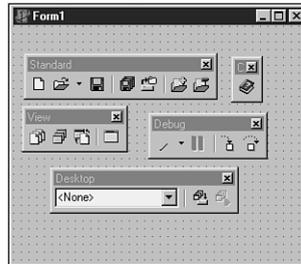
FIGURE 1.3

The Customize toolbar dialog box.

IDE toolbar customization doesn't stop at configuring which buttons are shown. You can also relocate each of the toolbars, the Component Palette, or the menu within the main window. To do this, click the raised gray bars on the right side of the toolbars and drag them around the main window. If you drag the mouse outside the confines of the main window while doing this, you'll see yet another level of customization: the toolbars can be undocked from the main window and reside in their own floating tool windows. Undocked views of the toolbars are shown in Figure 1.4.

The Component Palette

The Component Palette is a double-height toolbar that contains a page control filled with all the VCL components and ActiveX controls installed in the IDE. The order and appearance of pages and components on the Component Palette can be configured via a right-click or by selecting Component, Configure Palette from the main menu.

**FIGURE 1.4**

Undocked toolbars.

The Form Designer

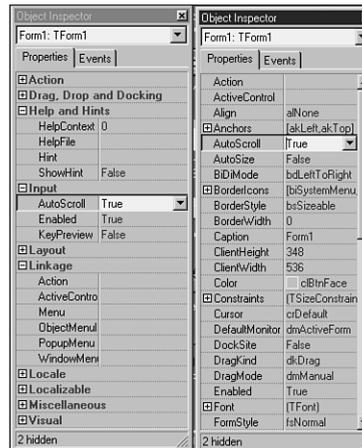
The Form Designer begins as an empty window, ready for you to turn it into a Windows application. Consider the Form Designer your artist's canvas for creating Windows applications; here is where you determine how your applications will be represented visually to your users. You interact with the Form Designer by selecting components from the Component Palette and dropping them onto your form. After you have a particular component on the form, you can use the mouse to adjust the position or size of the component. You can control the appearance and behavior of these components by using the Object Inspector and Code Editor.

The Object Inspector

With the Object Inspector, you can modify a form's or component's properties or enable your form or component to respond to different events. *Properties* are data such as height, color, and font that determine how an object appears onscreen. *Events* are portions of code executed in response to occurrences within your application. A mouse-click message and a message for a window to redraw itself are two examples of events. The Object Inspector window uses the standard Windows *notebook tab* metaphor in switching between component properties or events; just select the desired page from the tabs at the top of the window. The properties and events displayed in the Object Inspector reflect whichever form or component currently has focus in the Form Designer.

New to Delphi 5 is the ability to arrange the contents of the Object Inspector by category or alphabetically by name. You can do this by right-clicking anywhere in the Object Inspector and selecting *Arrange* from the local menu. Figure 1.5 shows two Object Inspectors side by side. The one on the left is arranged by category, and the one on the right is arranged by name. You can also specify which categories you would like to view by selecting *View* from the local menu.

One of the most useful tidbits of knowledge that you as a Delphi programmer should know is that the help system is tightly integrated with the Object Inspector. If you ever get stuck on a particular property or event, just press the F1 key, and WinHelp comes to the rescue.

**FIGURE 1.5**

Viewing the Object Inspector by category and by name.

The Code Editor

The Code Editor is where you type the code that dictates how your program behaves and where Delphi inserts the code that it generates based on the components in your application. The top of the Code Editor window contains notebook tabs, where each tab corresponds to a different source code module or file. Each time you add a new form to your application, a new unit is created and added to the set of tabs at the top of the Code Editor. The local menu in the Code Editor gives you a wide range of options while you're editing, such as closing files, setting bookmarks, and navigating to symbols.

TIP

You can view multiple Code Editor windows simultaneously by selecting View, New Edit Window from the main menu.

The Code Explorer

The Code Explorer provides a tree-style view of the unit shown in the Code Editor. The Code Explorer allows easy navigation of units in addition to the ability to easily add new elements or rename existing elements in a unit. It's important to remember that there's a one-to-one relationship between Code Explorer windows and Code Editor windows. Right-click a node in the Code Explorer to view the options available for that node. You can also control behaviors such

as sorting and filtering in the Code Explorer by modifying the options found on the Explorer tab of the Environment Options dialog box.

A Tour of Your Project's Source

The Delphi IDE generates Object Pascal source code for you as you work with the visual components of the Form Designer. The simplest example of this capability is starting a new project. Select File, New Application in the main window to see a new form in the Form Designer and that form's source code skeleton in the Code Editor. The source code for the new form's unit is shown in Listing 1.1.

LISTING 1.1 Source Code for an Empty Form

```
unit Unit1;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs;

type
  TForm1 = class(TForm)
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  Form1: TForm1;

implementation

{$R *.DFM}

end.
```

It's important to note that the source code module associated with any form is stored in a unit. Although every form has a unit, not every unit has a form. If you're not familiar with how the Pascal language works and what exactly a *unit* is, see Chapter 2, "The Object Pascal Language," which discusses the Object Pascal language for those who are new to Pascal from C++, Visual Basic, Java, or another language.

Let's take a unit skeleton one piece at a time. Here's the top portion:

```
type
  TForm1 = class(TForm)
  private
    { Private declarations }
  public
    { Public declarations }
  end;
```

It indicates that the form object, itself, is an object derived from `TForm`, and the space in which you can insert your own public and private variables is labeled clearly. Don't worry about what *object*, *public*, or *private* means right now. Chapter 2, "The Object Pascal Language," discusses Object Pascal in more detail.

The following line is very important:

```
{$R *.DFM}
```

The `$R` directive in Pascal is used to load an external resource file. This line links the `.DFM` (which stands for *Delphi form*) file into the executable. The `.DFM` file contains a binary representation of the form you created in the Form Designer. The `*` symbol in this case isn't intended to represent a wildcard; it represents the file having the same name as the current unit. So, for example, if the preceding line was in a file called `Unit1.pas`, the `*.DFM` would represent a file by the name of `Unit1.dfm`.

NOTE

A feature new to Delphi 5 is the ability for the IDE to save new DFM files a text rather than as binary. This option is enabled by default, but you can modify it using the *New forms as text* checkbox on the Preferences page of the Environment Options dialog. While saving forms as text format is just slightly less efficient in terms of size, it's a good practice for a couple of reasons: First, it is very easy to make minor changes to text DFMs in any text editor. Second, if the file should become corrupted, it is far easier to repair a corrupted text file than a corrupted binary file. Keep in mind also that previous versions of Delphi expect binary DFM files, so you will need to disable this option if you wish to create projects that will be used by other versions of Delphi.

The application's project file is worth a glance, too. A project filename ends in `.DPR` (which stands for *Delphi project*) and is really nothing more than a Pascal source file with a different file extension. The project file is where the main portion of your program (in the Pascal sense) lives. Unlike other versions of Pascal with which you might be familiar, most of the "work" of

your program is done in units rather than in the main module. You can load your project's source file into the Code Editor by selecting Project, View Source from the main menu. Here's the project file from the sample application:

```
program Project1;

uses
  Forms,
  Unit1 in 'Unit1.pas' {Form1};

{$R *.RES}

begin
  Application.Initialize;
  Application.CreateForm(TForm1, Form1);
  Application.Run;
end.
```

As you add more forms and units to the application, they appear in the uses clause of the project file. Notice, too, that after the name of a unit in the uses clause, the name of the related form appears in comments. If you ever get confused about which units go with which forms, you can regain your bearings by selecting View, Project Manager to bring up the Project Manager window.

NOTE

Each form has exactly one unit associated with it, and you can also have other "code-only" units that are not associated with any form. In Delphi, you work mostly within your program's units, and you'll rarely edit your project's .DPR file.

Tour of a Small Application

The simple act of plopping a component such as a button onto a form causes code for that element to be generated and added to the form object:

```
type
  TForm1 = class(TForm)
    Button1: TButton;
  private
    { Private declarations }
  public
    { Public declarations }
  end;
```

Now, as you can see, the button is an instance variable of the `TForm1` class. When you refer to the button in contexts outside `TForm1` later in your source code, you must remember to address it as part of the scope of `TForm1` by saying `Form1.Button1`. Scoping is explained in more detail in Chapter 2, “The Object Pascal Language.”

When this button is selected in the Form Designer, you can change its behavior through the Object Inspector. Suppose that, at design time, you want to change the width of the button to 100 pixels, and at runtime, you want to make the button respond to a press by doubling its own height. To change the button width, move over to the Object Browser window, find the `Width` property, and change the value associated with `Width` to `100`. Note that the change doesn’t take effect in the Form Designer until you press Enter or move off the `Width` property. To make the button respond to a mouse click, select the Events page on the Object Inspector window to reveal the list of events to which the button can respond. Double-click in the column next to the `OnClick` event, and Delphi generates a procedure skeleton for a mouse-click response and whisks you away to that spot in the source code—in this case, a procedure called `TForm1.Button1Click()`. All that’s left to do is to insert the code to double the button’s width between the `begin..end` of the event’s response method:

```
Button1.Height := Button1.Height * 2;
```

To verify that the “application” compiles and runs, press the F9 key on your keyboard and watch it go!

NOTE

Delphi maintains a reference between generated procedures and the controls to which they correspond. When you compile or save a source code module, Delphi scans your source code and removes all procedure skeletons for which you haven’t entered any code between the `begin` and `end`. This means that if you didn’t write any code between the `begin` and `end` of the `TForm1.Button1Click()` procedure, for example, Delphi would have removed the procedure from your source code. The bottom line here is this: Don’t delete event handler procedures that Delphi has created; just delete your code and let Delphi remove the procedures for you.

After you have fun making the button really big on the form, terminate your program and go back to the Delphi IDE. Now is a good time to mention that you could have generated a response to a mouse click for your button just by double-clicking a control after dropping it onto the form. Double-clicking a component automatically invokes its associated component editor. For most components, this response generates a handler for the first of that component’s events listed in the Object Inspector.

What's So Great About Events, Anyway?

If you've ever developed Windows applications the traditional way, without a doubt you'll find the ease of use of Delphi events a welcome alternative to manually catching Windows messages, cracking those messages, and testing for window handles, control IDs, `WParam` parameters, `LParam` parameters, and so on. If you don't know what all that means, that's okay; Chapter 5, "Understanding Windows Messaging," covers messaging internals.

A Delphi event is often triggered by a Windows message. The `OnMouseDown` event of a `TButton`, for example, is really just an encapsulation of the Windows `WM_XBUTTONDOWN` messages. Notice that the `OnMouseDown` event gives you information such as which button was pressed and the location of the mouse when it happened. A form's `OnKeyDown` event provides similar useful information for key presses. For example, here's the code that Delphi generates for an `OnKeyDown` handler:

```
procedure TForm1.FormKeyDown(Sender: TObject; var Key: Word;
  Shift: TShiftState);
begin
end;
```

All the information you need about the key is right at your fingertips. If you're an experienced Windows programmer, you'll appreciate that there aren't any `LParam` or `WParam` parameters, inherited handlers, translates, or dispatches to worry about. This goes way beyond "message cracking" as you might know it because one Delphi event can represent several different Windows messages, as it does with `OnMouseDown` (which handles a variety of mouse messages). What's more, each of the message parameters is passed in as easy-to-understand parameters. Chapter 5, "Understanding Windows Messaging," gets into the gory details of how Delphi's internal messaging system works.

Contract-Free Programming

Arguably the biggest benefit that Delphi's event system has over the standard Windows messaging system is that all events are contract free. What *contract free* means to the programmer is that you never are *required* to do anything inside your event handlers. Unlike standard Windows message handling, you don't have to call an inherited handler or pass information back to Windows after handling an event.

Of course, the downside to the contract-free programming model that Delphi's event system provides is that it doesn't always give you the power or flexibility that directly handling Windows messages gives you. You're at the mercy of those who designed the event as far as what level of control you'll have over your application's response to the event. For example, you can modify and kill keystrokes in an `OnKeyPress` handler, but an `OnResize` handler provides you only with a notification that the event occurred—you have no power to prevent or modify the resizing.

Never fear, though. Delphi doesn't prevent you from working directly with Windows messages. It's not as straightforward as the event system because message handling assumes that the programmer has a greater level of knowledge of what Windows expects of every handled message. You have complete power to handle all Windows messages directly by using the message keyword. You'll find out much more about writing Windows message handlers in Chapter 5, "Understanding Windows Messaging."

The great thing about developing applications with Delphi is that you can use the high-level easy stuff (such as events) when it suits you and still have access to the low-level stuff whenever you need it.

Turbo Prototyping

After hacking Delphi for a little while, you'll probably notice that the learning curve is especially mild. In fact, even if you're new to Delphi, you'll find that writing your first project in Delphi pays immediate dividends in the form of a short development cycle and a robust application. Delphi excels in the one facet of application development that has been the bane of many a Windows programmer: user interface (UI) design.

Sometimes the designing of the UI and the general layout of a program is referred to as *prototyping*. In a nonvisual environment, prototyping an application often takes longer than writing the application's implementation, or what is called the *back end*. Of course, the back end of an application is the whole objective of the program in the first place, right? Sure, an intuitive and visually pleasing UI is a big part of the application, but what good would it be, for example, to have a communications program with pretty windows and dialog boxes but no capacity to send data through a modem? As it is with people, so it is with applications; a pretty face is nice to look at, but it has to have substance to be a regular part of our lives. Please, no comments about back ends.

Delphi enables you to use its custom controls to whip out nice-looking UIs in no time flat. In fact, you'll find that after you become comfortable with Delphi's forms, controls, and event-response methods, you'll cut huge chunks off the time you usually take to develop application prototypes. You'll also find that the UIs you develop in Delphi look just as nice as—if not better than—those designed with traditional tools. Often, what you "mock up" in Delphi turns out to be the final product.

Extensible Components and Environment

Because of the object-oriented nature of Delphi, in addition to creating your own components from scratch, you can also create your own customized components based on stock Delphi components. Chapter 21, "Writing Delphi Custom Components," shows you how to take some

existing Delphi components and extend their behavior to create new components. Additionally, Chapter 7, “Using ActiveX Controls with Delphi,” describes how to incorporate ActiveX controls into your Delphi applications.

In addition to allowing you to integrate custom components into the IDE, Delphi provides the capability to integrate entire subprograms, called *experts*, into the environment. Delphi’s Expert Interface enables you to add special menu items and dialog boxes to the IDE to integrate some feature that you feel is worthwhile. An example of an expert is the Database Form Expert located on the Delphi Database menu. Chapter 26, “Using Delphi’s Open Tools API,” outlines the process for creating experts and integrating them into the Delphi IDE.

The Top 10 IDE Features You Must Know and Love

Before we can let you any further into the book, we’ve got to make sure you’re equipped with the tools you need to survive and the knowledge to use them. In that spirit, what follows is a list of what we feel are the top 10 IDE features you must learn to know and love.

1. Class Completion

Nothing wastes a developer’s time more than have to type in all that blasted code! How often is it that you know exactly what you want to write but are limited by how fast your fingers can fly over the keys? Until the spec for the PCI-to-medulla oblongata bus is completed to completely rid you of all that typing, Delphi has a feature called *class completion* that goes a long way toward alleviating the busy work.

Arguably, the most important feature of Class completion is that it is designed to work without being in your face. Simply type in part of a class declaration, hit the magic Ctrl+Shift+C key-stroke, and class completion will attempt to figure out what you’re trying to do and generate the right code. For example, if you put the declaration for a procedure called `Foo` in your class and invoke class completion, it will automatically create the definition for this method in the implementation part of the unit. Declare a new property that reads from a field and writes to a method and invoke class completion, and it will automatically generate the code for the field and declare and implement the method.

If you haven’t already gotten hooked on class completion, give it a whirl. Soon you’ll be lost without it.

2. AppBrowser Navigation

Do you ever look at a line of code in your Code Editor and think, “Gee, I wish I knew where that method is declared”? Well, finding out is as easy as holding down the Ctrl key and clicking the name of the token you wish to find. The IDE will use debug information assembled in

the background by the compiler to jump to the declaration of the token. Very handy. And like a web browser, there's a history stack that you can navigate forward and back through using the little arrows to the right of the tabs in the Code Editor.

3. Interface/Implementation Navigation

Want to navigate between the interface and implementation of a method? Just put the cursor on the method and use Ctrl+Shift+up arrow or down arrow to toggle between the two positions.

4. Dock It!

The IDE allows you to organize the windows on your screen by docking together multiple windows as panes in a single window. If you have full window drag set in your windows desktop, you can easily tell which windows are dockable because they draw a dithered box when they're dragged around the screen. The Code Editor offers three docking bays on its left, bottom, and right sides to which you can affix windows. Windows can be docked side-by-side by dragging one window to an edge of another or tab-docked by dragging one window to the middle of another. Once you come up with an arrangement you like, be sure to save it using the Desktops toolbar. Want to prevent a window from docking? Hold down the Ctrl key while dragging it or right-click in the window and uncheck Dockable in the local menu.

TIP

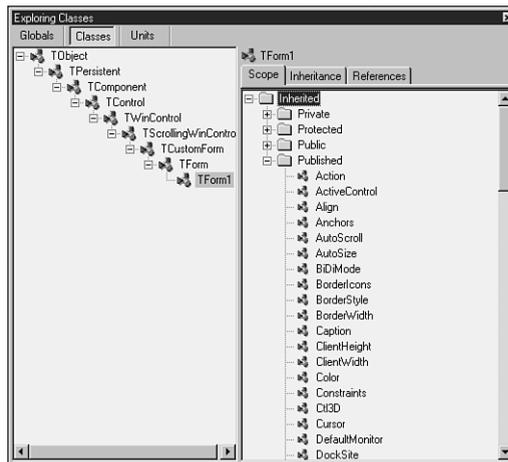
Here's a cute hidden feature: Right-click the tabs of tab-docked windows and you'll be able to move the tabs to the top, bottom, left, or right of the window.

5. A Real Browser

Delphi 1 through 4 shipped with essentially the same icky object browser. If you didn't know it was there, don't feel alone; many folks never used it because it didn't have a lot to offer. Finally, Delphi 5 comes equipped with a completely redone object browser! Shown in Figure 1.6, the new browser is accessible by selecting View, Browser in the main menu. This tool presents a tree view that lets you navigate globals, classes, and units and drill down into scope, inheritance, and references of the symbols.

6. GUID, Anyone?

In the small-but-useful category, you'll find the Ctrl+Shift+G keystroke. Striking this keystroke will place a fresh new GUID in the Code Editor. A real timesaver when you're declaring new interfaces.

**FIGURE 1.6**

The new browser.

7. C++ Syntax Highlighting

If you're like us, you often like to view C++ files, such as SDK headers, while you work in Delphi. Because Delphi and C++Builder share the same editor source code, one of the advantages to users is syntax highlighting of C++ files. Just load up a C++ file such as a .CPP or .H module in the Code Editor, and it handles the rest automatically.

8. To Do...

Use the To Do List to manage work in progress in your source files. You may view the To Do List by selecting View, To Do List from the main menu. This list is automatically populated from any comments in your source code that begin with the token *TODO*. You can use the To Do Items window to set the owner, priority, and category for any To Do item. This window is shown in Figure 1.7, docked to the bottom of the Code Editor.

9. Use the Project Manager

The Project Manager can be a big timesaver when navigating around large projects—especially those projects that are composed of multiple EXE or DLL modules, but it's amazing how many people forget that it's there. You can access the Project Manager by selecting View, Project Manager from the main menu. Delphi 5 adds some nice new features to the Project Manager, such as drag-and-drop copying and copy and paste between projects.



FIGURE 1.7

To Do Items window.

10. Use Code Insight to Complete Declarations and Parameters

When you type **Identifier.**, a window will automatically pop up after the dot to provide you with a list of properties, methods, events, and fields available for that identifier. You can right-click this window to sort the list by name or by scope. If the window goes away before you're ready, just hit Ctrl+space to bring it back up.

Remembering all the parameters to a function can be a pain, so it's nice that Code Insight automatically helps by providing a tooltip with the parameter list when you type **FunctionName(** in the Code Editor. Remember to hit Ctrl+Shift+space to bring the tooltip back up if it goes away before you're ready.

Summary

By now you should have an understanding of the Delphi 5 product line and the Delphi IDE as well as how Delphi fits into the Windows development picture in general. This chapter was intended to acclimate you to Delphi and to the concepts used throughout the book. Now the stage has been set for the really technical stuff to come. Before you move much deeper into the book, make sure you're comfortable using and navigating around the IDE and know how to work with small projects.

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This chapter sets aside the visual elements of Delphi in order to provide you with an overview of Delphi's underlying language—Object Pascal. To begin with, you'll receive an introduction to the basics of the Object Pascal language, such as language rules and constructs. Later on, you'll learn about some of the more advanced aspects of Object Pascal, such as classes and exception handling. Because this isn't a beginner's book, it assumes that you have some experience with other high-level computer languages such as C, C++, or Visual Basic, and it compares Object Pascal language structure to that of those other languages. By the time you're finished with this chapter, you'll understand how programming concepts such as variables, types, operators, loops, cases, exceptions, and objects work in Pascal as compared to C++ and Visual Basic.

Even if you have some recent experience with Pascal, you'll find this chapter useful, as this is really the only point in the book where you learn the nitty-gritty of Pascal syntax and semantics.

Comments

As a starting point, you should know how to make comments in your Pascal code. Object Pascal supports three types of comments: curly brace comments, parentheses/asterisk comments, and C++-style double backslash comments. Examples of each type of comment follow:

```
{ Comment using curly braces }  
  
(* Comment using paren and asterisk *)  
  
// C++-style comment
```

The two types of Pascal comments are virtually identical in behavior. The compiler considers the comment to be everything between the open-comment and close-comment delimiters. For C++-style comments, everything following the double backslash until the end of the line is considered a comment.

NOTE

You cannot nest comments of the same type. Although it is legal syntax to nest Pascal comments of different types inside one another, we don't recommend the practice. Here are some examples:

```
{ (* This is legal *) }  
(* { This is legal } *)  
(* (* This is illegal *) *)  
{ { This is illegal } }
```

New Procedure and Function Features

Because procedures and functions are fairly universal topics as far as programming languages are concerned, we won't go into too much detail here. We just want to fill you in on a few new or little-known features.

Parentheses

Although not new to Delphi 5, one of the lesser-known features of Object Pascal is that parentheses are optional when calling a procedure or function that takes no parameters. Therefore, the following syntax examples are both valid:

```
Form1.Show;  
Form1.Show();
```

Granted, this feature isn't one of those things that sends chills up and down your spine, but it's particularly nice for those who split their time between Delphi and languages such as C++ or Java, where parentheses are required. If you're not able to spend 100 percent of your time in Delphi, this feature means you don't have to remember to use different function-calling syntax for different languages.

Overloading

Delphi 4 introduced the concept of function overloading (that is, the ability to have multiple procedures or functions of the same name with different parameter lists). All overloaded methods are required to be declared with the `overload` directive, as shown here:

```
procedure Hello(I: Integer); overload;  
procedure Hello(S: string); overload;  
procedure Hello(D: Double); overload;
```

Note that the rules for overloading methods of a class are slightly different and are explained in the section "Method Overloading." Although this is one of the features most requested by developers since Delphi 1, the phrase that comes to mind is, "Be careful what you wish for." Having multiple functions and procedures with the same name (on top of the traditional ability to have functions and procedures of the same name in different units) can make it more difficult to predict the flow of control and debug your application. Because of this, overloading is a feature you should employ judiciously. Not to say that you should avoid it; just don't overuse it.

Default Value Parameters

Also introduced in Delphi 4 were default value parameters (that is, the ability to provide a default value for a function or procedure parameter and not have to pass that parameter when

calling the routine). In order to declare a procedure or function that contains default value parameters, follow the parameter type with an equal sign and the default value, as shown in the following example:

```
procedure HasDefVal(S: string; I: Integer = 0);
```

The `HasDefVal()` procedure can be called in one of two ways. First, you can specify both parameters:

```
HasDefVal('hello', 26);
```

Second, you can specify only parameter `S` and use the default value for `I`:

```
HasDefVal('hello'); // default value used for I
```

You must follow several rules when using default value parameters:

- Parameters having default values must appear at the end of the parameter list. Parameters without default values may not follow parameters with default values in a procedure or function's parameter list.
- Default value parameters must be of an ordinal, pointer, or set type.
- Default value parameters must be passed by value or as `const`. They may not be reference (out) or untyped parameters.

One of the biggest benefits of default value parameters is in adding functionality to existing functions and procedures without sacrificing backward compatibility. For example, suppose you sell a unit that contains a revolutionary function called `AddInts()` that adds two numbers:

```
function AddInts(I1, I2: Integer): Integer;  
begin  
    Result := I1 + I2;  
end;
```

In order to keep up with the competition, you feel you must update this function so that it has the capability for adding three numbers. However, you're loathe to do so because adding a parameter will cause existing code that calls this function to not compile. Thanks to default parameters, you can enhance the functionality of `AddInts()` without compromising compatibility. Here's an example:

```
function AddInts(I1, I2: Integer; I3: Integer = 0);  
begin  
    Result := I1 + I2 + I3;  
end;
```

Variables

You might be used to declaring variables off the cuff: "I need another integer, so I'll just declare one right here in the middle of this block of code." If that has been your practice,

you're going to have to retrain yourself a little in order to use variables in Object Pascal. Object Pascal requires you to declare all variables up front in their own section before you begin a procedure, function, or program. Perhaps you used to write free-wheeling code like this:

```
void foo(void)
{
    int x = 1;
    x++;
    int y = 2;
    float f;
    //... etc ...
}
```

In Object Pascal, any such code must be tidied up and structured a bit more to look like this:

```
Procedure Foo;
var
    x, y: Integer;
    f: Double;
begin
    x := 1;
    inc(x);
    y := 2;
    //... etc ...
end;
```

NOTE

Object Pascal—like Visual Basic, but unlike C and C++—is not a case-sensitive language. Upper- and lowercase is used for clarity's sake, so use your best judgment, as the style used in this book indicates. If the identifier name is several words mashed together, remember to capitalize for clarity. For example, the following name is unclear and difficult to read:

```
procedure thisprocedurenamemakesnosense;
```

This code is quite readable, however:

```
procedure ThisProcedureNameIsMoreClear;
```

For a complete reference on the coding style guidelines used for this book, see Chapter 6, "Coding Standards," on the CD accompanying this book.

You might be wondering what all this structure business is and why it's beneficial. You'll find, however, that Object Pascal's structured style lends itself to code that's more readable, maintainable, and less buggy than the more scattered style of C++ or Visual Basic.

Notice how Object Pascal enables you to group more than one variable of the same type together on the same line with the following syntax:

```
VarName1, VarName2: SomeType;
```

Remember that when you're declaring a variable in Object Pascal, the variable name precedes the type, and there's a colon between the variables and types. Note that the variable initialization is always separate from the variable declaration.

A language feature introduced in Delphi 2 enables you to initialize global variables inside a var block. Here are some examples demonstrating the syntax for doing so:

```
var
  i: Integer = 10;
  S: string = 'Hello world';
  D: Double = 3.141579;
```

NOTE

Preinitialization of variables is only allowed for global variables, not variables that are local to a procedure or function.

TIP

The Delphi compiler sees to it that all global data is automatically zero-initialized. When your application starts, all integer types will hold 0, floating-point types will hold 0.0, pointers will be nil, strings will be empty, and so forth. Therefore, it's not necessary to zero-initialize global data in your source code.

Constants

Constants in Pascal are defined in a const clause, which behaves similarly to C's const keyword. Here's an example of three constant declarations in C:

```
const float ADecimalNumber = 3.14;
const int i = 10;
const char * ErrorMessage = "Danger, Danger, Danger!";
```

The major difference between C constants and Object Pascal constants is that Object Pascal, like Visual Basic, does not require you to declare the constant's type along with the value in the declaration. The Delphi compiler automatically allocates proper space for the constant

based on its value, or, in the case of scalar constants such as `Integer`, the compiler keeps track of the values as it works, and space never is allocated. Here's an example:

```
const
  ADecimalNumber = 3.14;
  i = 10;
  ErrorString = 'Danger, Danger, Danger!';
```

NOTE

Space is allocated for constants as follows: Integer values are “fit” into the smallest type allowable (10 into a `ShortInt`, 32,000 into a `SmallInt`, and so on). Alphanumeric values fit into `Char` or the currently defined (by `$H`) string type. Floating-point values are mapped to the extended data type, unless the value contains four or fewer decimal places explicitly, in which case it's mapped to a `Comp` type. Sets of `Integer` and `Char` are of course stored as themselves.

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Optionally, you can also specify a constant's type in the declaration. This provides you with full control over how the compiler treats your constants:

```
const
  ADecimalNumber: Double = 3.14;
  I: Integer = 10;
  ErrorString: string = 'Danger, Danger, Danger!';
```

Object Pascal permits the usage of compile-time functions in `const` and `var` declarations. These routines include `Ord()`, `Chr()`, `Trunc()`, `Round()`, `High()`, `Low()`, and `SizeOf()`. For example, all of the following code is valid:

```
type
  A = array[1..2] of Integer;

const
  w: Word = SizeOf(Byte);

var
  i: Integer = 8;
  j: SmallInt = Ord('a');
  L: Longint = Trunc(3.14159);
  x: ShortInt = Round(2.71828);
  B1: Byte = High(A);
  B2: Byte = Low(A);
  C: char = Chr(46);
```

CAUTION

The behavior of 32-bit Delphi type-specified constants is different from that in 16-bit Delphi 1. In Delphi 1, the identifier declared wasn't treated as a constant but as a preinitialized variable called a *typed constant*. However, in Delphi 2 and later, type-specified constants have the capability of being truly constant. Delphi provides a backward-compatibility switch on the Compiler page of the Project, Options dialog box, or you can use the `$J` compiler directive. By default, this switch is enabled for compatibility with Delphi 1 code, but you're best served not to rely on this capability because the implementers of the Object Pascal language are trying to move away from the notion of assignable constants.

If you try to change the value of any of these constants, the Delphi compiler emits an error explaining that it's against the rules to change the value of a constant. Because constants are read-only, Object Pascal optimizes your data space by storing those constants that merit storage in the application's code pages. If you're unclear about the notions of code and data pages, see Chapter 3, "The Win32 API."

NOTE

Object Pascal does not have a preprocessor as do C and C++. There's no concept of a macro in Object Pascal and, therefore, no Object Pascal equivalent for C's `#define` for constant declaration. Although you may use Object Pascal's `$define` compiler directive for conditional compiles similar to C's `#define`, you cannot use it to define constants. Use `const` in Object Pascal where you would use `#define` to declare a constant in C or C++.

Operators

Operators are the symbols in your code that enable you to manipulate all types of data. For example, there are operators for adding, subtracting, multiplying, and dividing numeric data. There are also operators for addressing a particular element of an array. This section explains some of the Pascal operators and describes some of the differences between their C and Visual Basic counterparts.

Assignment Operators

If you're new to Pascal, Delphi's assignment operator is going to be one of the toughest things to get used to. To assign a value to a variable, use the `:=` operator as you would C or Visual

Basic's = operator. Pascal programmers often call this the *gets* or *assignment* operator, and the expression

```
Number1 := 5;
```

is read either "Number1 *gets* the value 5," or "Number1 *is assigned* the value 5."

Comparison Operators

If you've already programmed in Visual Basic, you should be very comfortable with Delphi's comparison operators because they're virtually identical. These operators are fairly standard throughout programming languages, so they're covered only briefly in this section.

Object Pascal uses the = operator to perform logical comparisons between two expressions or values. Object Pascal's = operator is analogous to C's == operator, so a C expression that would be written as

```
if (x == y)
```

would be written as this in Object Pascal:

```
if x = y
```

NOTE

Remember that in Object Pascal, the := operator is used to assign a value to a variable, and the = operator compares the values of two operands.

Delphi's "not equal to" operator is <>, and its purpose is identical to C's != operator. To determine whether two expressions are not equal, use this code:

```
if x <> y then DoSomething
```

Logical Operators

Pascal uses the words and and or as logical "and" and "or" operators, whereas C uses the && and || symbols, respectively, for these operators. The most common use of the and and or operators is as part of an if statement or loop, as demonstrated in the following two examples:

```
if (Condition 1) and (Condition 2) then  
    DoSomething;
```

```
while (Condition 1) or (Condition 2) do  
    DoSomething;
```

Pascal's logical "not" operator is `not`, which is used to invert a Boolean expression. It's analogous to C's `!` operator. It's also often used as a part of `if` statements, as shown here:

```
if not (condition) then (do something); // if condition is false then...
```

Table 2.1 provides an easy reference of how Pascal operators map to corresponding C/C++ and Visual Basic operators.

TABLE 2.1 Assignment, comparison, and logical operators

<i>Operator</i>	<i>Pascal</i>	<i>C/C++</i>	<i>Visual Basic</i>
Assignment	<code>:=</code>	<code>=</code>	<code>=</code>
Comparison	<code>=</code>	<code>==</code>	<code>=</code> or <code>Is*</code>
Not equal to	<code><></code>	<code>!=</code>	<code><></code>
Less than	<code><</code>	<code><</code>	<code><</code>
Greater than	<code>></code>	<code>></code>	<code>></code>
Less than or equal to	<code><=</code>	<code><=</code>	<code><=</code>
Greater than or equal to	<code>>=</code>	<code>>=</code>	<code>>=</code>
Logical and	<code>and</code>	<code>&&</code>	<code>And</code>
Logical or	<code>or</code>	<code> </code>	<code>Or</code>
Logical not	<code>not</code>	<code>!</code>	<code>Not</code>

**The `Is` comparison operator is used for objects, while the `=` comparison operator is used for other types.*

Arithmetic Operators

You should already be familiar with most Object Pascal arithmetic operators because they're generally similar to those used in C, C++, and Visual Basic. Table 2.2 illustrates all the Pascal arithmetic operators and their C/C++ and Visual Basic counterparts.

TABLE 2.2 Arithmetic operators

<i>Operator</i>	<i>Pascal</i>	<i>C/C++</i>	<i>Visual Basic</i>
Addition	<code>+</code>	<code>+</code>	<code>+</code>
Subtraction	<code>-</code>	<code>-</code>	<code>-</code>
Multiplication	<code>*</code>	<code>*</code>	<code>*</code>
Floating-point division	<code>/</code>	<code>/</code>	<code>/</code>
Integer division	<code>div</code>	<code>/</code>	<code>\</code>
Modulus	<code>mod</code>	<code>%</code>	<code>Mod</code>
Exponent	None	None	<code>^</code>

You may notice that Pascal and Visual Basic provide different division operators for floating-point and integer math, while this is not the case for C/C++. The `div` operator automatically truncates any remainder when you're dividing two integer expressions.

NOTE

Remember to use the correct division operator for the types of expressions with which you're working. The Object Pascal compiler gives you an error if you try to divide two floating-point numbers with the integer `div` operator or two integers with the floating-point `/` operator, as the following code illustrates:

```
var
  i: Integer;
  r: Real;
begin
  i := 4 / 3;           // This line will cause a compiler error
  f := 3.4 div 2.3;    // This line also will cause an error
end;
```

Many other programming languages do not distinguish between integer and floating-point division. Instead, they always perform floating-point division and then convert the result back to an integer when necessary. This can be rather expensive in terms of performance. The Pascal `div` operator is faster and more specific.

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Bitwise Operators

Bitwise operators are operators that enable you to modify individual bits of a given variable. Common bitwise operators enable you to shift the bits to the left or right or to perform bitwise “and,” “not,” “or,” and “exclusive or” (*xor*) operations with two numbers. The Shift+Left and Shift+Right operators are `shl` and `shr`, respectively, and they're much like C's `<<` and `>>` operators. The remainder of Pascal's bitwise operators is easy enough to remember: `and`, `not`, `or`, and `xor`. Table 2.3 lists the bitwise operators.

TABLE 2.3 Bitwise operators

<i>Operator</i>	<i>Pascal</i>	<i>C</i>	<i>Visual Basic</i>
And	<code>and</code>	<code>&</code>	And
Not	<code>not</code>	<code>~</code>	Not
Or	<code>or</code>	<code> </code>	Or
Xor	<code>xor</code>	<code>^</code>	Xor
Shift+Left	<code>shl</code>	<code><<</code>	None
Shift+Right	<code>shr</code>	<code>>></code>	None

Increment and Decrement Procedures

Increment and decrement procedures generate optimized code for adding or subtracting 1 from a given integral variable. Pascal doesn't really provide honest-to-gosh increment and decrement operators similar to C's ++ and -- operators, but Pascal's Inc() and Dec() procedures compile optimally to one machine instruction.

You can call Inc() or Dec() with one or two parameters. For example, the following two lines of code increment and decrement `variable`, respectively, by 1, using the `inc` and `dec` assembly instructions:

```
Inc(variable);
Dec(variable);
```

Compare the following two lines, which increment or decrement `variable` by 3 using the `add` and `sub` assembly instructions:

```
Inc(variable, 3);
Dec(variable, 3);
```

Table 2.4 compares the increment and decrement operators of different languages.

NOTE

With compiler optimization enabled, the Inc() and Dec() procedures often produce the same machine code as `variable :=variable + 1` syntax, so use whichever you feel more comfortable with for incrementing and decrementing variables.

TABLE 2.4 Increment and decrement operators

<i>Operator</i>	<i>Pascal</i>	<i>C</i>	<i>Visual Basic</i>
Increment	Inc ()	++	None
Decrement	Dec ()	--	None

Object Pascal Types

One of Object Pascal's greatest features is that it's strongly typed, or *typesafe*. This means that actual variables passed to procedures and functions must be of the same type as the formal parameters identified in the procedure or function definition. You won't see any of the famous compiler warnings about suspicious pointer conversions that C programmers have grown to know and love. This is because the Object Pascal compiler will not permit you to call a

function with one type of pointer when another type is specified in the function's formal parameters (although functions that take untyped `Pointer` types accept any type of pointer).

Basically, Pascal's strongly typed nature enables it to perform a sanity check of your code—to ensure you're not trying to put a square peg in a round hole.

A Comparison of Types

Delphi's base types are similar to those of C and Visual Basic. Table 2.5 compares and contrasts the base types of Object Pascal with those of C/C++ and Visual Basic. You may want to earmark this page because this table provides an excellent reference for matching types when calling functions in non-Delphi *dynamic link libraries* (DLLs) or *object files* (OBJS) from Delphi (and vice versa).

TABLE 2.5 A PASCAL TO C/C++ TO VISUAL BASIC 32-BIT TYPE COMPARISON

<i>Type of Variable</i>	<i>Pascal</i>	<i>C/C++</i>	<i>Visual Basic</i>
8-bit signed integer	ShortInt	char	None
8-bit unsigned integer	Byte	BYTE, unsigned short	Byte
16-bit signed integer	SmallInt	short	Short
16-bit unsigned integer	Word	unsigned short	None
32-bit signed integer	Integer, Longint	int, long	Integer, Long
32-bit unsigned integer	Cardinal, LongWord	unsigned long	None
64-bit signed integer	Int64	__int64	None
4-byte floating point	Single	float	Single
6-byte floating point	Real48	None	None
8-byte floating point	Double	double	Double
10-byte floating point	Extended	long double	None
64-bit currency	currency	None	Currency
8-byte date/time	TDateTime	None	Date
16-byte variant	Variant, OleVariant, TVarData	VARIANT, Variant†, OleVariant‡	Variant (Default)
1-byte character	Char	char	None

continues

TABLE 2.5 Continued

<i>Type of Variable</i>	<i>Pascal</i>	<i>C/C++</i>	<i>Visual Basic</i>
2-byte character	WideChar	WCHAR	
Fixed-length byte string	ShortString	None	None
Dynamic string	AnsiString	AnsiString†	String
Null-terminated string	PChar	char *	None
Null-terminated wide string	PWideChar	LPCWSTR	None
Dynamic 2-byte string	WideString	WideString†	None
1-byte Boolean	Boolean, ByteBool	(Any 1-byte)	None
2-byte Boolean	WordBool	(Any 2-byte)	Boolean
4-byte Boolean	BOOL, LongBool	BOOL	None

† A Borland C++Builder class that emulates the corresponding Object Pascal type

NOTE

If you're porting 16-bit code from Delphi 1.0, be sure to bear in mind that the size of both the Integer and Cardinal types has increased from 16 to 32 bits. Actually, that's not quite accurate: Under Delphi 2 and 3 the Cardinal type was treated as an unsigned 31-bit integer in order to preserve arithmetic precision (because Delphi 2 and 3 lacked a true unsigned 32-bit integer to which results of integer operations could be promoted). Under Delphi 4 and higher, Cardinal is a true unsigned 32-bit integer.

CAUTION

In Delphi 1, 2, and 3, the Real type identifier specified a 6-byte floating-point number, which is a type unique to Pascal and generally incompatible with other languages. In Delphi 4, Real is an alias for the Double type. The old 6-byte floating-point number is still there, but it's now identified by Real48. You can also force the Real identifier to refer to the 6-byte floating-point number using the {\$REALCOMPATIBILITY ON} directive.

Characters

Delphi provides three character types:

- `AnsiChar`. This is the standard one-byte ANSI character that programmers have grown to know and love.
- `WideChar`. This character is two bytes in size and represents a Unicode character.
- `Char`. This is currently identical to `AnsiChar`, but Borland warns that the definition may change in a later version of Delphi to a `WideChar`.

Keep in mind that because a character is no longer guaranteed to be one byte in size, you shouldn't hard-code the size into your applications. Instead, you should use the `SizeOf()` function where appropriate.

NOTE

The `SizeOf()` standard procedure returns the size, in bytes, of a type or instance.

A Multitude of Strings

Strings are variable types used to represent groups of characters. Every language has its own spin on how string types are stored and used. Pascal has several different string types to suit your programming needs:

- `AnsiString`, the default string type for Object Pascal, is comprised of `AnsiChar` characters and allows for virtually unlimited lengths. It's also compatible with null-terminated strings.
- `ShortString` remains in the language primarily for backward compatibility with Delphi 1. Its capacity is limited to 255 characters.
- `WideString` is similar in functionality to `AnsiString` except that it consists of `WideChar` characters.
- `PChar` is a pointer to a null-terminated `Char` string—like C's `char *` and `lpstr` types.
- `PAnsiChar` is a pointer to a null-terminated `AnsiChar` string.
- `PWideChar` is a pointer to a null-terminated `WideChar` string.

By default, when you declare a string variable in your code, as shown in the following example, the compiler assumes that you're creating an `AnsiString`:

```
var  
  S: string; // S is an AnsiString
```

Alternatively, you can cause variables declared as `string` types to instead be of type `ShortString` using the `$H` compiler directive. When the value of the `$H` compiler directive is negative, `string` variables are `ShortString` types, and when the value of the directive is positive (the default), `string` variables are `AnsiString` types. The following code demonstrates this behavior:

```
var
  {$H-}
  S1: string; // S1 is a ShortString
  {$H+}
  S2: string; // S2 is an AnsiString
```

The exception to the `$H` rule is that a `string` declared with an explicit size (limited to a maximum of 255 characters) is always a `ShortString`:

```
var
  S: string[63]; // A ShortString of up to 63 characters
```

The AnsiString Type

The `AnsiString` (or *long string*) type was introduced to the language in Delphi 2. It exists primarily as a result of widespread Delphi 1 customer demand for an easy-to-use `string` type without the intrusive 255-character limitation. `AnsiString` is that and more.

Although `AnsiString` types maintain an interface almost identical their predecessors, they're dynamically allocated and garbage-collected. Because of this, `AnsiString` is sometimes referred to as a *lifetime-managed* type. Object Pascal also automatically manages allocation of `string` temporaries as needed, so you needn't worry about allocating buffers for intermediate results as you would in C/C++. Additionally, `AnsiString` types are always guaranteed to be null terminated, which makes them compatible with the null-terminated strings used by the Win32 API. The `AnsiString` type is actually implemented as a pointer to a `string` structure in heap memory. Figure 2.1 shows how an `AnsiString` is laid out in memory.



FIGURE 2.1

An AnsiString in memory.

CAUTION

The complete internal format of the long `string` type is left undocumented by Borland, and Borland reserves the right to change the internal format of long strings.

with future releases of Delphi. The information here is intended mainly to help you understand how `AnsiString` types work, and you should avoid being dependent on the structure of an `AnsiString` in your code.

Developers who avoided the implementation of details of string moving from Delphi 1 to Delphi 2 were able to migrate their code with no problems. Those who wrote code that depended on the internal format (such as the 0th element in the string being the length) had to modify their code for Delphi 2.

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As Figure 2.1 illustrates, `AnsiString` types are reference counted, which means that several strings may point to the same physical memory. String copies, therefore, are very fast because it's merely a matter of copying a pointer rather than copying the actual string contents. When two or more `AnsiString` types share a reference to the same physical string, the Delphi memory manager uses a copy-on-write technique, which enables it to wait until a string is modified to release a reference and allocate a new physical string. The following example illustrates these concepts:

```
var
  S1, S2: string;
begin
  // store string in S1, ref count of S1 is 1
  S1 := 'And now for something... ';
  S2 := S1;          // S2 now references S1. Ref count of S1 is 2.
  // S2 is changed, so it is copied to its own
  // memory space, and ref count of S1 is decremented

  S2 := S2 + 'completely different!';
```

Lifetime-Managed Types

In addition to `AnsiString`, Delphi provides several other types that are lifetime-managed. These types include `WideString`, `Variant`, `OleVariant`, `interface`, `dispinterface`, and dynamic arrays. You'll learn more about each of these types later in this chapter. For now, we'll focus on what exactly lifetime-managed types are and how they work.

Lifetime-managed types, sometimes called *garbage-collected types*, are types that potentially consume some particular resource while in use and release the resource automatically when they fall out of scope. Of course, the variety of resources used

continues

depends on the type involved. For example, an `AnsiString` consumes memory for the character string while in use, and the memory occupied by the character string is released when it leaves scope.

For global variables, this process is fairly straightforward: As a part of the finalization code generated for your application, the compiler inserts code to ensure that each lifetime-managed global variable is cleaned up. Because all global data is zero-initialized when your application loads, each lifetime-managed global variable will always initially contain a zero, empty, or some other value indicating the variable is “unused.” This way, the finalization code won’t attempt to free resources unless they’re actually used in your application.

Whenever you declare a local lifetime-managed variable, the process is slightly more complex: First, the compiler inserts code to ensure that the variable is initialized to zero when the function or procedure is entered. Next, the compiler generates a `try..finally` exception-handling block, which it wraps around the entire function body. Finally, the compiler inserts code in the `finally` block to clean up the lifetime-managed variable (exception handling is explained in more detail in the section “Structured Exception Handling”). With this in mind, consider the following procedure:

```
procedure Foo;
var
  S: string;
begin
  // procedure body
  // use S here
end;
```

Although this procedure looks simple, if you take into account the code generation by the compiler behind the scenes, it would actually look like this:

```
procedure Foo;
var
  S: string;
begin
  S := '';
  try
    // procedure body
    // use S here
  finally
    // clean up S here
  end;
end;
```

String Operations

You can concatenate two strings by using the `+` operator or the `Concat()` function. The preferred method of string concatenation is the `+` operator because the `Concat()` function exists

primarily for backward compatibility. The following example demonstrates the use of + and Concat():

```
{ using + }
var
  S, S2: string
begin
  S:= 'Cookie ';
  S2 := 'Monster';
  S := S + S2;  { Cookie Monster }
end.

{ using Concat() }
var
  S, S2: string;
begin
  S:= 'Cookie ';
  S2 := 'Monster';
  S := Concat(S, S2);  { Cookie Monster }
end.
```

NOTE

Always use single quotation marks ('A String') when working with string literals in Object Pascal.

TIP

Concat() is one of many “compiler magic” functions and procedures (like ReadLn() and WriteLn(), for example) that don’t have an Object Pascal definition. Because such functions and procedures are intended to accept an indeterminate number of parameters or optional parameters, they cannot be defined in terms of the Object Pascal language. Because of this, the compiler provides a special case for each of these functions and generates a call to one of the “compiler magic” *helper functions* defined in the System unit. These helper functions are generally implemented in assembly language in order to circumvent Pascal language rules.

In addition to the “compiler magic” string support functions and procedures, there are a variety of functions and procedures in the SysUtils unit designed to make working with strings easier. Search for “String-handling routines (Pascal-style)” in the Delphi online help system.

Furthermore, you’ll find some very useful homebrewed string utility functions and procedures in the StrUtils unit in the \Source\Utils directory on the CD-ROM accompanying this book.

Length and Allocation

When first declared, an `AnsiString` has no length and therefore no space allocated for the characters in the string. To cause space to be allocated for the string, you can assign the string to a literal or another string, or you can use the `SetLength()` procedure, as shown here:

```
var
  S: string;           // string initially has no length
begin
  S := 'Doh!';        // allocates at least enough space for string literal
  { or }
  S := OtherString   // increases ref count of OtherString
                      // (assume OtherString already points to a valid string)
  { or }
  SetLength(S, 4);   // allocates enough space for at least 4 chars
end;
```

You can index the characters of an `AnsiString` like an array, but be careful not to index beyond the length of the string. For example, the following code snippet will cause an error:

```
var
  S: string;
begin
  S[1] := 'a'; // Won't work because S hasn't been allocated!
end;
```

This code, however, works properly:

```
var
  S: string;
begin
  SetLength(S, 1);
  S[1] := 'a'; // Now S has enough space to hold the character
end;
```

Win32 Compatibility

As mentioned earlier, `AnsiString` types are always null-terminated, so they're compatible with null-terminated strings. This makes it easy to call Win32 API functions or other functions requiring `PChar`-type strings. All that's required is that you typecast the string as a `PChar` (typecasting is explained in more detail in the section "Typecasting and Type Conversion"). The following code demonstrates how to call the Win32 `GetWindowsDirectory()` function, which accepts a `PChar` and buffer length as parameters:

```
var
  S: string;
begin
  SetLength(S, 256); // important! get space for string first
  // call function, S now holds directory string
  GetWindowsDirectory(PChar(S), 256);
end;
```

After using an `AnsiString` where a function or procedure expects a `PChar`, you must manually set the length of the string variable to its null-terminated length. The `RealizeLength()` function, which also comes from the `STRUTILS` unit, accomplishes that task:

```
procedure RealizeLength(var S: string);
begin
  SetLength(S, StrLen(PChar(S)));
end;
```

Calling `RealizeLength()` completes the substitution of a long string for a `PChar`:

```
var
  S: string;
begin
  SetLength(S, 256);           // important! get space for string first
  // call function, S now holds directory string
  GetWindowsDirectory(PChar(S), 256);
  RealizeLength(S);          // set S length to null length
end;
```

CAUTION

Exercise care when typecasting a string to a `PChar` variable. Because strings are garbage-collected when they go out of scope, you must pay attention when making assignments such as `P := PChar(Str)`, where the scope (or lifetime) of `P` is greater than `Str`.

Porting Issues

When you're porting 16-bit Delphi 1 applications, you need to keep in mind a number of issues when migrating to `AnsiString` types:

- In places where you used the `PString` (pointer to a `ShortString`) type, you should instead use the `string` type. Remember, an `AnsiString` is already a pointer to a string.
- You can no longer access the 0th element of a string to get or set the length. Instead, use the `Length()` function to get the string length and the `SetLength()` procedure to set the length.
- There's no longer any need to use `StrPas()` and `StrPCopy()` to convert back and forth between strings and `PChar` types. As shown earlier, you can typecast an `AnsiString` to a `PChar`. When you want to copy the contents of a `PChar` to an `AnsiString`, you can use a direct assignment:

```
StringVar := PCharVar;
```

CAUTION

Remember that you must use the `SetLength()` procedure to set the length of a long string, whereas the past practice was to directly access the 0th element of a short string to set the length. This issue will arise when you attempt to port 16-bit Delphi 1.0 code to 32 bits.

The ShortString Type

If you're a Delphi veteran, you'll recognize the `ShortString` type as the Delphi 1.0 string type. `ShortString` types are sometimes referred to as *Pascal strings* or *length-byte strings*. To reiterate, remember that the value of the `$H` directive determines whether variables declared as string are treated by the compiler as `AnsiString` or `ShortString`.

In memory, the string resembles an array of characters where the 0th character in the string contains the length of the string, and the string itself is contained in the following characters. The storage size of a `ShortString` defaults to the maximum of 256 bytes. This means that you can never have more than 255 characters in a `ShortString` (255 characters + 1 length byte = 256). As with `AnsiString`, working with `ShortString` is fairly painless because the compiler allocates string temporaries as needed, so you don't have to worry about allocating buffers for intermediate results or disposing of them as you do with C.

Figure 2.2 illustrates how a Pascal string is laid out in memory.



FIGURE 2.2

A ShortString in memory.

A `ShortString` variable is declared and initialized with the following syntax:

```
var
  S: ShortString;
begin
  S := 'Bob the cat.';
end.
```

Optionally, you can allocate fewer than 256 bytes for a `ShortString` using just the string type identifier and a length specifier, as in the following example:

```
var
  S: string[45]; { a 45-character ShortString }
begin
  S := 'This string must be 45 or fewer characters.';
end.
```

The preceding code causes a `ShortString` to be created regardless of the current setting of the `$H` directive. The maximum length you can specify is 255 characters.

Never store more characters to a `ShortString` than you have allocated memory for. If you declare a variable as a `string[8]`, for example, and try to assign `'a_pretty_darn_long_string'` to that variable, the string would be truncated to only eight characters, and you would lose data.

When using an array subscript to address a particular character in a `ShortString`, you could get bogus results or corrupt memory if you attempt to use a subscript index that's greater than the declared size of the `ShortString`. For example, suppose you declare a variable as follows:

```
var
  Str: string[8];
```

If you then attempt to write to the 10th element of the string as follows, you're likely to corrupt memory used by other variables:

```
var
  Str: string[8];
  i: Integer;
begin
  i := 10;
  Str[i] := 's'; // will corrupt memory
```

You can have the compiler link in special logic catch these types of errors at runtime by selecting Range Checking in the Options, Project dialog box.

TIP

Although including range-checking logic in your program helps you find string errors, range checking slightly hampers the performance of your application. It's common practice to use range checking during the development and debugging phases of your program, but you should remove range checking after you become confident in the stability of your program.

Unlike `AnsiString` types, `ShortString` types are not inherently compatible with null-terminated strings. Because of this, a bit of work is required to be able to pass a `ShortString` to a Win32 API function. The following function, `ShortStringAsPChar()`, is taken from the `STRU-TILS.PAS` unit mentioned earlier:

```
func function ShortStringAsPChar(var S: ShortString): PChar;
{ Function null-terminates a string so it can be passed to functions }
{ that require PChar types. If string is longer than 254 chars, then it will }
```

```
{ be truncated to 254. }
begin
  if Length(S) = High(S) then Dec(S[0]); { Truncate S if it's too long }
  S[Ord(Length(S)) + 1] := #0;          { Place null at end of string }
  Result := @S[1];                      { Return "PChar'd" string }
end;
```

CAUTION

The functions and procedures in the Win32 API require null-terminated strings. Do not try to pass a `ShortString` type to an API function because your program will not compile. Your life will be easier if you use long strings when working with the API.

The WideString Type

The `WideString` type is a lifetime-managed type similar to `AnsiString`; they're both dynamically allocated, garbage collected, and even assignment compatible with one another. However, `WideString` differs from `AnsiString` in three key respects:

- `WideString` types consist of `WideChar` characters rather than `AnsiChar` characters, making them compatible with Unicode strings.
- `WideString` types are allocated using the `SysAllocStrLen()` API function, making them compatible with OLE `BSTR` strings.
- `WideString` types are not reference counted, so assigning one `WideString` to another requires the entire string to be copied from one location in memory to another. This makes `WideString` types less efficient than `AnsiString` types in terms of speed and memory use.

As mentioned earlier, the compiler automatically knows how to convert between variables of `AnsiString` and `WideString` types, as shown here:

```
var
  W: WideString;
  S: string;
begin
  W := 'Margaritaville';
  S := W; // Wide converted to Ansi
  S := 'Come Monday';
  W := S; // Ansi converted to Wide
end;
```

In order to make working with `WideString` types feel natural, Object Pascal overloads the `Concat()`, `Copy()`, `Insert()`, `Length()`, `Pos()`, and `SetLength()` routines and the `+`, `=`, and `<>` operators for use with `WideString` types. Therefore, the following code is syntactically correct:

```
var
  W1, W2: WideString;
  P: Integer;
begin
  W1 := 'Enfield';
  W2 := 'field';
  if W1 <> W2 then
    P := Pos(W1, W2);
end;
```

As with the `AnsiString` and `ShortString` types, you can use array brackets to reference individual characters of a `WideString`:

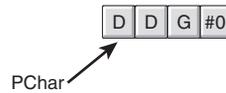
```
var
  W: WideString;
  C: WideChar;
begin
  W := 'Ebony and Ivory living in perfect harmony';
  C := W[Length(W)]; // C holds the last character in W
end;
```

Null-Terminated Strings

Earlier, this chapter mentioned that Delphi has three different null-terminated string types: `PChar`, `PAnsiChar`, and `PWideChar`. As their names imply, each of these represents a null-terminated string of each of Delphi's three character types. In this chapter, we refer to each of these string types generically as `PChar`. The `PChar` type in Delphi exists mainly for compatibility with Delphi 1.0 and the Win32 API, which makes extensive use of null-terminated strings. A `PChar` is defined as a pointer to a string followed by a null (zero) value (if you're unsure of exactly what a pointer is, read on; pointers are discussed in more detail later in this section). Unlike memory for `AnsiString` and `WideString` types, memory for `PChar` types is not automatically allocated and managed by Object Pascal. Therefore, you'll usually need to allocate memory for the string to which it points, using one of Object Pascal's memory-allocation functions. The theoretical maximum length of a `PChar` string is just under 4GB. The layout of a `PChar` variable in memory is shown in Figure 2.3.

TIP

Because Object Pascal's `AnsiString` type can be used as a `PChar` in most situations, you should use this type rather than the `PChar` type wherever possible. Because memory management for strings occurs automatically, you greatly reduce the chance of introducing memory-corruption bugs into your applications if, where possible, you avoid `PChar` types and the manual memory allocation associated with them.

**FIGURE 2.3**

A PChar in memory.

As mentioned earlier, PChar variables require you to manually allocate and free the memory buffers that contain their strings. Normally, you allocate memory for a PChar buffer using the `StrAlloc()` function, but several other functions can be used to allocate memory for PChar types, including `AllocMem()`, `GetMem()`, `StrNew()`, and even the `VirtualAlloc()` API function. Corresponding functions also exist for many of these functions, which must be used to deallocate memory. Table 2.6 lists several allocation functions and their corresponding deallocation functions.

TABLE 2.6 Memory allocation and deallocation functions

<i>Memory Allocated with...</i>	<i>Must Be Freed with...</i>
<code>AllocMem()</code>	<code>FreeMem()</code>
<code>GlobalAlloc()</code>	<code>GlobalFree()</code>
<code>GetMem()</code>	<code>FreeMem()</code>
<code>New()</code>	<code>Dispose()</code>
<code>StrAlloc()</code>	<code>StrDispose()</code>
<code>StrNew()</code>	<code>StrDispose()</code>
<code>VirtualAlloc()</code>	<code>VirtualFree()</code>

The following example demonstrates memory allocation techniques when working with PChar and string types:

```
var
  P1, P2: PChar;
  S1, S2: string;
begin
  P1 := StrAlloc(64 * SizeOf(Char)); // P1 points to an allocation of 63 Chars
  StrPCopy(P1, 'Delphi 5 ');        // Copy literal string into P1
  S1 := 'Developer's Guide';        // Put some text in string S1
  P2 := StrNew(PChar(S1));          // P1 points to a copy of S1
  StrCat(P1, P2);                   // concatenate P1 and P2
  S2 := P1;                          // S2 now holds 'Delphi 5 Developer's Guide'
  StrDispose(P1);                    // clean up P1 and P2 buffers
  StrDispose(P2);
```

end.

Notice, first of all, the use of `SizeOf(Char)` with `StrAlloc()` when allocating memory for `P1`. Remember that the size of a `Char` may change from one byte to two in future versions of Delphi; therefore, you cannot assume the value of `Char` to always be one byte. `SizeOf()` ensures that the allocation will work properly no matter how many bytes a character occupies.

`StrCat()` is used to concatenate two `PChar` strings. Note here that you cannot use the `+` operator for concatenation as you can with long string and `ShortString` types.

The `StrNew()` function is used to copy the value contained by string `S1` into `P2` (a `PChar`). Be careful when using this function. It's common to have memory-overwrite errors when using `StrNew()` because it allocates only enough memory to hold the string. Consider the following example:

```
var
P1, P2: Pchar;
begin
  P1 := StrNew('Hello '); // Allocate just enough memory for P1 and P2
  P2 := StrNew('World');
  StrCat(P1, P2); // BEWARE: Corrupts memory!
  .
```

TIP

```
.
.
end;
```

As with other types of strings, Object Pascal provides a decent library of utility functions and procedures for operating on `PChar` types. Search for “String-handling rou-

tines (null-terminated)” in the Delphi online help system.

You'll also find some useful null-terminated functions and procedures in the `StrUtils` unit in the `\Source\Utils` directory on the CD-ROM accompanying this book.

Variant Types

Delphi 2.0 introduced a powerful data type called the `Variant`. Variants were brought about primarily in order to support OLE Automation, which uses the `Variant` type heavily. In fact, Delphi's `Variant` data type is an encapsulation of the variant used with OLE. Delphi's imple-

mentation of variants has also proven to be useful in other areas of Delphi programming, as you'll soon learn. Object Pascal is the only compiled language that completely integrates variants as a dynamic data type at runtime and as a static type at compile time in that the compiler always knows that it's a variant.

Delphi 3 introduced a new type called `OleVariant`, which is identical to `Variant` except that it can only hold Automation-compatible types. In this section, we initially focus on the `Variant` type and then we discuss `OleVariant` and contrast it with `Variant`.

Variants Change Types Dynamically

One of the main purposes of variants is to have a variable whose underlying data type cannot be determined at compile time. This means that a variant can change the type to which it refers at runtime. For example, the following code will compile and run properly:

```
var
  V: Variant;
begin
  V := 'Delphi is Great!'; // Variant holds a string
  V := 1;                 // Variant now holds an Integer
  V := 123.34;            // Variant now holds a floating point
  V := True;              // Variant now holds a boolean
  V := CreateOleObject('Word.Basic'); // Variant now holds an OLE object
end;
```

Variants can support all simple data types, such as integers, floating-point values, strings, Booleans, date and time, currency, and also OLE Automation objects. Note that variants cannot refer to Object Pascal objects. Also, variants can refer to a nonhomogeneous array, which can vary in size and whose data elements can refer to any of the preceding data types (including another variant array).

The Variant Structure

The data structure defining the `Variant` type is defined in the `System` unit and is also shown in the following code:

```
type
  PVarData = ^TVarData;
  TVarData = packed record
    VType: Word;
    Reserved1, Reserved2, Reserved3: Word;
    case Integer of
      varSmallint: (VSmallint: Smallint);
      varInteger: (VInteger: Integer);
      varSingle: (VSingle: Single);
      varDouble: (VDouble: Double);
      varCurrency: (VCurrency: Currency);
```

```
    varDate:      (VDate: Double);
    varOleStr:    (VOleStr: PWideChar);
    varDispatch: (VDispatch: Pointer);
    varError:     (VError: LongWord);
    varBoolean:  (VBoolean: WordBool);
    varUnknown:  (VUnknown: Pointer);
    varByte:     (VByte: Byte);
    varString:   (VString: Pointer);
    varAny:      (VAny: Pointer);
    varArray:    (VArray: PVarArray);
    varByRef:    (VPointer: Pointer);
end;
```

The TVarData structure consumes 16 bytes of memory. The first two bytes of the TVarData structure contain a word value that represents the data type to which the variant refers. The following code shows the various values that may appear in the VType field of the TVarData record. The next six bytes are unused. The remaining eight bytes contain the actual data or a pointer to the data represented by the variant. Again, this structure maps directly to OLE's implementation of the variant type. Here's the code:

```
{ Variant type codes }
const
    varEmpty      = $0000;
    varNull       = $0001;
    varSmallint   = $0002;
    varInteger    = $0003;
    varSingle     = $0004;
    varDouble     = $0005;
    varCurrency  = $0006;
    varDate       = $0007;
    varOleStr     = $0008;
    varDispatch   = $0009;
    varError      = $000A;
    varBoolean    = $000B;
    varVariant    = $000C;
    varUnknown    = $000D;
    varByte       = $0011;
    varStrArg     = $0048;
```

NOTE

```
varString      = $0100;
varAny         = $0101;
```

```
varTypeMask = $0FFF;  
varArray    = $2000;  
varByRef    = $4000;
```

As you may notice from the type codes in the preceding listing, a `Variant` cannot contain a reference to a `Pointer` or `class` type.

You'll notice from the `TVarData` listing that the `TVarData` record is actually a *variant record*. Don't confuse this with the `Variant` type. Although the variant record and `Variant` type have similar names, they represent two totally different constructs. Variant records allow for multiple data fields to overlap in the same area of memory (like a C/C++ union). This is discussed in more detail in the "Records" section later in this chapter. The case statement in the `TVarData` variant record indicates the type of data to which the variant refers. For example, if the `VType` field contains the value `varInteger`, only four bytes of the eight data bytes in the variant portion of the record are used to hold an integer value. Likewise, if `VType` has the value `varByte`, only one byte of the eight are used to hold a byte value.

You'll notice that if `VType` contains the value `varString`, the eight data bytes don't actually hold the string; instead, they hold a pointer to this string. This is an important point because you can access fields of a variant directly, as shown here:

```
var  
  V: Variant;  
begin  
  TVarData(V).VType := varInteger;  
  TVarData(V).VInteger := 2;  
end;
```

You must understand that in some cases this is a dangerous practice because it's possible to lose the reference to a string or other lifetime-managed entity, which will result in your application leaking memory or other resources. You'll see what we mean by the term *garbage collected* in the following section.

Variants Are Lifetime Managed

Delphi automatically handles the allocation and deallocation of memory required of a `Variant` type. For example, examine the following code, which assigns a string to a `Variant` variable:

```
procedure ShowVariant(S: string);  
var  
  V: Variant  
begin  
  V := S;  
  ShowMessage(V);  
end;
```

As discussed earlier in this chapter in the sidebar on lifetime-managed types, several things are

going on here that might not be apparent. Delphi first initializes the variant to an unassigned value. During the assignment, it sets its `VType` field to `varString` and copies the string pointer into its `VString` field. It then increases the reference count of string `S`. When the variant leaves scope (that is, the procedure ends and returns to the code that called it), it's cleared and the reference count of string `S` is decremented. Delphi does this by implicitly inserting a `try..finally` block in the procedure, as shown here:

```
procedure ShowVariant(S: string);
var
  V: Variant
begin
  V := Unassigned; // initialize variant to "empty"
  try
    V := S;
    ShowMessage(V);
  finally
    // Now clean up the resources associated with the variant
  end;
end;
```

This same implicit release of resources occurs when you assign a different data type to the variant. For example, examine the following code:

```
procedure ChangeVariant(S: string);
var
  V: Variant
begin
  V := S;
  V := 34;
end;
```

This code boils down to the following pseudo-code:

```
procedure ChangeVariant(S: string);
var
  V: Variant
begin
  Clear Variant V, ensuring it is initialized to "empty"
  try
    V.VType := varString; V.VString := S; Inc(S.RefCount);
    Clear Variant V, thereby releasing reference to string;
    V.VType := varInteger; V.VInteger := 34;
  finally
    Clean up the resources associated with the variant
  end;
end;
```

If you understand what happens in the preceding examples, you'll see why it's not recommended that you manipulate fields of the `TVarData` record directly, as shown here:

```
procedure ChangeVariant(S: string);
var
  V: Variant
begin
  V := S;
  TVarData(V).VType := varInteger;
  TVarData(V).VInteger := 32;
  V := 34;
end;
```

Although this may appear to be safe, it's not because it results in the failure to decrement the reference count of string `S`, probably resulting in a memory leak. As a general rule, don't access the `TVarData` fields directly, or if you do, be absolutely sure that you know exactly what you're doing.

Typecasting Variants

You can explicitly typecast expressions to type `Variant`. For example, the expression

```
Variant(X)
```

results in a `Variant` type whose type code corresponds to the result of the expression `X`, which must be an integer, real, currency, string, character, or Boolean type.

You can also typecast a variant to that of a simple data type. For example, given the assignment

```
V := 1.6;
```

where `V` is a variable of type `Variant`, the following expressions will have the results shown:

```
S := string(V);    // S will contain the string '1.6';
// I is rounded to the nearest Integer value, in this case: 2.
I := Integer(V);
B := Boolean(V);   // B contains False if V contains 0, otherwise B is True
D := Double(V);    // D contains the value 1.6
```

These results are dictated by certain type-conversion rules applicable to `Variant` types. These rules are defined in detail in Delphi's Object Pascal Language Guide.

By the way, in the preceding example, it's not necessary to typecast the variant to another data type to make the assignment. The following code would work just as well:

```
V := 1.6;
S := V;
I := V;
B := V;
D := V;
```

What happens here is that the conversions to the target data types are made through an implicit typecast. However, because these conversions are made at runtime, there's much more code logic attached to this method. If you're sure of the type a variant contains, you're better off explicitly typecasting it to that type in order to speed up the operation. This is especially true if the variant is being used in an expression, which we'll discuss next.

Variants in Expressions

You can use variants in expressions with the following operators: +, =, *, /, div, mod, shl, shr, and, or, xor, not, :=, <>, <, >, <=, and >=.

When using variants in expressions, Delphi knows how to perform the operations based on the contents of the variant. For example, if two variants, *V1* and *V2*, contain integers, the expression *V1* + *V2* results in the addition of the two integers. However, if *V1* and *V2* contain strings, the result is a concatenation of the two strings. What happens if *V1* and *V2* contain two different data types? Delphi uses certain promotion rules in order to perform the operation. For example, if *V1* contains the string '4.5' and *V2* contains a floating-point number, *V1* will be converted to a floating point and then added to *V2*. The following code illustrates this:

```
var
  V1, V2, V3: Variant;
begin
  V1 := '100'; // A string type
  V2 := '50';  // A string type
  V3 := 200;   // An Integer type
  V1 := V1 + V2 + V3;
end;
```

Based on what we just mentioned about promotion rules, it would seem at first glance that the preceding code would result in the value 350 as an integer. However, if you take a closer look, you'll see that this is not the case. Because the order of precedence is from left to right, the first equation executed is *V1* + *V2*. Because these two variants refer to strings, a string concatenation is performed, resulting in the string '10050'. That result is then added to the integer value held by the variant *V3*. Because *V3* is an integer, the result '10050' is converted to an integer and added to *V3*, thus providing an end result of 10250.

Delphi promotes the variants to the highest type in the equation in order to successfully carry out the calculation. However, when an operation is attempted on two variants of which Delphi cannot make any sense, an "invalid variant type conversion" exception is raised. The following code illustrates this:

```
var
  V1, V2: Variant;
begin
  V1 := 77;
  V2 := 'hello';
  V1 := V1 / V2; // Raises an exception.
```

```
end;
```

As stated earlier, it's sometimes a good idea to explicitly typecast a variant to a specific data type if you know what that type is and if it's used in an expression. Consider the following line of code:

```
V4 := V1 * V2 / V3;
```

Before a result can be generated for this equation, each operation is handled by a runtime function that goes through several gyrations to determine the compatibility of the types the variants represent. Then the conversions are made to the appropriate data types. This results in a large amount of overhead and code size. A better solution is obviously not to use variants. However, when necessary, you can also explicitly typecast the variants so the data types are resolved at compile time:

```
V4 := Integer(V1) * Double(V2) / Integer(V3);
```

Keep in mind that this assumes you know the data types the variants represent.

Empty and Null

Two special `VType` values for variants merit a brief discussion. The first is `varEmpty`, which means that the variant has not yet been assigned a value. This is the initial value of the variant set by the compiler as it comes into scope. The other is `varNull`, which is different from `varEmpty` in that it actually represents the value `Null` as opposed to a lack of value. This distinction between no value and a `Null` value is especially important when applied to the field values of a database table. In Chapter 27, "Writing Desktop Database Applications," you'll learn how variants are used in the context of database applications.

Another difference is that attempting to perform any equation with a variant containing a `varEmpty` `VType` value will result in an "invalid variant operation" exception. The same is not

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true of variants containing a `varNull` value, however. When a variant involved in an equation contains a `Null` value, that value will propagate to the result. Therefore, the result of any equation containing a `Null` is always `Null`.

If you want to assign or compare a variant to one of these two special values, the `System` unit defines two variants, `Unassigned` and `Null`, which have the `VType` values of `varEmpty` and `varNull`, respectively.

It may be tempting to use variants instead of the conventional data types because

they seem to offer so much flexibility. However, this will increase the size of your code and cause your applications to run more slowly. Additionally, it will make your code more difficult to maintain. Variants are useful in many situations. In fact, the VCL, itself, uses variants in several places, most notably in the ActiveX and database areas, because of the data type flexibility they offer. Generally speaking, however, you should use the conventional data types instead of variants. Only in situations where the flexibility of the variant outweighs the performance of the conventional method should you resort to using variants. Ambiguous data types beget ambiguous bugs.

Variant Arrays

Earlier we mentioned that a variant can refer to a nonhomogeneous array. Therefore, the following syntax is valid:

```
var
  V: Variant;
  I, J: Integer;
begin
  I := V[J];
end;
```

Bear in mind that, although the preceding code will compile, you'll get an exception at runtime because *V* does not yet contain a variant array. Object Pascal provides several variant array support functions that allow you to create a variant array. Two of these functions are `VarArrayCreate()` and `VarArrayOf()`.

VarArrayCreate()

`VarArrayCreate()` is defined in the `System` unit as

```
function VarArrayCreate(const Bounds: array of Integer;
  VarType: Integer): Variant;
```

To use `VarArrayCreate()`, you pass in the array bounds for the array you want to create and a variant type code for the type of the array elements (the first parameter is an open array, which is discussed in the “Passing Parameters” section later in this chapter). For example, the following code returns a variant array of integers and assigns values to the array items:

```
var
  V: Variant;
begin
  V := VarArrayCreate([1, 4], varInteger); // Create a 4-element array
  V[1] := 1;
  V[2] := 2;
  V[3] := 3;
  V[4] := 4;
```

```
end;
```

If variant arrays of a single type aren't confusing enough, you can pass `varVariant` as the type code in order to create a variant array of variants! This way, each element in the array has the ability to contain a different type of data. You can also create a multidimensional array by passing in the additional bounds required. For example, the following code creates an array with the bounds [1..4, 1..5]:

```
V := VarArrayCreate([1, 4, 1, 5], varInteger);
```

VarArrayOf()

The `VarArrayOf()` function is defined in the `System` unit as

```
function VarArrayOf(const Values: array of Variant): Variant;
```

This function returns a one-dimensional array whose elements are given in the `Values` parameter. The following example creates a variant array of three elements with an integer, a string, and a floating-point value:

```
V := VarArrayOf([1, 'Delphi', 2.2]);
```

Variant Array Support Functions and Procedures

In addition to `VarArrayCreate()` and `VarArrayOf()`, there are several other variant array support functions and procedures. These functions are defined in the `System` unit and are also shown here:

```
procedure VarArrayRedim(var A: Variant; HighBound: Integer);
function VarArrayDimCount(const A: Variant): Integer;
function VarArrayLowBound(const A: Variant; Dim: Integer): Integer;
function VarArrayHighBound(const A: Variant; Dim: Integer): Integer;
function VarArrayLock(const A: Variant): Pointer;
procedure VarArrayUnlock(const A: Variant);
function VarArrayRef(const A: Variant): Variant;
function VarIsArray(const A: Variant): Boolean;
```

The `VarArrayRedim()` function allows you to resize the upper bound of the rightmost dimension of a variant array. The `VarArrayDimCount()` function returns the number of dimensions in a variant array. `VarArrayLowBound()` and `VarArrayHighBound()` return the lower and upper bounds of an array, respectively. `VarArrayLock()` and `VarArrayUnlock()` are two special functions, which are described in later detail in the next section.

`VarArrayRef()` is intended to work around a problem that exists in passing variant arrays to OLE Automation servers. The problem occurs when you pass a variant containing a variant array to an automation method, like this:

```
Server.PassVariantArray(VA);
```

The array is passed not as a variant array but rather as a variant containing a variant array—an important distinction. If the server expected a variant array rather than a reference to one, the server will likely encounter an error condition when you call the method with the preceding syntax. `VarArrayRef()` takes care of this situation by massaging the variant into the type and value expected by the server. Here's the syntax for using `VarArrayRef()`:

```
Server.PassVariantArray(VarArrayRef(VA));
```

`VarIsArray()` is a simple Boolean check, which returns `True` if the variant parameter passed to it is a variant array or `False` otherwise.

Initializing a Large Array: `VarArrayLock()` and `VarArrayUnlock()`

Variant arrays are important in OLE Automation because they provide the only means for passing raw binary data to an OLE Automation server (note that pointers are not a legal type in OLE Automation, as you'll learn in Chapter 23, "COM and ActiveX"). However, if used incorrectly, variant arrays can be a rather inefficient means of exchanging data. Consider the following line of code:

```
V := VarArrayCreate([1, 10000], VarByte);
```

This line creates a variant array of 10,000 bytes. Suppose you have another array (nonvariant) declared of the same size and you want to copy the contents of this nonvariant array to the variant array. Normally, you can only do this by looping through the elements and assigning them to the elements of the variant array, as shown here:

```
begin
  V := VarArrayCreate([1, 10000], VarByte);
  for i := 1 to 10000 do
    V[i] := A[i];
end;
```

The problem with this code is that it's bogged down by the significant overhead required just to initialize the variant array elements. This is due to the assignments to the array elements having to go through the runtime logic to determine type compatibility, the location of each element, and so forth. To avoid these runtime checks, you can use the `VarArrayLock()` function and the `VarArrayUnlock()` procedure.

`VarArrayLock()` locks the array in memory so that it cannot be moved or resized while it's locked, and it returns a pointer to the array data. `VarArrayUnlock()` unlocks an array locked with `VarArrayLock()` and once again allows the variant array to be resized and moved in memory. After the array is locked, you can employ a more efficient means to initialize the data by using, for example, the `Move()` procedure with the pointer to the array's data. The following code performs the initialization of the variant array shown earlier, but in a much more efficient manner:

```
begin
  V := VarArrayCreate([1, 10000], VarByte);
  P := VarArrayLock(V);
  try
    Move(A, P^, 10000);
  finally
    VarArrayUnlock(V);
  end;
end;
```

Supporting Functions

There are several other support functions for variants that you can use. These functions are declared in the `System` unit and are also listed here:

```
procedure VarClear(var V: Variant);
procedure VarCopy(var Dest: Variant; const Source: Variant);
procedure VarCast(var Dest: Variant; const Source: Variant; VarType: Integer);
function VarType(const V: Variant): Integer;
function VarAsType(const V: Variant; VarType: Integer): Variant;
function VarIsEmpty(const V: Variant): Boolean;
function VarIsNull(const V: Variant): Boolean;
function VarToStr(const V: Variant): string;
function VarFromDateTime(DateTime: TDateTime): Variant;
function VarToDateTime(const V: Variant): TDateTime;
```

The `VarClear()` procedure clears a variant and sets the `VType` field to `varEmpty`. `VarCopy()` copies the `Source` variant to the `Dest` variant. The `VarCast()` procedure converts a variant to a specified type and stores that result into another variant. `VarType()` returns one of the `varXXX` type codes for a specified variant. `VarAsType()` has the same functionality as `VarCast()`. `VarIsEmpty()` returns `True` if the type code on a specified variant is `varEmpty`. `VarIsNull()` indicates whether a variant contains a `Null` value. `VarToStr()` converts a variant to its string representation (an empty string in the case of a `Null` or empty variant). `VarFromDateTime()` returns a variant that contains a given `TDateTime` value. Finally, `VarToDateTime()` returns the `TDateTime` value contained in a variant.

OleVariant

The `OleVariant` type is nearly identical to the `Variant` type described throughout this section of this chapter. The only difference between `OleVariant` and `Variant` is that `OleVariant` only supports Automation-compatible types. Currently, the only `VType` supported that's not Automation-compatible is `varString`, the code for `AnsiString`. When an attempt is made to assign an `AnsiString` to an `OleVariant`, the `AnsiString` will be automatically converted to an OLE BSTR and stored in the variant as a `varOleStr`.

Currency

Delphi 2.0 introduced a new type called `Currency`, which is ideal for financial calculations. Unlike floating-point numbers, which allow the decimal point to “float” within a number, `Currency` is a fixed-point decimal type that’s hard-coded to a precision of 15 digits before the decimal and four digits after the decimal. As such, it’s not susceptible to round-off errors as are floating-point types. When porting your Delphi 1.0 projects, it’s a good idea to use this type in place of `Single`, `Real`, `Double`, and `Extended` where money is involved.

User-Defined Types

Integers, strings, and floating-point numbers often are not enough to adequately represent variables in the real-world problems that programmers must try to solve. In cases like these, you must create your own types to better represent variables in the current problem. In Pascal, these user-defined types usually come in the form of records or objects; you declare these types using the `Type` keyword.

Arrays

Object Pascal enables you to create arrays of any type of variable (except files). For example, a variable declared as an array of eight integers reads like this:

```
var
  A: Array[0..7] of Integer;
```

This statement is equivalent to the following C declaration:

```
int A[8];
```

It’s also equivalent to this Visual Basic statement:

```
Dim A(8) as Integer
```

Object Pascal arrays have a special property that differentiates them from other languages: They don’t have to begin at a certain number. You can therefore declare a three-element array that starts at 28, as in the following example:

```
var
  A: Array[28..30] of Integer;
```

Because Object Pascal arrays aren’t guaranteed to begin at 0 or 1, you must use some care when iterating over array elements in a `for` loop. The compiler provides built-in functions called `High()` and `Low()`, which return the lower and upper bounds of an array variable or

TIP

type, respectively. Your code will be less error prone and easier to maintain if you use these functions to control your for loop, as shown here:

```
var
  A: array[28..30] of Integer;
  i: Integer;
begin
  for i := Low(A) to High(A) do // don't hard-code for loop!
    A[i] := i;
end;
```

Always begin character arrays at 0. Zero-based character arrays can be passed to functions that require PChar-type variables. This is a special-case allowance that the compiler provides.

To specify multiple dimensions, use a comma-delimited list of bounds:

```
var
  // Two-dimensional array of Integer:
  A: array[1..2, 1..2] of Integer;
```

To access a multidimensional array, use commas to separate each dimension within one set of brackets:

```
I := A[1, 2];
```

Dynamic Arrays

Dynamic arrays are dynamically allocated arrays in which the dimensions are not known at compile time. To declare a dynamic array, just declare an array without including the dimensions, like this:

```
var
  // dynamic array of string:
  SA: array of string;
```

NOTE

Before you can use a dynamic array, you must use the `SetLength()` procedure to allocate

memory for the array:

```
begin
  // allocate room for 33 elements:
  SetLength(SA, 33);
```

Once memory has been allocated, you can access the elements of the dynamic array just like a normal array:

```
SA[0] := 'Pooh likes hunny';
OtherString := SA[0];
```

Dynamic arrays are always zero-based.

Dynamic arrays are lifetime managed, so there's no need to free them when you're through using them because they'll be released when they leave scope. However, there may come a time when you wish remove the dynamic array from memory before it leaves scope (if it uses a lot of memory, for example) To do this, you need only assign the dynamic array to `nil`:

```
SA := nil; // releases SA
```

Dynamic arrays are manipulated using reference semantics similar to `AnsiString` types rather than value semantics like a normal array. A quick test: What is the value of `A1[0]` at the end of the following code fragment?

```
var
  A1, A2: array of Integer;
begin
  SetLength(A1, 4);
  A2 := A1;
  A1[0] := 1;
  A2[0] := 26;
```

The correct answer is 26. The reason is because the assignment `A2 := A1` does not create a new array but instead provides `A2` with a reference to the same array as `A1`. Therefore, any modifications to `A2` will also affect `A1`. If you wish instead to make a complete copy of `A1` in `A2`, use the `Copy()` standard procedure:

```
A2 := Copy(A1);
```

After this line of code is executed, `A2` and `A1` will be two separate arrays initially containing the same data. Changes to one will not affect the other. You can optionally specify the starting element and number of elements to be copied as parameters to `Copy()`, as shown here:

```
// copy 2 elements, starting at element one:
A2 := Copy(A1, 1, 2);
```

Dynamic arrays can also be multidimensional. To specify multiple dimensions, add an additional array of to the declaration for each dimension:

```
var
  // two-dimensional dynamic array of Integer:
  IA: array of array of Integer;
```

To allocate memory for a multidimensional dynamic array, pass the sizes of the other dimensions as additional parameters to `SetLength()`:

```
begin
  // IA will be a 5 x 5 array of Integer
  SetLength(IA, 5, 5);
```

You access multidimensional dynamic arrays the same way you do normal multidimensional arrays; each element is separated by a comma with a single set of brackets:

```
IA[0,3] := 28;
```

Records

A user-defined structure is referred to as a record in Object Pascal, and it's the equivalent of C's `struct` or Visual Basic's `Type`. As an example, here's a record definition in Pascal as well as equivalent definitions in C and Visual Basic:

```
{ Pascal }
Type
  MyRec = record
    i: Integer;
    d: Double;
  end;

/* C */
typedef struct {
  int i;
  double d;
} MyRec;

'Visual Basic
Type MyRec
  i As Integer
  d As Double
End Type
```

When working with a record, you use the dot symbol to access its fields. Here's an example:

```
var
  N: MyRec;
begin
  N.i := 23;
  N.d := 3.4;
```

end;

Object Pascal also supports *variant records*, which allow different pieces of data to overlay the same portion of memory in the record. Not to be confused with the `Variant` data type, variant records allow each overlapping data field to be accessed independently. If your background is

NOTE

`C/C++`, you'll recognize a variant record as being the same concept as a union within `C` struct. The following code shows a variant record in which a `Double`, `Integer`, and `char` all

occupy the same memory space:

```
type
  TVariantRecord = record
    NullStrField: PChar;
    IntField: Integer;
    case Integer of
      0: (D: Double);
      1: (I: Integer);
      2: (C: char);
    end;
end;
```

The rules of Object Pascal state that the variant portion of a record cannot be of any lifetime-managed type.

Here's the `C++` equivalent of the preceding type declaration:

```
struct TUnionStruct
{
  char * StrField;
  int IntField;
  union
  {
    double D;
    int i;
    char c;
  };
};
```

Sets

Sets are a uniquely Pascal type that have no equivalent in Visual Basic, `C`, or `C++` (although Borland `C++Builder` does implement a template class called `Set`, which emulates the behavior of a Pascal set). Sets provide a very efficient means of representing a collection of ordinal, character, or enumerated values. You can declare a new set type using the keywords `set` of followed by an ordinal type or subrange of possible set values. Here's an example:

```

type
  TCharSet = set of char;      // possible members: #0 - #255
  TEnum = (Monday, Tuesday, Wednesday, Thursday, Friday);
  TEnumSet = set of TEnum;    // can contain any combination of TEnum members
  TSubrangeSet = set of 1..10; // possible members: 1 - 10
  TAlphaSet = set of 'A'..'z'; // possible members: 'A' - 'z'

```

Note that a set can only contain up to 256 elements. Additionally, only ordinal types may follow the `set` of keywords. Therefore, the following declarations are illegal:

```

type
  TIntSet = set of Integer; // Invalid: too many elements
  TStrSet = set of string;   // Invalid: not an ordinal type

```

Sets store their elements internally as individual bits. This makes them very efficient in terms of speed and memory usage. Sets with fewer than 32 elements in the base type can be stored and operated upon in CPU registers, for even greater efficiency. Sets with 32 or more elements (such as a set of `char`—255 elements) are stored in memory. To get the maximum performance benefit from sets, keep the number of elements in the set's base type under 32.

Using Sets

Use square brackets when referencing set elements. The following code demonstrates how to declare set-type variables and assign them values:

```

type
  TCharSet = set of char;      // possible members: #0 - #255
  TEnum = (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday);
  TEnumSet = set of TEnum;    // can contain any combination of TEnum members
var
  CharSet: TCharSet;
  EnumSet: TEnumSet;
  SubrangeSet: set of 1..10; // possible members: 1 - 10
  AlphaSet: set of 'A'..'z'; // possible members: 'A' - 'z'
begin
  CharSet := ['A'..'J', 'a', 'm'];
  EnumSet := [Saturday, Sunday];
  SubrangeSet := [1, 2, 4..6];
  AlphaSet := []; // Empty; no elements
end;

```

Set Operators

Object Pascal provides several operators for use in manipulating sets. You can use these operators to determine set membership, union, difference, and intersection.

Membership

Use the `in` operator to determine whether a given element is contained in a particular set. For

example, the following code would be used to determine whether the CharSet set mentioned earlier contains the letter 'S':

```
if 'S' in CharSet then
```

TIP

```
// do something;
```

The following code determines whether EnumSet lacks the member Monday:

```
if not (Monday in EnumSet) then
```

```
// do something;
```

Union and Difference

Use the + and - operators or the Include() and Exclude() procedures to add and remove elements to and from a set variable:

```
Include(CharSet, 'a');           // add 'a' to set
CharSet := CharSet + ['b'];     // add 'b' to set
Exclude(CharSet, 'x');          // remove 'z' from set
CharSet := CharSet - ['y', 'z']; // remove 'y' and 'z' from set
```

When possible, use Include() and Exclude() to add and remove a single element to and from a set rather than the + and - operators. Both Include() and Exclude() constitute only one machine instruction each, whereas the + and - operators require $13 + 6n$ (where n is the size in bits of the set) instructions.

Intersection

Use the * operator to calculate the intersection of two sets. The result of the expression Set1 * Set2 is a set containing all the members that Set1 and Set2 have in common. For example, the following code could be used as an efficient means for determining whether a given set contains multiple elements:

```
if ['a', 'b', 'c'] * CharSet = ['a', 'b', 'c'] then
  // do something
```

Objects

Think of objects as records that also contain functions and procedures. Delphi's object model is discussed in much greater detail later in the "Using Delphi Objects" section of this chapter, so this section covers just the basic syntax of Object Pascal objects. An object is defined as fol-

lows:

Type

```
TChildObject = class(TParentObject);  
    SomeVar: Integer;  
    procedure SomeProc;  
end;
```

Although Delphi objects are not identical to C++ objects, this declaration is roughly equivalent to the following C++ declaration:

```
class TChildObject : public TParentObject  
{  
    int SomeVar;
```

NOTE

```
    void SomeProc();  
};
```

Methods are defined in the same way as normal procedures and functions (which are discussed in the section “Procedures and Functions”), with the addition of the object name and the dot symbol operator:

```
procedure TChildObject.SomeProc;
```

```
begin  
    { procedure code goes here }  
end;
```

Object Pascal’s `.` symbol is similar in functionality to Visual Basic’s `.` operator and C++’s `::` operator. You should note that, although all three languages allow usage of classes, only Object Pascal and C++ allow creation of new classes that behave in a fully object-oriented manner, which we’ll describe in the section “Object-Oriented Programming.”

NOTE

Object Pascal objects are not laid out in memory the same as C++ objects, so it’s not possible to use C++ objects directly from Delphi (and vice versa). However, Chapter 13, “Hard-Core Techniques,” shows a technique for sharing objects between C++ and

Delphi.

An exception to this is Borland C++Builder's capability of creating classes that map directly to Object Pascal classes using the proprietary `__declspec(delphiclass)` directive. Such objects are likewise incompatible with regular C++ objects.

Pointers

A *pointer* is a variable that contains a memory location. You already saw an example of a pointer in the `PChar` type earlier in this chapter. Pascal's generic pointer type is called, aptly, `Pointer`. A `Pointer` is sometimes called an untyped pointer because it contains only a memory address, and the compiler doesn't maintain any information on the data to which it points. That notion, however, goes against the grain of Pascal's typesafe nature, so pointers in your code will usually be typed pointers.

NOTE

Pointers are a somewhat advanced topic, and you definitely don't need to master them to write a Delphi application. As you become more experienced, pointers will

become another valuable tool for your programmer's toolbox.

Typed pointers are declared by using the `^` (or *pointer*) operator in the `Type` section of your program. Typed pointers help the compiler keep track of exactly what kind of type a particular

NOTE

pointer points to, thus enabling the compiler to keep track of what you're doing (and can do) with a pointer variable. Here are some typical declarations for pointers:

```
Type
  PInt = ^Integer;           // PInt is now a pointer to an Integer
  Foo = record               // A record type
    Gobbledygook: string;
    Snarf: Real;
  end;
  PFoo = ^Foo;              // PFoo is a pointer to a foo type
var
  P: Pointer;               // Untyped pointer
  P2: PFoo;                 // Instance of PFoo
```

C programmers will notice the similarity between Object Pascal's `^` operator and C's `*` operator. Pascal's `Pointer` type corresponds to C's `void *` type.

Remember that a pointer variable only stores a memory address. Allocating space for whatever the pointer points to is your job as a programmer. You can allocate space for a pointer by using one of the memory-allocation routines discussed earlier and shown in Table 2.6.

When a pointer doesn't point to anything (its value is zero), its value is said to be `Nil`, and it is often called a *nil* or *null* pointer.

If you want to access the data that a particular pointer points to, follow the pointer variable name with the `^` operator. This method is known as *dereferencing* the pointer. The following

code illustrates working with pointers:

```
Program PtrTest;
Type
  MyRec = record
    I: Integer;
    S: string;
    R: Real;
  end;
  PMyRec = ^MyRec;
var
  Rec : PMyRec;
begin
  New(Rec);      // allocate memory for Rec
  Rec^.I := 10;  // Put stuff in Rec. Note the dereference
  Rec^.S := 'And now for something completely different.';
  Rec^.R := 6.384;
  { Rec is now full }
```

```
Dispose(Rec); // Don't forget to free memory!
end.
```

When to Use `New()`

Use the `New()` function to allocate memory for a pointer to a structure of a known size. Because the compiler knows how big a particular structure is, a call to `New()` will cause the correct number of bytes to be allocated, thus making it safer and more convenient to use than `GetMem()` or `AllocMem()`. Never allocate `Pointer` or `PChar` variables by using the `New()` function because the compiler cannot guess how many bytes you need for this allocation. Remember to use `Dispose()` to free any memory you allocate using the `New()` function.

You'll typically use `GetMem()` or `AllocMem()` to allocate memory for structures for which the compiler cannot know the size. The compiler cannot tell ahead of time how

much memory you want to allocate for PChar or Pointer types, for example, because of their variable-length nature. Be careful not to try to manipulate more data than you have allocated with these functions, however, because this is one of the classic causes of an Access Violation error. You should use FreeMem() to clean up any memory you allocate with GetMem() or AllocMem(). AllocMem(), by the way, is a bit safer than GetMem() because AllocMem() always initializes the memory it allocates to zero.

One aspect of Object Pascal that may give C programmers some headaches is the strict type checking performed on pointer types. For example, the variables a and b in the following example are not type compatible:

```
var
  a: ^Integer;
  b: ^Integer;
```

By contrast, the variables a and b in the equivalent declaration in C are type compatible:

```
int *a;
int *b
```

Object Pascal creates a unique type for each pointer-to-type declaration, so you must create a named type if you want to assign values from a to b, as shown here:

```
type
  PtrInteger = ^Integer; // create named type
var
  a, b: PtrInteger;      // now a and b are compatible
```

Type Aliases

Object Pascal has the ability to create new names, or *aliases*, for types that are already defined. For example, if you want to create a new name for an Integer called MyReallyNiftyInteger, you could do so using the following code:

```
type
  MyReallyNiftyInteger = Integer;
```

The newly defined type alias is compatible in all ways with type for which it's an alias. Meaning, in this case, that you could use MyReallyNiftyInteger anywhere where you could use Integer.

It's possible, however, to define *strongly typed* aliases that are considered new, unique types by the compiler. To do this, use the type reserved word in the following manner:

```
type
  MyOtherNeatInteger = type Integer;
```

Using this syntax, the MyOtherNeatInteger type will be converted to an Integer when neces-

sary for purposes of assignment, but `MyOtherNeatInteger` will not be compatible with `Integer` when used in `var` and `out` parameters. Therefore, the following code is syntactically correct:

```
var
  MONI: MyOtherNeatInteger;
  I: Integer;
begin
  I := 1;
  MONI := I;
```

On the other hand, the following code will not compile:

```
procedure Goon(var Value: Integer);
begin
  // some code
end;

var
  M: MyOtherNeatInteger;
begin
  M := 29;
  Goon(M); // Error: M is not var compatible with Integer
```

In addition to these compiler-enforced type compatibility issues, the compiler also generates runtime type information for strongly typed aliases. This enables you to create unique property editors for simple types, as you'll learn in Chapter 22, "Advanced Component Techniques."

Typecasting and Type Conversion

Typecasting is a technique by which you can force the compiler to view a variable of one type as another type. Because of Pascal's strongly typed nature, you'll find that the compiler is very picky about types matching up in the formal and actual parameters of a function call. Hence,

NOTE

you occasionally will be required to cast a variable of one type to a variable of another type to make the compiler happy. Suppose, for example, you need to assign the value of a character to a byte variable:

```
var

  c: char;
  b: byte;
begin
```

```
c := 's';
b := c; // compiler complains on this line
end.
```

In the following syntax, a typecast is required to convert `c` into a byte. In effect, a typecast tells the compiler that you really know what you're doing and want to convert one type to another:

```
var
  c: char;
  b: byte;
begin
  c := 's';
  b := byte(c); // compiler happy as a clam on this line
end.
```

You can typecast a variable of one type to another type only if the data size of the two variables is the same. For example, you cannot typecast a `Double` as an `Integer`. To convert a floating-point type to an integer, use the `Trunc()` or `Round()` functions. To convert an integer into a floating-point value, use the assignment operator:
`FloatVar := IntVar.`

Object Pascal also supports a special variety of typecasting between objects using the `as` operator, which is described later in the “Runtime Type Information” section of this chapter.

String Resources

Delphi 3 introduced the ability to place string resources directly into Object Pascal source code using the `resourcestring` clause. String resources are literal strings (usually those displayed to the user) that are physically located in a resource attached to the application or library rather than embedded in the source code. Your source code references the string resources in place of string literals. By separating strings from source code, your application can be more easily translated by added string resources in a different language. String resources are declared in the form of *identifier = string literal* in the `resourcestring` clause, as shown here:

```
resourcestring
  ResString1 = 'Resource string 1';
  ResString2 = 'Resource string 2';
  ResString3 = 'Resource string 3';
```

Syntactically, resource strings can be used in your source code in a manner identical to string constants:

```
resourcestring
  ResString1 = 'hello';
  ResString2 = 'world';
```

```
var
  String1: string;

begin
  String1 := ResString1 + ' ' + ResString2;
```

NOTE

```
.
.
.
end;
```

Testing Conditions

This section compares `if` and `case` constructs in Pascal to similar constructs in C and Visual Basic. We assume you've used these types of programmatic constructs before, so we don't spend time explaining them to you.

The if Statement

An `if` statement enables you to determine whether certain conditions are met before executing a particular block of code. As an example, here's an `if` statement in Pascal, followed by equivalent definitions in C and Visual Basic:

```
{ Pascal }
if x = 4 then y := x;

/* C */
if (x == 4) y = x;

'Visual Basic
If x = 4 Then y = x
```

If you have an `if` statement that makes multiple comparisons, make sure you enclose each set of comparisons in parentheses for code clarity. Do this:

```
if (x = 7) and (y = 8) then
```

However, don't do this (it causes the compiler displeasure):

```
if x = 7 and y = 8 then
```

Use the `begin` and `end` keywords in Pascal almost as you would use `{` and `}` in C and C++. For example, use the following construct if you want to execute multiple lines of text when a given condition is true:

```
if x = 6 then begin
  DoSomething;
  DoSomethingElse;
  DoAnotherThing;
end;
```

NOTE

You can combine multiple conditions using the `if..else` construct:

```
if x = 100 then

  SomeFunction
else if x = 200 then
  SomeOtherFunction
else begin
  SomethingElse;
  Entirely;
end;
```

2**THE OBJECT
PASCAL
LANGUAGE**

Using case Statements

The case statement in Pascal works in much the same way as a switch statement in C and C++. A case statement provides a means for choosing one condition among many possibilities without a huge `if..else if..else if` construct. Here's an example of Pascal's case statement:

```
case SomeIntegerVariable of
  101 : DoSomething;
  202 : begin
    DoSomething;
    DoSomethingElse;
  end;
  303 : DoAnotherThing;
else DoTheDefault;
end;
```

The selector type of a case statement must be an ordinal type. It's illegal to use nonordinal types, such as strings, as case selectors.

Here's the C switch statement equivalent to the preceding example:

```
switch (SomeIntegerVariable)
{
  case 101: DoSomething; break;
  case 202: DoSomething;
```

```
        DoSomethingElse; break
    case 303: DoAnotherThing; break;
    default: DoTheDefault;
}
```

Loops

A *loop* is a construct that enables you to repeatedly perform some type of action. Pascal's loop constructs are very similar to what you should be familiar with from your experience with other languages, so this chapter doesn't spend any time teaching you about loops. This section describes the various loop constructs you can use in Pascal.

CAUTION

The for Loop

A for loop is ideal when you need to repeat an action a predetermined number of times.

Here's an example, albeit not a very useful one, of a for loop that adds the loop index to a variable 10 times:

```
var
    I, X: Integer;
begin
    X := 0;
    for I := 1 to 10 do
        inc(X, I);
    end.
```

The C equivalent of the preceding example is as follows:

```
void main(void) {
    int x, i;
    x = 0;
    for(i=1; i<=10; i++)
        x += i;
}
```

Here's the Visual Basic equivalent of the same concept:

```
X = 0
For I = 1 to 10
    X = X + I
Next I
```

A caveat to those familiar with Delphi 1: Assignments to the loop control variable are no longer allowed due to the way the loop is optimized and managed by the 32-bit compiler.

The while Loop

Use a `while` loop construct when you want some part of your code to repeat itself while some condition is true. A `while` loop's conditions are tested before the loop is executed, and a classic example for the use of a `while` loop is to repeatedly perform some action on a file as long as the end of the file is not encountered. Here's an example that demonstrates a loop that reads one line at a time from a file and writes it to the screen:

Program FileIt;

```
{$APPTYPE CONSOLE}
```

```
var
  f: TextFile; // a text file
  s: string;
begin
  AssignFile(f, 'foo.txt');
  Reset(f);
  while not EOF(f) do begin
    readln(f, S);
    writeln(S);
  end;
  CloseFile(f);
end.
```

Pascal's `while` loop works basically the same as C's `while` loop or Visual Basic's `Do While` loop.

repeat..until

The `repeat..until` loop addresses the same type of problem as a `while` loop but from a different angle. It repeats a given block of code until a certain condition becomes `True`. Unlike a `while` loop, the loop code is always executed at least once because the condition is tested at the end of the loop. Pascal's `repeat..until` is roughly equivalent to C's `do..while` loop.

For example, the following code snippet repeats a statement that increments a counter until the value of the counter becomes greater than 100:

```
var
  x: Integer;
begin
  X := 1;
  repeat
    inc(x);
```

```
    until x > 100;  
end.
```

The Break() Procedure

Calling `Break()` from inside a `while`, `for`, or `repeat` loop causes the flow of your program to skip immediately to the end of the currently executing loop. This method is useful when you need to leave the loop immediately because of some circumstance that may arise within the loop. Pascal's `Break()` procedure is analogous to C's `Break` and Visual Basic's `Exit` statement. The following loop uses `Break()` to terminate the loop after five iterations:

```
var  
    i: Integer;  
begin  
    for i := 1 to 1000000 do  
        begin  
            MessageBeep(0);           // make the computer beep  
            if i = 5 then Break;  
        end;  
    end;  
end;
```

The Continue() Procedure

Call `Continue()` inside a loop when you want to skip over a portion of code and the flow of control to continue with the next iteration of the loop. Note in the following example that the code after `Continue()` is not executed in the first iteration of the loop:

```
var  
    i: Integer;  
begin  
    for i := 1 to 3 do  
        begin  
            writeln(i, '. Before continue');  
            if i = 1 then Continue;  
            writeln(i, '. After continue');  
        end;  
    end;  
end;
```

Procedures and Functions

As a programmer, you should already be familiar with the basics of procedures and functions. A *procedure* is a discrete program part that performs some particular task when it's called and then returns to the calling part of your code. A function works the same except that a function returns a value after its exit to the calling part of the program.

If you're familiar with C or C++, consider that a Pascal procedure is equivalent to a C or C++ function that returns `void`, whereas a function corresponds to a C or C++ function that has a

return value.

Listing 2.1 demonstrates a short Pascal program with a procedure and a function.

LISTING 2.1 An Example of Functions and Procedures

Program FuncProc;

~~(\$APPTYPE=CONSOLE)~~

NOTE

```
procedure BiggerThanTen(i: Integer);
{ writes something to the screen if I is greater than 10 }
begin
  if I > 10 then
    writeln('Funky. ');
end;

function IsPositive(I: Integer): Boolean;
{ Returns True if I is 0 or positive, False if I is negative }
begin
  if I < 0 then
    Result := False
  else
    Result := True;
end;
```

```
var
  Num: Integer;
begin
  Num := 23;
  BiggerThanTen(Num);
  if IsPositive(Num) then
    writeln(Num, 'Is positive.')
  else
    writeln(Num, 'Is negative. ');
end.
```

The local variable `Result` in the `IsPositive()` function deserves special attention. Every Object Pascal function has an implicit local variable called `Result` that contains the return value of the function. Note that unlike C and C++, the function doesn't terminate as soon as a value is assigned to `Result`.

You also can return a value from a function by assigning the name of a function to a

value inside the function's code. This is standard Pascal syntax and a holdover from previous versions of Borland Pascal. If you choose to use the function name within the body, be careful to note that there is a huge difference between using the function name on the left side of an assignment operator and using it somewhere else in your code. If you use it on the left, you are assigning the function return value. If you use it somewhere else in your code, you are calling the function recursively!

Note that the implicit `Result` variable is not allowed when the compiler's Extended Syntax option is disabled in the Project, Options, Compiler dialog box or when you're using the `{X-}` directive.

Passing Parameters

Pascal enables you to pass parameters by value or by reference to functions and procedures. The parameters you pass can be of any base or user-defined type or an open array (open arrays are discussed later in this chapter). Parameters also can be constant if their values will not change in the procedure or function.

Value Parameters

Value parameters are the default mode of parameter passing. When a parameter is passed by value, it means that a local copy of that variable is created, and the function or procedure operates on the copy. Consider the following example:

```
procedure Foo(s: string);
```

When you call a procedure in this way, a copy of string `s` will be made, and `Foo()` will operate on the local copy of `s`. This means that you can choose the value of `s` without having any effect on the variable passed into `Foo()`.

Reference Parameters

Pascal enables you to pass variables to functions and procedures by reference; parameters passed by reference are also called *variable parameters*. Passing by reference means that the function or procedure receiving the variable can modify the value of that variable. To pass a variable by reference, use the keyword `var` in the procedure's or function's parameter list:

```
procedure ChangeMe(var x: longint);
begin
  x := 2; { x is now changed in the calling procedure }
end;
```

Instead of making a copy of `x`, the `var` keyword causes the address of the parameter to be copied so that its value can be directly modified.

Using `var` parameters is equivalent to passing variables by reference in C++ using the `&` operator. Like C++'s `&` operator, the `var` keyword causes the address of the variable to be passed to

the function or procedure rather than the value of the variable.

Constant Parameters

If you don't want the value of a parameter passed into a function to change, you can declare it with the `const` keyword. The `const` keyword not only prevents you from modifying the value of the parameters but it also generates more optimal code for strings and records passed into the procedure or function. Here's an example of a procedure declaration that receives a constant string parameter:

```
procedure Goon(const s: string);
```

Open Array Parameters

Open array parameters provide you with the capability for passing a variable number of arguments to functions and procedures. You can either pass open arrays of some homogenous type or constant arrays of differing types. The following code declares a function that accepts an open array of integers:

```
function AddEmUp(A: array of Integer): Integer;
```

You may pass variables, constants, or constant expressions to open array functions and procedures. The following code demonstrates this by calling `AddEmUp()` and passing a variety of different elements:

```
var
    i, Rez: Integer;
const
    j = 23;
begin
    i := 8;
    Rez := AddEmUp([i, 50, j, 89]);
```

In order to work with an open array inside the function or procedure, you can use the `High()`, `Low()`, and `SizeOf()` functions in order to obtain information about the array. To illustrate this, the following code shows an implementation of the `AddEmUp()` function that returns the sum of all the numbers passed in `A`:

```
function AddEmUp(A: array of Integer): Integer;
var
    i: Integer;
begin
    Result := 0;
    for i := Low(A) to High(A) do
        inc(Result, A[i]);
end;
```

Object Pascal also supports an `array of const`, which allows you to pass heterogeneous data

types in an array to a function or procedure. The syntax for defining a function or procedure that accepts an array of `const` is as follows:

```
procedure WhatHaveIGot(A: array of const);
```

You could call the preceding function with the following syntax:

```
WhatHaveIGot(['Tabasco', 90, 5.6, @WhatHaveIGot, 3.14159, True, 's']);
```

The compiler implicitly converts all parameters to type `TVarRec` when they are passed to the function or procedure accepting the array of `const`. `TVarRec` is defined in the `System` unit as follows:

```
type
PVarRec = ^TVarRec;
  TVarRec = record
    case Byte of
      vtInteger:   (VInteger: Integer; VType: Byte);
      vtBoolean:   (VBoolean: Boolean);
      vtChar:      (VChar: Char);
      vtExtended:  (VExtended: PExtended);
      vtString:    (VString: PShortString);
      vtPointer:   (VPointer: Pointer);
      vtPChar:     (VPChar: PChar);
      vtObject:    (VObject: TObject);
      vtClass:     (VClass: TClass);
      vtWideChar:  (VWideChar: WideChar);
      vtPWideChar: (VPWideChar: PWideChar);
      vtAnsiString: (VAnsiString: Pointer);
      vtCurrency:  (VCurrency: PCurrency);
      vtVariant:   (VVariant: PVariant);
      vtInterface: (VInterface: Pointer);
      vtWideString: (VWideString: Pointer);
      vtInt64:     (VInt64: PInt64);
    end;
```

The `VType` field indicates what type of data the `TVarRec` contains. This field can have any one of the following values:

```
const
  { TVarRec.VType values }
  vtInteger   = 0;
  vtBoolean   = 1;
  vtChar      = 2;
  vtExtended  = 3;
  vtString    = 4;
  vtPointer   = 5;
  vtPChar     = 6;
  vtObject    = 7;
  vtClass     = 8;
```

```
vtWideChar    = 9;
vtPWideChar   = 10;
vtAnsiString  = 11;
vtCurrency    = 12;
vtVariant     = 13;
vtInterface   = 14;
vtWideString  = 15;
vtInt64       = 16;
```

As you might guess, because `array of const` in the code allows you to pass parameters regardless of their type, they can be difficult to work with on the receiving end. As an example of how to work with `array of const`, the following implementation for `WhatHaveIGot()` iterates through the array and shows a message to the user indicating what type of data was passed in which index:

```
procedure WhatHaveIGot(A: array of const);
var
  i: Integer;
  TypeStr: string;
begin
  for i := Low(A) to High(A) do
  begin
    case A[i].VType of
      vtInteger    : TypeStr := 'Integer';
      vtBoolean    : TypeStr := 'Boolean';
      vtChar       : TypeStr := 'Char';
      vtExtended   : TypeStr := 'Extended';
      vtString     : TypeStr := 'String';
      vtPointer    : TypeStr := 'Pointer';
      vtPChar      : TypeStr := 'PChar';
      vtObject     : TypeStr := 'Object';
      vtClass      : TypeStr := 'Class';
      vtWideChar   : TypeStr := 'WideChar';
      vtPWideChar  : TypeStr := 'PWideChar';
      vtAnsiString : TypeStr := 'AnsiString';
      vtCurrency   : TypeStr := 'Currency';
      vtVariant    : TypeStr := 'Variant';
      vtInterface  : TypeStr := 'Interface';
      vtWideString : TypeStr := 'WideString';
      vtInt64      : TypeStr := 'Int64';
    end;
    ShowMessage(Format('Array item %d is a %s', [i, TypeStr]));
  end;
end;
```

Scope

Scope refers to some part of your program in which a given function or variable is known to

the compiler. A global constant is in scope at all points in your program, for example, whereas a variable local to some procedure only has scope within that procedure. Consider Listing 2.2.

LISTING 2.2 An Illustration of Scope

```
program Foo;

{$APPTYPE CONSOLE}

const
    SomeConstant = 100;

var
    SomeGlobal: Integer;
    R: Real;

procedure SomeProc(var R: Real);
var
    LocalReal: Real;
begin
    LocalReal := 10.0;
    R := R - LocalReal;
end;

begin
    SomeGlobal := SomeConstant;
    R := 4.593;
    SomeProc(R);
end.
```

`SomeConstant`, `SomeGlobal`, and `R` have global scope—their values are known to the compiler at all points within the program. Procedure `SomeProc()` has two variables in which the scope is local to that procedure: `R` and `LocalReal`. If you try to access `LocalReal` outside of `SomeProc()`, the compiler displays an unknown identifier error. If you access `R` within `SomeProc()`, you'll be referring to the local version, but if you access `R` outside that procedure, you'll be referring to the global version.

Units

Units are the individual source code modules that make up a Pascal program. A unit is a place for you to group functions and procedures that can be called from your main program. To be a unit, a source module must consist of at least three parts:

- *A unit statement.* Every unit must have as its first line a statement saying that it's a unit and identifying the unit name. The name of the unit always must match the filename. For

example, if you have a file named `FooBar`, the statement would be
`unit FooBar;`

- *The interface part.* After the `unit` statement, a unit's next functional line of code

NOTE

should be the `interface` statement. Everything following this statement, up to the `implementation` statement, is information that can be shared with your program and with other units. The `interface` part of a unit is where you declare the types, constants, variables, procedures, and functions that you want to make available to your main program and to other units. Only declarations—never procedure bodies—can appear in the `interface`. The `interface` statement should be one word on one line:

```
interface
```

- *The implementation part.* This follows the `interface` part of the unit. Although the `implementation` part of the unit contains primarily procedures and functions, it's also where you declare any types, constants, and variables that you do not want to make available outside of this unit. The `implementation` part is where you define any functions or procedures that you declared in the `interface` part. The `implementation` statement should be one word on one line:

```
implementation
```

Optionally, a unit can also include two other parts:

- *An initialization part.* This portion of the unit, which is located near the end of the file, contains any initialization code for the unit. This code will be executed before the main program begins execution, and it executes only once.
- *A finalization part.* This portion of the unit, which is located in between the `initialization` and `end.` of the unit, contains any cleanup code that executes when the program terminates. The `finalization` section was introduced to the language in Delphi 2.0. In Delphi 1.0, unit finalization was accomplished by adding a new exit procedure using the `AddExitProc()` function. If you're porting an application from Delphi 1.0, you should move your exit procedures into the `finalization` part of your units.

When several units have `initialization/finalization` code, execution of each section proceeds in the order in which the units are encountered by the compiler (the first unit in the program's `uses` clause, then the first unit in that unit's `uses` clause, and so on). Also, it's a bad idea to write `initialization` and `finalization` code that relies on such ordering because one small change to the `uses` clause can cause some difficult-to-find bugs!

The uses Clause

The uses clause is where you list the units that you want to include in a particular program or unit. For example, if you have a program called FooProg that uses functions and types in two units, UnitA and UnitB, the proper uses declaration is as follows:

```
Program FooProg;
```

```
uses UnitA, UnitB;
```

Units can have two uses clauses: one in the interface section and one in the implementation section.

Here's code for a sample unit:

```
Unit FooBar;

interface

uses BarFoo;

    { public declarations here }

implementation

uses BarFly;

    { private declarations here }

initialization
    { unit initialization here }
finalization
    { unit clean-up here }
end.
```

Circular Unit References

Occasionally, you'll have a situation where UnitA uses UnitB and UnitB uses UnitA. This is called a *circular unit reference*. The occurrence of a circular unit reference is often an indication of a design flaw in your application; you should avoid structuring your program with a circular reference. The optimal solution is often to move a piece of data that both UnitA and UnitB need to use out to a third unit. However, as with most things, sometimes you just can't avoid the circular unit reference. In such a case, move one of the uses clauses to the implementation part of your unit and leave the other one in the interface part. This usually solves the problem.

Packages

Delphi *packages* enable you to place portions of your application into separate modules, which can be shared across multiple applications. If you already have an existing investment in Delphi 1 or 2 code, you'll appreciate that you can take advantage of packages without any changes to your existing source code.

Think of a package as a collection of units stored in a separate DLL-like module (a Borland Package Library, or *BPL file*). Your application can then link with these “packaged” units at runtime rather than compile/link time. Because the code for these units resides in the BPL file rather than in your EXE or DLL, the size of your EXE or DLL can become very small. Four types of packages are available for you to create and use:

- *Runtime package*. This type of package contains units required at runtime by your application. When compiled to depend on a particular runtime package, your application will not run in the absence of that package. Delphi's `VCL50.BPL` is an example of this type of package.
- *Design package*. This type of package contains elements necessary for application design such as components, property and component editors, and experts. It can be installed into Delphi's component library using the Component, Install Package menu item. Delphi's `DCL*.BPL` packages are examples of this type of package. This type of package is described in more detail in Chapter 21, “Writing Delphi Custom Components.”
- *Runtime and design package*. This package serves both of the purposes listed in the first two items. Creating this type of package makes application development and distribution a bit simpler, but this type of package is less efficient because it must carry the baggage of design support even in your distributed applications.
- *Neither runtime nor design package*. This rare breed of package is intended to be used only by other packages and is not intended to be referenced directly by an application or used in the design environment.

Using Delphi Packages

Package-enabling your Delphi applications is easy. Simply check the Build with Runtime Packages check box in the Project, Options, Packages dialog box. The next time you build your application after selecting this option, your application will be linked dynamically to runtime packages rather than having units linked statically into your EXE or DLL. The result will be a much more svelte application (although bear in mind that you'll have to deploy the necessary packages with your application).

Package Syntax

Packages are most commonly created using the Package Editor, which you invoke by choosing the File, New, Package menu item. This editor generates a *Delphi Package Source* (DPK) file, which will be compiled into a package. The syntax for this DPK file is quite simple, and it uses the following format:

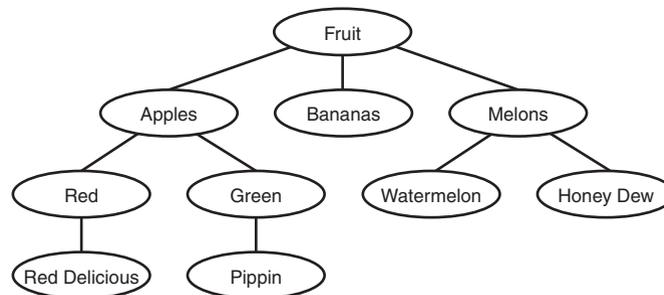
```
package PackageName

requires Package1, Package2, ...;

contains
  Unit1 in 'Unit1.pas',
  Unit2, in 'Unit2.pas',

  ...;
end.
```

Packages listed in the `requires` clause are required in order for this package to load. Typically, packages containing units used by units listed in the `contains` clause are listed here. Units listed in the `contains` clause will be compiled into this package. Note that units listed here must not also be listed in the `contains` clause of any of the packages listed in the `requires` clause. Note also that any units used by units in the `contains` clause will be implicitly pulled into this package (unless they're contained in a required package).



Object-Oriented Programming

Volumes have been written on the subject of *object-oriented programming* (OOP). Often, OOP seems more like a religion than a programming methodology, spawning arguments about its merits (or lack thereof) passionate and spirited enough to make the Crusades look like a slight

disagreement. We're not orthodox OOPists, and we're not going to get involved in the relative merits of OOP; we just want to give you the lowdown on a fundamental principle on which Delphi's Object Pascal Language is based.

OOP is a programming paradigm that uses discrete objects—containing both data and code—as application building blocks. Although the OOP paradigm doesn't necessarily lend itself to easier-to-write code, the result of using OOP traditionally has been easy-to-maintain code. Having objects' data and code together simplifies the process of hunting down bugs, fixing them with minimal effect on other objects, and improving your program one part at a time. Traditionally, an OOP language contains implementations of at least three OOP concepts:

- *Encapsulation.* Deals with combining related data fields and hiding the implementation details. The advantages of encapsulation include modularity and isolation of code from other code.

- *Inheritance.* The capability to create new objects that maintain the properties and behavior of ancestor objects. This concept enables you to create object hierarchies such as VCL—first creating generic objects and then creating more specific descendants of those objects that have more narrow functionality.

The advantage of inheritance is the sharing of common code. Figure 2.4 presents an example of inheritance—how one root object, fruit, is the ancestor object of all fruits, including the melon. The melon is ancestor of all melons, including the watermelon. You get the picture.

FIGURE 2.4

An illustration of inheritance.

NOTE

- *Polymorphism.* Literally, *polymorphism* means “many shapes.” Calls to methods of an object variable will call code appropriate to whatever instance is actually in the variable.

A Note on Multiple Inheritance

Object Pascal does not support multiple inheritance of objects as C++ does. *Multiple*

inheritance is the concept of a given object being derived from two separate objects, creating an object that contains all the code and data of the two parent objects.

To expand on the analogy presented in Figure 2.4, multiple inheritance enables you

to create a candy apple object by creating a new object that inherits from the apple class and some other class called "candy." Although this functionality seems useful, it often introduces more problems and inefficiencies into your code than it solves.

Object Pascal provides two approaches to solving this problem. The first solution is to make one class *contain* the other class. You'll see this solution throughout Delphi's VCL. To build upon the candy apple analogy, you would make the candy object a member of the apple object. The second solution is to use *interfaces* (you'll learn more about interfaces in the section "Interfaces"). Using interfaces, you could essentially have one object that supports both a candy and an apple interface.

You should understand the following three terms before you continue to explore the concept of objects:

- *Field*. Also called *field definitions* or *instance variables*, fields are data variables contained within objects. A field in an object is just like a field in a Pascal record. In C++, fields sometimes are referred to as *data members*.
- *Method*. The name for procedures and functions belonging to an object. Methods are called *member functions* in C++.
- *Property*. An entity that acts as an accessor to the data and code contained within an object. Properties insulate the end user from the implementation details of an object.

It's generally considered bad OOP style to access an object's fields directly. This is because the implementation details of the object may change. Instead, use *accessor properties*, which allow a standard object interface without becoming embroiled in the details of how the objects are implemented. Properties are explained in the "Properties" section later in this chapter.

Object-Based Versus Object-Oriented Programming

In some tools, you manipulate entities (objects), but you cannot create your own objects. ActiveX (formerly OCX) controls in Visual Basic are a good example of this. Although you can use an ActiveX control in your applications, you cannot create one, and you cannot inherit one ActiveX control from another in Visual Basic. Environments such as these often are called *object-based environments*.

Delphi is a fully object-oriented environment. This means that you can create new objects in Delphi either from scratch or based on existing components. This includes all Delphi objects, be they visual, nonvisual, or even design-time forms.

Using Delphi Objects

As mentioned earlier, objects (also called *classes*) are entities that can contain both data and code. Delphi objects also provide you with all the power of object-oriented programming in

offering full support of inheritance, encapsulation, and polymorphism.

Declaration and Instantiation

Of course, before using an object, you must have declared an object using the `class` keyword.

NOTE

As described earlier in this chapter, objects are declared in the `type` section of a unit or program:

```
type
```

```
    TFooObject = class;
```

In addition to an object type, you usually also will have a variable of that class type, or *instance*, declared in the `var` section:

```
var  
    FooObject: TFooObject;
```

You create an instance of an object in Object Pascal by calling one of its *constructors*. A constructor is responsible for creating an instance of your object and allocating any memory or initializing any fields necessary so that the object is in a usable state upon exiting the constructor. Object Pascal objects always have at least one constructor called `Create()`—although it's

CAUTION

possible for an object to have more than one constructor. Depending on the type of object, `Create()` can take different numbers of parameters. This chapter focuses on the simple case where `Create()` takes no parameters.

Unlike C++, object constructors in Object Pascal are not called automatically, and it's incumbent on the programmer to call the object constructor. The syntax for calling a constructor is as follows:

```
FooObject := TFooObject.Create;
```

Notice that the syntax for a constructor call is a bit unique. You're referencing the `Create()` method of the object by the type rather than the instance, as you would with other methods. This may seem odd at first, but it does make sense. `FooObject`, a variable, is undefined at the time of the call, but the code for `TFooObject`, a type, is static in memory. A static call to its

Create() method is therefore totally valid.

The act of calling a constructor to create an instance of an object is often called *instantiation*.

When an object instance is created using the constructor, the compiler will ensure that every field in your object is initialized. You can safely assume that all numbers will be initialized to 0, all pointers to Nil, and all strings will be empty.

Destruction

When you're finished using an object, you should deallocate the instance by calling its Free() method. The Free() method first checks to ensure that the object instance is not Nil; then it calls the object's *destructor* method, Destroy(). The destructor, of course, does the opposite of the constructor; it deallocates any allocated memory and performs any other housekeeping required in order for the object to be properly removed from memory. The syntax is simple:

```
FooObject.Free;
```

Unlike the call to Create(), the object instance is used in the call to the Free() method. Remember never to call Destroy() directly but instead to call the safer Free() method.

In C++, the destructor of an object declared statically is called automatically when your object leaves scope, but you must call the destructor for any dynamically allocated objects. The rule is the same in Object Pascal, except that all objects are implicitly dynamic in Object Pascal, so you must follow the rule of thumb that anything you create, you must free. There are a couple of important exceptions to this rule, however. The first is when your object is owned by other objects (as described in Chapter 20, "Key Elements of the Visual Component Library"), it will be freed for you. The second is reference counted objects (such as those descending from TInterfacedObject or TComObject), which are destroyed when the last reference is released.

You might be asking yourself how all these methods got into your little object. You certainly didn't declare them yourself, right? Right. The methods just discussed actually come from the Object Pascal's base TObject object. In Object Pascal, all objects are always descendants of TObject regardless of whether they're declared as such. Therefore, the declaration

```
Type TFoo = Class;
```

is equivalent to the declaration

```
Type TFoo = Class(TObject);
```

Methods

Methods are procedures and functions belonging to a given object. Methods are those things that give an object behavior rather than just data. Two important methods of the objects you create are the constructor and the destructor methods, which we just covered. You can also cre-

ate custom methods in your objects to perform a variety of tasks.

Creating a method is a two-step process. You first must declare the method in the object type declaration, and then you must define the method in the code. The following code demonstrates the process of declaring and defining a method:

```
type
  TBoogieNights = class
    Dance: Boolean;
    procedure DoTheHustle;
  end;
procedure TBoogieNights.DoTheHustle;
begin
  Dance := True;
end;
```

Note that when defining the method body, you have to use the fully qualified name, as you did when defining the `DoTheHustle` method. It's important also to note that the object's `Dance` field can be accessed directly from within the method.

Method Types

Object methods can be declared as `static`, `virtual`, `dynamic`, or `message`. Consider the following example object:

```
TFoo = class
  procedure IAmAStatic;
  procedure IAmAVirtual; virtual;
  procedure IAmADynamic; dynamic;
  procedure IAmAMessage(var M: TMessage); message wm_SomeMessage;
end;
```

Static Methods

`IAmAStatic` is a static method. The *static* method is the default method type, and it works similarly to a regular procedure or function call. The compiler knows the address of these methods, and so, when you call a static method, it's able to link that information into the executable statically. Static methods execute the fastest; however, they do not have the ability to be overridden to provide *polymorphism*.

Virtual Methods

`IAmAVirtual` is a virtual method. *Virtual* methods are called in the same way as static methods, but because virtual methods can be overridden, the compiler does not know the address of a particular virtual function when you call it in your code. The compiler, therefore, builds a *Virtual Method Table* (VMT) that provides a means to look up function addresses at runtime. All virtual method calls are dispatched at runtime through the VMT. An object's VMT contains

all its ancestor's virtual methods as well as the ones it declares; therefore, virtual methods use more memory than dynamic methods, although they execute faster.

Dynamic Methods

`IAMADynamic` is a dynamic method. *Dynamic* methods are basically virtual methods with a different dispatching system. The compiler assigns a unique number to each dynamic method and uses those numbers, along with method addresses, to build a *Dynamic Method Table* (DMT). Unlike the VMT, an object's DMT contains only the dynamic methods that it declares, and that method relies on its ancestor's DMTs for the rest of its dynamic methods. Because of this, dynamic methods are less memory intensive than virtual methods, but they take longer to call because you may have to propagate through several ancestor DMTs before finding the address of a particular dynamic method.

Message Methods

`IAMAMessage` is a message-handling method. The value after the `message` keyword dictates what message the method will respond to. Message methods are used to create an automatic response to Windows messages, and you generally don't call them directly. Message handling is discussed in detail in Chapter 5, "Understanding Messages."

Overriding Methods

Overriding a method is Object Pascal's implementation of the OOP concept of polymorphism. It enables you to change the behavior of a method from descendant to descendant. Object Pascal methods can be overridden only if they're first declared as `virtual` or `dynamic`. To override a method, just use the `override` directive instead of `virtual` or `dynamic` in your descendant object type. For example, you could override the `IAMAVirtual` and `IAMADynamic` methods as shown here:

```
TFooChild = class(TFoo)
    procedure IAMAVirtual; override;
    procedure IAMADynamic; override;
    procedure IAMAMessage(var M: TMessage); message wm_SomeMessage;
end;
```

The `override` directive replaces the original method's entry in the VMT with the new method. If you had re-declared `IAMAVirtual` and `IAMADynamic` with the `virtual` or `dynamic` keyword instead of `override`, you would have created new methods rather than overriding the ancestor methods. Also, if you attempt to override a static method in a descendant type, the static method in the new object completely replaces the method in the ancestor type.

Method Overloading

Like regular procedures and functions, methods can be overloaded so that a class can contain multiple methods of the same name with differing parameter lists. Overloaded methods must

be marked with the `overload` directive, although the use of the directive on the first instance of a method name in a class hierarchy is optional. The following code example shows a class containing three overloaded methods:

```
type
  TSomeClass = class
    procedure AMethod(I: Integer); overload;
    procedure AMethod(S: string); overload;
    procedure AMethod(D: Double); overload;
  end;
```

Reintroducing Method Names

Occasionally, you may want to add a method to one of your classes to replace a method of the same name in an ancestor of your class. In this case, you don't want to override the ancestor method but instead obscure and completely supplant the base class method. If you simply add the method and compile, you'll see that the compiler will produce a warning explaining that the new method hides a method of the same name in a base class. To suppress this error, use the `reintroduce` directive on the method in the ancestor class. The following code example demonstrates proper use of the `reintroduce` directive:

```
type
  TSomeBase = class
    procedure Cooper;
  end;

  TSomeClass = class
    procedure Cooper; reintroduce;
  end;
```

Self

An implicit variable called `Self` is available within all object methods. `Self` is a pointer to the class instance that was used to call the method. `Self` is passed by the compiler as a hidden parameter to all methods.

Properties

It may help to think of properties as special accessor fields that enable you to modify data and execute code contained within your class. For components, properties are those things that show up in the Object Inspector window when published. The following example illustrates a simplified `Object` with a property:

```
TMyObject = class
private
  SomeValue: Integer;
  procedure SetSomeValue(AValue: Integer);
```

```
public
  property Value: Integer read SomeValue write SetSomeValue;
end;
procedure TMyObject.SetSomeValue(AValue: Integer);
begin
  if SomeValue <> AValue then
    SomeValue := AValue;
end;
```

TMyObject is an object that contains the following: one field (an integer called `SomeValue`), one method (a procedure called `SetSomeValue`), and one property called `Value`. The sole purpose of the `SetSomeValue` procedure is to set the value of the `SomeValue` field. The `Value` property doesn't actually contain any data. `Value` is an accessor for the `SomeValue` field; when you ask `Value` what number it contains, it reads the value from `SomeValue`. When you attempt to set the value of the `Value` property, `Value` calls `SetSomeValue` to modify the value of `SomeValue`. This is useful for two reasons: First, it allows you to present the users of the class with a simple variable without making them worry about the class's implementation details. Second, you can allow the users to override accessor methods in descendant classes for polymorphic behavior.

Visibility Specifiers

Object Pascal offers you further control over the behavior of your objects by enabling you to declare fields and methods with directives such as `protected`, `private`, `public`, `published`, and `automated`. The syntax for using these keywords is as follows:

```
TSomeObject = class
private
  APrivateVariable: Integer;
  AnotherPrivateVariable: Boolean;
protected
  procedure AProtectedProcedure;
  function ProtectMe: Byte;
public
  constructor APublicConstructor;
  destructor APublicKiller;
published
  property AProperty read APrivateVariable write APrivateVariable;
end;
```

You can place as many fields or methods as you want under each directive. Style dictates that you should indent the specifier the same as you indent the class name. The meanings of these directives follow:

- `private`. These parts of your object are accessible only to code in the same unit as your object's implementation. Use this directive to hide implementation details of your objects

from users and to prevent users from directly modifying sensitive members of your object.

- `protected`. Your object's `protected` members can be accessed by descendants of your object. This capability enables you to hide the implementation details of your object from users while still providing maximum flexibility to descendants of your object.
- `public`. These fields and methods are accessible anywhere in your program. Object constructors and destructors always should be `public`.
- `published`. *Runtime Type Information* (RTTI) to be generated for the published portion of your objects enables other parts of your application to get information on your object's published parts. The Object Inspector uses RTTI to build its list of properties.
- `automated`. The `automated` specifier is obsolete but remains for compatibility with Delphi 2. Chapter 23, "COM and ActiveX," has more details on this.

Here, then, is code for the `TMyObject` class that was introduced earlier, with directives added to improve the integrity of the object:

```
TMyObject = class
private
    SomeValue: Integer;
    procedure SetSomeValue(AValue: Integer);
published
    property Value: Integer read SomeValue write SetSomeValue;
end;

procedure TMyObject.SetSomeValue(AValue: Integer);
begin
    if SomeValue <> AValue then
        SomeValue := AValue;
end;
```

Now, users of your object will not be able to modify the value of `SomeValue` directly, and they will have to go through the interface provided by the property `Value` to modify the object's data.

"Friend" Classes

The C++ language has a concept of *friend* classes (that is, classes that are allowed access to the private data and functions in other classes). This is accomplished in C++ using the `friend` keyword. Although, strictly speaking, Object Pascal doesn't have a similar keyword, it does allow for similar functionality. All objects declared within the same unit are considered "friends" and are allowed access to the private information located in other objects in that unit.

Inside Objects

All class instances in Object Pascal are actually stored as 32-bit pointers to class instance data located in heap memory. When you access fields, methods, or properties within a class, the compiler automatically performs a little bit of hocus-pocus that generates the code to dereference that pointer for you. Therefore, to the untrained eye, a class appears as a static variable. What this means, however, is that unlike C++, Object Pascal offers no reasonable way to allocate a class from an application's data segment other than from the heap.

TObject: The Mother of All Objects

Because everything descends from `TObject`, every class has some methods that it inherits from `TObject`, and you can make some special assumptions about the capabilities of an object. Every class has the ability, for example, to tell you its name, its type, or even whether it's inherited from a particular class. The beauty of this is that you, as an applications programmer, don't have to care what kind of magic the compiler does to makes this happen. You can just take advantage of the functionality it provides!

`TObject` is a special object because its definition comes from the `System` unit, and the Object Pascal compiler is "aware" of `TObject`. The following code illustrates the definition of the `TObject` class:

```
type
  TObject = class
    constructor Create;
    procedure Free;
    class function InitInstance(Instance: Pointer): TObject;
    procedure CleanupInstance;
    function ClassType: TClass;
    class function ClassName: ShortString;
    class function ClassNameIs(const Name: string): Boolean;
    class function ClassParent: TClass;
    class function ClassInfo: Pointer;
    class function InstanceSize: Longint;
    class function InheritsFrom(AClass: TClass): Boolean;
    class function MethodAddress(const Name: ShortString): Pointer;
    class function MethodName(Address: Pointer): ShortString;
    function FieldAddress(const Name: ShortString): Pointer;
    function GetInterface(const IID: TGUID; out Obj): Boolean;
    class function GetInterfaceEntry(const IID: TGUID): PInterfaceEntry;
    class function GetInterfaceTable: PInterfaceTable;
    function SafeCallException(ExceptObject: TObject;
      ExceptAddr: Pointer): HRESULT; virtual;
    procedure AfterConstruction; virtual;
    procedure BeforeDestruction; virtual;
    procedure Dispatch(var Message); virtual;
    procedure DefaultHandler(var Message); virtual;
```

```
class function NewInstance: TObject; virtual;  
  procedure FreeInstance; virtual;  
  destructor Destroy; virtual;  
end;
```

You'll find each of these methods documented in Delphi's online help system.

In particular, note the methods that are preceded by the keyword `class`. Prepending the `class` keyword to a method enables it to be called like a normal procedure or function without actually having an instance of the class of which the method is a member. This is a juicy bit of functionality that was borrowed from C++'s static functions. Be careful, though, not to make a class method depend on any instance information; otherwise, you'll get a compiler error.

Interfaces

Perhaps the most significant addition to the Object Pascal language in the recent past is the native support for *interfaces*, which was introduced in Delphi 3. Simply put, an interface defines a set of functions and procedures that can be used to interact with an object. The defin-

TIP

ition of a given interface is known to both the implementer and the client of the interface—acting as a contract of sorts for how an interface will be defined and used. A class can implement

multiple interfaces, providing multiple known “faces” by which a client can control an object.

As its name implies, an interface defines only, well, an interface by which object and clients communicate. This is similar in concept to a C++ PURE VIRTUAL class. It's the job of a class that supports an interface to implement each of the interface's functions and procedures.

In this chapter you'll learn about the language elements of interfaces. For information on using interfaces within your applications, see Chapter 23, “COM and ActiveX.”

Defining Interfaces

Just as all Delphi classes implicitly descend from `TObject`, all interfaces are implicitly derived from an interface called `IUnknown`. `IUnknown` is defined in the `System` unit as follows:

```
type  
  IUnknown = interface  
    ['{00000000-0000-0000-C000-000000000046}']  
    function QueryInterface(const IID: TGUID; out Obj): Integer; stdcall;  
    function _AddRef: Integer; stdcall;  
    function _Release: Integer; stdcall;  
  end;
```

As you can see, the syntax for defining an interface is very similar to that of a class. The primary difference is that an interface can optionally be associated with a *globally unique identifier* (GUID), which is unique to the interface. The definition of `IUnknown` comes from the *Component Object Model* (COM) specification provided by Microsoft. This is also described in more detail in Chapter 23, “COM and ActiveX.”

Defining a custom interface is straightforward if you understand how to create Delphi classes. The following code defines a new interface called `IFoo`, which implements one method called `F1()`:

```
type
  IFoo = interface
    ['{2137BF60-AA33-11D0-A9BF-9A4537A42701}']
    function F1: Integer;
  end;
```

The Delphi IDE will manufacture new GUIDs for your interfaces when you use the `Ctrl+Shift+G` key combination.

The following code defines a new interface, `IBar`, which descends from `IFoo`:

```
type
  IBar = interface(IFoo)
    ['{2137BF61-AA33-11D0-A9BF-9A4537A42701}']
    function F2: Integer;
  end;
```

Implementing Interfaces

The following bit of code demonstrates how to implement `IFoo` and `IBar` in a class called `TFooBar`:

```
type
  TFooBar = class(TInterfacedObject, IFoo, IBar)
    function F1: Integer;
    function F2: Integer;
  end;

function TFooBar.F1: Integer;
begin
  Result := 0;
end;

function TFooBar.F2: Integer;
begin
  Result := 0;
end;
```

Note that multiple interfaces can be listed after the ancestor class in the first line of the class declaration in order to implement multiple interfaces. The binding of an interface function to a particular function in the class happens when the compiler matches a method signature in the interface with a matching signature in the class. A compiler error will occur if a class declares that it implements an interface but the class fails to implement one or more of the interface's methods.

If a class implements multiple interfaces that have methods of the same signature, you must alias the same-named methods as shown in the short example following:

```
type
  IFoo = interface
    ['{2137BF60-AA33-11D0-A9BF-9A4537A42701}']
    function F1: Integer;
  end;

  IBar = interface
    ['{2137BF61-AA33-11D0-A9BF-9A4537A42701}']
    function F1: Integer;
  end;

  TFooBar = class(TInterfacedObject, IFoo, IBar)
    // aliased methods
    function IFoo.F1 = FooF1;
    function IBar.F1 = BarF1;
    // interface methods
    function FooF1: Integer;
    function BarF1: Integer;
  end;

function TFooBar.FooF1: Integer;
begin
  Result := 0;
end;

function TFooBar.BarF1: Integer;
begin
  Result := 0;
end;
```

The implements Directive

Delphi 4 introduced the `implements` directive, which enables you to delegate the implementation of interface methods to another class or interface. This technique is sometimes called *implementation by delegation*. `implements` is used as the last directive on a property of class or interface type like this:

```
type
  TSomeClass = class(TInterfacedObject, IFoo)
    // stuff
    function GetFoo: TFoo;
    property Foo: TFoo read GetFoo implements IFoo;
    // stuff
  end;
```

The use of `implements` in the preceding code example instructs the compiler to look to the `Foo` property for the methods that implement the `IFoo` interface. The type of the property must be a class that contains `IFoo` methods or an interface of type `IFoo` or a descendant of `IFoo`. You can also provide a comma-delimited list of interfaces following the `implements` directive, in which case the type of the property must contain the methods to implement the multiple interfaces.

The `implements` directive buys you two key advantages in your development: First, it allows you to perform aggregation in a no-hassle manner. Aggregation is a COM concept pertaining to the combination of multiple classes for a single purpose (see Chapter 23, “COM and ActiveX,” for more information on aggregation). Second, it allows you to defer the consumption of resources necessary to implement an interface until it’s absolutely necessary. For example, say there was an interface whose implementation requires allocation of a 1MB bitmap, but that interface is seldom required by clients. You probably wouldn’t want to implement that interface all the time “just in case” because that would be a waste of resources. Using `implements`, you could create the class to implement the interface on demand in the property accessor method.

Using Interfaces

A few important language rules apply when you’re using variables of interface types in your applications. The foremost rule to remember is that an interface is a lifetime-managed type. This means it’s always initialized to `nil`, it’s reference counted, a reference is automatically added when you obtain an interface, and it’s automatically released when it leaves scope or is assigned the value `nil`. The following code example illustrates the lifetime management of an interface variable:

```
var
  I: ISomeInterface;
begin
  // I is initialized to nil
  I := FunctionReturningAnInterface; // ref count of I is incremented
  I.SomeFunc;
  // ref count of I is decremented. If 0, I is automatically released
end;
```

Another unique rule of interface variables is that an interface is assignment compatible with classes that implement the interface. For example, the following code is legal using the `TFooBar` class defined earlier:

```
procedure Test(FB: TFooBar)
var
    F: IFoo;
begin
    F := FB; // legal because FB supports IFoo
    .
    .
    .
```

Finally, the `as` typecast operator can be used to QueryInterface a given interface variable for another interface (this is explained in greater detail in Chapter 23). This is illustrated here:

```
var
    FB: TFooBar;
    F: IFoo;
    B: IBar;
begin
    FB := TFooBar.Create
    F := FB; // legal because FB supports IFoo
    B := F as IBar; // QueryInterface F for IBar
    .
    .
    .
```

If the requested interface is not supported, an exception will be raised.

Structured Exception Handling

Structured exception handling (SEH) is a method of error handling that enables your application to recover gracefully from otherwise fatal error conditions. In Delphi 1, exceptions were implemented in the Object Pascal language, but starting in Delphi 2, exceptions are a part of the Win32 API. What makes Object Pascal exceptions easy to use is that they're just classes that happen to contain information about the location and nature of a particular error. This

NOTE

makes exceptions as easy to implement and use in your applications as any other class.

Delphi contains predefined exceptions for common program-error conditions, such as out of memory, divide by zero, numerical overflow and underflow, and file I/O errors. Delphi also enables you to define your own exception classes as you may see fit in your applications.

Listing 2.3 demonstrates how to use exception handling during file I/O.

LISTING 2.3 File I/O using exception handling

```
Program FileIO;

uses Classes, Dialogs;

{$APPTYPE CONSOLE}

var
  F: TextFile;
  S: string;
begin
  AssignFile(F, 'F00.TXT');
  try
    Reset(F);
    try
      ReadLn(F, S);
    finally
      CloseFile(F);
    end;
  except
    on EInOutError do
      ShowMessage('Error Accessing File!');
  end;
end.
```

In Listing 2.3, the inner `try..finally` block is used to ensure that the file is closed regardless of whether any exceptions come down the pike. What this block means in English is “Hey, program, try to execute the statements between the `try` and the `finally`. If you finish them or run into an exception, execute the statements between the `finally` and the `end`. If an exception does occur, move on to the next exception-handling block.” This means that the file will be closed and the error can be properly handled no matter what error occurs.

The statements after `finally` in a `try..finally` block execute regardless of whether an exception occurs. Make sure that the code in your `finally` block does not assume that an exception has occurred. Also, because the `finally` statement doesn’t stop the migration of an exception, the flow of your program’s execution will continue on to the next exception handler.

The outer `try..except` block is used to handle the exceptions as they occur in the program. After the file is closed in the `finally` block, the `except` block puts up a message informing the user that an I/O error occurred.

One of the key advantages that exception handling provides over the traditional method of error handling is the ability to distinctly separate the error-detection code from the error-correction code. This is a good thing primarily because it makes your code easier to read and maintain by enabling you to concentrate on one distinct aspect of the code at a time.

The fact that you cannot trap any specific exception by using the `try..finally` block is significant. When you use a `try..finally` block in your code, it means that you don't care what exceptions might occur. You just want to perform some tasks when they do occur to gracefully get out of a tight spot. The `finally` block is an ideal place to free any resources you've allocated (such as files or Windows resources), because it will always execute in the case of an

CAUTION

error. In many cases, however, you need some type of error handling that's able to respond differently depending on the type of error that occurs. You can trap specific exceptions by using a `try..except` block, which is again illustrated in Listing 2.4.

LISTING 2.4 A `try..except` exception-handling block

```
Program HandleIt;

{$APPTYPE CONSOLE}

var
  R1, R2: Double;
begin
  while True do begin
    try
      Write('Enter a real number: ');
      ReadLn(R1);
      Write('Enter another real number: ');
      ReadLn(R2);
      WriteLn('I will now divide the first number by the second...');
      WriteLn('The answer is: ', (R1 / R2):5:2);
    except
      On EZeroDivide do
        WriteLn('You cannot divide by zero!');
      On EInOutError do
        WriteLn('That is not a valid number!');
    end;
  end;
end;
```

```
end;  
end.
```

Although you can trap specific exceptions with the `try..except` block, you also can catch other exceptions by adding the catchall `else` clause to this construct. The syntax of the `try..except..else` construct follows:

```
try  
    Statements  
except  
    On ESomeException do Something;  
else  
    { do some default exception handling }  
end;
```

When using the `try..except..else` construct, you should be aware that the `else` part will catch *all* exceptions—even exceptions you might not expect, such as out-of-memory or other runtime-library exceptions. Be careful when using the `else` clause, and use the clause sparingly. You should always reraise the exception when you trap with unqualified exception handlers. This is explained in the section “Reraising an Exception.”

You can achieve the same effect as a `try..except..else` construct by not specifying the exception class in a `try..except` block, as shown in this example:

```
try
```

CAUTION

```
    Statements  
except  
    HandleException // almost the same as else statement
```

```
end;
```

Exception Classes

Exceptions are merely special instances of objects. These objects are instantiated when an exception occurs and are destroyed when an exception is handled. The base exception object is called `Exception`, and that object is defined as follows:

```
type  
    Exception = class(TObject)  
    private
```

```

    FMessage: string;
    FHelpContext: Integer;
public
    constructor Create(const Msg: string);
    constructor CreateFmt(const Msg: string; const Args: array of const);
    constructor CreateRes(Ident: Integer); overload;
    constructor CreateRes(ResStringRec: PResStringRec); overload;
    constructor CreateResFmt(Ident: Integer; const Args: array of const);
overload;
    constructor CreateResFmt(ResStringRec: PResStringRec; const Args: array of
const); overload;
    constructor CreateHelp(const Msg: string; AHelpContext: Integer);
    constructor CreateFmtHelp(const Msg: string; const Args: array of const;
    AHelpContext: Integer);
    constructor CreateResHelp(Ident: Integer; AHelpContext: Integer); overload;
    constructor CreateResHelp(ResStringRec: PResStringRec; AHelpContext:
Integer); overload;
    constructor CreateResFmtHelp(ResStringRec: PResStringRec; const Args: array
of const;
    AHelpContext: Integer); overload;
    constructor CreateResFmtHelp(Ident: Integer; const Args: array of const;
    AHelpContext: Integer); overload;
    property HelpContext: Integer read FHelpContext write FHelpContext;
    property Message: string read FMessage write FMessage;
end;

```

The important element of the Exception object is the Message property, which is a string. Message provides more information or explanation on the exception. The information provided by Message depends on the type of exception that's raised.

If you define your own exception object, make sure that you derive it from a known exception object such as Exception or one of its descendants. The reason for this is so that generic exception handlers will be able to trap your exception.

When you handle a specific type of exception in an except block, that handler also will catch any exceptions that are descendants of the specified exception. For example, EMathError is the ancestor object for a variety of math-related exceptions, such as EZeroDivide and EOverflow. You can catch any of these exceptions by setting up a handler for EMathError, as shown here:

```

try
    Statements
except
    on EMathError do // will catch EMathError or any descendant
        HandleException
end;

```

Any exceptions that you do not explicitly handle in your program eventually will flow to, and be handled by, the default handler located within the Delphi runtime library. The default han-

dlg will put up a message dialog box informing the user that an exception occurred. Incidentally, Chapter 4, “Application Frameworks and Design Concepts,” will show an example of how to override the default exception handling.

When handling an exception, you sometimes need to access the instance of the exception object in order to retrieve more information on the exception, such as that provided by its `Message` property. There are two ways to do this: Use an optional identifier with the `on ESomeException` construct or use the `ExceptObject()` function.

TIP

You can insert an optional identifier in the `on ESomeException` portion of an `except` block and have the identifier map to an instance of the currently raised exception. The syntax for this is to preface the exception type with an identifier and a colon, as follows:

```
try
    Something
except
    on E:ESomeException do
        ShowMessage(E.Message);
end;
```

In this case, the identifier (`E` in this case) becomes the instance of the currently raised exception. This identifier is always of the same type as the exception it prefaces.

You can also use the `ExceptObject()` function, which returns an instance of the currently raised exception. The drawback to `ExceptObject()`, however, is that it returns a `TObject` that you must then typecast to the exception object of your choice. The following example shows the usage of this function:

```
try
    Something
except
    on ESomeException do
        ShowMessage(ESomeException(ExceptObject).Message);
end;
```

The `ExceptObject()` function will return `Nil` if there is no active exception.

The syntax for raising an exception is similar to the syntax for creating an object instance. To raise a user-defined exception called `EBadStuff`, for example, you would use this syntax:

```
Raise EBadStuff.Create('Some bad stuff happened.');
```

Flow of Execution

After an exception is raised, the flow of execution of your program propagates up to the next exception handler until the exception instance is finally handled and destroyed. This process is determined by the call stack and therefore works program-wide (not just within one procedure or unit). Listing 2.5 illustrates the flow of execution of a program when an exception is raised. This listing is the main unit of a Delphi application that consists of one form with one button on the form. When the button is clicked, the `Button1Click()` method calls `Proc1()`, which calls `Proc2()`, which in turn calls `Proc3()`. An exception is raised in `Proc3()`, and you can witness the flow of execution propagating through each `try..finally` block until the exception is finally handled inside `Button1Click()`.

When you run this program from the Delphi IDE, you'll be able to see the flow of execution better if you disable the integrated debugger's handling of exceptions by unchecking Tools, Debugger Options, Language Exceptions, Stop on Delphi Exceptions.

LISTING 2.5 Main unit for the exception propagation project

```
unit Main;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls;

type
  TForm1 = class(TForm)
    Button1: TButton;
    procedure Button1Click(Sender: TObject);
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  Form1: TForm1;

implementation

{$R *.DFM}

type
  EBadStuff = class(Exception);

procedure Proc3;
begin
```

```
    try
        raise EBadStuff.Create('Up the stack we go!');
    finally
        ShowMessage('Exception raised. Proc3 sees the exception');
    end;
end;

procedure Proc2;
begin
    try
        Proc3;
    finally
        ShowMessage('Proc2 sees the exception');
    end;
end;

procedure Proc1;
begin
    try
        Proc2;
    finally
        ShowMessage('Proc1 sees the exception');
    end;
end;

procedure TForm1.Button1Click(Sender: TObject);
const
    ExceptMsg = 'Exception handled in calling procedure. The message is "%s"';
begin
    ShowMessage('This method calls Proc1 which calls Proc2 which calls Proc3');
    try
        Proc1;
    except
        on E:EBadStuff do
            ShowMessage(Format(ExceptMsg, [E.Message]));
        end;
    end;
end;

end.
```

Reraising an Exception

When you need to perform special handling for a statement inside an existing `try..except` block and still need to allow the exception to flow to the block's outer default handler, you can use a technique called *reraising the exception*. Listing 2.6 demonstrates an example of reraising an exception.

LISTING 2.6 Reraising an exception

```

try                // this is outer block
  { statements }
  { statements }
  ( statements }
try                // this is the special inner block
  { some statement that may require special handling }
except
  on ESomeException do
  begin
    { special handling for the inner block statement }
    raise;        // reraise the exception to the outer block
  end;
end;
except
  // outer block will always perform default handling
  on ESomeException do Something;
end;

```

2

 THE OBJECT
 PASCAL
 LANGUAGE

Runtime Type Information

Runtime Type Information (RTTI) is a language feature that gives a Delphi application the capability to retrieve information about its objects at runtime. RTTI is also the key to links between Delphi components and their incorporation into the Delphi IDE, but it isn't just an academic process that occurs in the shadows of the IDE.

Objects, by virtue of being `TObject` descendants, contain a pointer to their RTTI and have several built-in methods that enable you to get some useful information out of the RTTI. The following table lists some of the `TObject` methods that use RTTI to retrieve information about a particular object instance.

<i>Function</i>	<i>Return Type</i>	<i>Returns</i>
<code>ClassName()</code>	string	The name of the object's class
<code>ClassType()</code>	<code>TClass</code>	The object's type
<code>InheritsFrom()</code>	Boolean	Boolean to indicate whether the class descends from a given class
<code>ClassParent()</code>	<code>TClass</code>	The object ancestor's type
<code>InstanceSize()</code>	word	The size, in bytes, of an instance
<code>ClassInfo()</code>	Pointer	A pointer to the object's in-memory RTTI

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This chapter gives you an introduction to the Win32 API and the Win32 system in general. The chapter discusses the capabilities of the Win32 system and also points out some key differences from the 16-bit implementation of various features. The intent of this chapter is not to document the Win32 system in depth but rather to give you a basic idea of how Win32 operates. By having a basic understanding of the Win32 operation, you'll be able use advanced features provided by the Win32 system whenever the need arises.

Objects—Then and Now

The term *objects* is used for a number of reasons. When we speak of the Win32 architecture, we're not speaking of objects as they exist in object-oriented programming or the Component Object Model (COM). Objects have a totally different meaning in this context, and to make things more confusing, *object* means something different in 16-bit Windows than it does in Win32. We want to make sure you understand what objects are in Win32.

Basically two types of objects are in the Win32 environment: kernel objects and GDI/User objects.

Kernel Objects

Kernel objects are native to the Win32 system and include events, file mappings, files, mail-slots, mutexes, pipes, processes, semaphores, and threads. The Win32 API includes various functions specific to each kernel object. Before discussing kernel objects in general, we want to discuss processes that are essential to understanding how objects are managed in the Win32 environment.

Processes and Threads

A *process* can be thought of as a running application or an application instance. Therefore, several processes can be active at once in the Win32 environment. Each process gets its own 4GB address space for its code and data. Within this 4GB address space, any memory allocations, threads, file mappings, and so on exist. Additionally, any dynamic link libraries (DLLs) loaded by a process are loaded into the address space of the process. We'll say more about the memory management of the Win32 system later in this chapter, in the section "Win32 Memory Management."

Processes are inert. In other words, they execute nothing. Instead, each process gets a *primary thread* that executes code within the context of the process that owns this thread. A process may contain several threads; however, it has only one main or primary thread.

NOTE

A *thread* is an operating system object that represents a path of code execution within a particular process. Every Win32 application has at least one thread—often called the *primary thread* or *default thread*—but applications are free to create other threads to perform other tasks. Threads are covered in greater depth in Chapter 11, “Writing Multithreaded Applications.”

When a process is created, the system creates the main thread for it. This thread may then create additional threads, if necessary. The Win32 system allocates CPU time called *time slices* to the threads of the process.

Table 3.1 shows some common process functions of the Win32 API.

TABLE 3.1 Process Functions

<i>Function</i>	<i>Purpose</i>
CreateProcess()	Creates a new process and its primary thread. This function replaces the WinExec() function used in Windows 3.11.
ExitProcess()	Exits the current process, terminating the process and all threads related to that process.
GetCurrentProcess()	Returns a pseudohandle of the current process. A <i>pseudohandle</i> is a special handle that can be interpreted as the current process handle. A real handle can be obtained by using the DuplicateHandle() function.
DuplicateHandle()	Duplicates the handle of a kernel object.
GetCurrentProcessID()	Retrieves the current process ID, which uniquely identifies the process throughout the system until the process has terminated.
GetExitCodeProcess()	Retrieves the exit status of a specified process.
GetPriorityClass()	Retrieves the priority class for a specified process. This value and the values of each thread priority in the process determine the base priority level for each thread.
GetStartupInfo()	Retrieves the contents of the TStartupInfo structure initialized when the process was created.
OpenProcess()	Returns a handle of an existing process as specified by a process ID.
SetPriorityClass()	Sets a process's priority class.
TerminateProcess()	Terminates a process and kills all threads associated with that process.
WaitForInputIdle()	Waits until the process is waiting for input from the user.

Some Win32 API functions require an application's instance handle, whereas others require a module handle. In 16-bit Windows, there was a distinction between these two values. This is not true under Win32. Every process gets its own instance handle. Your Delphi 5 applications can refer to this instance handle by accessing the global variable, `HInstance`. Because `HInstance` and the application's module handle are the same, you can pass `HInstance` to Win32 API functions calling for a module handle, such as the `GetModuleFileName()` function, which returns the filename of a specified module. See the following Caution for when `HInstance` does not refer to the module handle of the current application.

CAUTION

`HInstance` will not be the module handle of the application for code that's compiled into packages. Use `MainInstance` to refer always to the host application module and `HInstance` to refer to the module in which your code resides.

Another difference between Win32 and 16-bit Windows has to do with the `HPrevInst` global variable. In 16-bit Windows, this variable held the handle of a previously run instance of the same application. You could use the value to prevent multiple instances of your application from running. This no longer works in Win32. Each process runs within its own 4GB address space and can't see any other processes. Therefore, `HPrevInst` is always assigned the value `0`. You must use other techniques to prevent multiple instances of your application from running, as shown in Chapter 13, "Hard-core Techniques."

Types of Kernel Objects

There are several kinds of kernel objects. When a kernel object is created, it exists in the address space of the process, and that process gets a handle to that object. This handle can't be passed to other processes or reused by the next process to access the same kernel object. However, a second process can obtain its own handle to a kernel object that already exists by using the appropriate Win32 API function. For example, the `CreateMutex()` Win32 API function creates a named or unnamed mutex object and returns its handle. The `OpenMutex()` Win32 API returns the handle to an existing named mutex object. `OpenMutex()` passes the name of the mutex whose handle is being requested.

NOTE

Named kernel objects are optionally assigned a null-terminated string name when created with their respective `CreateXXXX()` functions. This name is registered in the Win32 system. Other processes can access the same kernel object by opening it, using

the `OpenXXXX()` function, and passing the specified object name. A demonstration of this technique is used in Chapter 13, “Hard-core Techniques,” where we show you how to prevent multiple instances of an application from running.

If you want to share a mutex across processes, you can have the first process create the mutex by using the `CreateMutex()` function. This process must pass a name that will be associated with this new mutex. Other processes must use the `OpenMutex()` function, to which they pass the same name of the mutex used by the first process. `OpenMutex()` will return a handle to the mutex object of the given name. Various security constraints may be imposed on other processes accessing existing kernel objects. Such security constraints are specified when the mutex is initially created with `CreateMutex()`. Look to the online help for these constraints as they apply to each kernel object.

Because multiple processes can access kernel objects, kernel objects are maintained by a usage count. As a second application accesses the object, the usage count is incremented. When it's done with the object, the application should call the `CloseHandle()` function, which decrements the object's usage count.

GDI and User Objects

Objects in 16-bit Windows referred to entities that could be referenced by a handle. This didn't include kernel objects because they didn't exist under 16-bit Windows.

In 16-bit Windows, there are two types of objects: those stored in the GDI and User local heaps, and those allocated from the global heap. Examples of GDI objects are brushes, pens, fonts, palettes, bitmaps, and regions. Examples of User objects are windows, window classes, atoms, and menus.

A direct relationship exists between an object and its handle. An object's handle is a selector that, when converted into a pointer, points to a data structure describing an object. This structure exists in either the GDI or User default data segment, depending on the type of object to which the handle refers. Additionally, a handle for an object referring to the global heap is a selector to the global memory segment; therefore, when converted to a pointer, it points to that memory block.

A result of this particular design is that objects in 16-bit Windows are sharable. The globally accessible Local Descriptor Table (LDT) stores the handles to these objects. The GDI and User default data segments are also globally accessible to all applications and DLLs under 16-bit Windows. Therefore, any application or DLL can get to an object used by another application. Do note that objects such as the LDT are only sharable in Windows 3.1 (16-bit Windows). Many applications use this arrangement for different purposes. One example is to enable applications to share memory.

Win32 deals with GDI and User objects a bit differently, and the same techniques you used in 16-bit Windows might not be applicable to the Win32 environment.

To begin with, Win32 introduces kernel objects, which we've already discussed. Also, the implementation of GDI and User objects is different under Win32 than under 16-bit Windows.

Under Win32, GDI objects are not shared like their 16-bit counterparts. GDI objects are stored in the address space of the process rather than in a globally accessible memory block (each process gets its own 4GB address space). Additionally, each process gets its own handle table, which stores handles to GDI objects within the process. This is an important point to remember, because you don't want to be passing GDI object handles to other processes.

Earlier, we mentioned that LDTs are accessible from other applications. In Win32, each process address space is defined by its own LDT. Therefore, Win32 uses LDTs as they were intended: as process-local tables.

CAUTION

Although it's possible that a process could call `SelectObject()` on a handle from another process and successfully use that handle, this would be entirely coincidental. GDI objects have different meanings in different processes, so you don't want to practice this method.

The managing of GDI handles happens in the Win32 GDI subsystem, which includes the validation of GDI objects and the recycling of handles.

User objects work similarly to GDI objects and are managed by the Win32 User subsystem. However, any handle tables are also maintained by User—not in the address space of the process, as with the GDI handle tables. Therefore, objects such as windows, window classes, atoms, and so on are sharable across processes.

Multitasking and Multithreading

Multitasking is a term used to describe an operating system's capability of running multiple applications concurrently. The system does this by issuing time slices to each application. In this sense, multitasking is not true multitasking but rather *task switching*. In other words, the operating system isn't really running multiple applications at the same time. Instead, it's running one application for a certain amount of time and then switching to another application and running it for a certain amount of time. It does this for each application. To the user it appears as though all applications are running simultaneously because the time slices are small.

This concept of multitasking isn't really a new feature of Windows and has existed in previous versions. The key difference between the Win32 implementation of multitasking and that of earlier versions of Windows is that Win32 uses *preemptive multitasking*, whereas earlier versions use *nonpreemptive multitasking* (which means that the Windows system doesn't schedule time to applications based on the system timer). Applications have to tell Windows that they're finished processing code before Windows can grant time to other applications. This is a problem because a single application can tie up the system with a lengthy process. Therefore, unless the programmers of the application make sure that the application gives up time to other applications, problems can arise for the user.

Under Win32, the system grants CPU time to the threads for each process. The Win32 system manages the time allotted to each thread based on thread priorities. This concept is discussed in greater depth in Chapter 11, "Writing Multithreaded Applications."

NOTE

The Windows NT/2000 implementation of Win32 offers the capacity to perform true multitasking on machines with multiple processors. Under these conditions, each application can be granted time on its own processor. Actually, each individual thread can be given CPU time on any available CPU in a multiprocessor machine.

Multithreading is the capability of an application to multitask within itself. This means that your application can perform different types of processing simultaneously. A process can have several threads, and each thread contains its own distinct code to execute. Threads may have dependencies on one another and therefore must be synchronized. For example, it wouldn't be a good idea to assume that a particular thread will finish processing its code when its result will be used by another thread. Thread-synchronization techniques are used to coordinate multiple-thread execution. Threads are discussed in greater depth in Chapter 11, "Writing Multithreaded Applications."

Win32 Memory Management

The Win32 environment introduces you to the 32-bit flat memory model. Finally, Pascal programmers can declare that big array without running into a compile error:

```
BigArray = array[1..100000] of integer;
```

The following sections discuss the Win32 memory model and how the Win32 system lets you manipulate memory.

Just What Is the Flat Memory Model?

The 16-bit world uses a segmented memory model. Under that model, addresses are represented with a *segment:offset* pair. The *segment* refers to a base address, and the *offset* represents a number of bytes from that base. The problem with this scheme is that it's confusing to the average programmer, especially when dealing with large memory requirements. It's also limiting—data structures larger than 64KB are extremely painful to manage and are therefore avoided.

Under the flat-memory model, these limitations are gone. Each process has its own 4GB address space to use for allocating large data structures. Additionally, an address actually represents a unique memory location.

How Does the Win32 System Manage Memory?

It's not likely that your computer has 4GB installed. How does the Win32 system make more memory available to your processes than the amount of physical memory installed on the computer? Addresses that are 32 bit don't actually represent a memory location in physical memory. Instead, Win32 uses *virtual addresses*.

By using virtual memory, each process can get its own 4GB virtual address space. The upper 2MB area of this address space belongs to Windows, and the bottom 2MB is where your applications reside and where you can allocate memory. One advantage to this scheme is that the thread for one process can't access the memory in another process. The address \$54545454 in one process points to a completely different location than the same address in another process.

It's important to note that a process doesn't actually have 4GB of memory but rather has the capability to access a range of addresses up to 4GB. The amount of memory available to a process really depends on how much physical RAM is installed on the machine and how much space is available on disk for a paging file. The physical RAM and the paging file are used by the system to break the memory available to a process into pages. The size of a page depends on the type of system on which Win32 is installed. These page sizes are 4KB for Intel platforms and 8KB for Alpha platforms. The defunct PowerPC and MIPS platforms used 4KB pages as well. The system then moves pages from the paging file to physical memory and back as needed. The system maintains a page map to translate the virtual addresses of a process to a physical address. We won't get into the hairy details of how all this happens; we just want to familiarize you with the general scheme of things at this point.

A developer can manipulate memory in the Win32 environment in essentially three ways: using virtual memory, file-mapping objects, and heaps.

Virtual Memory

Win32 provides you with a set of low-level functions that enable you to manipulate the virtual memory of a process. This memory exists in one of the following three states:

- *Free*. Memory that's available to be reserved and/or committed.
- *Reserved*. Memory within an address range that's reserved for future use. Memory within this address is protected from other allocation requests. However, this memory cannot be accessed by the process because no *physical* memory is associated with it until it's committed. The `VirtualAlloc()` function is used to reserve memory.
- *Committed*. Memory that has been allocated and associated with physical memory. Committed memory can be accessed by the process. The `VirtualAlloc()` function is used to commit virtual memory.

As stated earlier, Win32 provides various `VirtualXXXX()` functions for manipulating virtual memory, as shown in Table 3.2. These functions are also documented in detail in the online help.

TABLE 3.2 Virtual Memory Functions

<i>Function</i>	<i>Purpose</i>
<code>VirtualAlloc()</code>	Reserves and/or commits pages in a process's virtual address space.
<code>VirtualFree()</code>	Releases and/or decommits pages in a process's virtual address space.
<code>VirtualLock()</code>	Locks a region of a process's virtual address to prevent it from being swapped to a page file. This prevents page faults with subsequent accesses to that region.
<code>VirtualUnlock()</code>	Unlocks a specified region of memory in a process's address space so that it can be swapped to a page file if necessary.
<code>VirtualQuery()</code>	Returns information about a range of pages in the calling process's virtual address space.
<code>VirtualQueryEx()</code>	Returns the same information as <code>VirtualQuery()</code> except that it allows you to specify the process.
<code>VirtualProtect()</code>	Changes access protection for a region of committed pages in the calling process's virtual address space.
<code>VirtualProtectEx()</code>	Same as <code>VirtualProtect()</code> except that it makes changes to a specified process.

NOTE

The `xxxEx()` routines listed in this table can only be used by a process that has debugging privileges on the other process. It's complicated and rare for anything but a debugger to use these routines.

Memory-Mapped Files

Memory-mapped files (file-mapping objects) allow you to access disk files in the same way you would access dynamically allocated memory. This is done by mapping all or part of the file to the calling process's address range. After this is done, you can access the file's data by using a simple pointer. Memory-mapped files are discussed in greater detail in Chapter 12, "Working with Files."

Heaps

Heaps are contiguous blocks of memory in which smaller blocks can be allocated. Heaps efficiently manage the allocation and manipulation of dynamic memory. Heap memory is manipulated using various `HeapXXXX()` Win32 API functions. These functions are listed in Table 3.3 and are also documented in detail in Delphi's online help.

TABLE 3.3 Heap Functions

<i>Function</i>	<i>Purpose</i>
<code>HeapCreate()</code>	Reserves a contiguous block in the virtual address space of the calling process and allocates physical storage for a specified initial portion of this block
<code>HeapAlloc()</code>	Allocates a block of nonmovable memory from a heap
<code>HeapReAlloc()</code>	Reallocates a block of memory from the heap, thus allowing you to resize or change the heap's properties
<code>HeapFree()</code>	Frees a memory block allocated from the heap with <code>HeapAlloc()</code>
<code>HeapDestroy()</code>	Destroys a heap object created with <code>HeapCreate()</code>

NOTE

It's important to note that there are several differences in the Win32 implementation of Windows NT/2000 and Windows 95/98. Generally, these differences have to do with security and speed. The Windows 95/98 memory manager, for instance, is leaner than that of Windows NT/2000 (NT maintains more internal tracking information on heap blocks). However, the NT virtual memory manager is generally regarded as much faster than Windows 95/98.

Be aware of such differences when using the various functions associated with these Windows objects. The online help will point out platform-specific variations of such a function's usage. Be sure to refer to the help whenever using these functions.

Error Handling in Win32

Most Win32 API functions return either `True` or `False`, indicating that the function was either successful or unsuccessful, respectively. If the function is unsuccessful (the function returns `False`), you must use the `GetLastError()` Win32 API function to obtain the error code value for the thread in which the error occurred.

NOTE

Not all Win32 system API functions set error codes that are accessible by `GetLastError()`. For example, many GDI routines don't set error codes.

This error code is maintained on a per-thread basis, so `GetLastError()` must be called in the context of the thread causing the error. The following is an example of this function's usage:

```
if not CreateProcess(CommandLine, nil, nil, nil, False,
  NORMAL_PRIORITY_CLASS, nil, nil, StartupInfo, ProcessInfo) then
  raise Exception.Create('Error creating process: '+
    IntToStr(GetLastError));
```

TIP

The Delphi 5 `SysUtils.pas` unit has a standard exception class and utility function to convert system errors into exceptions. These functions are `Win32Check()` and `RaiseLastWin32Error()`, which raises an `EWin32Error` exception. Use these helper routines instead of writing your own result checks.

This code attempts to create a process specified by the null-terminated string `CommandLine`. We'll defer discussing the `CreateProcess()` method for a later chapter since we're focusing on the `GetLastError()` function. If `CreateProcess()` fails, an exception is raised. This exception displays the last error code that resulted from the function call by getting it from the `GetLastError()` function. You might use a similar approach in your application.

TIP

Error codes returned by `GetLastError()` are typically documented in the online help under the functions that cause the error to occur. Therefore, the error code for `CreateMutex()` would be documented under `CreateMutex()` in the Win32 online help.

Summary

This chapter introduced you to the Win32 API. You should now have an idea of the new kernel objects available as well as how Win32 manages memory. You should also be familiar with the different memory-management features available to you. As a Delphi developer, it isn't necessary that you know all the ins and outs of the Win32 system. However, you should possess a basic understanding of the Win32 system, its functions, and how you can use these functions to maximize your development effort. This chapter provides you with a starting point.

Application Frameworks and Design Concepts

CHAPTER

4

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This chapter is about Delphi project management and architecting. It shows you how to use forms properly in your applications as well as how to manipulate their behavioral and visual characteristics. The techniques discussed in this chapter include application startup/initialization procedures, form reuse/inheritance, and user interface enhancement. The text discusses the framework classes that make up Delphi 5 applications: `TApplication`, `TForm`, `TFrame`, and `TScreen`. We'll then show you why understanding these concepts is essential to properly architecting Delphi applications.

Understanding the Delphi Environment and Project Architecture

There are at least two important factors in properly building and managing Delphi 5 projects. The first is knowing the ins and outs of the development environment in which you create your projects. The second is having a solid understanding of the inherent architecture of the applications created with Delphi 5. This chapter doesn't walk you through the Delphi 5 environment (the Delphi documentation shows you how to work within that environment); instead, this chapter points out features of the Delphi 5 IDE that help you manage your projects more effectively. This chapter will also explain the architecture inherent in all Delphi applications. This will not only allow you to maximize the environment's features but also to properly use a solid architecture instead of fighting it—a common mistake among those who don't understand Delphi project architectures.

Our first suggestion is to become well acquainted with the Delphi 5 development environment. This book assumes that you're already familiar with the Delphi 5 IDE. Second, this book assumes that you've thoroughly read the Delphi 5 documentation (hint). However, you should navigate through each of the Delphi 5 menus and bring up each of its dialog boxes. When you see an option, setting, or action you're unsure of, bring up the online help and read through it. The time you spend doing this can prove interesting as well as insightful (not to mention that you'll learn how to navigate through the online help efficiently).

TIP

The Delphi 5 help system is without a doubt the most valuable and speedy reference you have at your disposal. It would be advantageous to learn how to use it to explore the thousands of help screens available.

Delphi 5 contains help on everything from how to use the Delphi 5 environment to details on the Win32 API and complex Win32 structures. You can get immediate help on a topic by typing the topic in the editor and, with the cursor still on the word you typed, pressing `Ctrl+F1`. The help screen appears immediately. Help is also available

from the Delphi 5 dialog boxes by selecting the Help button or by pressing F1 when a particular component has focus. You can also navigate through help by simply selecting Help from Delphi 5's Help menu.

Files That Make Up a Delphi 5 Project

A Delphi 5 project is composed of several related files. Some files are created at design time as you define forms. Others aren't created until you compile the project. To manage a Delphi 5 project effectively, you must know the purpose of each of these files. Both the Delphi 5 documentation and the online help give detailed descriptions of the Delphi 5 project files. It's a good idea to review the documentation to ensure that you're familiar with these files before going on with this chapter.

The Project File

The *project file* is created at design time and has the extension `.dpr`. This file is the main program source file. The project file is where the main form and any automatically created forms are instantiated. You'll seldom have to edit this file except when performing program initialization routines, displaying a splash screen, or performing various other routines that must happen immediately when the program starts. The following code shows a typical project file:

```
program Project1;
uses
  Forms,
  Unit1 in 'Unit1.pas' {Form1};
{$R *.RES}
begin
  Application.Initialize;
  Application.CreateForm(TForm1, Form1);
  Application.Run;
end.
```

Pascal programmers will recognize this file as a standard Pascal program file. Notice that this file lists the form unit `Unit1` in the `uses` clause. Project files list all form units that belong to the project in the same manner. The following line refers to the project's resource file:

```
{$R *.RES}
```

This line tells the compiler to link the resource file that has the same name as the project file and an `.RES` extension to this project. The project resource file contains the program icon and version information.

Finally, the `begin..end` block is where the application's main code is executed. In this simple example, the main form, `Form1`, is created. When `Application.Run()` executes, `Form1` is displayed as the main form. You can add code in this block, as shown later in this chapter.

Project Unit Files

Units are Pascal source files with a `.pas` extension. There are basically three types of units files: form/data module and frame units, component units, and general-purpose units.

- *Form/data module and frame units* are units automatically generated by Delphi 5. There's one unit for each form/data module or frame you create. For example, you can't have two forms defined in one unit and use them both in the Form Designer. For the purpose of explaining form files, we won't make a distinction between forms, data modules, and frames.
- *Component units* are unit files created by you or Delphi 5 whenever you create a new component.
- *General-purpose units* are units you can create for data types, variables, procedures, and classes you want to make accessible to your applications.

Details about units are provided later in this chapter.

Form Files

A *form file* contains a binary representation of a form. Whenever you create a new form, Delphi 5 creates both a form file (with the extension `.dfm`) and a Pascal unit (with the extension `.pas`) for your new form. If you look at a form's unit file, you'll see the following line:

```
{$R *.DFM}
```

This line tells the compiler to link the corresponding form file (the form file that has the same name as the unit file and a `.DFM` extension) to the project.

You typically don't edit the form file itself (although it's possible to do so). You can load the form file into the Delphi 5 editor so that you can view or edit the text representation of this file. Select File, Open and then select the option to open only form files (`.dfm`). You can also do this by simply right-clicking the Form Designer and selecting View as Text from the pop-up menu. When you open the file, you see the text representation of the form.

Viewing the textual representation of the form is handy because you can see the nondefault property settings for the form and any components that exist on the form. One way you can edit the form file is to change a component type. For example, suppose that the form file contains this definition for a `TButton` component:

```
object Button1: TButton  
  Left = 8
```

```
Top = 8
Width = 75
Height = 25
Caption = 'Button1'
TabOrder = 0
end
```

If you change the line object `Button1: TButton` to object `Button1: TLabel`, you change the component type to a `TLabel` component. When you view the form, you see a label on the form and not a button.

NOTE

Changing component types in the form file might result in a property read error. For example, changing a `TButton` component (which has a `TabOrder` property) to a `TLabel` component (which doesn't have a `TabOrder` property) results in this error. However, there's no need for concern because Delphi will correct the reference to the property the next time the form is saved.

CAUTION

You must be extremely careful when you edit the form file. It's possible to corrupt it, which will prevent Delphi 5 from opening the form later.

NOTE

New to Delphi 5 is the ability to save forms in text file format. This was made possible to allow editing with other common tools such as `Notepad.exe`. Simply right-click the form to invoke the context menu and select `Text DFM`.

Resource Files

Resource files contain binary data, also called *resources*, that are linked to the application's executable file. The `RES` file automatically created by Delphi 5 contains the project's application icon, the application's version information, and other information. You can add resources to your application by creating a separate resource file and linking it to your project. You can create this resource file with a resource editor such as the Image Editor provided with Delphi 5 or the Resource Workshop.

CAUTION

Don't edit the resource file that Delphi creates automatically at compile time. Doing so will cause any changes to be lost the next time you compile. If you want to add resources to your application, create a separate resource file with a different name from that of your project file. Then link the new file to your project by using the `$R` directive, as shown in the following line:

```
{ $R MYRESFIL.RES }
```

Project Options and Desktop Settings Files

The *project options file* (with the extension `.dof`) is where the options specified from the Project, Options menu are saved. This file is created when you first save your project; the file is saved again with each subsequent save.

The *desktop options file* (with the extension `.dsk`) stores the options specified from the Tools, Environment Options menu for the desktop. Desktop option settings differ from project option settings in that project options are specific to a given project; desktop settings apply to the Delphi 5 environment.

TIP

A corrupt DSK or DOF file can cause unexpected results, such as a GPF, during compilation. If this happens, delete both the DOF and DSK files. They're regenerated when you save your project and when you exit Delphi 5; the IDE and project will revert to the default settings.

Backup Files

Delphi 5 creates *backup files* for the DPR project file and for any PAS units on the second and any subsequent saves. The backup files contain the last copy of the file before the save was performed. The project backup file has the extension `.-dp`. Unit backup files have the extension `.-pa`.

A binary backup of the DFM form file is also created after you've saved it for the second or subsequent time. This form file backup has a `.-df` extension.

You harm nothing if you delete any of these files—as long as you realize that you're deleting your last backup. Also, if you find that you prefer not to create these files at all, you can prevent Delphi from creating them by deselecting Create Backup File in the Editor Properties dialog box's Display page.

Package Files

Packages are simply DLLs that contain code that can be shared among many applications. However, packages are specific to Delphi in that they allow you to share components, classes, data, and code between modules. This means that you can now reduce the footprint of your applications drastically by using components residing in packages instead of linking them directly into your applications. Later chapters talk much more about packages. Package source files use the extension `.dpc` (short for *Delphi package*). When compiled, a BPL file is created (A `.BPL` file is simply a dll). This BPL may be composed of several units or DCU (*Delphi compiled units*) files, which can be any of the unit types previously mentioned. The binary image of a DPK file containing all included units and the package header has the extension `.dcp` (Delphi compiled package). Don't be concerned if this seems confusing now; we'll explain packages in more detail later.

Project Management Tips

There are several ways to optimize the development process by using techniques that facilitate better organization and code reuse. The next few sections offer some tips on these techniques.

One Project, One Directory

It's a good idea to manage your projects so that one project's files are separate from other projects' files. Doing so prevents one project from overwriting another project's files.

Notice that each project on the CD-ROM that accompanies this book is in its own directory. You should follow this approach and maintain each of your projects in its own directory.

File Naming Conventions

It's a good idea to establish a standard file naming convention for the files that make up your projects. You might take a look at the DDG Coding Standards Document included on the CD-ROM and used by the authors for the projects contained in this book. (See Chapter 6, "Delphi 5 Developer's Guide Coding Standards Document.")

Units for Sharing Code

You can share commonly used routines with other applications by placing such routines in units that can be accessed by multiple projects. Typically, you create a utility directory somewhere on your hard drive and place your units in that directory. When you need to access a particular function that exists in one of the units in that directory, you just place the unit's name in the `uses` clause of the unit/project file requiring access.

You must also add the utility directory's path to the search path on the Directories/Conditionals page in the Project Options dialog box. Doing so ensures that Delphi 5 knows where to find your utility units.

TIP

By using the Project Manager, you can add a unit from another directory to an existing project, which automatically takes care of adding the search path.

To explain how to use utility units, Listing 4.1 shows a small unit, `StrUtils.pas`, that contains a single string-utility function. In reality, such units would probably contain many more routines, but this suffices as an example. The comments explain the function's purpose.

LISTING 4.1 The `StrUtils.pas` Unit

```
unit strutils;
interface
function ShortStringAsPChar(var S: ShortString): PChar;
implementation
function ShortStringAsPChar(var S: ShortString): PChar;
{ This function null-terminates a short string so that it can be passed to
  functions that require PChar types. If string is longer than 254 chars, then
  it will be truncated to 254.
}
begin
  if Length(S) = High(S) then Dec(S[0]); { Truncate S if it's too long }
  S[Ord(Length(S)) + 1] := #0;          { Place null at end of string }
  Result := @S[1];                      { Return "PChar'd" string }
end;
end.
```

Suppose that you have a unit, `SomeUnit.Pas`, that requires the use of this function. Simply add `StrUtils` to the `uses` clause of the unit in need, as shown here:

```
unit SomeUnit;
interface
...
implementation
uses
  strutils;
...
end.
```

Also, you must ensure that Delphi 5 can find the unit `StrUtils.pas` by adding it to the search path from the Project, Options menu.

When you do this, you can use the function `ShortStringAsPChar()` anywhere in the implementation section of `SomeUnit.pas`. You must place `StrUtils` in the `uses` clause of all units that need access to the `ShortStringAsPChar()` function. It isn't enough to add `StrUtils` to only one unit in a project, or even to the project file (DPR) of the application to make the routine available throughout the entire application.

TIP

Because `ShortStringAsPChar()` is a handy function, it pays to place it in a utility unit where it can be reused by any application so that you don't have to remember how or where you last used it.

Units for Global Identifiers

Units are also useful for declaring global identifiers for your project. As mentioned earlier, a project typically consists of many units—form units, component units, and general-purpose units. What if you need a particular variable to be present and accessible to all units throughout the running of your application? The following steps show a simple way to create a unit to store these global identifiers:

1. Create a new unit in Delphi 5.
2. Give the unit a name indicating that it holds global identifiers for the application (for example, `Globals.Pas` or `ProjGlob.pas`).
3. Place the variables, types, and so on in the `interface` section of your global unit. These are the identifiers that will be accessible to other units in the application.
4. To make these identifiers accessible to a unit, just add the unit name to the `uses` clause of the unit that needs access (as described earlier in this chapter in the discussion about sharing code in units).

Making Forms Know About Other Forms

Just because each form is contained within its own unit doesn't mean that it can't access another form's variables, properties, and methods. Delphi generates code in the form's corresponding PAS file, declaring the instance of that form as a global variable. All that's required is that you add the name of the unit defining a particular form to the `uses` clause of the unit defining the form needing access. For example, if `Form1`, defined in `UNIT1.PAS`, needs access to `Form2`, defined in `UNIT2.PAS`, just add `UNIT2` to `UNIT1`'s `uses` clause:

```
unit Unit1;  
interface  
...  
implementation  
uses  
    Unit2;  
...  
end.
```

Now UNIT1 can refer to Form2 anywhere in its implementation section.

NOTE

Form linking will ask you if you want to include Unit2 in Unit1's uses clause when you compile the project if you refer to the Unit2's form (call it Form2); all that's necessary is to refer to Form2 somewhere in Unit1.

Multiple Projects Management (Project Groups)

Often, a product is made up of multiple projects (projects that are dependent on one another). Examples of such projects are the separate tiers in a multitiered application. Also, DLLs to be used in other projects might be considered part of the overall project, even though DLLs are separate projects themselves.

Delphi 5 allows you to manage such project groups. The Project Manager allows you to combine several Delphi projects into one grouping called a *project group*. We won't go into the details of using the Project Manager because Delphi's documentation already does this. We do want to emphasize how important it is to organize project groups and how the Project Manager helps you do this.

It's still important that each project live in its own directory and that all files specific to that project alone reside in the same directory. Any shared units, forms, and so on should be placed in a common directory that's accessed by the separate projects. For example, your directory structure might look something like this:

```
\DDGBugProduct  
\DDGBugProduct\BugReportProject  
\DDGBugProduct\BugAdminTool  
\DDGBugProduct\CommonFiles
```

Given this structure, you have two separate directories for each Delphi project: BugReportProject and BugAdminTool. However, both of these projects may use forms and units that are common. You would place these files into the CommonFiles directory.

Organization is crucial in your development efforts, especially in a team development environment. It's highly recommended that you establish a standard before your team dives into creating a bunch of files that are going to be difficult to manage. You can use the Delphi Project Manager to help you understand your project-management structure.

The Framework Classes of a Delphi 5 Project

Most Delphi 5 applications have at least one instance of a `TForm` class. Also, Delphi 5 VCL applications will have only one instance of a `TApplication` class and a `TScreen` class. These three classes play important roles in managing the behavior of a Delphi 5 project. The following sections familiarize you with the roles of these classes so that you have the knowledge to modify their default behaviors when necessary.

The TForm Class

The `TForm` class is the focal point for Delphi 5 applications. In most cases, the entire application revolves around the main form. From the main form, you can launch other forms, usually as a result of a menu or button-click event. You might want Delphi 5 to create your forms automatically, in which case you don't have to worry about creating and destroying them. You may also choose to create the forms dynamically at runtime.

NOTE

Delphi can create applications that don't use forms (for example, console apps, services, and COM servers). Therefore, the `TForm` class is not always the focal point of your applications.

You can display the form to the end user by using one of two methods: modal or modeless. The method you choose depends on how you intend the user to interact with the form and other forms concurrently.

Displaying a Modal Form

A *modal form* is displayed so that the user can't access the rest of the application until he or she has dismissed the form. Modal forms are typically associated with dialog boxes, much like the dialog boxes in Delphi 5 itself. In fact, you'll probably use modal forms in most cases. To display a form as modal, simply call its `ShowModal()` method. The following code shows how you create an instance of a user-defined form, `TModalForm`, and then display it as a modal form:

```
Begin
  // Create ModalForm instance
  ModalForm := TModalForm.Create(Application);
```

```

try
  if ModalForm.ShowModal = mrOk then      // Show form in modal state
    { do something };                    // Execute some code
finally
  ModalForm.Free;                        // Free form instance
  ModalForm := nil;                      // Set form variable to nil
end;
end;

```

This code shows how you would dynamically create an instance of `TModalForm` and assign it to the variable `ModalForm`. It's important to note that, if you create a form dynamically, you must remove it from the list of available forms from the Auto-Create list box in the Project Options dialog box. This dialog box is invoked by selecting Project, Options from the menu. If the form instance is already created, however, you can show it as a modal form just by calling the `ShowModal()` method. The surrounding code can be removed:

```

begin
  if ModalForm.ShowModal = mrOk then    // ModalForm is already created
    { do something }
end;

```

The `ShowModal()` method returns the value assigned to `ModalForm`'s `ModalResult` property. By default, `ModalResult` is zero, which is the value of the predefined constant `mrNone`. When you assign any nonzero value to `ModalResult`, the form is closed, and the assignment made to `ModalResult` is passed back to the calling routine through the `ShowModal()` method.

Buttons have a `ModalResult` property. You can assign a value to this property that's passed to the form's `ModalResult` property when the button is pressed. If this value is anything other than `mrNone`, the form will close, and the value passed back from the `ShowModal()` method will reflect that assigned to `ModalResult`.

You can also assign a value to the form's `ModalResult` property at runtime:

```

begin
  ModalForm.ModalResult := 100; // Assigning a value to ModalResult
  // causing form to close.
end;

```

Table 4.1 shows the predefined `ModalResult` values.

TABLE 4.1 ModalResult Values?

<i>Constant</i>	<i>Value</i>
<code>mrNone</code>	<code>0</code>
<code>mrOk</code>	<code>idOk</code>
<code>mrCancel</code>	<code>idCancel</code>

<i>Constant</i>	<i>Value</i>
mrAbort	idAbort
mrRetry	idRetry
mrIgnore	idIgnore
mrYes	idYes
mrNo	idNo
mrAll	mrNo+1

Launching Modeless Forms

You can launch a modeless form by calling its `Show()` method. Calling a modeless form differs from the modal method in that the user can switch between the modeless form and other forms in the application. The intent of modeless forms is to allow users to work with different parts of the application at the same time as the form is displayed. The following code shows how you can dynamically create a modeless form:

```
Begin
// Check for an instance of modeless first
  if not Assigned(Modeless) then
    Modeless := TModeless.Create(Application); // Create form
    Modeless.Show                               // Show form as non-modal
  end;                                           // instance already exists
```

This code also shows how you prevent multiple instances of one form class from being created. Remember that a modeless form allows the user to interact with the rest of the application. Therefore, nothing prevents the user from selecting the menu option again to create another form instance of `TModeless`. It's important that you manage the creation and destruction of forms.

Here's an important note about form instances: When you close a modeless form—either by accessing the system menu or clicking the close button in the upper-right corner of the form—the form isn't actually freed from memory. The instance of the form still exists in memory until you close the main form (that is, the application). In the preceding code example, the `then` clause is executed only once, provided that the form is not autocreated. From that point on, the `else` clause is executed because the form instance always exists from its previous creation. This is fine if that's the way you want your application to function. However, if you want the form to be freed whenever the user closes it, you must provide code for the `OnClose` event handler for the form and set its `Action` parameter to `caFree`. This tells the VCL to free the form when it's closed:

```
procedure TModeless.FormClose(Sender: TObject;
  var Action: TCloseAction);
```

```
begin
  Action := caFree; // Free the form instance when closed
end;
```

The preceding version of the code solves the issue of the form not being freed. There's another issue, however. You might have noticed that this line was used in the first snippet of code showing modeless forms:

```
if not Assigned(Modeless) then begin
```

This line checks for an instance of `TModeless` referenced by the `Modeless` variable. Actually, this really checks to see that `Modeless` is not `nil`. Although `Modeless` will be `nil` the first time you enter the routine, it won't be `nil` when you enter the routine a second time after having destroyed the form. The reason is because the VCL doesn't set the variable `Modeless` to `nil` when it's destroyed. Therefore, this is something you must do yourself.

Unlike with a modal form, you can't determine in code when the modeless form will be destroyed. Therefore, you can't destroy the form inside the routine that creates it. The user can close the form at any moment while running the application. Therefore, setting `Modeless` to `nil` must be a process of the `TModeless` class itself. The best place to do this is in the `OnDestroy` event handler for `TModeless`:

```
procedure TModeless.FormDestroy(Sender: TObject);
begin
  Modeless := nil; // Set the Modeless variable to nil when destroyed
end;
```

This ensures that the `Modeless` variable is set to `nil` every time it's destroyed, thus preventing the `Assigned()` method from failing. Keep in mind that it's up to you to ensure that only one instance of `TModeless` is created at a time, as shown in this routine.

CAUTION

Avoid the following pitfall when working with modeless forms:

```
begin
  Form1 := TForm1.Create(Application);
  Form1.Show;
end;
```

This code results in memory unnecessarily being consumed because, each time you create a form instance, you overwrite the previous instance referenced by `Form1`. Although you could refer to each instance of the form created through the `Screen.Forms` list, the practice shown in the preceding code is not recommended. Passing `nil` to the `Create()` constructor will result in no way to refer to the form instance pointer after the `Form1` instance variable is overwritten.

The project `ModState.dpr` on the accompanying CD-ROM illustrates using both modal and modeless forms.

Managing a Form's Icons and Borders

`TForm` has a `BorderIcons` property that's a set that may contain the following values: `biSystemMenu`, `biMinimize`, `biMaximize`, and `biHelp`. By setting any or all of these values to `False`, you can remove the system menu, the maximize button, the minimize button and the help button from the form. All forms have the Windows 95/98 close button.

You also can change the nonclient area of the form by changing the `BorderStyle` property. The `BorderStyle` property is defined as follows:

```
TFormBorderStyle = (bsNone, bsSingle, bsSizeable, bsDialog,  
↳bsSizeToolWin, bsToolWindow);
```

The `BorderStyle` property gives forms the following characteristics:

- `bsDialog`. Nonsizable border; close button only.
- `bsNone`. No border, nonsizable, and no buttons.
- `bsSingle`. Nonsizable border; all buttons available. If only one of the `biMinimize` and `biMaximize` buttons is set to `False`, both buttons appear on the form. However, the button set to `False` is disabled. If both are `False`, neither button appears on the form. If `biSystemMenu` is `False`, no buttons appear on the form.
- `bsSizeable`. Sizable border. All buttons are available. The same circumstances exist for this option regarding buttons as with the `bsSingle` setting.
- `bsSizeToolWin`. Sizable border. Close button only and small caption bar.
- `bsToolWindow`. Nonsizable border. Close button only and small caption bar.

NOTE

Changes to the `BorderIcon` and `BorderStyle` properties aren't reflected at design time. These changes happen at runtime only. This is also the case with other properties, most of which are found on `TForm`. The reason for this behavior is that it doesn't make sense to change the appearance of certain properties at design time. Take, for example, the `Visible` property. It's difficult to select a control on the form when its `Visible` property is set to `False` because the control is invisible.

Sticky Captions!

You might have noticed that none of the options mentioned allow you to create captionless, resizable forms. Although this isn't impossible, doing so requires a bit of trickery not yet covered. You must override the form's `CreateParams()` method and set the styles required for that window style. The following code snippet does this:

```
unit Nocapu;
interface
uses
  SysUtils, WinTypes, WinProcs, Messages, Classes,
  Graphics, Controls, Forms, Dialogs;
type
  TForm1 = class(TForm)
public
  { override CreateParams method }
  procedure CreateParams(var Params: TCreateParams); override;
end;
var
  Form1: TForm1;
implementation
{$R *.DFM}
procedure TForm1.CreateParams(var Params: TCreateParams);
begin
  inherited CreateParams(Params); { Call the inherited Params }
  { Set the style accordingly }
  Params.Style := WS_THICKFRAME or WS_POPUP or WS_BORDER;
end;
end.
```

You'll learn more about the `CreateParams()` method in Chapter 21, "Writing Delphi Custom Components."

You can find an example of a sizable, borderless form in the project `NoCaption.dpr` on the CD-ROM that accompanies this book. This demo also illustrates how to capture the `WM_NCHITTEST` message to enable moving the form without the caption by dragging the form.

Take a look at the `BrdrIcon.dpr` project on the CD-ROM. This project shows how you can change the `BorderIcon` and `BorderStyle` property at runtime so that you see the visual effect. Listing 4.2 shows the main form for this project, which contains the relevant code.

LISTING 4.2 The Main Form for the `BorderStyle/BorderIcon` Project

```
unit MainFrm;

interface
```

```
uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, ExtCtrls;

type
  TMainForm = class(TForm)
    gbBorderIcons: TGroupBox;
    cbSystemMenu: TCheckBox;
    cbMinimize: TCheckBox;
    cbMaximize: TCheckBox;
    rgBorderStyle: TRadioGroup;
    cbHelp: TCheckBox;
    procedure cbMinimizeClick(Sender: TObject);
    procedure rgBorderStyleClick(Sender: TObject);
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.cbMinimizeClick(Sender: TObject);
var
  IconSet: TBorderIcons; // Temp variable to hold values.
begin
  IconSet := []; // Initialize to an empty set
  if cbSystemMenu.Checked then
    IconSet := IconSet + [biSystemMenu]; // Add the biSystemMenu button
  if cbMinimize.Checked then
    IconSet := IconSet + [biMinimize]; // Add the biMinimize button
  if cbMaximize.Checked then
    IconSet := IconSet + [biMaximize]; // Add the biMaximize button
  if cbHelp.Checked then
    IconSet := IconSet + [biHelp];

  BorderIcons := IconSet; // Assign result to the form's
end; // BorderIcons property.

procedure TMainForm.rgBorderStyleClick(Sender: TObject);
begin
  BorderStyle := TBorderStyle(rgBorderStyle.ItemIndex);
end;

end.
```

NOTE

Some properties in the Object Inspector affect the appearance of your form; others define behavioral aspects for your form. Experiment with each property that's unfamiliar. If you need to know more about a property, use the Delphi 5 help system to find additional information.

Form Reusability: Visual Form Inheritance

A useful feature of Delphi 5 is a concept known as *visual form inheritance*. In the first version of Delphi, you could create a form and save it as a template, but you didn't have the advantage of true *inheritance* (the capability to access the ancestor form's components, methods, and properties). By using inheritance, all descendant forms share the same code as their ancestor. The only overhead involves the methods you add to your descendant forms. Therefore, you also gain the advantage of reducing your application's overall footprint. Another advantage is that changes made to the ancestor code are also applied to its descendants.

The Object Repository

Delphi 5 has a project-management feature that allows programmers to share forms, dialog boxes, data modules, and project templates. This feature is called the *Object Repository*. By using the Object Repository, developers can share the various objects listed with developers of other projects. Additionally, the Object Repository allows developers to maximize code reuse by allowing them to inherit their objects from objects that exist in the Object Repository. Chapter 4 of the Delphi 5 User's Guide covers the Object Repository. It's a good idea to become familiar with this powerful feature.

TIP

In a network environment, you might want to share form templates with other programmers. This is possible by creating a shared repository. In the Environment Options dialog box (select Tools, Environment Options), you can specify the location of a shared repository. Each programmer must map to the same drive that points to this directory location. Then, whenever File, New is selected, Delphi will scan this directory for any shared items in the repository.

Inheriting a form from another form is simple because it's completely built into the Delphi 5 environment. To create a form that descends from another form definition, you simply select File, New from Delphi's main menu, which invokes the New Items dialog box. This dialog box

actually gives you a view of the objects that exist in the Object Repository (see the sidebar “The Object Repository”). You then select the Forms page, which lists the forms that have been added to the Object Repository.

NOTE

You don’t have to go through the Object Repository to get form inheritance. You can inherit from forms that are in your project. Select File, New and then select the Project page. From there, you can select an existing form in your project. Forms shown in the Project page are not in the Object Repository.

The various forms listed are those that have been added previously to the Object Repository. You’ll notice that there are three options for how to include the form in your project: Copy, Inherit, and Use.

Choosing Copy adds an exact duplicate of the form to your project. If the form kept in the Object Repository is modified, this won’t affect your copied form.

Choosing Inherit causes a new form class derived from the form you selected to be added to your project. This powerful feature allows you to inherit from the class in the Object Repository so that changes made to the Object Repository’s form are reflected by the form in your project as well. This is the option that most developers ought to select.

Choosing Use causes the form to be added to your project as if you had created it as part of the project. Changes you make to the item at design time will appear in all projects that also use the form and any projects that inherit from the form.

The TApplication Class

Every form-based Delphi 5 program contains a global variable, `Application`, of the type `TApplication`. `TApplication` encapsulates your program and performs many behind-the-scenes functions that enable your application to work correctly within the Windows environment. These functions include creating your window class definition, creating the main window for your application, activating your application, processing messages, adding context-sensitive help, processing menu accelerator keys, and handling VCL exceptions.

NOTE

Only form-based Delphi applications contain the global `Application` object. Applications such as console apps don’t contain a VCL `Application` object.

You typically won't have to be concerned about the background tasks that `TApplication` performs. However, some situations might necessitate that you delve into the inner workings of `TApplication`.

Because `TApplication` doesn't appear in the Object Inspector, you can't modify its properties there. However, you can choose Project, Options and select the Application page, from which you can set some of the properties for `TApplication`. Mostly, you work with the `TApplication` instance, `Application`, at runtime—that is, you set its property values and assign event handlers to `Application` when the program is running.

TApplication's Properties

`TApplication` has several properties that you can access at runtime. The following sections discuss some of the properties specific to `TApplication` and how you can use them to change the default behavior of `Application` to enhance your project. `TApplication`'s properties are also well documented in the Delphi 5 online help.

The TApplication.ExeName Property

The `ExeName` property of `Application` holds the full path and filename for the project. Because this is a runtime, read-only property, you can't modify it. However, you can read it—or even let your users know where they ran the application from. For example, the following line of code changes a main form's caption to the contents of `ExeName`:

```
Application.MainForm.Caption := Application.ExeName;
```

TIP

Use the `ExtractFileName()` function to retrieve the filename from a string containing the full path of a file:

```
ShowMessage(ExtractFileName(Application.ExeName));
```

Use `ExtractFilePath()` to retrieve the path of a full path string:

```
ShowMessage(ExtractFilePath(Application.ExeName));
```

Finally, use `ExtractFileExt()` to extract the extension of a filename:

```
ShowMessage(ExtractFileExt(Application.ExeName));
```

The TApplication.MainForm Property

In the preceding section, you saw how to access the `MainForm` property to change its `Caption` to reflect the `ExeName` for the application. `MainForm` points to a `TForm` so that you can access any `TForm` property through `MainForm`. You can also access properties that you add to your descendant forms, as long as you typecast `MainForm` accordingly:

```
(MainForm as TForm1).SongTitle := 'The Flood';
```

MainForm is a read-only property. You can specify which form in your application is the main form at design time by using the Forms page in the Project Options dialog box.

The TApplication.Handle Property

The Handle property is an HWND (a *window handle*, in Win32 API terms). The window handle is the owner of all top-level windows in your application. Handle is what makes modal dialog boxes modal over all windows of your application. You don't have to access Handle that often, unless you intend to take over the default behavior of the application in a way that isn't provided by Delphi. You may also refer to the Handle property when using Win32 API functions requiring the application's window handle. We'll discuss Handle more later in the chapter.

The TApplication.Icon and TApplication.Title Properties

The Icon property holds the icon that represents the application when your project is minimized. You can change the application's icon by providing another icon and assigning it to Application.Icon, as described in the later section "Adding Resources to Your Project."

The text that appears next to the icon in the application's task button on the Windows 95/98 taskbar is the application's Title property. If you're running Windows NT, this text appears just underneath the icon. Changing the title of the task button is simple—just make a string assignment to the Title property:

```
Application.Title := 'New Title';
```

Other Properties

The Active property is a read-only Boolean property that indicates whether the application has focus and is active.

The ComponentCount property indicates the number of components that Application contains. Mainly, these components are forms and a THintWindow instance if the Application.ShowHint property is True. ComponentIndex is always -1 for any component that does not have an owner. Therefore, TApplication.ComponentIndex is always -1. This property mainly applies to forms and components on forms.

The Components property is an array of components that belong to the Application. There will be TApplication.ComponentCount items in the Components array. The following code shows how you would add the class names of all components referred to by ComponentCount to a TListBox component:

```
var
  i: integer;
begin
  for i := 0 to Application.ComponentCount - 1 do
    ListBox1.Items.Add(Application.Components[i].ClassName);
end;
```

The `HelpFile` property contains the Windows help filename, which enables you to add online help to your application. It's used by `TApplication.HelpContext` and other help invocation methods.

The `TApplication.Owner` property is always `nil` because `TApplication` can't be owned by any other component.

The `ShowHint` property enables or disables the display of hints for the entire application. The `Application.ShowHint` property overrides the values of any other component's `ShowHint` property. Therefore, if `Application.ShowHint` is `False`, hints are not displayed for any component.

The `Terminated` property is `True` whenever the application has been terminated by closing the main form or by calling the `TApplication.Terminate()` method.

Application's Methods

`TApplication` has several methods with which you should be familiar. The following sections discuss some of the methods specific to `TApplication`.

The `TApplication.CreateForm()` Method

The `TApplication.CreateForm()` method is defined as follows:

```
procedure CreateForm(InstanceClass: TComponentClass; var Reference)
```

This method creates an instance of a form with the type specified by `InstanceClass` and assigns that instance to the `Reference` variable. Earlier, you saw how this method was called in the project's DPR file. The code had the following line, which creates the instance of `Form1` of type `TForm1`:

```
Application.CreateForm(TForm1, Form1);
```

The line would have been created automatically by Delphi 5 if `Form1` appeared in the project's Auto-Create list. However, you can call this method elsewhere in your code if you're creating a form that doesn't appear in the Auto-Create list (in which case the form's instance wouldn't have been created automatically). This approach doesn't differ much from calling the form's own `Create()` method, except that `TApplication.CreateForm()` checks to see whether the `Application.MainForm` property is `nil`; if so, `CreateForm()` assigns the newly created form to `Application.MainForm`. Subsequent calls to `CreateForm()` don't affect this assignment. Typically, you don't call `CreateForm()`; you use a form's `Create()` method instead.

The `TApplication.HandleException()` Method

The `HandleException()` method is where the `TApplication` instance displays information about exceptions that occur in your project. This information is displayed with a standard exception message box defined by VCL. You can override this message box by attaching an

event handler to the `Application.OnException` event, as shown in the later section “Overriding the Application’s Exception Handling.”

TApplication’s HelpCommand(), HelpContext(), and HelpJump() Methods

The `HelpCommand()`, `HelpContext()`, and `HelpJump()` methods each provide a way for you to interface your projects with the Windows help system provided by the `WINHELP.EXE` program that ships with Windows. `HelpCommand()` allows you to call any of the `WinHelp` macro commands and macros defined in your help file. `HelpContext()` allows you to launch a help page in the help file specified by the `TApplication.HelpFile` property. The page displayed is based on the value of the `Context` parameter passed to `HelpContext()`. `HelpJump()` is much like `HelpContext()`, except that it takes a `JumpID` string parameter.

The TApplication.ProcessMessages() Method

`ProcessMessages()` causes your application to actively go get any messages that are waiting for it and then process them. This is useful when you have to perform a process within a tight loop and you don’t want your code to prevent you from executing other code (such as processing an abort button). In contrast, `TApplication.HandleMessages()` puts the application into an idle state if there are no messages, whereas `ProcessMessages()` won’t put it in an idle state. The `ProcessMessages()` method is used in Chapter 10, “Printing in Delphi 5.”

The TApplication.Run() Method

Delphi 5 automatically places the `Run()` method within the project file’s main block. You never have to call this method yourself, but you should know where it goes and what it does in case you ever have to modify the project file. Basically, `TApplication.Run()` first sets up an exit procedure for the project, which ensures that all components are freed when the project ends. It then enters a loop that calls the methods to process messages for the project until the application is terminated.

The TApplication.ShowException() Method

The `ShowException()` method simply takes an exception class as a parameter and displays a message box with information about that exception. This method comes in handy if you’re overriding the Application’s exception handling method, as shown in the later section “Overriding the Application’s Exception Handling.”

Other Methods

`TApplication.Create()` creates the `TApplication` instance. This method is called internally by Delphi 5; you should never call it.

`TApplication.Destroy()` destroys the `TApplication` instance. This method is called internally by Delphi 5. You should never call this method.

`TApplication.MessageBox()` allows you to display a Windows message box. However, this method doesn't require that you pass a window's handle, as the Windows `MessageBox()` function does.

`TApplication.Minimize()` places your application in a minimized state.

`TApplication.Restore()` restores your application to its previous size from a minimized or maximized state.

`TApplication.Terminate()` terminates the execution of your application. `Terminate` is an indirect call to `PostQuitMessage`, resulting in a graceful shutdown of the application (unlike `Halt()`).

NOTE

Use the `TApplication.Terminate()` method to halt an application. `Terminate()` calls the Windows API function `PostQuitMessage()`, which posts a message to your application's message queue. VCL responds by properly freeing objects that have been created in your application. The `Terminate()` method is a clean way to stop your application's process. It's important to note that your application does not terminate at the call to `Terminate()`. Instead, it continues to run until the application returns to its message queue and retrieves the `WM_QUIT` message. `Halt()`, on the other hand, forcibly terminates your application without freeing any objects or shutting down gracefully. Execution does not return from a call to `Halt()`.

TApplication's Events

`TApplication` has several events to which you can add event handlers. In past versions of Delphi, these events were not accessible from the Object Inspector (for example, the events for the form or components on the Component Palette). You had to add an event handler to the `Application` variable by first defining the handler as a method and then assigning that method to the handler at runtime. Delphi 5 adds a new component to the Additional page of the Component Palette—`TApplicationEvents`. This component allows you to assign event handlers at design time to the global `Application` instance. Table 4.2 lists the events associated with `TApplication`.

TABLE 4.2 `TApplication` and `TApplicationEvents` Events

<i>Event</i>	<i>Description</i>
<code>OnActivate</code>	Occurs when the application becomes active; <code>OnDeactivate</code> occurs when the application stops being active (for example, when you switch to another application).

<i>Event</i>	<i>Description</i>
<code>OnException</code>	Occurs when an unhandled exception has occurred; you can add default processing for unhandled exceptions. <code>OnException</code> occurs if the exception makes it all the way up to the application object. Normally, you should allow exceptions to be handled by the default exception handler and not trapped by <code>Application.OnException</code> or lower code. If you must trap an exception, reraise it and make sure that the exception instance carries a full description of the situation so that the default exception handler can present useful information.
<code>OnHelp</code>	Occurs for any invocation of the help system, such as when F1 is pressed or when the following methods are called: <code>HelpCommand()</code> , <code>HelpContext()</code> , and <code>HelpJump()</code> .
<code>OnMessage</code>	Enables you to process messages before they're dispatched to their intended controls. <code>OnMessage</code> gets to peek at all messages posted to all controls in the application. Exercise caution when using <code>OnMessage</code> because it could result in a bottleneck.
<code>OnHint</code>	Enables you to display hints associated with controls when the mouse is positioned over the control. An example of this is a status line hint.
<code>OnIdle</code>	Occurs when the application is switched into an idle state. <code>OnIdle</code> is not called continuously. Once in the idle state, an application will not wake up until it receives a message.

You work more with `TApplication` later in this chapter as well as in other projects in other chapters.

NOTE

The `TApplication.OnIdle` event provides a handy way to perform certain processing when no user interaction is occurring. One common use for the `OnIdle` event handler is to update menus and speedbuttons based on the status of the application.

The TScreen Class

The `TScreen` class simply encapsulates the state of the screen on which your applications runs. `TScreen` is not a component that you add to your Delphi 5 forms, nor do you create it dynamically during runtime. Delphi 5 automatically creates a `TScreen` global variable called `Screen`, which you can access from within your application. The `TScreen` class contains several properties that you'll find useful. These properties are listed in Table 4.3.

TABLE 4.3 TScreen Properties

<i>Property</i>	<i>Meaning</i>
ActiveControl	A read-only property that indicates which control on the screen has current focus. As focus shifts from one control to another, <code>ActiveControl</code> is assigned the newly focused control before the <code>OnExit</code> event of the control losing focus finishes.
ActiveForm	Indicates the form that has focus. This property is set when another form switches focus or when the Delphi 5 application gains focus from another application.
Cursor	The cursor shape that's global to the application. By default, this is set to <code>crDefault</code> . Each windowed component has its own <code>Cursor</code> property that may be modified. However, when the cursor is set to something other than <code>crDefault</code> , all other controls reflect that change until <code>Screen.Cursor</code> is set back to <code>crDefault</code> . Another way to look at this is <code>Screen.Cursor = crDefault</code> means "ask the control under the mouse what cursor should be displayed." <code>Screen.Cursor <> crDefault</code> means "don't ask."
Cursors	A list of all cursors available to the screen device.
DataModules	A list of all data modules belonging to the application.
DataModuleCount	The number of data modules belonging to the application.
FormCount	The number of available forms in the application.
Forms	A list of forms available to the application.
Fonts	A list of font names available to the screen device.
Height	The height of the screen device in pixels.
PixelsPerInch	Indicates the relative scale of the system font.
Width	The width of the screen device in pixels.

Defining a Common Architecture: Using the Object Repository

Delphi makes it so easy to develop applications that you can get 60 percent into your application development before you realize that you should have spent more time up front on application architecture. A common problem with development is that developers are too anxious to get coding before spending the appropriate time really thinking about application design. This alone is one of the biggest contributors to project failure.

Thoughts on Application Architecture

This is not a book on architecture or object-oriented analysis and design. However, we strongly feel that this is one of the most important aspects of application development in addition to requirements, detail design, and everything else that constitutes the initial 80 percent of a product before coding begins. We've listed some of our favorite references on topics such as object-oriented analysis in Appendix C, "Suggested Reading." It would be to your best interest to research this topic thoroughly before you roll your sleeves up and start coding.

Here are a few examples of the many issues that come into play when considering application architecture:

- Does the architecture support code reuse?
- Is the system organized so that modules, objects, and so on are localized?
- Can changes more easily be made to the architecture?
- Are the user interface and back end localized so that either can be replaced?
- Does the architecture support a team development effort? In other words, can team members easily work on separate modules without overlap?

These are just a few of the things to consider during development.

Volumes have been written on this topic alone, so we won't attempt to compete with that information. We do, however, hope that we've sparked your interest enough to make you learn about it if you aren't already an architecture guru. The following sections illustrate a simple method of architecting a common UI for a database application and how Delphi can help you do that.

Delphi's Inherent Architecture

You'll often hear that you don't have to be a component writer to be a Delphi developer. Although true, it's also true that if you're a component writer, you're a much better Delphi developer.

This is because component writers clearly understand the object model and architecture that Delphi applications inherit just by being Delphi applications. This means that component writers are better equipped to take advantage of this powerful and flexible model in their own applications. In fact, you've probably already heard that Delphi is written in Delphi. Delphi is an example of an application written with the same inherent architecture that your applications can also use.

Even if you don't intend to write components, you'll be better off if you learn it anyway. Become thoroughly knowledgeable of the VCL and the Object Pascal model as well as of the Win32 operating system.

An Architecture Example

To demonstrate the power of form inheritance as well as the use of the Object Repository, we're going to define a common application architecture. The issues we're focusing on are code reusability, flexibility for change, consistency, and facility for team development.

The form class hierarchy, or rather, *framework*, consists of forms to be used specifically for database applications. These forms are typical of most database applications. The forms should be aware of the state of the database operation (edit, add, or browse). They should also contain the common controls used in performing these operations on a database table, such as a toolbar and status bar whose displays and controls change according to the form's state. Additionally, they should provide an event that can be invoked whenever the form mode changes.

This framework should also enable a team to work on isolated parts of an application without requiring the entire application's source code. Otherwise, there's the likelihood that different programmers would modify the same files.

For now, this framework's hierarchy will contain three levels. This will be expanded on later in the book.

Table 4.4 describes the purpose of each form in the framework.

TABLE 4.4 Database Form Framework

<i>Form Class</i>	<i>Purpose</i>
<code>TChildForm = class(TForm)</code>	Provides the capability to be inserted as a child to another window
<code>TDBModeForm = class(TChildForm)</code>	Is aware of a database state (browse, insert, edit) and contains an event to be invoked upon state change
<code>TDBNavStatForm = class(TDBBaseForm)</code>	Typical database entry form that's aware of its state and contains the standard navigation bar and status bar to be used by all database applications

The Child Form (TChildForm)

`TChildForm` is a base class for forms that can be launched as independent modal and modeless forms and can become child windows to any other window.

This capability makes it easy for a team of developers to work on separate pieces of an application apart from the overall application. It also provides a nice UI feature in that the user can launch a form as a separate entity in an application, even though that might not be the normal

method of interacting with that form. Listing 4.3 is the source for TChildForm. You'll find this and all the other forms to be placed in the Object Repository in the \Code directory on the CD-ROM.

LISTING 4.3 TChildForm Source

```
unit ChildFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, ExtCtrls, Menus;

type
  TChildForm = class(TForm)
  private
    FAsChild: Boolean;
    FTempParent: TWinControl;
  protected
    procedure CreateParams(var Params: TCreateParams); override;
    procedure Loaded; override;
  public
    constructor Create(AOwner: TComponent); overload; override;
    constructor Create(AOwner: TComponent;
      AParent: TWinControl); reintroduce; overload;

    // The method below must be overridden to return either the main menu
    // of the form, or nil.
    function GetFormMenu: TMainMenu; virtual; abstract;
    function CanChange: Boolean; virtual;
  end;

implementation

{$R *.DFM}
constructor TChildForm.Create(AOwner: TComponent);
begin
  FAsChild := False;
  inherited Create(AOwner);
end;

constructor TChildForm.Create(AOwner: TComponent; AParent: TWinControl);
begin
```

```
    FAsChild := True;
    FTempParent := aParent;
    inherited Create(AOwner);
end;

procedure TChildForm.Loaded;
begin
    inherited;
    if FAsChild then
    begin
        align := alClient;
        BorderStyle := bsNone;
        BorderIcons := [];
        Parent := FTempParent;
        Position := poDefault;
    end;
end;

procedure TChildForm.CreateParams(var Params: TCreateParams);
Begin
    Inherited CreateParams(Params);
    if FAsChild then
        Params.Style := Params.Style or WS_CHILD;
end;

function TChildForm.CanChange: Boolean;
begin
    Result := True;
end;

end.
```

This listing demonstrates a couple of techniques. First, it shows how to use the overload extensions to the Object Pascal language, and second, it shows how to make a form a child of another window.

Providing a Second Constructor

You'll notice that we've declared two constructors for this child form. The first constructor declared is used when the form is created as a normal form. This is the constructor with one parameter. The second constructor, which takes two parameters, is declared as an overloaded constructor. You would use this constructor to create the form as a child window. The parent to the form gets passed as the *AParent* parameter. Notice that we've used the *reintroduce* directive to suppress the warning about hiding the virtual constructor.

The first constructor simply sets the `FAsChild` variable to `False` to ensure that the form is created normally. The second constructor sets the value to `True` and sets `FTempParent` to the `AParent` parameter. This value is used later as the parent of the child form in the `Loaded()` method.

Making a Form a Child Window

To make a form a child window, there are a few things you need to do. First, you have to make sure that various property settings have been set, which you'll see is done programmatically in `TChildForm.Loaded()`. In Listing 4.3, we ensure that when the form becomes a child it doesn't look like a dialog box. We do this by removing the border and any border icons. We also make sure that the form is client-aligned and set the parent to the window referred to by the `FTempParent` variable. If this form were going to be used as a child only, we could have made these settings at design time. However, this form will also be launched as a normal form, so we set these properties only if the `FAsChild` variable is `True`.

We also have to override the `CreateParams()` method to tell Windows to create the form as a child window. We do this by setting the `WS_CHILD` style in the `Params.Style` property.

This base form is not restricted to a database application. In fact, you can use it for any form that you want to have child window capabilities. You'll find a demo of this child form being used as both a normal form and as a child form in the `ChildTest.dpr` project found in the `\Form Framework` directory on the CD-ROM.

NOTE

Delphi 5 introduces frames to the VCL. Frames work so that they can be embedded within a form. Because frames serve as containers for components, they function much like the child form shown previously. We'll discuss frames in more detail momentarily.

The Database Base Mode Form (TDBModeForm)

`TDBModeForm` is a descendant of `TChildForm`. Its purpose is to be aware of the state of a table (browse, insert, and edit). This form also provides an event that occurs whenever the mode is changed.

Listing 4.4. shows the source code for `TDBModeForm`.

LISTING 4.4 TDBModeForm

```
unit DBModeFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  CHILDFRM;

type

  TFormMode = (fmBrowse, fmInsert, fmEdit);

  TDBModeForm = class(TChildForm)
  private
    FFormMode      : TFormMode;
    FOnSetFormMode : TNotifyEvent;
  protected
    procedure SetFormMode(AValue: TFormMode); virtual;
    function  GetFormMode: TFormMode; virtual;
  public
    property FormMode: TFormMode read GetFormMode write SetFormMode;
  published
    property OnSetFormMode: TNotifyEvent read FOnSetFormMode
      write FOnSetFormMode;

  end;

var
  DBModeForm: TDBModeForm;

implementation

{$R *.DFM}

procedure TDBModeForm.SetFormMode(AValue: TFormMode);
begin
  FFormMode := AValue;
  if Assigned(FOnSetFormMode) then
    FOnSetFormMode(self);
end;

function TDBModeForm.GetFormMode: TFormMode;
begin
  Result := FFormMode;
end;

end.
```

The implementation of `TDBModeForm` is straightforward. Although we're using some techniques we haven't yet discussed, you should be able to follow what's happening here. First, we just defined the enumerated type, `TFormMode`, to represent the form's state. Then we provided the `FormMode` property and its read and write methods. The technique for creating the property and read/write methods is discussed further in Chapter 21, "Writing Delphi Custom Components."

A demo using `TDBModeForm` is in the project `FormModeTest.DPR` found in the `\Form Framework` directory on the CD-ROM.

The Database Navigation/Status Form (TDBNavStatForm)

`TDBNavStatForm` brings the bulk of the functionality of this framework. This form contains the common set of components to be used in our database applications. In particular, it has a navigation bar and status bar that automatically change based on the form's state. For example, you'll see that the Accept and Cancel buttons are initially disabled when the form is in the state of `fsBrowse`. However, when the user places the form in the `fsInsert` or `fsEdit` state, the buttons become enabled. The status bar also displays the state the form is in.

Listing 4.5 shows the source code for `TDBNavStatForm`. Notice that we've eliminated the component list from the listing. You'll see these if you load the demo project for this form.

LISTING 4.5 TDBNavStatForm

```
unit DBNavStatFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  DBMODEFRM, ComCtrls, ToolWin, Menus, ExtCtrls, ImgList;

type
  TDBNavStatForm = class(TDBModeForm)
  { components not included in listing. }
  procedure sbAcceptClick(Sender: TObject);
  procedure sbInsertClick(Sender: TObject);
  procedure sbEditClick(Sender: TObject);
  private
  { Private declarations }
  protected
  procedure Setbuttons; virtual;
  procedure SetStatusBar; virtual;
  procedure SetFormMode(AValue: TFormMode); override;
  public
```

continues

LISTING 4.5 Continued

```
    constructor Create(AOwner: TComponent); overload; override;
    constructor Create(AOwner: TComponent; AParent: TWinControl); overload;
    procedure SetToolBarParent(AParent: TWinControl);
    procedure SetStatusBarParent(AParent: TWinControl);
end;

var
    DBNavStatForm: TDBNavStatForm;

implementation

{$R *.DFM}

{ TDBModeForm3 }

procedure TDBNavStatForm.SetFormMode(AValue: TFormMode);
begin
    inherited SetFormMode(AValue);
    SetButtons;
    SetStatusBar;
end;

procedure TDBNavStatForm.Setbuttons;

    procedure SetBrowseButtons;
    begin
        sbAccept.Enabled := False;
        sbCancel.Enabled := False;

        sbInsert.Enabled := True;
        sbDelete.Enabled := True;
        sbEdit.Enabled := True;

        sbFind.Enabled := True;
        sbBrowse.Enabled := True;

        sbFirst.Enabled := True ;
        sbPrev.Enabled := True ;
        sbNext.Enabled := True ;
        sbLast.Enabled := True ;
    end;

    procedure SetInsertButtons;
```

```
begin
  sbAccept.Enabled := True;
  sbCancel.Enabled := True;

  sbInsert.Enabled := False;
  sbDelete.Enabled := False;
  sbEdit.Enabled   := False;

  sbFind.Enabled   := False;
  sbBrowse.Enabled := False;

  sbFirst.Enabled := False;
  sbPrev.Enabled  := False;
  sbNext.Enabled  := False;
  sbLast.Enabled  := False;
end;

procedure SetEditButtons;
begin
  sbAccept.Enabled := True;
  sbCancel.Enabled := True;

  sbInsert.Enabled := False;
  sbDelete.Enabled := False;
  sbEdit.Enabled   := False;

  sbFind.Enabled := False;
  sbBrowse.Enabled := True;

  sbFirst.Enabled := False;
  sbPrev.Enabled  := False;
  sbNext.Enabled  := False;
  sbLast.Enabled  := False;
end;

begin
  case FormMode of
    fmBrowse: SetBrowseButtons;
    fmInsert: SetInsertButtons;
    fmEdit:   SetEditButtons;
  end; { case }

end;

procedure TDBNavStatForm.SetStatusBar;
begin
```

continues

LISTING 4.5 Continued

```
case FormMode of
  fmBrowse: stbStatusBar.Panels[1].Text := 'Browsing';
  fmInsert: stbStatusBar.Panels[1].Text := 'Inserting';
  fmEdit:   stbStatusBar.Panels[1].Text := 'Edit';
end;

mmiInsert.Enabled := sbInsert.Enabled;
mmiEdit.Enabled   := sbEdit.Enabled;
mmiDelete.Enabled := sbDelete.Enabled;
mmiCancel.Enabled := sbCancel.Enabled;
mmiFind.Enabled   := sbFind.Enabled;

mmiNext.Enabled   := sbNext.Enabled;
mmiPrevious.Enabled := sbPrev.Enabled;
mmiFirst.Enabled  := sbFirst.Enabled;
mmiLast.Enabled   := sbLast.Enabled;

end;

procedure TDBNavStatForm.sbAcceptClick(Sender: TObject);
begin
  inherited;
  FormMode := fmBrowse;
end;

procedure TDBNavStatForm.sbInsertClick(Sender: TObject);
begin
  inherited;
  FormMode := fmInsert;
end;

procedure TDBNavStatForm.sbEditClick(Sender: TObject);
begin
  inherited;
  FormMode := fmEdit;
end;

constructor TDBNavStatForm.Create(AOwner: TComponent);
begin
  inherited Create(AOwner);
  FormMode := fmBrowse;
end;

constructor TDBNavStatForm.Create(AOwner: TComponent; AParent: TWinControl);
```

```
begin
  inherited Create(AOwner, AParent);
  FormMode := fmBrowse;
end;

procedure TDBNavStatForm.SetStatusBarParent(AParent: TWinControl);
begin
  stbStatusBar.Parent := AParent;
end;

procedure TDBNavStatForm.SetToolBarParent(AParent: TWinControl);
begin
  tlbNavigationBar.Parent := AParent;
end;

end.
```

The event handlers for the various `TToolButton` components basically set the form to its appropriate state. This, in turn, invokes the `SetFormMode()` methods, which we've overridden to call the `SetButtons()` and `SetStatusBar()` methods. `SetButtons()` enables or disables the buttons accordingly based on the form's mode.

You'll notice that we've also provided two procedures to change the parent of the `TToolBar` and `TStatusBar` components on the form. This functionality is provided so that when the form is invoked as a child window, we can set the parent of these components to the main form. When you run the demo provided in the `\Form Framework` directory on the CD-ROM, you'll see why this makes sense.

As stated earlier, `TDBNavStatForm` inherits the functionality to be an independent form as well as a child window. The demo invokes an instance of `TDBNavStatForm` with the following code:

```
procedure TMainForm.btnNormalClick(Sender: TObject);
var
  LocalNavStatForm: TNavStatForm;
begin
  LocalNavStatForm := TNavStatForm.Create(Application);
  try
    LocalNavStatForm.ShowModal;
  finally
    LocalNavStatForm.Free;
  end;
end;
```

The following code shows how to invoke the form as a child window:

```
procedure TMainForm.btnAsChildClick(Sender: TObject);
begin
```

```
    if not Assigned(FNavStatForm) then
    begin
        FNavStatForm := TNavStatForm.Create(Application, pnlParent);
        FNavStatForm.SetToolBarParent(self);
        FNavStatForm.SetStatusBarParent(self);
        mmMainMenu.Merge(FNavStatForm.mmFormMenu);
        FNavStatForm.Show;
        pnlParent.Height := pnlParent.Height - 1;
    end;
end;
```

This code not only invokes the form as a child to the `TPanel` component, `pnlParent`, but also sets the form's `TToolBar` and `TStatusBar` components to reside on the main form. Additionally, notice the call to `TMainForm.mmMainMenu.Merge()`. This allows us to merge any menus that reside on the `TDBNavStatForm` instance with `MainForm`'s main menu. Naturally, when we free the `TDBNavStatForm` instance, we must also make a call to `TMainForm.mmMainMenu.UnMerge()`, as shown in the following code:

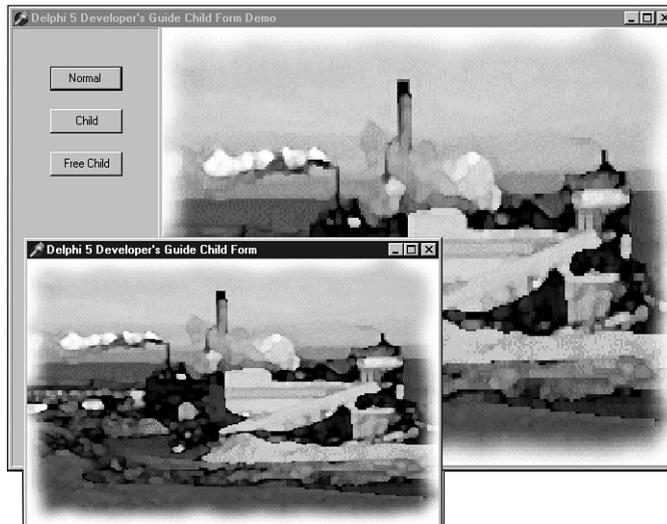
```
procedure TMainForm.btnFreeChildClick(Sender: TObject);
begin
    if Assigned(FNavStatForm) then
    begin
        mmMainMenu.UnMerge(FNavStatForm.mmFormMenu);
        FNavStatForm.Free;
        FNavStatForm := nil;
    end;
end;
```

Take a look at the demo provided on the CD-ROM. Figure 4.1 shows this project with both the child form and independent `TDBNavStatForm` instances created. Notice that we've placed a `TImage` component on the form to better display the form as a child. Figure 4.1 shows how we use the same child form (the one with the picture) as both an embedded window and as a separate form.

Later, we'll use and expand on this same framework to create a fully functional database application.

Using Frames in Application Framework Design

Delphi 5 now has frames. They allow you to create component containers that may be embedded within another form. This is similar to what we've already demonstrated using `TChildForm`. Frames, however, allow you to manipulate your component containers at design time and to add them to the Component Palette so that they may be reused. Listing 4.6 shows the main form for a project similar to the child form demo, except that it uses frames.

**FIGURE 4.1**

TDBNavStatForm as a normal form and as a child window.

LISTING 4.6 Frames Demo

```

unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ExtCtrls;

type
  TMainForm = class(TForm)
    spltrMain: TSplitter;
    pnlParent: TPanel;
    pnlMain: TPanel;
    btnFrame1: TButton;
    btnFrame2: TButton;
    procedure btnFrame1Click(Sender: TObject);
    procedure btnFrame2Click(Sender: TObject);
  private
    { Private declarations }
    FFrame: TFrame;
  public

```

continues

LISTING 4.6 Continued

```
    { Public declarations }
  end;

var
  MainForm: TMainForm;

implementation
uses Frame1Fram, Frame2Fram;

{$R *.DFM}

procedure TMainForm.btnFrame1Click(Sender: TObject);
begin
  if FFrame <> nil then
    FFrame.Free;
  FFrame := TFrame1.Create(pnlParent);
  FFrame.Align := alClient;
  FFrame.Parent := pnlParent;
end;

procedure TMainForm.btnFrame2Click(Sender: TObject);
begin
  if FFrame <> nil then
    FFrame.Free;
  FFrame := TFrame2.Create(pnlParent);
  FFrame.Align := alClient;
  FFrame.Parent := pnlParent;
end;

end.
```

In Listing 4.6, we show a main form that contains two panes made up of two separate panels. The panel on the right will serve to hold our frame. We've defined two separate frames. The private field, `FFrame`, is a reference to a `TFrame` class. Since, both our frames descend directly from `TFrame`, `FFrame` can refer to both our `TFrame` descendants. The two buttons on the main form each create a different `TFrame` and assign it to `FFrame`. The effect is the same as with `TChildForm`. The demo `FrameDemo.dpr` is located on the accompanying CD-ROM.

Miscellaneous Project Management Routines

The projects that follow are a series of project-management routines that have been helpful to many Delphi 5 developers.

Adding Resources to Your Project

Earlier, you learned that the RES file is the resource file for your application. You also learned what Windows resources are. You can add resources to your applications by creating a separate RES file to store your bitmaps, icons, cursors, and so on.

You must use a resource editor to build an RES file. After you create your RES file, you simply link it to your application by placing this statement in the application's DPR file:

```
{$R MYFILE.RES}
```

This statement can be placed directly under the following statement, which links the resource file with the same name as the project file to your project:

```
{$R *.RES}
```

If you've done this correctly, you can then load resources from the RES file by using the `TBitmap.LoadFromResourceName()` or `TBitmap.LoadFromResourceID()` method. Listing 4.7 shows the technique for loading a bitmap, icon, and cursor from a resource (RES) file. You can find this project, `Resource.dpr`, on the CD-ROM that accompanies this book. Notice that the API functions used here—`LoadIcon()` and `LoadCursor()`—are all documented in the Windows API help.

NOTE

The Windows API provides a function called `LoadBitmap()` that loads a bitmap (as its name implies). However, this function does not return a color palette and therefore does not work for loading 256-color bitmaps. Use `TBitmap.LoadFromResourceName()` or `TBitmap.LoadFromResourceID()` instead.

LISTING 4.7 Examples of Loading Resources from an RES File

```
unit MainForm;
interface
uses
  Windows, Forms, Controls, Classes, StdCtrls, ExtCtrls;

const
  crXHair = 1; // Declare a constant for the new cursor. This value
type      // must be a positive number. or less than -20.

TMainForm = class(TForm)
  imgBitmap: TImage;
  btnChemicals: TButton;
```

continues

LISTING 4.7 Continued

```
    btnClear: TButton;
    btnChangeIcon: TButton;
    btnNewCursor: TButton;
    btnOldCursor: TButton;
    btnOldIcon: TButton;
    btnAthena: TButton;
    procedure btnChemicalsClick(Sender: TObject);
    procedure btnClearClick(Sender: TObject);
    procedure btnChangeIconClick(Sender: TObject);
    procedure btnNewCursorClick(Sender: TObject);
    procedure btnOldCursorClick(Sender: TObject);
    procedure btnOldIconClick(Sender: TObject);
    procedure btnAthenaClick(Sender: TObject);
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.btnChemicalsClick(Sender: TObject);
begin
    { Load the bitmap from the resource file. The bitmap must be
      specified in all CAPS! }
    imgBitmap.Picture.Bitmap.LoadFromResourceName(hInstance, 'CHEMICAL');
end;

procedure TMainForm.btnClearClick(Sender: TObject);
begin
    imgBitmap.Picture.Assign(nil); // Clear the image
end;

procedure TMainForm.btnChangeIconClick(Sender: TObject);
begin
    { Load the icon from the resource file. The icon must be
      specified in all CAPS! }
    Application.Icon.Handle := LoadIcon(hInstance, 'SKYLINE');
end;

procedure TMainForm.btnNewCursorClick(Sender: TObject);
begin
    { Assign the new cursor to the Screen's Cursor array }
    Screen.Cursors[crXHair] := LoadCursor(hInstance, 'XHAIR');
    Screen.Cursor := crXHair; // Now change the cursor
```

```
end;

procedure TMainForm.btnOldCursorClick(Sender: TObject);
begin
    // Change back to default cursor
    Screen.Cursor := crDefault;
end;

procedure TMainForm.btnOldIconClick(Sender: TObject);
begin
    { Load the icon from the resource file. The icon must be
      specified in all CAPS! }
    Application.Icon.Handle := LoadIcon(hInstance, 'DELPHI');
end;

procedure TMainForm.btnAthenaClick(Sender: TObject);
begin
    { Load the bitmap from the resource file. The bitmap must be
      specified in all CAPS! }
    imgBitmap.Picture.Bitmap.LoadFromResourceName(hInstance, 'ATHENA');
end;

end.
```

Changing the Screen's Cursor

Probably one of the most commonly used `TScreen` properties is the `Cursor` property, which enables you to change the global cursor for the application. For example, the following code changes the current cursor to an hourglass to indicate that users must wait while a lengthy process executes:

```
Screen.Cursor := crHourGlass
{ Do some lengthy process }
Screen.Cursor := crDefault;
```

`crHourGlass` is a predefined constant that indexes into the `Cursors` array. There are other cursor constants, such as `crBeam` and `crSize`. The existing cursor values range from 0 to -20 (`crDefault` to `crHelp`). Look in the online help for the `Cursors` property to see a list of all available cursors. You can assign these values to `Screen.Cursor` when necessary.

You also can create your own cursors and add them to the `Cursors` property array. To do this, you must first define a constant with a value that doesn't conflict with the already-available cursors. Predefined cursor values are from -20 to 0. Application cursors should only use positive ID numbers. All negative cursor ID numbers are reserved by Borland. Here's an example:

```
crCrossHair := 1;
```

You can use any resource editor (such as the Image Editor that ships with Delphi 5) to create your custom cursor. You must save the cursor into a resource (RES) file. One important point: You must give your RES file a different name than that of your project. Remember that Delphi 5 creates a RES file of the same name as your project whenever you compile your project. You don't want Delphi 5 to overwrite the cursor you create. When you compile your project, make sure that the RES file is in the same directory as your source files so that Delphi 5 will link the cursor resource with your application. You tell Delphi 5 to link the RES file by placing a statement such as the following into the application's DPR file:

```
{$R CrossHairRes.RES}
```

Finally, you must add the following lines of code to load the cursor, add it to the `Cursors` property, and then switch to that cursor:

```
procedure TMainForm.FormCreate(Sender: TObject);
begin
    Screen.Cursors[crCrossHair] := LoadCursor (hInstance, 'CROSSHAIR');
    Screen.Cursor := crCrossHair;
end;
```

Here you use the `LoadCursor()` Win32 API function to load the cursor. `LoadCursor()` takes two parameters: An instance handle to the module from which you want to get the cursor and the name of the cursor as specified in the RES file. Make sure to write the cursor name in the file in ALL CAPS!

`hInstance` refers to the application currently running. Next, assign the value returned from `LoadCursor()` to the `Cursors` property at the location specified by `crCrossHair`, which was previously defined. Finally, assign the current cursor to `Screen.Cursor`.

For an example, locate the project `CrossHair.dpr` on the CD-ROM. This project loads and changes to the crosshair cursor created here and placed in the file `CrossHairRes.res`.

You might also want to invoke the Image Editor by selecting Tools, Image Editor and opening the `CrossHairRes.res` file to see how the cursor was created.

Preventing Multiple Instances of a Form from Being Created

If you use `Application.CreateForm()` or `TForm.Create()` in your code to create a form instance, it's a good idea to ensure that no instance of the form is being held by the `Reference` parameter (as described in the earlier section "The `TForm` Class"). The following code fragment shows this:

```
begin
    if not Assigned(SomeForm) then begin
        Application.CreateForm(TSomeForm, SomeForm);
    end;
```

```
try
  SomeForm.ShowModal;
finally
  SomeForm.Free;
  SomeForm := nil;
end;
end
else
  SomeForm.ShowModal;
end;
```

In this code, it's necessary to assign `nil` to the `SomeForm` variable after it has been destroyed. Otherwise, the `Assigned()` method doesn't function properly, and the method fails. This wouldn't work for a modeless form, however. With modeless forms, you can't determine in code when the form is going to be destroyed. Therefore, you must make the `nil` assignment from within the `OnDestroy` event handler of the form being destroyed. This method was described earlier in this chapter.

Adding Code to the DPR File

You can place code in the project's DPR file before you launch your main form. Such code can be initialization code, a splash screen, database initialization—anything you deem necessary before the main form is displayed. You also have the opportunity to terminate the application before the main form comes up. Listing 4.8 shows a DPR file that prompts the user for a password before granting access to the application. This project is also on the CD-ROM as `Initialize.dpr`.

LISTING 4.8 The `Initialize.dpr` File, Showing Project Initialization

```
program Initialize;

uses
  Forms,
  Dialogs,
  Controls,
  MainFrm in 'MainFrm.pas' {MainForm};

{$R *.RES}

var
  Password: String;
begin
  if InputQuery('Password', 'Enter your password', Password) then
    if Password = 'D5DG' then
```

continues

LISTING 4.8 Continued

```
begin
    // Other initialization routines can go here.
    Application.CreateForm(TMainForm, MainForm);
    Application.Run;
end
else
    MessageDlg('Incorrect Password, terminating program', mtError, [mbok],
0);
end.
```

Overriding the Application's Exception Handling

The Win32 system has a powerful error-handling capability—exceptions. By default, whenever an exception occurs in your project, the `Application` instance automatically handles that exception by displaying to the user a standard error box.

As you build larger applications, you'll start to define exception classes of your own. Perhaps the Delphi 5 default exception handling will no longer suit your needs because you have to perform special processing on a specific exception. In such cases, it will be necessary to override `TApplication`'s default exception handling and replace it with your own custom routine.

You saw that `TApplication` has an `OnException` event handler to which you can add code. When an exception occurs, this event handler is called. There you can perform your special processing so that the default exception message doesn't show.

However, recall that the `TApplication` object's properties aren't editable from the Object Inspector. Therefore, you must use the `TApplicationEvents` component to add specialized exception handling to your application.

Listing 4.9 shows you what you need to do to override the application's default exception handling.

LISTING 4.9 Main Form for the Exception Override Demo

```
unit MainFrm;

interface

uses
    SysUtils, Windows, Messages, Classes, Graphics, Controls,
    Forms, Dialogs, StdCtrls, AppEvnts, Buttons;

type
```

```
ENotSoBadError = class(Exception);
EBadError      = class(Exception);
ERealBadError  = class(Exception);

TMainForm = class(TForm)
  btnNotSoBad: TButton;
  btnBad: TButton;
  btnRealBad: TButton;
  appevnMain: TApplicationEvents;
  procedure btnNotSoBadClick(Sender: TObject);
  procedure btnBadClick(Sender: TObject);
  procedure btnRealBadClick(Sender: TObject);
  procedure appevnMainException(Sender: TObject; E: Exception);
public
end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.btnNotSoBadClick(Sender: TObject);
begin
  raise ENotSoBadError.Create('This isn't so bad!');
end;

procedure TMainForm.btnBadClick(Sender: TObject);
begin
  raise EBadError.Create('This is bad!');
end;

procedure TMainForm.btnRealBadClick(Sender: TObject);
begin
  raise ERealBadError.Create('This is real bad!');
end;

procedure TMainForm.appevnMainException(Sender: TObject; E: Exception);
var
  rslt: Boolean;
begin
  if E is EBadError then
  begin
    { Show a custom message box and prompt for application termination. }
    rslt := MessageDlg(Format('%s %s %s %s %s', ['An', E.ClassName,
```

continues

LISTING 4.9 Continued

```
        'exception has occurred.', E.Message, 'Quit App?']],
        mtError, [mbYes, mbNo], 0) = mrYes;
    if rslt then
        Application.Terminate;
    end
    else if E is ERealBadError then
    begin // Show a custom message
        // and terminate the application.
        MessageDlg(Format('%s %s %s %s %s', ['An', E.ClassName,
            'exception has occurred.', E.Message, 'Quitting Application']),
            mtError, [mbOK], 0);
        Application.Terminate;
    end
    else // Perform default exception handling
        Application.ShowException(E);
    end;

end.
```

In Listing 4.9, the `appenvMainException()` method is the `OnException` event handler to the `TApplicationEvent` component. This event handler uses RTTI to check the type of exception that occurred and performs special processing based on the exception type. The comments in the code discuss the process. You'll also find the project that uses these routines, `OnException.dpr`, on the CD-ROM accompanying this book.

TIP

If the Stop on Delphi Exceptions check box is selected in the Language Exceptions page of the Debugger Options dialog box (accessed by selecting Tools, Debugger Options), Delphi 5's IDE debugger reports the exception in its own dialog box, before your application has a chance to handle the exception. Although useful for debugging, having this check box selected can be annoying when you want to see how your project handles exceptions. Disable the option to make your project run normally.

Displaying a Splash Screen

Suppose you want to create a splash screen for your project. This form can display when you launch your application and can stay visible while your application initializes. Displaying a splash screen is actually simple. Here are the initial steps for creating a splash screen:

1. After creating your application's main form, create another form to represent the splash screen. Call this form `SplashForm`.
2. Use the Project, Options menu to ensure that `SplashForm` is not in the Auto-Create list.
3. Assign `bsNone` to `SplashForm`'s `BorderStyle` property and [] to its `BorderIcons` property.
4. Place a `TImage` component onto `SplashForm` and assign `alClient` to the image's `Align` property.
5. Load a bitmap into the `TImage` component by selecting its `Picture` property.

Now that you've designed the splash screen, you only have to edit the project's DPR file to display it. Listing 4.10 shows the project file (DPR) for which the splash screen is displayed. You'll find this project, `Splash.dpr`, on the accompanying CD-ROM.

LISTING 4.10 A DPR File with a Splash Screen

```
program splash;

uses
  Forms,
  MainFrm in 'MainFrm.pas' {MainForm},
  SplashFrm in 'SplashFrm.pas' {SplashForm};

{$R *.RES}
begin
  Application.Initialize;
  { Create the splash screen }
  SplashForm := TSplashForm.Create(Application);
  SplashForm.Show; // Display the splash screen
  SplashForm.Update; // Update the splash screen to ensure it gets drawn

  { This while loop simply uses the TTimer component on the SplashForm
    to simulate a lengthy process. }
  while SplashForm.tmMainTimer.Enabled do
    Application.ProcessMessages;

  Application.CreateForm(TMainForm, MainForm);
  SplashForm.Hide; // Hide the splash screen
  SplashForm.Free; // Free the splash screen
  Application.Run;
end.
```

Notice the `while` loop:

```
while SplashForm.tmMainTimer.Enabled do
    Application.ProcessMessages;
```

This is simply a way to simulate a long process. A `TTimer` component was placed on `SplashForm`, and its `Interval` property was set to `3000`. When the `OnTimer` event of the `TTimer` component occurs, after about three seconds, it executes the following line:

```
tmMainTimer.Enabled := False;
```

This will cause the `while` loop's condition to be `False` and will jump execution out of the loop.

Minimizing Form Size

To illustrate how to suppress or control form sizing, we've created a project whose main form has a blue background and a panel onto which components are placed. When the user resizes the form, the panel remains centered. The form also prevents the user from shrinking the form smaller than its panel. Listing 4.11 shows the form's unit source code.

LISTING 4.11 The Source Code for the Template Form

```
unit BlueBackFrm;

interface

uses
    SysUtils, Windows, Messages, Classes, Graphics, Controls, Forms, Dialogs,
    StdCtrls, Buttons, ExtCtrls;

type
    TBlueBackForm = class(TForm)
        pnlMain: TPanel;
        bbtnOK: TBitBtn;
        bbtnCancel: TBitBtn;
        procedure FormResize(Sender: TObject);
    private
        Procedure CenterPanel;
        { Create a message handler for the WM_WINDOWPOSCHANGING message }
        procedure WMWindowPosChanging(var Msg: TWMWindowPosChanging);
            message WM_WINDOWPOSCHANGING;
    end;

var
    BlueBackForm: TBlueBackForm;

implementation
```

```
uses Math;
{$R *.DFM}

procedure TBlueBackForm.CenterPanel;
{ This procedure centers the main panel horizontally and
  vertically inside the form's client area
}
begin
  { Center horizontally }
  if pnlMain.Width < ClientWidth then
    pnlMain.Left := (ClientWidth - pnlMain.Width) div 2
  else
    pnlMain.Left := 0;

  { Center vertically }
  if pnlMain.Height < ClientHeight then
    pnlMain.Top := (ClientHeight - pnlMain.Height) div 2
  else
    pnlMain.Top := 0;
end;

procedure TBlueBackForm.WMWindowPosChanging(var Msg: TWMWindowPosChanging);
var
  CaptionHeight: integer;
begin
  { Calculate the caption height }
  CaptionHeight := GetSystemMetrics(SM_CYCAPTION);
  { This procedure does not take into account the width and
    height of the form's frame. You can use
    GetSystemMetrics() to obtain these values. }

  // Prevent window from shrinking smaller than MainPanel's width
  Msg.WindowPos^.cx := Max(Msg.WindowPos^.cx, pnlMain.Width+20);

  // Prevent window from shrinking smaller than MainPanel's width
  Msg.WindowPos^.cy := Max(Msg.WindowPos^.cy, pnlMain.Height+20+CaptionHeight);

  inherited;
end;

procedure TBlueBackForm.FormResize(Sender: TObject);
begin
  CenterPanel; // Center MainPanel when the form is resized.
end;

end.
```

This form illustrates capturing window messages, specifically the `WM_WINDOWPOSCHANGING` message, which occurs whenever the window size is about to be changed. This is an opportune time to prevent the resizing of a window. Chapter 5, “Understanding Messages,” will delve further into Windows messages. This demo can be found in the project `TempDemo.dpr` on the CD-ROM.

Running a Formless Project

The form is the focal point of all Delphi 5 applications. However, nothing prevents you from creating an application that has no form. The DPR file is nothing more than a program file that “uses” units that define the forms and other objects. This program file can certainly perform other programming processes that require no form. To do this, simply create a new project and remove the main form from the project by selecting Project, Remove From Project. Your DPR file will now contain the following code:

```
program Project1;
uses
  Forms;
{$R *.RES}
begin
  Application.Initialize;
  Application.Run;
end.
```

In fact, you can even remove the `uses` clause and the calls to `Application.Initialize` and `Application.Run`:

```
program Project1;
begin
end.
```

This is a rather useless project, but keep in mind that you can place pretty much whatever you want in the `begin..end` block, which would be the starting point of a Win32 console application.

Exiting Windows

One reason you might want to exit Windows from an application is because your application has made some system configuration changes that don’t go into effect until the user restarts Windows. Rather than have the user perform that task through Windows, your application can ask the user whether he or she wants to exit Windows; your application can then take care of the dirty work. Keep in mind, however, that requiring a system restart is considered bad form and should be avoided.

Exiting Windows requires the use of one of two Windows API functions: `ExitWindows()` or `ExitWindowsEx()`.

The `ExitWindows()` function is a carryover from 16-bit Windows. In that previous version of Windows, you could specify various options that allowed you to reboot Windows after exiting. However, in Win32, this function just logs the current user out of Windows and enables another user to log on to the next Windows session.

`ExitWindows()` has been replaced by the new function `ExitWindowsEx()`. With this function, you can log off, shut down Windows, or shut down Windows and restart the system (reboot). Listing 4.12 shows the use of both functions.

LISTING 4.12 Exiting Windows Using `ExitWindows()` and `ExitWindowsEx()`

```
unit MainFrm;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ExtCtrls;

type
  TMainForm = class(TForm)
    btnExit: TButton;
    rgExitOptions: TRadioGroup;
    procedure btnExitClick(Sender: TObject);
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.btnExitClick(Sender: TObject);
begin
  case rgExitOptions.ItemIndex of
    0: Win32Check(ExitWindows(0, 0)); // Exit and log on as a
      // different user.
    1: Win32Check(ExitWindowsEx(EWX_REBOOT, 0)); // Exit/Reboot
    2: Win32Check(ExitWindowsEx(EWX_SHUTDOWN, 0)); // Exit to Power Off
      // Exit/Log off/Log on as different user
    3: Win32Check(ExitWindowsEx(EWX_LOGOFF, 0));
  end;
end;

end.
```

Listing 4.12 uses the value of a radio button to determine which Windows exit option to use. The first option uses `ExitWindows()` to log the user off and restart Windows, asking the user to log on again.

The remaining options use the `ExitWindowsEx()` function. The second option exits Windows and reboots the system. The third option exits Windows and shuts down the system so that the user can turn off the computer. The fourth option performs the same task as the first, except that it uses the `ExitWindowsEx()` function.

Both `ExitWindows()` and `ExitWindowsEx()` return `True` if successful and `False` otherwise. You can use the `Win32Check()` function from `SysUtils.pas`, which calls the Win32 API function `GetLastError()` and displays the proper error string in the event of an error.

NOTE

If you're running Windows NT, the `ExitWindowsEx()` function will not shut down the system; this requires a special privilege. You must use the Win32 API function `AdjustTokenPrivileges()` to enable the `SE_SHUTDOWN_NAME` privilege. More information on this topic can be found in the Win32 online help.

You'll find an example of this code in the project `ExitWin.dpr` on the CD-ROM accompanying this book.

Preventing Windows Shutdown

Shutting down Windows is one thing, but what if another application performs the same task—that is, calls `ExitWindowsEx()`—while you're editing a file and haven't yet saved the file? Unless you somehow capture the exit request, you chance losing valuable data. It's simple to capture the exit request. All that's required is that you process the `OnCloseQuery` event for the main form in your application. In that event handler, you can place code similar to the following:

```
procedure TMainForm.FormCloseQuery(Sender: TObject; var CanClose: Boolean);
begin
    if MessageDlg('Shutdown?', mtConfirmation, mbYesNoCancel, 0) = mrYes then
        CanClose := True
    else
        CanClose := False;
end;
```

By setting `CanClose` to `False`, you tell Windows not to shut down. Another option is to set `CanClose` to `True` only after prompting you to save a file if necessary. You'll find this demonstrated in the project `NoClose.dpr` on the accompanying CD-ROM.

NOTE

If you're running a formless project, you must subclass the application's window procedure and capture the `WM_QUERYENDSESSION` message that's sent to each application running whenever `ExitWindows()` or `ExitWindowsEx()` is called from any application. If the application returns a nonzero value from this message, that application can end successfully. The application should return zero to prevent Windows from shutting down. You'll learn more about processing Windows messages in Chapter 5, "Understanding Messages."

Summary

This chapter focuses on project management techniques and architectural issues. It discusses the key components that make up most Delphi 5 projects: `TForm`, `TApplication`, and `TScreen`. We demonstrated how you might start designing your applications by first developing a common architecture. The chapter also shows various useful routines for your application.

Understanding Windows Messaging

CHAPTER

5

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Although Visual Component Library (VCL) components expose many Win32 messages via Object Pascal events, it's still essential that you, the Win32 programmer, understand how the Windows message system works.

As a Delphi applications programmer, you'll find that the events surfaced by VCL will suit most of your needs; only occasionally will you have to delve into the world of Win32 message handling. As a Delphi component developer, however, you and messages will become very good friends because you have to directly handle many Windows messages and then invoke events corresponding to those messages.

What Is a Message?

A *message* is a notification of some occurrence sent by Windows to an application. Clicking a mouse button, resizing a window, or pressing a key on the keyboard, for example, causes Windows to send a message to an application notifying it of what occurred.

A message manifests itself as a *record* passed to an application by Windows. That record contains information such as what type of event occurred and additional information specific to the message. The message record for a mouse button click message, for example, contains the mouse coordinates at the time the button was pressed. The record type passed from Windows to the application is called a `TMsg`, which is defined in the `Windows` unit as shown in the following code:

```
type
  TMsg = packed record
    hwnd: HWND;      // the handle of the Window for which the message
                    // is intended
    message: UINT;  // the message constant identifier
    wParam: WPARAM; // 32 bits of additional message-specific information
    lParam: LPARAM; // 32 bits of additional message-specific information
    time: DWORD;    // the time that the message was created
    pt: TPoint;     // the position of the mouse cursor when the message
                    // was created
  end;
```

What's in a Message?

Does the information in a message record look like Greek to you? If so, here's a little insight to what's what:

<code>hwnd</code>	The 32-bit window handle of the window for which the message is intended. The window can be almost any type of screen object because Win32 maintains window handles for most visual objects (windows, dialog boxes, buttons, edits, and so on).
-------------------	---

message	A constant value that represents some message. These constants can be defined by Windows in the <code>Windows</code> unit or by you through user-defined messages.
wParam	This field often contains a constant value associated with the message; it can also contain a window handle or the identification number of some window or control associated with the message.
lParam	This field often holds an index or pointer to some data in memory. Because <code>wParam</code> , <code>lParam</code> , and <code>Pointer</code> are all 32 bits in size, you can typecast interchangeably between them.

Now that you have an idea what makes up an message, it's time to take a look at some different types of Windows messages.

Types of Messages

The Win32 API predefines a constant for each Windows message. These constants are the values kept in the message field of the `TMsg` record. All these constants are defined in Delphi's `Messages` unit; most are also described in the online help. Notice that each of these constants begins with the letters *WM*, which stand for *Windows Message*. Table 5.1 lists some of the common Windows messages, along with their meanings and values.

TABLE 5.1 Common Windows Messages

<i>Message Identifier</i>	<i>Value</i>	<i>Tells a Window That...</i>
<code>WM_ACTIVATE</code>	<code>\$0006</code>	It's being activated or deactivated.
<code>WM_CHAR</code>	<code>\$0102</code>	<code>WM_KEYDOWN</code> and <code>WM_KEYUP</code> messages have been sent for one key.
<code>WM_CLOSE</code>	<code>\$0010</code>	It should terminate.
<code>WM_KEYDOWN</code>	<code>\$0100</code>	A keyboard key is being pressed.
<code>WM_KEYUP</code>	<code>\$0101</code>	A keyboard key has been released.
<code>WM_LBUTTONDOWN</code>	<code>\$0201</code>	The user is pressing the left mouse button.
<code>WM_MOUSEMOVE</code>	<code>\$0200</code>	The mouse is being moved.
<code>WM_PAINT</code>	<code>\$000F</code>	It must repaint its client area.
<code>WM_TIMER</code>	<code>\$0113</code>	A timer event has occurred.
<code>WM_QUIT</code>	<code>\$0012</code>	A request has been made to shut down the program.

How the Windows Message System Works

A Windows application's message system has three key components:

- *Message queue.* Windows maintains a message queue for each application. A Windows application must get messages from this queue and dispatch them to the proper windows.
- *Message loop.* This is the loop mechanism in a Windows program that fetches a message from the application queue and dispatches it to the appropriate window, fetches the next message, dispatches it to the appropriate window, and so on.
- *Window procedure.* Each window in your application has a window procedure that receives each of the messages passed to it by the message loop. The window procedure's job is to take each window message and respond to it accordingly. A window procedure is a callback function; a window procedure usually returns a value to Windows after processing a message.

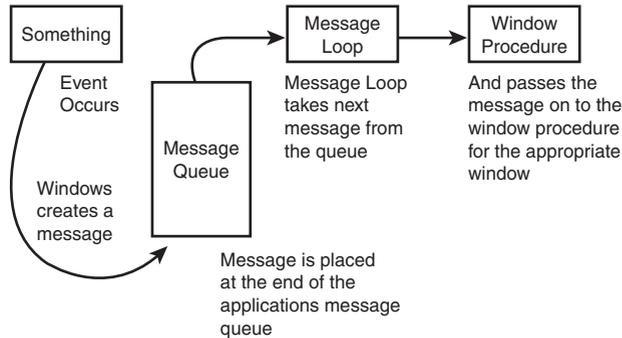
NOTE

A *callback function* is a function in your program that's called by Windows or some other external module.

Getting a message from point A (some event occurs, creating a message) to point B (a window in your application responds to the message) is a five-step process:

1. Some event occurs in the system.
2. Windows translates this event into a message and places it into the message queue for your application.
3. Your application retrieves the message from the queue and places it in a `TMsg` record.
4. Your application passes on the message to the window procedure of the appropriate window in your application.
5. The window procedure performs some action in response to the message.

Steps 3 and 4 make up the application's message loop. The message loop is often considered the heart of a Windows program because it's the facility that enables your program to respond to external events. The message loop spends its whole life fetching messages from the application queue and passing them to the appropriate windows in your application. If there are no messages in your application's queue, Windows allows other applications to process their messages. Figure 5.1 shows these steps.

**FIGURE 5.1**

The Windows Message system.

Delphi's Message System

VCL handles many of the details of the Windows message system for you. The message loop is built into VCL's Forms unit, for example, so you don't have to worry about fetching messages from the queue or dispatching them to a window procedure. Delphi also places the information located in the Windows TMsg record into a generic TMessage record:

```

type
  TMessage = record
    Msg: Cardinal;
    case Integer of
      0: (
        WParam: Longint;
        LParam: Longint;
        Result: Longint);
      1: (
        WParamLo: Word;
        WParamHi: Word;
        LParamLo: Word;
        LParamHi: Word;
        ResultLo: Word;
        ResultHi: Word);
    end;

```

Notice that TMessage record has a little less information than does TMsg. That's because Delphi internalizes the other TMsg fields; TMessage contains just the essential information you need to handle a message.

It's important to note that the `TMessage` record also contains a `Result` field. As mentioned earlier, some messages require the window procedure to return some value after processing a message. With Delphi, you accomplish this process in a straightforward fashion by placing the return value in the `Result` field of `TMessage`. This process is explained in detail in the later section "Assigning Message Result Values."

Message-Specific Records

In addition to the generic `TMessage` record, Delphi defines a message-specific record for every Windows message. The purpose of these message-specific records is to give you all the information the message offers without having to decipher the `wParam` and `lParam` fields of a record. All the message-specific records can be found in the `Messages` unit. As an example, here's the message record used to hold most mouse messages:

```
type
  TWMMouse = record
    Msg: Cardinal;
    Keys: Longint;
    case Integer of
      0: (
        XPos: Smallint;
        YPos: Smallint);
      1: (
        Pos: TSmallPoint;
        Result: Longint);
    end;
```

All the record types for specific mouse messages (`WM_LBUTTONDOWN` and `WM_RBUTTONDOWN`, for example) are simply defined as equal to `TWMMouse`, as in the following example:

```
TWMRButtonUp = TWMMouse;
TWMLButtonDown = TWMMouse;
```

NOTE

A message record is defined for nearly every standard Windows message. The naming convention dictates that the name of the record must be the same as the name of the message with a *T* prepended, using camel capitalization and without the underscore. For example, the name of the message record type for a `WM_SETFONT` message is `TWMSetFont`.

By the way, `TMessage` works with all messages in all situations but isn't as convenient as message-specific records.

Handling Messages

Handling or processing a message means that your application responds in some manner to a Windows message. In a standard Windows application, message handling is performed in each window procedure. By internalizing the window procedure, however, Delphi makes it much easier to handle individual messages; instead of having one procedure that handles all messages, each message has its own procedure. Three requirements must be met for a procedure to be a message-handling procedure:

- The procedure must be a method of an object.
- The procedure must take one var parameter of a TMessage or other message-specific record type.
- The procedure must use the message directive followed by the constant value of the message you want to process.

Here's an example of a procedure that handles WM_PAINT messages:

```
procedure WMPaint(var Msg: TWMPaint); message WM_PAINT;
```

NOTE

When naming message-handling procedures, the convention is to give them the same name as the message itself, using camel-capitalization and without the underscore.

As another example, let's write a simple message-handling procedure for WM_PAINT that processes the message simply by beeping.

Start by creating a new, blank project. Then access the Code Editor window for this project and add the header for the WMPaint function to the private section of the TForm1 object:

```
procedure WMPaint(var Msg: TWMPaint); message WM_PAINT;
```

Now add the function definition to the implementation part of this unit. Remember to use the dot operator to scope this procedure as a method of TForm1. Don't use the message directive as part of the function implementation:

```
procedure TForm1.WMPaint(var Msg: TWMPaint);  
begin  
    Beep;  
    inherited;  
end;
```

Notice the use of the `inherited` keyword here. Call `inherited` when you want to pass the message to the ancestor object's handler. By calling `inherited` in this example, you pass on the message to TForm's `WM_PAINT` handler.

NOTE

Unlike normal calls to inherited methods, here you don't give the name of the inherited method. That's because the name of the method is unimportant when it's dispatched. Delphi knows what method to call based on the message value used with the message directive in the class interface.

The main unit in Listing 5.1 provides a simple example of a form that processes the `WM_PAINT` message. Creating this project is easy: Just create a new project and add the code for the `WMPaint` procedure to the TForm object.

LISTING 5.1 *GetMess*: A Message-Handling Example

```
unit GMMain;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls,
  Forms, Dialogs;

type
  TForm1 = class(TForm)
  private
    procedure WMPaint(var Msg: TWMPaint); message WM_PAINT;
  end;

var
  Form1: TForm1;

implementation

{$R *.DFM}

procedure TForm1.WMPaint(var Msg: TWMPaint);
begin
  MessageBeep(0);
  inherited;
end;

end.
```

Whenever a `WM_PAINT` message comes down the pike, it's passed to the `WMPaint` procedure. The `WMPaint` procedure simply informs you of the `WM_PAINT` message by making some noise with the `MessageBeep()` procedure and then passes the message to the inherited handler.

MessageBeep(): The Poor Man's Debugger

While we're on the topic of beeping, now is a good time for a slight digression. The `MessageBeep()` procedure is one of the most straightforward and useful elements in the Win32 API. Its use is simple: Call `MessageBeep()`, pass a predefined constant, and Windows beeps the PC's speaker (if you have a sound card, it plays a WAV file). Big deal, you say? On the surface it may not seem like much, but `MessageBeep()` really shines as an aid in debugging your programs.

If you're looking for a quick-and-dirty way to tell whether your program is reaching a certain place in your code—without having to bother with the debugger and breakpoints—`MessageBeep()` is for you. Because it doesn't require a handle or some other Windows resource, you can use it practically anywhere in your code, and as a wise man once said, "`MessageBeep()` is for the itch you can't scratch with the debugger." If you have a sound card, you can pass `MessageBeep()` one of several predefined constants to have it play a wider variety of sounds—these constants are defined under `MessageBeep()` in the Win32 API help file.

If you're like the authors and are too lazy to type out that whole big, long function name and parameter, you can use the `Beep()` procedure found in the `SysUtils` unit. The implementation of `Beep()` is simply a call to `MessageBeep()` with the parameter `0`.

Message Handling: Not Contract Free

Unlike responding to Delphi events, handling Windows messages is not "contract free." Often, when you decide to handle a message yourself, Windows expects you to perform some action when processing the message. Most of the time, VCL has much of this basic message processing built in—all you have to do is call `inherited` to get to it. Think of it this way: You write a message handler so that your application will do the things you expect, and you call `inherited` so that your application will do the additional things Windows expects.

NOTE

The contractual nature of message handling can be more than just calling the inherited handler. In message handlers, you're sometimes restricted in what you can do. For example, in a `WM_KILLFOCUS` message, you cannot set focus to another control without causing a crash.

To demonstrate the inherited elements, try running the program in Listing 5.1 without calling `inherited` in the `WMPaint()` method. Just remove the line that calls `inherited` so that the procedure looks like this:

```
procedure TForm1.WMPaint(var Msg: TWMPaint);
begin
    MessageBeep(0);
end;
```

Because you never give Windows a chance to perform basic handling of the `WM_PAINT` message, the form will never paint itself.

Sometimes there are circumstances in which you don't want to call the inherited message handler. An example is handling the `WM_SYSCOMMAND` messages to prevent a window from being minimized or maximized.

Assigning Message Result Values

When you handle some Windows messages, Windows expects you to return a result value. The classic example is the `WM_CTLCOLOR` message. When you handle this message, Windows expects you to return a handle to a brush with which you want Windows to paint a dialog box or control. (Delphi provides a `Color` property for components that does this for you, so the example is just for illustration purposes.) You can return this brush handle easily with a message-handling procedure by assigning a value to the `Result` field of `TMessage` (or another message record) after calling `inherited`. For example, if you were handling `WM_CTLCOLOR`, you could return a brush handle value to Windows with the following code:

```
procedure TForm1.WMctlColor(var Msg: TWMctlColor);
var
    BrushHand: hBrush;
begin
    inherited;
    { Create a brush handle and place into BrushHand variable }
    Msg.Result := BrushHand;
end;
```

The TApplication Type's OnMessage Event

Another technique for handling messages is to use `TApplication`'s `OnMessage` event. When you assign a procedure to `OnMessage`, that procedure is called whenever a message is pulled from the queue and about to be processed. This event handler is called before Windows itself has a chance to process the message. The `Application.OnMessage` event handler is of `TMessageEvent` type and must be defined with a parameter list, as shown here:

```
procedure SomeObject.AppMessageHandler(var Msg: TMsg;
    var Handled: Boolean);
```

All the message parameters are passed to the `OnMessage` event handler in the `Msg` parameter. (Note that this parameter is of the Windows `TMsg` record type described earlier in this chapter.) The `Handled` field requires you to assign a Boolean value indicating whether you have handled the message.

The first step in creating an `OnMessage` event handler is to create a method that accepts the same parameter list as a `TMessageEvent`. For example, here's a method that keeps a running count of how many messages your application receives:

```
var
  NumMessages: Integer;

procedure Form1.AppMessageHandler(var Msg: TMsg; var Handled: Boolean);
begin
  Inc(NumMessages);
  Handled := False;
end;
```

The second and final step in creating the event handler is to assign a procedure to `Application.OnMessage` somewhere in your code. This can be done in the DPR file after creating the project's forms but before calling `Application.Run`:

```
Application.OnMessage := Form1.AppMessageHandler;
```

One limitation of `OnMessage` is that it's executed only for messages pulled out of the queue and not for messages sent directly to the window procedures of windows in your application. Chapter 13, "Hard-core Techniques," shows techniques for working around this limitation by hooking into the application window procedure.

TIP

`OnMessage` sees all messages posted to all window handles in your application. This is the busiest event in your application (thousands of messages per second), so don't do anything in an `OnMessage` handler that takes a lot of time because you'll slow your whole application to a crawl. Clearly, this is one place where a breakpoint would be a very bad idea.

Sending Your Own Messages

Just as Windows sends messages to your application's windows, you will occasionally need to send messages between windows and controls within your application. Delphi provides several ways to send messages within your application, such as the `Perform()` method (which works independently of the Windows API) and the `SendMessage()` and `PostMessage()` API functions.

The Perform() Method

VCL provides the `Perform()` method for all `TControl` descendants; `Perform()` enables you to send a message to any form or control object given an instance of that object. The `Perform()` method takes three parameters—a message and its corresponding `lParam` and `wParam`—and is defined as follows:

```
function TControl.Perform(Msg: Cardinal; wParam, lParam: Longint):  
    Longint;
```

To send a message to a form or control, use the following syntax:

```
RetVal := ControlName.Perform(MessageID, wParam, lParam);
```

After you call `Perform()`, it doesn't return until the message has been handled. The `Perform()` method packages its parameters into a `TMessage` record and then calls the object's `Dispatch()` method to send the message—bypassing the Windows API messaging system. The `Dispatch()` method is described later in this chapter.

The SendMessage() and PostMessage() API Functions

Sometimes you need to send a message to a window for which you don't have a Delphi object instance. For example, you might want to send a message to a non-Delphi window, but you have only a handle to that window. Fortunately, the Windows API offers two functions that fit this bill: `SendMessage()` and `PostMessage()`. These two functions are essentially identical, except for one key difference: `SendMessage()`, similar to `Perform()`, sends a message directly to the window procedure of the intended window and waits until the message is processed before returning; `PostMessage()` posts a message to the Windows message queue and returns immediately.

`SendMessage()` and `PostMessage()` are declared as follows:

```
function SendMessage(hWnd: HWND; Msg: UINT; wParam: WPARAM;  
    lParam: LPARAM): LRESULT; stdcall;  
function PostMessage(hWnd: HWND; Msg: UINT; wParam: WPARAM;  
    lParam: LPARAM): BOOL; stdcall;
```

- `hWnd` is the window handle for which the message is intended.
- `Msg` is the message identifier.
- `wParam` is 32 bits of additional message-specific information.
- `lParam` is 32 bits of additional message-specific information.

NOTE

Although `SendMessage()` and `PostMessage()` are used similarly, their respective return values are different. `SendMessage()` returns the result value of the message being processed, but `PostMessage()` returns only a `BOOL` that indicates whether the message was placed in the target window's queue.

Nonstandard Messages

Until now, the discussion has centered on regular Windows messages (those that begin with `WM_XXX`). However, two other major categories of messages merit some discussion: notification messages and user-defined messages.

Notification Messages

Notification messages are messages sent to a parent window when something happens in one of its child controls that may require the parent's attention. Notification messages occur only with the standard Windows controls (button, list box, combo box, and edit control) and with the Windows Common Controls (tree view, list view, and so on). For example, clicking or double-clicking a control, selecting some text in a control, and moving the scroll bar in a control all generate notification messages.

You can handle notification messages by writing message-handling procedures in the form that contains a particular control. Table 5.2 lists the Win32 notification messages for standard Windows controls.

TABLE 5.2 Standard Control Notification Messages

<i>Notification</i>	<i>Meaning</i>
<i>Button Notification</i>	
<code>BN_CLICKED</code>	The user clicked a button.
<code>BN_DISABLE</code>	A button is disabled.
<code>BN_DOUBLECLICKED</code>	The user double-clicked a button.
<code>BN_HILITE</code>	The user highlighted a button.
<code>BN_PAINT</code>	The button should be painted.
<code>BN_UNHILITE</code>	The highlight should be removed.

continues

TABLE 5.2 Continued

<i>Notification</i>	<i>Meaning</i>
<i>Combo Box Notification</i>	
CBN_CLOSEUP	The list box of a combo box has closed.
CBN_DBLCLK	The user double-clicked a string.
CBN_DROPDOWN	The list box of a combo box is dropping down.
CBN_EDITCHANGE	The user has changed text in the edit control.
CBN_EDITUPDATE	Altered text is about to be displayed.
CBN_ERRSPACE	The combo box is out of memory.
CBN_KILLFOCUS	The combo box is losing the input focus.
CBN_SELCHANGE	A new combo box list item is selected.
CBN_SELENDCANCEL	The user's selection should be canceled.
CBN_SELENDOK	The user's selection is valid.
CBN_SETFOCUS	The combo box is receiving the input focus.
<i>Edit Notification</i>	
EN_CHANGE	The display is updated after text changes.
EN_ERRSPACE	The edit control is out of memory.
EN_HSCROLL	The user clicked the horizontal scrollbar.
EN_KILLFOCUS	The edit control is losing the input focus.
EN_MAXTEXT	The insertion is truncated.
EN_SETFOCUS	The edit control is receiving the input focus.
EN_UPDATE	The edit control is about to display altered text.
EN_VSCROLL	The user clicked the vertical scrollbar.
<i>List Box Notification</i>	
LBN_DBLCLK	The user double-clicked a string.
LBN_ERRSPACE	The list box is out of memory.
LBN_KILLFOCUS	The list box is losing the input focus.
LBN_SELCANCEL	The selection is canceled.
LBN_SELCHANGE	The selection is about to change.
LBN_SETFOCUS	The list box is receiving the input focus.

Internal VCL Messages

VCL has an extensive collection of its own internal and notification messages. Although you don't commonly use these messages in your Delphi applications, Delphi component writers

will find them useful. These messages begin with `CM_` (for *component message*) or `CN_` (for *component notification*), and they are used to manage VCL internals such as focus, color, visibility, window re-creation, dragging, and so on. You can find a complete list of these messages in the “Creating Custom Components” portion of the Delphi online help.

User-Defined Messages

At some point, you’ll come across a situation in which one of your own applications must send a message to itself, or you have to send messages between two of your own applications. At this point, one question that might come to mind is, “Why would I send myself a message instead of simply calling a procedure?” It’s a good question, and there are actually several answers. First, messages give you polymorphism without requiring knowledge of the recipient’s type. Messages are therefore as powerful as virtual methods but more flexible. Also, messages allow for optional handling: If the recipient doesn’t do anything with the message, no harm is done. Finally, messages allow for broadcast notifications to multiple recipients and “parasitic” eavesdropping, which isn’t easily done with procedures alone.

Messages Within Your Application

Having an application send a message to itself is easy. Just use the `Perform()`, `SendMessage()`, or `PostMessage()` function and use a message value in the range of `WM_USER + 100` through `$7FFF` (the value Windows reserves for user-defined messages):

```
const
  SX_MYMESSAGE = WM_USER + 100;

begin
  SomeForm.Perform(SX_MYMESSAGE, 0, 0);
  { or }
  SendMessage(SomeForm.Handle, SX_MYMESSAGE, 0, 0);
  { or }
  PostMessage(SomeForm.Handle, SX_MYMESSAGE, 0, 0);
  .
  .
  .
end;
```

Then create a normal message-handling procedure for this message in the form in which you want to handle the message:

```
TForm1 = class(TForm)
  .
  .
  .
private
```

```
procedure SXMyMessage(var Msg: TMessage); message SX_MYMESSAGE;
end;

procedure TForm1.SXMyMessage(var Msg: TMessage);
begin
  MessageDlg('She turned me into a newt!', mtInformation, [mbOk], 0);
end;
```

As you can see, there's little difference between using a user-defined message in your application and handling any standard Windows message. The real key here is to start at `WM_USER + 100` for interapplication messages and to give each message a name that has something to do with its purpose.

CAUTION

Never send messages with values of `WM_USER` through `$7FFF` unless you're sure that the intended recipient is equipped to handle the message. Because each window can define these values independently, the potential for bad things to happen is great unless you keep careful tabs on which recipients you send `WM_USER` through `$7FFF` messages to.

Messaging Between Applications

When you want to send messages between two or more applications, it's usually best to use the `RegisterWindowMessage()` API function in each application. This method ensures that every application uses the same message number for a given message.

`RegisterWindowMessage()` accepts a null-terminated string as a parameter and returns a new message constant in the range of `$C000` through `$FFFF`. This means that all you have to do is call `RegisterWindowMessage()` with the same string in each application between which you want to send messages; Windows returns the same message value for each application. The true benefit of `RegisterWindowMessage()` is that, because a message value for any given string is guaranteed to be unique throughout the system, you can safely broadcast such messages to all windows with fewer harmful side effects. It can be a bit more work to handle this kind of message, though; because the message identifier isn't known until runtime, you can't use a standard message handler procedure, and you must override a control's `WndProc()` or `DefaultHandler()` method or subclass an existing window procedure. A technique for handling registered messages is demonstrated in Chapter 13, "Hard-core Techniques."

NOTE

The number returned by `RegisterWindowMessage()` varies between Windows sessions and can't be determined until runtime.

Broadcasting Messages

`TWinControl` descendants can broadcast a message record to each of their owned controls—thanks to the `Broadcast()` method. This technique is useful when you need to send the same message to a group of components. For example, to send a user-defined message called `um_Foo` to all of `Panel1`'s owned controls, use the following code:

```
var
  M: TMessage;
begin
  with M do
  begin
    Message := UM_FOO;
    wParam := 0;
    lParam := 0;
    Result := 0;
  end;
  Panel1.Broadcast(M);
end;
```

Anatomy of a Message System: VCL

There's much more to VCL's message system than handling messages with the `message` directive. After a message is issued by Windows, it makes a couple of stops before reaching your message-handling procedure (and it may make a few more stops afterward). All along the way, you have the power to act on the message.

For posted messages, the first stop for a Windows message in VCL is the `Application.ProcessMessage()` method, which houses the VCL main message loop. The next stop for a message is the handler for the `Application.OnMessage` event. `OnMessage` is called as messages are fetched from the application queue in the `ProcessMessage()` method. Because sent messages aren't queued, `OnMessage` won't be called for sent messages.

For posted messages, the `DispatchMessage()` API is then called internally to dispatch the message to the `StdWndProc()` function. For sent messages, `StdWndProc()` will be called directly by `Win32.StdWndProc()`. `StdWndProc()` is an assembler function that accepts the message from Windows and routes it to the object for which the message is intended.

The object method that receives the message is called `MainWndProc()`. Beginning with `MainWndProc()`, you can perform any special handling of the message your program might require. Generally, you handle a message at this point only if you don't want a message to go through VCL's normal dispatching.

After leaving the `MainWndProc()` method, the message is routed to the object's `WndProc()` method and then on to the dispatch mechanism. The dispatch mechanism, found in the object's `Dispatch()` method, routes the message to any specific message-handling procedure that you've defined or that already exists within VCL.

Then the message finally reaches your message-specific handling procedure. After flowing through your handler and the inherited handlers you might have invoked using the `inherited` keyword, the message goes to the object's `DefaultHandler()` method. `DefaultHandler()` performs any final message processing and then passes the message to the Windows `DefWindowProc()` function or other default window procedure (such as `DefMDIProc`) for any Windows default processing. Figure 5.2 shows VCL's message-processing mechanism.

NOTE

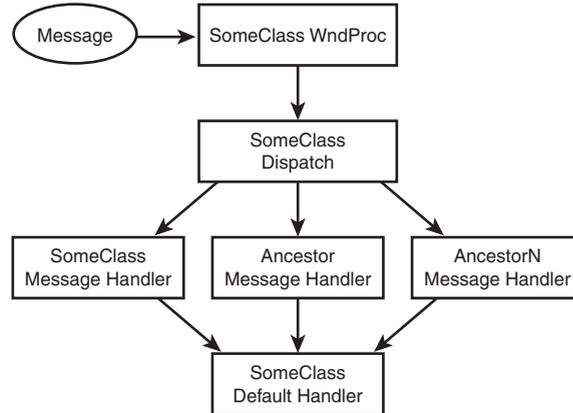
You should always call `inherited` when handling messages unless you're absolutely certain you want to prevent normal message processing.

TIP

Because all unhandled messages flow to `DefaultHandler()`, that's usually the best place to handle interapplication messages in which the values were obtained by way of the `RegisterWindowMessage()` procedure.

To better understand VCL's message system, create a small program that can handle a message at the `Application.OnMessage`, `WndProc()`, message procedure, or `DefaultHandler()` stage. This project is called `CatchIt`; its main form is shown in Figure 5.3.

The `OnClick` event handlers for `PostMessButton` and `SendMessButton` are shown in the following code. The former uses `PostMessage()` to post a user-defined message to the form; the latter uses `SendMessage()` to send a user-defined message to the form. To differentiate between post and send, note that the value 1 is passed in the `wParam` of `PostMessage()` and that the value 0 (zero) is passed for `SendMessage()`. Here's the code:

**FIGURE 5.2**

VCL's message system.

**FIGURE 5.3**

The main form of the CatchIt message example.

```

procedure TMainForm.PostMessButtonClick(Sender: TObject);
{ posts message to form }
begin
  PostMessage(Handle, SX_MYMESSAGE, 1, 0);
end;

```

```

procedure TMainForm.SendMessButtonClick(Sender: TObject);
{ sends message to form }
begin
  SendMessage(Handle, SX_MYMESSAGE, 0, 0); // send message to form
end;

```

This application provides the user with the opportunity to “eat” the message in the `OnMessage` handler, `WndProc()` method, message-handling method, or `DefaultHandler()` method (that is, to not trigger the inherited behavior and to therefore stop the message from fully circulating

through VCL's message-handling system). Listing 5.2 shows the completed source code for the main unit of this project, thus demonstrating the flow of messages in a Delphi application.

LISTING 5.2 The Source Code for *CIMain.PAS*

```
unit CIMain;

interface

uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, ExtCtrls, Menus;

const
  SX_MYMESSAGE = WM_USER;           // User-defined message value
  MessString = '%s message now in %s.'; // String to alert user

type
  TMainForm = class(TForm)
    GroupBox1: TGroupBox;
    PostMessButton: TButton;
    WndProcCB: TCheckBox;
    MessProcCB: TCheckBox;
    DefHandCB: TCheckBox;
    SendMessButton: TButton;
    AppMsgCB: TCheckBox;
    EatMsgCB: TCheckBox;
    EatMsgGB: TGroupBox;
    OnMsgRB: TRadioButton;
    WndProcRB: TRadioButton;
    MsgProcRB: TRadioButton;
    DefHandlerRB: TRadioButton;
    procedure PostMessButtonClick(Sender: TObject);
    procedure SendMessButtonClick(Sender: TObject);
    procedure EatMsgCBClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure AppMsgCBClick(Sender: TObject);
  private
    { Handles messages at Application level }
    procedure OnAppMessage(var Msg: TMsg; var Handled: Boolean);
    { Handles messages at WndProc level }
    procedure WndProc(var Msg: TMessage); override;
    { Handles message after dispatch }
    procedure SXMyMessage(var Msg: TMessage); message SX_MYMESSAGE;
    { Default message handler }
    procedure DefaultHandler(var Msg); override;
  end;
```

```

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

const
  // strings which will indicate whether a message is sent or posted
  SendPostStrings: array[0..1] of String = ('Sent', 'Posted');

procedure TMainForm.FormCreate(Sender: TObject);
{ OnCreate handler for main form }
begin
  // set OnMessage to my OnAppMessage method
  Application.OnMessage := OnAppMessage;
  // use the Tag property of checkboxes to store a reference to their
  // associated radio buttons
  AppMsgCB.Tag := Longint(OnMsgRB);
  WndProcCB.Tag := Longint(WndProcRB);
  MessProcCB.Tag := Longint(MsgProcRB);
  DefHandCB.Tag := Longint(DefHandlerRB);
  // use the Tag property of radio buttons to store a reference to their
  // associated checkbox
  OnMsgRB.Tag := Longint(AppMsgCB);
  WndProcRB.Tag := Longint(WndProcCB);
  MsgProcRB.Tag := Longint(MessProcCB);
  DefHandlerRB.Tag := Longint(DefHandCB);
end;

procedure TMainForm.OnAppMessage(var Msg: TMsg; var Handled: Boolean);
{ OnMessage handler for Application }
begin
  // check to see if message is my user-defined message
  if Msg.Message = SX_MYMESSAGE then
    begin
      if AppMsgCB.Checked then
        begin
          // Let user know about the message. Set Handled flag appropriately
          ShowMessage(Format(MessString, [SendPostStrings[Msg.WParam],
            'Application.OnMessage']));
          Handled := OnMsgRB.Checked;
        end;
      end;
    end;
end;
end;

```

continues

LISTING 5.2 Continued

```
procedure TMainForm.WndProc(var Msg: TMessage);
{ WndProc procedure of form }
var
  CallInherited: Boolean;
begin
  CallInherited := True;          // assume we will call the inherited
  if Msg.Msg = SX_MYMESSAGE then // check for our user-defined message
  begin
    if WndProcCB.Checked then    // if WndProcCB checkbox is checked...
    begin
      // Let user know about the message.
      ShowMessage(Format(MessString, [SendPostStrings[Msg.WParam],
        'WndProc']));
      // Call inherited only if we are not supposed to eat the message.
      CallInherited := not WndProcRB.Checked;
    end;
  end;
  if CallInherited then inherited WndProc(Msg);
end;

procedure TMainForm.SXMyMessage(var Msg: TMessage);
{ Message procedure for user-defined message }
var
  CallInherited: Boolean;
begin
  CallInherited := True;          // assume we will call the inherited
  if MessProcCB.Checked then     // if MessProcCB checkbox is checked
  begin
    // Let user know about the message.
    ShowMessage(Format(MessString, [SendPostStrings[Msg.WParam],
      'Message Procedure']));
    // Call inherited only if we are not supposed to eat the message.
    CallInherited := not MsgProcRB.Checked;
  end;
  if CallInherited then Inherited;
end;

procedure TMainForm.DefaultHandler(var Msg);
{ Default message handler for form }
var
  CallInherited: Boolean;
begin
  CallInherited := True;          // assume we will call the inherited
  // check for our user-defined message
  if TMessage(Msg).Msg = SX_MYMESSAGE then begin
```

```
    if DefHandCB.Checked then          // if DefHandCB checkbox is checked
    begin
        // Let user know about the message.
        ShowMessage(Format(MessString,
            [SendPostStrings[TMessage(Msg).WParam], 'DefaultHandler']));
        // Call inherited only if we are not supposed to eat the message.
        CallInherited := not DefHandlerRB.Checked;
    end;
end;
if CallInherited then inherited DefaultHandler(Msg);
end;

procedure TMainForm.PostMessButtonClick(Sender: TObject);
{ posts message to form }
begin
    PostMessage(Handle, SX_MYMESSAGE, 1, 0);
end;

procedure TMainForm.SendMessButtonClick(Sender: TObject);
{ sends message to form }
begin
    SendMessage(Handle, SX_MYMESSAGE, 0, 0); // send message to form
end;

procedure TMainForm.AppMsgCBClick(Sender: TObject);
{ enables/disables proper radio button for checkbox click }
begin
    if EatMsgCB.Checked then
    begin
        with TRadioButton((Sender as TCheckBox).Tag) do
        begin
            Enabled := TCheckBox(Sender).Checked;
            if not Enabled then Checked := False;
        end;
    end;
end;

procedure TMainForm.EatMsgCBClick(Sender: TObject);
{ enables/disables radio buttons as appropriate }
var
    i: Integer;
    DoEnable, EatEnabled: Boolean;
begin
    // get enable/disable flag
    EatEnabled := EatMsgCB.Checked;
    // iterate over child controls of GroupBox in order to
```

continues

LISTING 5.2 Continued

```
// enable/disable and check/uncheck radio buttons
for i := 0 to EatMsgGB.ControlCount - 1 do
  with EatMsgGB.Controls[i] as TRadioButton do
  begin
    DoEnable := EatEnabled;
    if DoEnable then DoEnable := TCheckbox(Tag).Checked;
    if not DoEnable then Checked := False;
    Enabled := DoEnable;
  end;
end;

end.
```

CAUTION

Although it's fine to use just the `inherited` keyword to send the message to an inherited handler in message-handler procedures, this technique doesn't work with `WndProc()` or `DefaultHandler()`. With these procedures, you must also provide the name of the inherited procedure or function, as in this example:

```
inherited WndProc(Msg);
```

You might have noticed that the `DefaultHandler()` procedure is somewhat unusual in that it takes one *untyped var* parameter. That's because `DefaultHandler()` assumes that the first word in the parameter is the message number; it isn't concerned with the rest of the information being passed. Because of this, you typecast the parameter as a `TMessage` so that you can access the message parameters.

The Relationship Between Messages and Events

Now that you know all the ins and outs of messages, recall that this chapter began by stating that VCL encapsulates many Windows messages in its event system. Delphi's event system is designed to be an easy interface into Windows messages. Many VCL events have a direct correlation with `WM_XXX` Windows messages. Table 5.3 shows some common VCL events and the Windows message responsible for each event.

TABLE 5.3 VCL Events and Corresponding Windows Messages

<i>VCL Event</i>	<i>Windows Message</i>
OnActivate	WM_ACTIVATE
OnClick	WM_XBUTTONDOWN

<i>VCL Event</i>	<i>Windows Message</i>
OnCreate	WM_CREATE
OnDb1Click	WM_XBUTTONDOWNBLCLICK
OnKeyDown	WM_KEYDOWN
OnKeyPress	WM_CHAR
OnKeyUp	WM_KEYUP
OnPaint	WM_PAINT
OnResize	WM_SIZE
OnTimer	WM_TIMER

Table 5.3 is a good rule-of-thumb reference when you're looking for events that correspond directly to messages.

TIP

Never write a message handler when you can use a predefined event to do the same thing. Because of the contract-free nature of events, you'll have fewer problems handling events than you will handling messages.

Summary

By now, you should have a pretty clear understanding of how the Win32 messaging system works and how VCL encapsulates that messaging system. Although Delphi's event system is great, knowing how messages work is essential for any serious Win32 programmer.

If you're eager to learn more about handling Windows messages, check out Chapter 21, "Writing Delphi Custom Components." In that chapter, you see practical application of the knowledge you gained in this chapter. For the next chapter, you'll learn about how to write your Delphi code to a set of standards in order to facilitate logical coding practices and sharing of source code.

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Introduction

This document describes the coding standards for Delphi programming as used in *Delphi 5 Developer's Guide*. In general, this document follows the often “unspoken” formatting guidelines used by Borland International with a few minor exceptions. The purpose for including this document in *Delphi 5 Developer's Guide* is to present a method by which development teams can enforce a consistent style to the coding they do. The intent is to make it so that every programmer on a team can understand the code being written by other programmers. This is accomplished by making the code more readable by use of consistency.

This document by no means includes everything that might exist in a coding standard. However, it does contain enough detail to get you started. Feel free to use and modify these standards to fit your needs. We don't recommend, however, that you deviate too far from the standards used by Borland's development staff. We recommend this because as you bring new programmers to your team, the standards that they're most likely to be most familiar with are Borland's. Like most coding standards documents, this document will evolve as needed. Therefore, you'll find the most updated version online at www.xapware.com/ddg.

This document does not cover *user interface standards*. This is a separate but equally important topic. Enough third-party books and Microsoft documentation cover such guidelines that we decided not to replicate this information but rather refer you to the Microsoft Developers Network and other sources where that information is available.

General Source Code Formatting Rules

Indentation

Indenting shall be two spaces per level. Do not save tab characters to source files. The reason for this is because tab characters are expanded to different widths with different users' settings and by different source management utilities (print, archive, version control, and so on).

You can disable saving tab characters by turning off the Use Tab Character and Optimal Fill check boxes on the General page of the Editor Properties dialog box (accessed via Tools, Editor Options).

Margins

Margins will be set to 80 characters. In general, source shall not exceed this margin, with the exception to finish a word. However, this guideline is somewhat flexible. Wherever possible, statements that extend beyond one line shall be wrapped after a comma or an operator. When a statement is wrapped, it shall be indented two characters from the original statement line.

begin..end Pair

The `begin` statement appears on its own line. For example, the following first line is incorrect; the second line is correct:

```
for I := 0 to 10 do begin // Incorrect, begin on same line as for
```

```
for I := 0 to 10 do          // Correct, begin appears on a separate line
begin
```

An exception to this rule is when the `begin` statement appears as part of an `else` clause. Here's an example:

```
if some statement = then
begin
...
end
else begin
    SomeOtherStatement;
end;
```

The `end` statement always appears on its own line.

When the `begin` statement is not part of an `else` clause, the corresponding `end` statement is always indented to match its `begin` part.

Object Pascal

Parentheses

There shall never be white space between an open parenthesis and the next character. Likewise, there shall never be white space between a closed parenthesis and the previous character. The following example illustrates incorrect and correct spacing with regard to parentheses:

```
CallProc( AParameter ); // incorrect
CallProc(AParameter);   // correct
```

Never include extraneous parentheses in a statement. Parentheses shall only be used where required to achieve the intended meaning in source code. The following examples illustrate incorrect and correct usage:

```
if (I = 42) then           // incorrect - extraneous parentheses
if (I = 42) or (J = 42) then // correct - parentheses required
```

Reserved Words and Key Words

Object Pascal language reserved words and key words shall always be completely lowercase.

Procedures and Functions (Routines)

Naming/Formatting

Routine names shall always begin with a capital letter and be camel-capped for readability. The following is an example of an incorrectly formatted procedure name:

```
procedure thisisapoorlyformattedroutinename;
```

This is an example of an appropriately capitalized routine name:

```
procedure ThisIsMuchMoreReadableRoutineName;
```

Routines shall be given names meaningful to their content. Routines that cause an action to occur will be prefixed with the action verb. Here's an example:

```
procedure FormatHardDrive;
```

Routines that set values of input parameters shall be prefixed with the word `set`:

```
procedure SetUserName;
```

Routines that retrieve a value shall be prefixed with the word `get`:

```
function GetUserName: string;
```

Formal Parameters

Formatting

Where possible, formal parameters of the same type shall be combined into one statement:

```
procedure Foo(Param1, Param2, Param3: Integer; Param4: string);
```

Naming

All formal parameter names shall be meaningful to their purpose and typically will be based off the name of the identifier that was passed to the routine. When appropriate, parameter names shall be prefixed with the character `A`:

```
procedure SomeProc(AUserName: string; AUserAge: integer);
```

The `A` prefix is a convention to disambiguate when the parameter name is the same as a property or field name in the class.

Ordering of Parameters

The following formal parameter ordering emphasizes taking advantage of register calling conventions calls.

Most frequently used (by the caller) parameters shall be in the first parameter slots. Less frequently used parameters shall be listed after that in left-to-right order.

Input lists shall exist before output lists in left-to-right order.

Place most generic parameters before most specific parameters in left-to-right order. For example: `SomeProc(APlanet, AContinent, ACountry, AState, ACity)`.

Exceptions to the ordering rule are possible, such as in the case of event handlers, where a parameter named `Sender` of type `TObject` is often passed as the first parameter.

Constant Parameters

When parameters of a record, array, `ShortString`, or interface type are unmodified by a routine, the formal parameters for that routine shall mark the parameter as `const`. This ensures that the compiler will generate code to pass these unmodified parameters in the most efficient manner.

Parameters of other types may optionally be marked as `const` if they're unmodified by a routine. Although this will have no effect on efficiency, it provides more information about parameter use to the caller of the routine.

Name Collisions

When using two units that each contain a routine of the same name, the routine residing in the unit appearing last in the `uses` clause will be invoked if you call that routine. To avoid these `uses` clause–dependent ambiguities, always prefix such method calls with the intended unit name. Here are two examples:

```
SysUtils.FindClose(SR);
```

and

```
Windows.FindClose(Handle);
```

Variables

Variable Naming and Formatting

Variables shall be given names meaningful to their purpose.

Loop control variables are generally given a single character name such as `I`, `J`, or `K`. It's acceptable to use a more meaningful name as well, such as `UserIndex`.

Boolean variable names must be descriptive enough so that the meanings of `True` and `False` values will be clear.

Local Variables

Local variables used within procedures follow the same usage and naming conventions for all other variables. Temporary variables shall be named appropriately.

When necessary, initialization of local variables will occur immediately upon entry into the routine. Local `AnsiString` variables are automatically initialized to an empty string, local interface and `dispinterface` type variables are automatically initialized to `nil`, and local `Variant` and `OleVariant` type variables are automatically initialized to `Unassigned`.

Use of Global Variables

Use of global variables is discouraged. However, they may be used when necessary. When this is the case, you're encouraged to keep global variables within the context in which they're used. For example, a global variable may be global only within the scope of a single unit's implementation section.

Global data that's intended to be used by a number of units shall be moved into a common unit used by all.

Global data may be initialized with a value directly in the `var` section. Bear in mind that all global data is automatically zero initialized; therefore, do not initialize global variables to "empty" values such as `0`, `nil`, `' '`, `Unassigned`, and so on. One reason for this is because zero-initialized global data occupies no space in the EXE file. Zero-initialized data is stored in a virtual data segment that's allocated only in memory when the application starts up. Nonzero initialized global data occupies space in the EXE file on disk.

Types

Capitalization Convention

Type names that are reserved words shall be completely lowercase. Win32 API types are generally completely uppercase, and you shall follow the convention for a particular type name shown in the `Windows.pas` or other API unit. For other variable names, the first letter shall be uppercase, and the rest shall be camel-capped for clarity. Here are some examples:

```
var
  MyString: string;      // reserved word
  WindowHandle: HWND;   // Win32 API type
  I: Integer;           // type identifier introduced in System unit
```

Floating-Point Types

Use of the `Real` type is discouraged because it existed only for backward compatibility with older Pascal code. Although it's now the same as `Double`, this fact may be confusing to other developers. Use `Double` for general-purpose floating-point needs. Also, `Double` is what the processor instructions and busses are optimized for and is an IEEE-defined standard data format. Use `Extended` only when more range is required than that offered by `Double`. `Extended` is an Intel-specified type and is not supported in Java. Use `Single` only when the physical byte size of the floating-point variable is significant (such as when using other-language DLLs).

Enumerated Types

Names for enumerated types must be meaningful to the purpose of the enumeration. The type name must be prefixed with the `T` character to annotate it as a type declaration. The identifier list of the enumerated type must contain a lowercase two-to-three-character prefix that relates it to the original enumerated type name. Here's an example:

```
TSongType = (stRock, stClassical, stCountry, stAlternative, stHeavyMetal,  
            stRB);
```

Variable instances of an enumerated type will be given the same name as the type without the `T` prefix (`SongType`) unless there's a reason to give the variable a more specific name, such as `FavoriteSongType1`, `FavoriteSongType2`, and so on.

Variant and OleVariant Types

The use of the `Variant` and `OleVariant` types is discouraged in general, but these types are necessary for programming when data types are known only at runtime, as is often the case in COM and database development. Use `OleVariant` for COM-based programming such as Automation and ActiveX controls, and use `Variant` for non-COM programming. The reason is that a `Variant` can store native Delphi strings efficiently (like a `string var`), but `OleVariant` converts all strings to OLE strings (`WideChar` strings) and are not reference counted; instead, they're always copied.

Structured Types

Array Types

Names for array types must be meaningful to the purpose for the array. The type name must be prefixed with a `T` character. If a pointer to the array type is declared, it must be prefixed with the character `P` and declared immediately prior to the type declaration. Here's an example:

```
type  
  PCycleArray = ^TCycleArray;  
  TCycleArray = array[1..100] of integer;
```

When practical, variable instances of the array type shall be given the same name as the type name without the `T` prefix.

Record Types

A record type shall be given a name meaningful to its purpose. The type declaration must be prefixed with the character `T`. If a pointer to the record type is declared, it must be prefixed with the character `P` and declared immediately prior to the type declaration. The type declaration for each element may be optionally aligned in a column to the right. Here's an example:

```
type
```

```
PEmployee = ^TEmployee;  
  
TEmployee = record  
    EmployeeName: string  
    EmployeeRate: Double;  
end;
```

Statements

if Statements

The most likely case to execute in an `if/then/else` statement shall be placed in the `then` clause, with less likely cases residing in the `else` clause(s).

Try to avoid chaining `if` statements and use case statements instead if at all possible.

Do not nest `if` statements more than five levels deep. Create a clearer approach to the code.

Do not use extraneous parentheses in an `if` statement.

If multiple conditions are being tested in an `if` statement, conditions shall be arranged from left to right in order of least to most computation intensive. This enables your code to take advantage of short-circuit Boolean evaluation logic built into the compiler. For example, if `Condition1` is faster than `Condition2`, and `Condition2` is faster than `Condition3`, then the `if` statement shall be constructed as follows:

```
if Condition1 and Condition2 and Condition3 then
```

case Statements

General Topics

The individual cases in a case statement shall be ordered by the case constant either numerically or alphabetically.

The actions statements of each case shall be kept simple and generally shall not exceed four to five lines of code. If the actions are more complex, the code shall be placed in a separate procedure or function.

The `else` clause of a case statement shall be used only for legitimate defaults or to detect errors.

Formatting

case statements follow the same formatting rules as other constructs in regards to indentation and naming conventions.

while Statements

The use of the `Exit` procedure to exit a `while` loop is discouraged; when possible, you shall exit the loop using only the loop condition.

All initialization code for a `while` loop shall occur directly before entering the `while` loop and shall not be separated by other nonrelated statements.

Any ending housekeeping shall be done immediately following the loop.

for Statements

`for` statements shall be used in place of `while` statements when the code must execute for a known number of increments.

repeat Statements

`repeat` statements are similar to `while` loops and shall follow the same general guidelines.

with Statements

General Topics

The `with` statement shall be used sparingly and with considerable caution. Avoid overuse of `with` statements and beware of using multiple objects, records, and so on in the `with` statement. For example,

```
with Record1, Record2 do
```

can confuse the programmer and can easily lead to difficult-to-detect bugs.

Formatting

`with` statements follow the same formatting rules in regard to naming conventions and indentation as described previously in this document.

Structured Exception Handling

General Topics

Exception handling shall be used abundantly for both error correction and resource protection. This means that in all cases where resources are allocated, a `try..finally` must be used to ensure proper deallocation of the resource. The exception to this involves cases where resources are allocated/freed in the initialization/finalization of a unit or the constructor/destructor of an object.

Use of `try..finally`

Where possible, each allocation shall be matched with a `try..finally` construct. For example, the following code could lead to possible bugs:

```
SomeClass1 := TSomeClass.Create;  
SomeClass2 := TSomeClass.Create;  
try  
    { do some code }  
finally
```

```
    SomeClass1.Free;
    SomeClass2.Free;
end;
```

A safer approach to the preceding allocation would be this:

```
SomeClass1 := TSomeClass.Create
try
    SomeClass2 := TSomeClass.Create;
    try
        { do some code }
    finally
        SomeClass2.Free;
    end;
finally
    SomeClass1.Free;
end;
```

Use of try..except

Use `try..except` only when you want to perform some task when an exception is raised. In general, you shall not use `try..except` to simply show an error message on the screen because that will be done automatically in the context of an application by the `Application` object. If you want to invoke the default exception handling after you've performed some task in the `except` clause, use `raise` to reraise the exception to the next handler.

Use of try..except..else

The use of the `else` clause with `try..except` is discouraged because it will block all exceptions, even those for which you may not be prepared.

Classes

Naming/Formatting

Type names for classes shall be meaningful to the purpose of the class. The type name must have the `T` prefix to annotate it as a type definition. Here's an example:

```
type
    TCustomer = class(TObject)
```

Instance names for classes will generally match the type name of the class without the `T` prefix:

```
var
    Customer: TCustomer;
```

NOTE

See the section “Component Type Naming Standards” for further information on naming components.

6**Fields****Naming/Formatting**

Class field names follow the same naming conventions as variable identifiers, except they’re prefixed with the `F` annotation to signify that they’re field names.

Visibility

All fields shall be private. Fields that are accessible outside the class scope shall be made accessible through the use of a property.

Methods**Naming/Formatting**

Method names follow the same naming conventions as described for procedures and functions in this document.

Use of Static Methods

Use static methods when you do not intend for a method to be overridden by descendant classes.

Use of Virtual/Dynamic Methods

Use virtual methods when you intend for a method to be overridden by descendant classes. Dynamic methods shall only be used on classes of which there will be many descendants (direct or indirect). For example, when working with a class that contains one infrequently overridden method and 100 descendent classes, you shall make the method dynamic to reduce the memory use by the 100 descendent classes.

Use of Abstract Methods

Do not use abstract methods on classes of which instances will be created. Use abstract methods only on base classes that will never be created.

Property-Access Methods

All access methods must appear in the `private` or `protected` sections of the class definition.

The naming conventions for property-access methods follow the same rules as for procedures and functions. The read accessor method (reader method) must be prefixed with the word `Get`.

The write accessor method (writer method) must be prefixed with the word `Set`. The parameter for the writer method shall have the name `Value`, and its type shall be that of the property it represents. Here's an example:

```
TSomeClass = class(TObject)
private
    FSomeField: Integer;
protected
    function GetSomeField: Integer;
    procedure SetSomeField( Value: Integer);
public
    property SomeField: Integer read GetSomeField write SetSomeField;
end;
```

Properties

Naming/Formatting

Properties that serve as accessors to private fields will be named the same as the fields they represent, without the `F` annotator.

Property names shall be nouns, not verbs. Properties represent data; methods represent actions.

Array property names shall be plural. Normal property names shall be singular.

Use of Access Methods

Although not required, it's encouraged that you use, at a minimum, a write access method for properties that represent a private field.

Files

Project Files

Naming

Project files shall be given descriptive names. For example, *The Delphi 5 Developer's Guide Bug Manager* is given the project name `DDGBugs.dpr`. A system information program shall be given a name such as `SysInfo.dpr`.

Form Files

Naming

A form file shall be given a name descriptive of the form's purpose, postfixed with the characters `Frm`. For example, an About form would have the filename `AboutFrm.dpr`, and a Main form would have the filename `MainFrm.dpr`.

Data Module Files

Naming

A data module shall be given a name that's descriptive of the data module's purpose. The name shall be postfixed with the characters `DM`. For example, a Customers data module will have the form filename `CustomersDM.dfm`.

Remote Data Module Files

Naming

A remote data module shall be given a name that's descriptive of the remote data module's purpose. The name shall be postfixed with the characters `RDM`. For example, a Customers remote data module would have the form filename `CustomersRDM.dfm`.

Unit Files

General Unit Structure

Unit Name

Unit files shall be given descriptive names. For example, the unit containing an application's main form might be called `MainFrm.pas`.

The uses Clause

A `uses` clause in the `interface` section shall only contain units required by code in the `interface` section. Remove any extraneous unit names that might have been automatically inserted by Delphi.

A `uses` clause in the `implementation` section shall only contain units required by code in the `implementation` section. Remove any extraneous unit names.

The interface Section

The `interface` section shall contain declarations for only those types, variables, procedure/function forward declarations, and so on that are to be accessible by external units. Otherwise, these declarations shall go into the `implementation` section.

The implementation Section

The `implementation` section shall contain any declarations for types, variables, procedures/functions, and so on that are private to the containing unit.

The initialization Section

Do not place time-intensive code in the `initialization` section of a unit. This will cause the application to seem sluggish upon startup.

The finalization Section

Make sure you deallocate any items you allocated in the initialization section.

Form Units

Naming

A unit file for a form shall be given the same name as its corresponding form file. For example, an About form would have the unit name `AboutFrm.pas`, and a Main form would have the unit filename `MainFrm.pas`.

Data Module Units

Naming

Unit files or data modules shall be given the same names as their corresponding form files. For example, a Customers data module unit would have the unit name `CustomersDM.pas`.

General-purpose Units

Naming

A general-purpose unit shall be given a name meaningful to the unit's purpose. For example, a utilities unit would be given the name `BugUtilities.pas`, and a unit containing global variables would be given the name `CustomerGlobals.pas`.

Keep in mind that unit names must be unique across all packages used by a project. Generic or common unit names are not recommended.

Component Units

Naming

Component units shall be placed in a separate directory to distinguish them as units defining components or sets of components. They shall never be placed in the same directory as the project. The unit name must be meaningful to its content.

NOTE

See the section "User-Defined Components" for further information on component-naming standards.

File Headers

Use of informational file headers is encouraged for all source files, project files, units, and so on. A proper file header must contain the following information:

```
{  
Copyright © YEAR by AUTHORS  
}
```

Forms and Data Modules

Forms

Form Type Naming Standard

Form types shall be given names descriptive of the form's purpose. The type definition shall be prefixed with a `T`, and a descriptive name shall follow the prefix. Finally, `Form` shall postfix the descriptive name. For example, the type name for an About form would be

```
TAboutForm = class(TForm)
```

A main form definition would be

```
TMainForm = class(TForm)
```

The customer entry form would have a name such as

```
TCustomerEntryForm = class(TForm)
```

Form Instance Naming Standard

Form instances shall be named the same as their corresponding types, without the `T` prefix. For example, for the preceding form types, the instance names are as follows:

<i>Type Name</i>	<i>Instance Name</i>
<code>TAboutForm</code>	<code>AboutForm</code>
<code>TMainForm</code>	<code>MainForm</code>
<code>TCustomerEntryForm</code>	<code>CustomerEntryForm</code>

Auto-creating Forms

Only the main form shall be autocreated unless there's a good reason to do otherwise. All other forms must be removed from the Autocreate list in the Project Options dialog box. See the following section for more information.

Modal Form Instantiation Functions

All form units shall contain a form-instantiation function that creates, sets up, and shows the form modally as well as frees the form. This function shall return the modal result returned by the form. Parameters passed to this function shall follow the parameter-passing standard specified in this document. This functionality is to be encapsulated in this way to facilitate code reuse and maintenance.

The form variable shall be removed from the unit and declared locally in the form-instantiation function. (Note that this requires that the form be removed from the Autocreate list in the Project Options dialog box. See "Autocreating Forms" earlier in this document.)

For example, the following unit illustrates such a function for a GetUserData form:

```
unit UserDataFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls;

type
  TUserDataForm = class(TForm)
    edtUserName: TEdit;
    edtUserID: TEdit;
  private
    { Private declarations }
  public
    { Public declarations }
  end;

function GetUserData(var aUserName: String; var aUserID: Integer): Word;

implementation
{$R *.DFM}

function GetUserData(var aUserName: String; var aUserID: Integer): Word;
var
  UserDataForm: TUserDataForm;
begin
  UserDataForm := TUserDataForm.Create(Application);
  try
    UserDataForm.Caption := 'Getting User Data';
    Result := UserDataForm.ShowModal;
    if ( Result = mrOK ) then begin
      aUserName := UserDataForm.edtUserName.Text;
      aUserID := StrToInt(UserDataForm.edtUserID.Text);
    end;
  finally
    UserDataForm.Free;
  end;
end;

end.
```

Data Modules

Data Module Naming Standard

A `DataModule` type shall be given a name descriptive of the data module's purpose. The type definition shall be prefixed with a `T`, and a descriptive name shall follow the prefix. Finally, the name shall be postfixed with the word `DataModule`. For example, the type name for a Customer data module would be something such as this:

```
TCustomerDataModule = class(TDataModule)
```

Similarly, an Orders data module might have the following name:

```
TOrdersDataModule = class(TDataModule)
```

Data Module Instance Naming Standard

Data module instances will be named the same as their corresponding types, without the `T` prefix. For example, for the preceding form types, the instance names are as follows:

<i>Type Name</i>	<i>Instance Name</i>
<code>TCustomerDataModule</code>	<code>CustomerDataModule</code>
<code>TOrdersDataModule</code>	<code>OrdersDataModule</code>

Packages

Use of Runtime Versus Design Packages

Runtime packages shall contain only units/components required by other components in that package. Other units containing property/component editors and other design-only code shall be placed into a design package. Registration units shall also be placed into a design package.

File Naming Standards

Packages shall be named according to the following templates:

- `iii libvv.dpk` (design package)
- `iii stdvv.dpk` (runtime package)

Here, the characters `iii` signify a three-character identifying prefix. This prefix may be used to identify a company, person, or any other identifying entity.

The characters `vv` signify a version for the package corresponding to the Delphi version for which the package is intended.

Note that the package name contains either `lib` or `std` to signify it as a runtime or design-time package.

In cases where there are both design-time and runtime packages, the files shall be named similarly. For example, packages for *Delphi 5 Developer's Guide* are named as follows:

- DdgLib50.dpk (design package)
- DdgStd50.dpk (runtime package)

Components

User-Defined Components

Component Type Naming Standards

Components shall be named similarly to classes as defined in the “Classes” section, with the exception that components are given a three-character identifying prefix. This prefix may be used to identify a company, person, or any other entity. For example, a clock component written for *Delphi 5 Developer's Guide* would be defined as follows:

```
TddgClock = class(TComponent)
```

Note that the three-character prefix is in lowercase.

Component Units

Component units shall contain only one major component. A *major component* is any component that appears on the Component Palette. Any ancillary components/objects may also reside in the same unit as the major component.

Use of Registration Units

The registration procedure for components shall be removed from the component unit and placed in a separate unit. This registration unit shall be used to register any components, property editors, component editors, experts, and so on.

Component registering shall be done only in the design packages; therefore, the registration unit shall be contained in the design package and not in the runtime package.

It's suggested that registration units be named as follows:

```
XxxReg.pas
```

Here, *Xxx* is a three-character prefix used to identify a company, person, or any other entity. For example, the registration unit for the components in the *Delphi 5 Developer's Guide* would be named DdgReg.pas.

Component Instance Naming Conventions

All components must be given descriptive names. No components shall be left with the default names assigned to them by Delphi. Components shall be named using a variation of the

Hungarian naming convention. According to this standard, the component name shall consist of two parts: a component type prefix and qualifier name.

Component Type Prefixes

The component type prefix is a set of lower case letters that represent the component type. For example, the following are valid component type prefixes for the components specified.

TButton	btn
TEdit	edt
TSpeedButton	spdbtn
TListBox	lstbx

As shown above, the component type prefix is created by modifying the component type name (ie: TButton, TEdit) to a prefix. The following rules illustrate how to define a component type prefix:

1. Remove any “T” prefixes from the components type name. For example, “TButton” becomes “Button”
2. Remove any vowels from the name formed in step 1 with the exception of the first vowel. For example, “Button” becomes “bbtn” and “edit” becomes “edt.”
3. Suppress double consonants. For example, “bbtn” becomes “btn.”
4. If a naming conflict occurs, start adding vowels to the prefix for one of the components. For example, if a new component “Tbatton” is added, it will conflict with “TButton.” Therefore, the prefix for “Tbatton” becomes “batn.”

Component Qualifier Name

The component qualifier name shall be a descriptive of the component’s purpose. For example, a TButton component with the purpose of closing a form would have the name “btnClose.” A TEdit component used for editing the first name of a person would have the name “edtFirstName.”

Coding Standards Document Updates

This document will be updated regularly to reflect changes and enhancements to the Object Pascal language and Visual Component Library. You can retrieve updates at <http://www.xapware.com/ddg>.

Using ActiveX Controls with Delphi

CHAPTER

7

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Delphi gives you the great advantage of easily integrating industry-standard ActiveX controls (formerly known as *OCX* or *OLE controls*) into your applications. Unlike Delphi's own custom components, ActiveX controls are designed to be independent of any particular development tool. This means that you can count on many vendors to provide a variety of ActiveX solutions that open up a world of features and functionality.

ActiveX control support in 32-bit Delphi works similarly to the way VBX support works in 16-bit Delphi 1. You select an option to add new ActiveX controls from Delphi's IDE main menu or package editor, and Delphi builds an Object Pascal wrapper for the ActiveX control—which is then compiled into a package and added to the Delphi Component Palette. Once there, the ActiveX control seamlessly merges into the Component Palette along with your other VCL and ActiveX components. From that point, you're just a click and a drop away from adding an ActiveX control to any of your applications. This chapter discusses integrating ActiveX controls into Delphi, using an ActiveX control in your application, and shipping ActiveX-equipped applications.

NOTE

Delphi 1 was the last version of Delphi to support VBX (Visual Basic Extension) controls. If you have a Delphi 1 project that relies on one or more VBX controls, check with the VBX vendors to see whether they supply a comparable ActiveX solution for use in your 32-bit Delphi applications.

What Is an ActiveX Control?

ActiveX controls are custom controls for 16-bit and 32-bit Windows applications that take advantage of the COM-based OLE and ActiveX technologies. Unlike VBX controls, which are designed for 16-bit Visual Basic (and therefore share Visual Basic's limitations), ActiveX controls were designed from the ground up with application independence in mind. Roughly speaking, you can think of ActiveX controls as a merging of the easy-to-use VBX technology with the open ActiveX standard. For the purposes of this chapter, you can think of OLE and ActiveX as the same thing. If you're looking for greater distinction between these terms, take a look at Chapter 23, "COM and ActiveX."

Under the skin, an ActiveX control is really an ActiveX server that, in one package, can provide all the power of ActiveX—including all OLE functions and services, visual editing, drag and drop, and OLE Automation. Like all ActiveX servers, ActiveX controls are registered in the System Registry. ActiveX controls can be developed using a variety of products, including Delphi, Borland C++Builder, Visual C++, and Visual Basic.

Microsoft is actively promoting ActiveX controls as the choice medium for application-independent custom controls; Microsoft has stated that VBX technology will not be directly supported in the Win32 operating systems and beyond. For this reason, developers should look to ActiveX controls rather than VBX controls when developing 32-bit applications.

NOTE

For a more complete description of ActiveX control technology, see Chapter 25, “Creating ActiveX Controls.”

7**USING ACTIVEX
CONTROLS WITH
DELPHI**

Deciding When To Use an ActiveX Control

There are typically two reasons why you would use an ActiveX control rather than a native Delphi component. The first reason is that no Delphi component is available that fits your particular need. Because the ActiveX control market is larger than that for VCL controls, you’re likely to find a greater variety of fully featured “industrial strength” controls, such as word processors, World Wide Web browsers, and spreadsheets, as ActiveX controls. The second reason you would use an ActiveX control instead of a native Delphi control is if you develop in multiple programming languages and you want to leverage your expertise in some particular control or controls across the multiple development platforms.

Although ActiveX controls integrate seamlessly into the Delphi IDE, keep in mind some inherent disadvantages to using ActiveX controls in your applications. The most obvious issue is that, although Delphi components are built directly into an application executable, ActiveX controls typically require one or more additional runtime files that must be deployed with an executable. Another issue is that ActiveX controls communicate with applications through the COM layer, whereas Delphi components communicate directly with applications and other components. This means that a well-written Delphi component typically performs better than a well-written ActiveX control. A more subtle disadvantage of ActiveX controls is that they’re a “lowest common denominator” solution, so they won’t exploit all the capabilities of the development tool in which they’re used.

Adding an ActiveX Control to the Component Palette

The first step in using a particular ActiveX control in your Delphi application is adding that control to the Component Palette in the Delphi IDE. This places an icon for the ActiveX control on the Component Palette among your other Delphi and ActiveX controls. After you add a particular ActiveX control to the Component Palette, you can drop it on any form and use it as you would any other Delphi control.

To add an ActiveX control to the Component Palette, follow these steps:

1. Choose Component, Import ActiveX Control from the main menu. The Import ActiveX dialog box appears (see Figure 7.1).

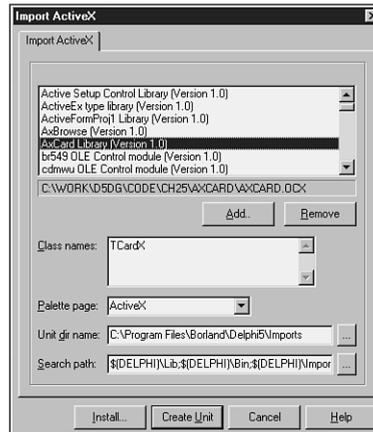
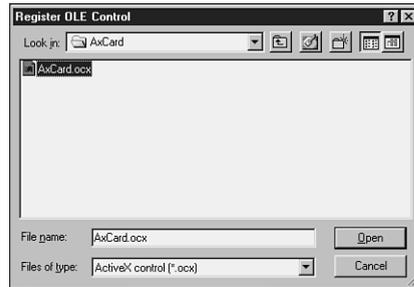


FIGURE 7.1

The Import ActiveX dialog box.

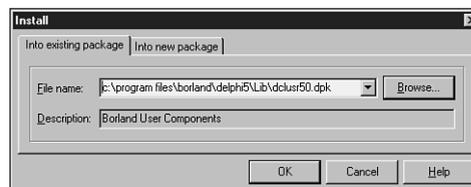
2. The Import ActiveX dialog box is divided into two parts: the top portion contains a list box of registered ActiveX controls and provides Add and Remove buttons that enable you to register and unregister controls. The bottom portion of the dialog box allows you to specify parameters for creating a Delphi component and unit that encapsulates the control.
3. If the name of the ActiveX control you want to use is listed in the top portion of the dialog box, proceed to step 4. Otherwise, click the Add button to register a new control with the system. Clicking the Add button invokes the Register OLE Control dialog box (see Figure 7.2). Select the name of the OCX or DLL file that represents the ActiveX control you want to add to the system and click the Open button. This registers the selected ActiveX control with the System Registry and dismisses the Register OLE Control dialog box.
4. In the upper portion of the Import ActiveX dialog box, select the name of the ActiveX control you want to add to the Component Palette. The lower portion of the dialog box contains edit controls for unit directory name, palette page, and search path as well as a memo control that lists the classes contained within the OCX file. The pathname shown in the Unit Dir Name edit box is the pathname of the Delphi wrapper component created to interface with the ActiveX control. The filename defaults to the same name as the

OCX file (with a .pas extension); the path defaults to the \Delphi5\Imports subdirectory. Although the default is fine to use, you can edit the directory path to your liking.

**FIGURE 7.2**

The Register OLE Control dialog box.

5. The Palette Page edit control in the Import ActiveX dialog box contains the name of the page on the Component Palette where you want this control to reside. The default is the ActiveX page. You can choose another existing page; alternatively, if you make up a new name, a corresponding page is created on the Component Palette.
6. The Class Names memo control in the Import ActiveX dialog box contains the names of the new objects created in this control. You should normally leave these names set to the default unless you have a specific reason for doing otherwise. For example, such a reason would be if the default class name conflicts with another component already installed in the IDE.
7. At this point, you can click either the Install or the Create Unit button in the Import ActiveX dialog box. The Create Unit button will generate the source code for the unit for the ActiveX control component wrapper. The Install button will generate the wrapper code and then invoke the Install dialog box, which allows you to choose a package into which you may install the component (see Figure 7.3).

**FIGURE 7.3**

The Install dialog box.

8. In the Install dialog box, you can choose to add the control to an existing package or create a new package that will be installed to the Component Palette. Click OK in this dialog box, and the component will be installed to the palette.

Now your ActiveX control is on the Component Palette and ready to roll.

The Delphi Component Wrapper

Now is a good time to look into the Object Pascal wrapper created to encapsulate the ActiveX control. Doing so can help shed some light on how Delphi's ActiveX support works so that you can understand the capabilities and limitations inherent in ActiveX controls. Listing 7.1 shows the `Card_TLB.pas` unit generated by Delphi; this unit encapsulates the `AxCard.ocx` ActiveX control.

NOTE

`AxCard.ocx` is an ActiveX control developed in Chapter 25, "Creating ActiveX Controls."

LISTING 7.1 The Delphi Component Wrapper Unit for `AxCard.ocx`.

```
unit AxCard_TLB;

// ***** //
// WARNING
// ---
// The types declared in this file were generated from data read from a
// Type Library. If this type library is explicitly or indirectly (via
// another type library referring to this type library) re-imported, or
// the 'Refresh' command of the Type Library Editor activated while
// editing the Type Library, the contents of this file will be
// regenerated and all manual modifications will be lost.
// ***** //

// PASTLWTR : $Revision: 1.88 $
// File generated on 8/24/99 9:24:19 AM from Type Library described below

// *****//
// NOTE:
// Items guarded by $IFDEF LIVE_SERVER_AT_DESIGN_TIME are used by
// properties which return objects that may need to be explicitly created
// via a function call prior to any access via the property. These items
```

```

// have been disabled in order to prevent accidental use from within the
// object inspector. You may enable them by defining
// LIVE_SERVER_AT_DESIGN_TIME or by selectively removing them from the
// $IFDEF blocks. However, such items must still be programmatically
// created via a method of the appropriate CoClass before they can be
// used.
// *****
// Type Lib: C:\work\d5dg\code\Ch25\AxCard\AxCard.tlb (1)
// IID\LCID: {7B33D940-0A2C-11D2-AE5C-04640BC10000}\0
// Helpfile:
// DepndLst:
// (1) v2.0 stdole, (C:\WINDOWS\SYSTEM\STDOLE2.TLB)
// (2) v4.0 StdVCL, (C:\WINDOWS\SYSTEM\STDVCL40.DLL)
// *****
{$TYPEDADDRESS OFF} // Unit must be compiled without type-checked
// pointers.

interface

uses Windows, ActiveX, Classes, Graphics, OleServer, OleCtrls, StdVCL;

// *****//
// GUIDS declared in the TypeLibrary. Following prefixes are used:
// Type Libraries      : LIBID_xxxx
// CoClasses           : CLASS_xxxx
// DISPInterfaces     : DIID_xxxx
// Non-DISP interfaces: IID_xxxx
// *****//
const
  // TypeLibrary Major and minor versions
  AxCardMajorVersion = 1;
  AxCardMinorVersion = 0;

  LIBID_AxCard: TGUID = '{7B33D940-0A2C-11D2-AE5C-04640BC10000}';

  IID_ICardX: TGUID = '{7B33D941-0A2C-11D2-AE5C-04640BC10000}';
  DIID_ICardXEvents: TGUID = '{7B33D943-0A2C-11D2-AE5C-04640BC10000}';
  CLASS_CardX: TGUID = '{7B33D945-0A2C-11D2-AE5C-04640BC10000}';

// *****//
// Declaration of Enumerations defined in Type Library
// *****//
// Constants for enum TxDragMode
type
  TxDragMode = ToleEnum;
const
  dmManual = $00000000;
  dmAutomatic = $00000001;

```

LISTING 7.1 Continued

```
// Constants for enum TxCardSuit
type
    TxCardSuit = ToleEnum;
const
    csClub = $00000000;
    csDiamond = $00000001;
    csHeart = $00000002;
    csSpade = $00000003;

// Constants for enum TxCardValue
type
    TxCardValue = ToleEnum;
const
    cvAce = $00000000;
    cvTwo = $00000001;
    cvThree = $00000002;
    cvFour = $00000003;
    cvFive = $00000004;
    cvSix = $00000005;
    cvSeven = $00000006;
    cvEight = $00000007;
    cvNine = $00000008;
    cvTen = $00000009;
    cvJack = $0000000A;
    cvQueen = $0000000B;
    cvKing = $0000000C;

// Constants for enum TxMouseButton
type
    TxMouseButton = ToleEnum;
const
    mbLeft = $00000000;
    mbRight = $00000001;
    mbMiddle = $00000002;

// Constants for enum TxAlignment
type
    TxAlignment = ToleEnum;
const
    taLeftJustify = $00000000;
    taRightJustify = $00000001;
    taCenter = $00000002;

// Constants for enum TxBiDiMode
type
```

```

    TxBiDiMode = ToleEnum;
const
    bdLeftToRight = $00000000;
    bdRightToLeft = $00000001;
    bdRightToLeftNoAlign = $00000002;
    bdRightToLeftReadingOnly = $00000003;

type

// *****//
// Forward declaration of types defined in TypeLibrary
// *****//
    ICardX = interface;
    ICardXDisp = dispinterface;
    ICardXEvents = dispinterface;

// *****//
// Declaration of CoClasses defined in Type Library
// (NOTE: Here we map each CoClass to its Default Interface)
// *****//
    CardX = ICardX;

// *****//
// Interface: ICardX
// Flags:      (4416) Dual OleAutomation Dispatchable
// GUID:      {7B33D941-0A2C-11D2-AE5C-04640BC10000}
// *****//
ICardX = interface(IDispatch)
    ['{7B33D941-0A2C-11D2-AE5C-04640BC10000}']
    function Get_BackColor: OLE_COLOR; safecall;
    procedure Set_BackColor(Value: OLE_COLOR); safecall;
    function Get_Color: OLE_COLOR; safecall;
    procedure Set_Color(Value: OLE_COLOR); safecall;
    function Get_DragCursor: Smallint; safecall;
    procedure Set_DragCursor(Value: Smallint); safecall;
    function Get_DragMode: TxDragMode; safecall;
    procedure Set_DragMode(Value: TxDragMode); safecall;
    function Get_FaceUp: WordBool; safecall;
    procedure Set_FaceUp(Value: WordBool); safecall;
    function Get_ParentColor: WordBool; safecall;
    procedure Set_ParentColor(Value: WordBool); safecall;
    function Get_Suit: TxCardSuit; safecall;
    procedure Set_Suit(Value: TxCardSuit); safecall;
    function Get_Value: TxCardValue; safecall;
    procedure Set_Value(Value: TxCardValue); safecall;

```

LISTING 7.1 Continued

```

function Get_DoubleBuffered: WordBool; safecall;
procedure Set_DoubleBuffered(Value: WordBool); safecall;
procedure FlipChildren(AllLevels: WordBool); safecall;
function DrawTextBiDiModeFlags(Flags: Integer): Integer; safecall;
function DrawTextBiDiModeFlagsReadingOnly: Integer; safecall;
function Get_Enabled: WordBool; safecall;
procedure Set_Enabled(Value: WordBool); safecall;
function GetControlsAlignment: TxAlignment; safecall;
procedure InitiateAction; safecall;
function IsRightToLeft: WordBool; safecall;
function UseRightToLeftAlignment: WordBool; safecall;
function UseRightToLeftReading: WordBool; safecall;
function UseRightToLeftScrollBar: WordBool; safecall;
function Get_BiDiMode: TxBiDiMode; safecall;
procedure Set_BiDiMode(Value: TxBiDiMode); safecall;
function Get_Visible: WordBool; safecall;
procedure Set_Visible(Value: WordBool); safecall;
function Get_Cursor: Smallint; safecall;
procedure Set_Cursor(Value: Smallint); safecall;
function ClassNameIs(const Name: WideString): WordBool; safecall;
procedure AboutBox; safecall;
property BackColor: OLE_COLOR read Get_BackColor write Set_BackColor;
property Color: OLE_COLOR read Get_Color write Set_Color;
property DragCursor: Smallint read Get_DragCursor write
    Set_DragCursor;
property DragMode: TxDragMode read Get_DragMode write Set_DragMode;
property FaceUp: WordBool read Get_FaceUp write Set_FaceUp;
property ParentColor: WordBool read Get_ParentColor write
    Set_ParentColor;
property Suit: TxCardSuit read Get_Suit write Set_Suit;
property Value: TxCardValue read Get_Value write Set_Value;
property DoubleBuffered: WordBool read Get_DoubleBuffered write
    Set_DoubleBuffered;
property Enabled: WordBool read Get_Enabled write Set_Enabled;
property BiDiMode: TxBiDiMode read Get_BiDiMode write Set_BiDiMode;
property Visible: WordBool read Get_Visible write Set_Visible;
property Cursor: Smallint read Get_Cursor write Set_Cursor;
end;

// *****//
// DispIntf: ICardXDisp
// Flags:      (4416) Dual OleAutomation Dispatchable
// GUID:      {7B33D941-0A2C-11D2-AE5C-04640BC10000}
// *****//
ICardXDisp = dispinterface

```

```

    ['{7B33D941-0A2C-11D2-AE5C-04640BC10000}']
    property BackColor: OLE_COLOR dispid 1;
    property Color: OLE_COLOR dispid -501;
    property DragCursor: Smallint dispid 2;
    property DragMode: TxDragMode dispid 3;
    property FaceUp: WordBool dispid 4;
    property ParentColor: WordBool dispid 5;
    property Suit: TxCardSuit dispid 6;
    property Value: TxCardValue dispid 7;
    property DoubleBuffered: WordBool dispid 10;
    procedure FlipChildren(AllLevels: WordBool); dispid 11;
    function DrawTextBiDiModeFlags(Flags: Integer): Integer; dispid 14;
    function DrawTextBiDiModeFlagsReadingOnly: Integer; dispid 15;
    property Enabled: WordBool dispid -514;
    function GetControlsAlignment: TxAlignment; dispid 16;
    procedure InitiateAction; dispid 18;
    function IsRightToLeft: WordBool; dispid 19;
    function UseRightToLeftAlignment: WordBool; dispid 24;
    function UseRightToLeftReading: WordBool; dispid 25;
    function UseRightToLeftScrollBar: WordBool; dispid 26;
    property BiDiMode: TxBiDiMode dispid 27;
    property Visible: WordBool dispid 28;
    property Cursor: Smallint dispid 29;
    function ClassNameIs(const Name: WideString): WordBool; dispid 33;
    procedure AboutBox; dispid -552;
end;

// *****
// DispIntf: ICardXEvents
// Flags: (4096) Dispatchable
// GUID: {7B33D943-0A2C-11D2-AE5C-04640BC10000}
// *****
ICardXEvents = dispinterface
    ['{7B33D943-0A2C-11D2-AE5C-04640BC10000}']
    procedure OnClick; dispid 1;
    procedure OnDblClick; dispid 2;
    procedure OnKeyPress(var Key: Smallint); dispid 7;
end;

// *****
// OLE Control Proxy class declaration
// Control Name : TCardX
// Help String : CardX Control
// Default Interface: ICardX
// Def. Intf. DISP? : No

```

continues

7

USING ACTIVE X
CONTROLS WITH
DELPHI

LISTING 7.1 Continued

```
// Event Interface: ICardXEvents
// TypeFlags      : (34) CanCreate Control
// *****//
TCardXOnKeyPress = procedure(Sender: TObject; var Key: Smallint) of
    object;

TCardX = class(TOLEControl)
private
    FOnClick: TNotifyEvent;
    FOnDbClick: TNotifyEvent;
    FOnKeyPress: TCardXOnKeyPress;
    FIntf: ICardX;
    function GetControlInterface: ICardX;
protected
    procedure CreateControl;
    procedure InitControlData; override;
public
    procedure FlipChildren(AllLevels: WordBool);
    function DrawTextBiDiModeFlags(Flags: Integer): Integer;
    function DrawTextBiDiModeFlagsReadingOnly: Integer;
    function GetControlsAlignment: TxAlignment;
    procedure InitiateAction;
    function IsRightToLeft: WordBool;
    function UseRightToLeftAlignment: WordBool;
    function UseRightToLeftReading: WordBool;
    function UseRightToLeftScrollBar: WordBool;
    function ClassNameIs(const Name: WideString): WordBool;
    procedure AboutBox;
    property ControlInterface: ICardX read GetControlInterface;
    property DefaultInterface: ICardX read GetControlInterface;
    property DoubleBuffered: WordBool index 10 read GetWordBoolProp write
        SetWordBoolProp;
    property Enabled: WordBool index -514 read GetWordBoolProp write
        SetWordBoolProp;
    property BiDiMode: TOLEEnum index 27 read GetTOLEEnumProp write
        SetTOLEEnumProp;
    property Visible: WordBool index 28 read GetWordBoolProp write
        SetWordBoolProp;
published
    property TabStop;
    property Align;
    property ParentShowHint;
    property PopupMenu;
    property ShowHint;
    property TabOrder;
```

```

property OnDragDrop;
property OnDragOver;
property OnEndDrag;
property OnEnter;
property OnExit;
property OnStartDrag;
property BackColor: TColor index 1 read GetTColorProp write
    SetTColorProp stored False;
property Color: TColor index -501 read GetTColorProp write
    SetTColorProp stored False;
property DragCursor: Smallint index 2 read GetSmallintProp write
    SetSmallintProp stored False;
property DragMode: ToleEnum index 3 read GetTOleEnumProp write
    SetTOleEnumProp stored False;
property FaceUp: WordBool index 4 read GetWordBoolProp write
    SetWordBoolProp stored False;
property ParentColor: WordBool index 5 read GetWordBoolProp write
    SetWordBoolProp stored False;
property Suit: ToleEnum index 6 read GetTOleEnumProp write
    SetTOleEnumProp stored False;
property Value: ToleEnum index 7 read GetTOleEnumProp write
    SetTOleEnumProp stored False;
property Cursor: Smallint index 29 read GetSmallintProp write
    SetSmallintProp stored False;
property OnClick: TNotifyEvent read FOnClick write FOnClick;
property OnDblClick: TNotifyEvent read FOnDblClick write FOnDblClick;
property OnKeyPress: TCardXOnKeyPress read FOnKeyPress write
    FOnKeyPress;
end;

```

```
procedure Register;
```

```
implementation
```

```
uses ComObj;
```

```
procedure TCardX.InitControlData;
```

```
const
```

```

CEventDispIDs: array [0..2] of DWORD = (
    $00000001, $00000002, $00000007);
CControlData: TControlData2 = (
    ClassID: '{7B33D945-0A2C-11D2-AE5C-04640BC10000}';
    EventIID: '{7B33D943-0A2C-11D2-AE5C-04640BC10000}';
    EventCount: 3;
    EventDispIDs: @CEventDispIDs;
    LicenseKey: nil (*HR:$00000000*);

```

LISTING 7.1 Continued

```
    Flags: $00000009;
    Version: 401);
begin
    ControlData := @CControlData;
    TControlData2(CControlData).FirstEventOfs :=
        Cardinal(@@FOnClick) - Cardinal(Self);
end;

procedure TCardX.CreateControl;

    procedure DoCreate;
    begin
        FIntf := IUnknown(OleObject) as ICardX;
    end;

begin
    if FIntf = nil then DoCreate;
end;

function TCardX.GetControlInterface: ICardX;
begin
    CreateControl;
    Result := FIntf;
end;

procedure TCardX.FlipChildren(AllLevels: WordBool);
begin
    DefaultInterface.FlipChildren(AllLevels);
end;

function TCardX.DrawTextBiDiModeFlags(Flags: Integer): Integer;
begin
    Result := DefaultInterface.DrawTextBiDiModeFlags(Flags);
end;

function TCardX.DrawTextBiDiModeFlagsReadingOnly: Integer;
begin
    Result := DefaultInterface.DrawTextBiDiModeFlagsReadingOnly;
end;

function TCardX.GetControlsAlignment: TxAlignment;
begin
    Result := DefaultInterface.GetControlsAlignment;
end;
```

```
procedure TCardX.InitiateAction;
begin
  DefaultInterface.InitiateAction;
end;

function TCardX.IsRightToLeft: WordBool;
begin
  Result := DefaultInterface.IsRightToLeft;
end;

function TCardX.UseRightToLeftAlignment: WordBool;
begin
  Result := DefaultInterface.UseRightToLeftAlignment;
end;

function TCardX.UseRightToLeftReading: WordBool;
begin
  Result := DefaultInterface.UseRightToLeftReading;
end;

function TCardX.UseRightToLeftScrollBar: WordBool;
begin
  Result := DefaultInterface.UseRightToLeftScrollBar;
end;

function TCardX.ClassNameIs(const Name: WideString): WordBool;
begin
  Result := DefaultInterface.ClassNameIs(Name);
end;

procedure TCardX.AboutBox;
begin
  DefaultInterface.AboutBox;
end;

procedure Register;
begin
  RegisterComponents('ActiveX',[TCardX]);
end;

end.
```

Now that you've seen the code generated by the type library editor, let's look a little deeper at the type library import mechanism.

Where Do Wrapper Files Come From?

The first thing you might notice is that the filename ends in `_TLB`. More subtly, you might have caught on to the fact that there are several references to “library” in the generated source file. Both of these are clues as to the origin of the wrapper file: the control’s type library. An ActiveX control’s type library is special information linked to the control as a resource that describes the different elements of an ActiveX control. In particular, type libraries contain information such as the interfaces supported by a control, the properties, methods, and events of a control, and the enumerated types used by the control. The first entry in the wrapper file is the GUID of the control’s type library.

NOTE

Type libraries are used more generally for any type of Automation object. Chapter 23, “COM and ActiveX,” contains more information on type libraries and their use.

Enumerations

Looking at the generated unit from the top down, immediately following the type library GUID, are the enumerated types used by the control. Notice that the enumerations are declared as simple constants rather than true enumerated types. This is done because type library enumerations, like those in the C language, do not need to start at zero, and the element ordinals do not need to be contiguous. Because this type of declaration isn’t legal in Object Pascal, the enumerations must be declared as constants.

Control Interfaces

Next in the wrapper file, the control’s primary interface is declared. Here, you’ll find all the properties and methods of the ActiveX control. The properties are also redeclared in a `dispinterface`, thus allowing the control to be used as a dual interface. The events are declared separately next in a `dispinterface`. You definitely don’t need to know about interfaces to use ActiveX controls in your applications. What’s more, working with interfaces can be a complicated topic, so we won’t go into too much detail right now. You’ll find more information on interfaces in general in Chapter 23, “COM and ActiveX,” and information on interfaces with ActiveX controls in Chapter 25, “Creating ActiveX Controls.”

TOLeControl Descendant

Next in the unit file comes the class definition for the control wrapper. By default, the name of the ActiveX control wrapper object is `TXX`, where `X` is the name of the control’s `coclass` in the type library. This object, like all ActiveX control wrappers, descends from the `TOLeControl`

class. `TOLEControl` is a window handle-bearing component that descends from `TWinControl`. `TOLEControl` encapsulates the complexities of mapping the functionality of ActiveX controls to Delphi components so that ActiveX controls work seamlessly from Delphi. `TOLEControl` is an *abstract class*—meaning that you never want to create an instance of one but instead use it as a starting place for other classes.

The Methods

The first procedure shown is the `InitControlData()` procedure. This procedure is introduced in the `TOLEControl` object and is overridden for all descendants. It sets up the unique OLE class and event identification numbers in addition to other control-specific information. In particular, this method makes the `TOLEControl` aware of important ActiveX control details such as class IDs, control miscellaneous flags, and a license key if the control is licensed. This method is found in the protected part of the class definition because it's not useful to users of the class—it only has meaning internal to the class.

The `InitControlInterface()` method is overridden to initialize the private `FIntf` interface field with a pointer to the control's `ICardsX` interface.

The `CardX` ActiveX control exposes only one other method: `AboutBox()`. It's standard for ActiveX controls to contain a method called `AboutBox()` that invokes a custom About dialog box for the control. This method is called through the `vTable` interface using the `ControlInterface` property, which is read from the `FIntf` field.

NOTE

In addition to `vTable` calls using the `ControlInterface` property, `Control` methods can also be invoked via Automation using `TOLEControl`'s `OLEObject` property. As you'll learn in Chapter 23, "COM and ActiveX," it's usually more efficient to call methods via the `vTable` rather than through Automation.

The Properties

You might have noticed that the `TCardX` class has two distinct groups of properties. One group does not have read and write values specified. These are standard Delphi component properties and events inherited from the `TWinControl` and `TComponent` ancestor classes. The other group of properties all have an index as well as get and set methods specified. This group of properties includes the ActiveX control properties being encapsulated by the `TOLEControl`.

The specialized get and set methods for the encapsulated properties provide the magic that bridges the gap between the ActiveX control properties and the Object Pascal component properties. Notice the read and write methods that get and set properties for every specific type

(such as `GetBoolProp()`, `SetBoolProp()`, `GetStringProp()`, `SetStringProp()`, and so on). Although there are get and set methods for each property type, they all operate similarly. In fact, the following code shows generic get and set methods for `TOLEControl` that would work given a property of type *X*:

```
function TOLEControl.GetXProp(Index: Integer): X;
var
    Temp: TVarData;
begin
    GetProperty(Index, Temp);
    Result := Temp.VX;
end;

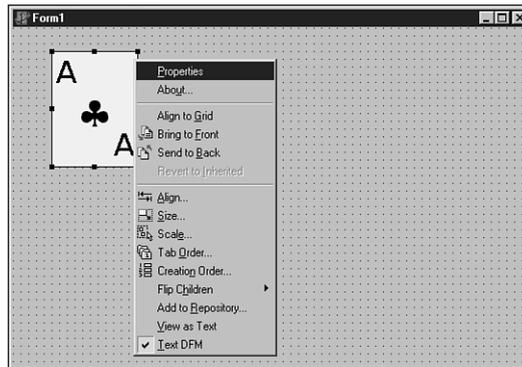
procedure TOLEControl.SetXProp(Index: Integer; Value: X);
var
    Temp: TVarData;
begin
    Temp.VType := varX;
    Temp.VX := Value;
    SetProperty(Index, Temp);
end;
```

In this code, the index of the property (as indicated by the `index` directive in the properties of the `TCardsCtrl` component) is implicitly passed to the procedures. The variable of type *X* is packaged into a `TVarData` (a record that represents a Variant) data record, and those parameters are passed to the `GetProperty()` or `SetProperty()` method of `TOLEControl`. Each property of the ActiveX control has a unique index that acts as an identifier. Using this index and the `TVarData` variable `Temp`, `GetProperty()` and `SetProperty()` use OLE Automation to get and set the property values inside the ActiveX control.

If you've worked with other development packages before, you'll appreciate that Delphi provides easy access not only to the ActiveX control's own properties but also to normal `TWinControl` properties and methods. This enables you to use an ActiveX control like other handle-bearing controls in Delphi and makes it possible for you to use object-oriented principles to override the behavior of an ActiveX control by creating customized descendants of ActiveX controls in the Delphi environment.

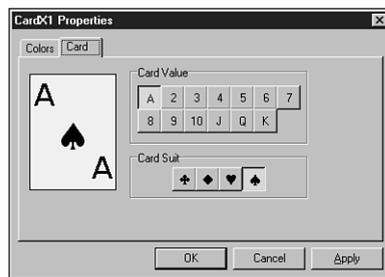
Using ActiveX Controls in Your Applications

After you link your ActiveX control wrapper into the component library, you've actually fought most of the battle. After an ActiveX control has been placed on the Component Palette, its usage is much the same as that of a regular Delphi component. Figure 7.4 shows the Delphi environment with a `TCardX` focused in the Form Designer. Notice the `TCardX` properties listed in the Object Inspector.

**FIGURE 7.4**

Working with an ActiveX control in Delphi.

In addition to an ActiveX control's properties being set with the Object Inspector, some ActiveX controls also provide a Properties dialog box that's revealed by selecting the Properties option from the context menu in the Delphi Form Designer. The context menu, also shown in Figure 7.4, is revealed by right-clicking over a particular control. The Properties dialog box actually lives within the ActiveX control; its look, feel, and contents are determined entirely by the control designer. Figure 7.5 shows the Properties dialog box for the TCardX ActiveX control.

**FIGURE 7.5**

The TCardX Properties dialog box.

As you can imagine, this particular control comes equipped with properties that enable you to specify card suit, value, color and picture for card back as well as the standard properties that refer to position, tab order, and so on. The card in Figure 7.4 has its Value property set to 1 (Ace) and its Suit property set to 3 (Spades).

Shipping ActiveX Control–Equipped Applications

When you're ready to ship your ActiveX control–equipped application, there are some deployment issues to bear in mind as you prepare to send your ActiveX control and associated files to your customers:

- You must ship the OCX or DLL file that contains the ActiveX controls you're using in your application. OCX files, being DLLs, are not linked into your application's executable. Additionally, before the user can use your application, the ActiveX control must be registered in that user's System Registry. ActiveX control registration is discussed in the following section.
- Some ActiveX controls require one or more external DLLs or other files to operate. Check the documentation for your third-party ActiveX controls to determine whether any additional files must be deployed with your ActiveX control. See Chapter 25, "Creating ActiveX Controls," for information on what additional files might need to be deployed along with your Delphi-written controls.
- Many ActiveX controls come with a license file that's required if you want to use the control at design time. This file comes from the ActiveX control vendor, and it prevents your end users from designing applications with ActiveX controls you ship with your applications. You should not ship these LIC files with your application unless you intend for users of your application to use the licensed controls in a development tool and you have the appropriate license for such redistribution.

ActiveX Control Registration

Before an ActiveX control can be used on any system (including those of customers or clients who run your applications), it must be registered with the System Registry. Most commonly, this is accomplished using the `RegSvr32.exe` application, which comes with most versions of Windows. Alternatively, you can use the `TRegSvr.exe` command-line registration utility found in the Delphi `bin` directory. Occasionally, you might want to register the control more transparently to give your application an integrated feel. Luckily, it's not difficult to integrate ActiveX control registration (and unregistration) into your application. Inprise provides the source code for the `TRegSvr` utility as a sample application, and it provides an excellent demonstration for how to register ActiveX servers and type libraries.

BlackJack: An OCX Application Example

The best way to demonstrate how to use an ActiveX control in an application is to show you how to write a useful application that incorporates an ActiveX control. This example uses the `TCardX` ActiveX control; what better way to demonstrate a card control than to make a black-jack game? For the sake of argument, assume that all programmers are high rollers and don't

need to be told the rules of the game (didn't know this book was a comedy, did you?). This way, you can concentrate on the programming job at hand.

As you can imagine, most of the code for this application deals with the logic of the game of blackjack. All the code is provided in the listings later in this chapter; right now, the discussion is narrowed to the individual portions of code that deal directly with managing and manipulating the ActiveX controls. The name of this project is BJ; to give you an idea of where the code comes from, Figure 7.6 shows a game of DDG BlackJack in progress.

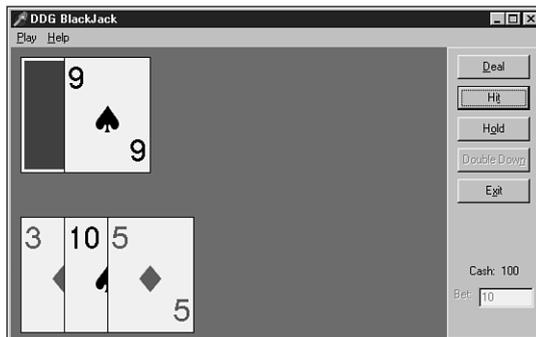


FIGURE 7.6

Playing DDG BlackJack.

The Card Deck

Before writing the game itself, you must first write an object that encapsulates a deck of playing cards. Unlike a real card deck (in which cards are picked from the top of a scrambled deck), this card deck object contains an unscrambled card deck and uses pseudorandom numbers to pick a random card from the unscrambled deck. This is possible because each card has a notion of whether it has been used. This greatly simplifies the shuffle procedure, too, because all the object has to do is set each of the cards to unused. The code for the `PlayCard.pas` unit, which contains the `TCardDeck` object, is shown in Listing 7.2.

LISTING 7.2 The `PlayCard.pas` Unit

```
unit PlayCard;  
  
interface  
  
uses SysUtils, Cards;  
  
type
```

continues

LISTING 7.2 Continued

```
ECardError = class(Exception); // generic card exception

TPlayingCard = record          // represents one card
  Face: TCardValue;           // card face value
  Suit: TCardSuit;            // card suit value
end;

{ an array of 52 cards representing one deck }
TCardArray = array[1..52] of TPlayingCard;

{ Object which represents a deck of 52 UNIQUE cards. }
{ This is a scrambled deck of 52 cards, and the      }
{ object keeps track of how far throughout the deck }
{ the user has picked. }
TCardDeck = class
private
  FCardArray: TCardArray;
  FTop: integer;
  procedure InitCards;
  function GetCount: integer;
public
  property Count: integer read GetCount;
  constructor Create; virtual;
  procedure Shuffle;
  function Draw: TPlayingCard;
end;

{ GetCardValue returns the numeric value of any card }
function GetCardValue(C: TPlayingCard): Integer;

implementation

function GetCardValue(C: TPlayingCard): Integer;
{ returns a card's numeric value }
begin
  Result := Ord(C.Face) + 1;
  if Result > 10 then Result := 10;
end;

procedure TCardDeck.InitCards;
{ initializes the deck by assigning a unique value/suit combination }
{ to each card. }
var
  i: integer;
```

```

    AFace: TCardValue;
    ASuit: TCardSuit;
begin
    AFace := cvAce;           // start with ace
    ASuit := csClub;         // start with clubs
    for i := 1 to 52 do      // for each card in deck...
    begin
        FCardArray[i].Face := AFace; // assign face
        FCardArray[i].Suit := ASuit;  // assign suit
        if (i mod 4 = 0) and (i <> 52) then // every four cards...
            inc(AFace); // increment the face
        if ASuit <> High(TCardSuit) then // always increment the suit
            inc(ASuit)
        else
            ASuit := Low(TCardSuit);
    end;
end;

constructor TCardDeck.Create;
{ constructor for TCardDeck object. }
begin
    inherited Create;
    InitCards;
    Shuffle;
end;

function TCardDeck.GetCount: integer;
{ Returns a count of unused cards }
begin
    Result := 52 - FTop;
end;

procedure TCardDeck.Shuffle;
{ Re-mixes cards and sets top card to 0. }
var
    i: integer;
    RandCard: TPlayingCard;
    RandNum: integer;
begin
    for i := 1 to 52 do
    begin
        RandNum := Random(51) + 1; // pick random number
        RandCard := FCardArray[RandNum]; // swap next card with
        FCardArray[RandNum] := FCardArray[i]; // random card in deck
        FCardArray[i] := RandCard;
    end;
end;

```



```

end;
DblBtn.Enabled := False;           // hit disables double down
if CurCard.Face = cvAce then PAceFlag := True; // set ace flag
Inc(PlayerTotal, GetCardValue(CurCard));      // keep running total
PlayLbl.Caption := IntToStr(PlayerTotal);     // cheat
if PlayerTotal > 21 then                     // track bust
begin
  ShowMessage('Busted!');
  ShowFirstCard;
  ShowWinner;
end;
end;
end;

```

In this procedure, a random card, called `CurCard`, is drawn from a `TCardDeck` object called `CardDeck`. A `TCardX` ActiveX control is then created, and property values are assigned. `NextPlayerPos` is a variable that keeps track of the position on the X-axis for the next card. `PYPos` is a constant that dictates the Y-axis position of the player hand. The `Suit` and `Value` properties are assigned values that correspond to the `Suit` and `Face` of `CurCard`. `MainForm` is assigned to be the Parent of the control, and the `NextPlayerPos` variable is incremented by half the width of a card. After all that, the `PlayerTotal` variable is incremented by the card value to keep track of the player's score.

The `DealerHit()` procedure works similarly to the `Hit()` procedure. The code from that procedure is shown here:

```

procedure TMainForm.DealerHit(CardVisible: Boolean);
{ Dealer takes a hit }
begin
  CurCard := CardDeck.Draw;           // dealer draws a card
  with TCardX.Create(Self) do        // create the ActiveX control
  begin
    Left := NextDealerPos;           // place card on form
    Top := DYPos;
    Suit := Ord(CurCard.Suit);       // assign suit
    FaceUp := CardVisible;
    Value := Ord(CurCard.Face);      // assign face
    Parent := Self;                  // assign parent for OCX
    Inc(NextDealerPos, Width div 2); // track where to place next card
    Update;                           // Display card
  end;
  if CurCard.Face = cvAce then DAceFlag := True; // set Ace flag
  Inc(DealerTotal, GetCardValue(CurCard));      // keep count
  DealLbl.Caption := IntToStr(DealerTotal);     // cheat
  if DealerTotal > 21 then                     // track dealer bust
    ShowMessage('Dealer Busted!');
end;
end;

```

This method accepts a Boolean parameter called `CardVisible`, which indicates whether the card should be dealt face up. This is because blackjack rules dictate that the dealer's first card must remain face down until the player has chosen to hold or has busted. Observing this rule, the first call to `DealerHit()` will result in `False` being passed in `CardVisible`.

The `FreeCards()` procedure is responsible for removing all the `TCardX` controls on the main form. Because the application doesn't keep an array or a bunch of variables of type `TCardX` around to manage the cards on the screen, this procedure iterates through the form's `Controls` array property looking for elements of type `TCardX`. When a control of that type is found, its `Free` method is called to remove it from memory. The trick here is to be sure to go *backward* through the array. If you don't go backward, you run the risk of changing the order of controls in the array while you're traversing the array, which can cause errors. The code for the `FreeCards` procedure is shown here:

```
procedure TMainForm.FreeCards;
{ frees all AX Ctl cards on the screen }
var
  i: integer;
begin
  for i := ControlCount - 1 downto 0 do // go backward!
    if Controls[i] is TCardX then
      Controls[i].Free;
end;
```

That completes the explanation of the main portions of the code that manipulates the ActiveX controls. The complete listing for `Main.pas`, the main unit for this application, is shown in Listing 7.3.

LISTING 7.3 The Main.pas Unit for the BJ Project

```
unit Main;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  OleCtrls, Card_TLB, Cards, PlayCard, StdCtrls, ExtCtrls, Menus;

type
  TMainForm = class(TForm)
    Panel1: TPanel;
    MainMenu1: TMainMenu;
    Play1: TMenuItem;
    Deal1: TMenuItem;
    Hit1: TMenuItem;
```

```
Hold1: TMenuItem;
DoubleDown1: TMenuItem;
N1: TMenuItem;
Close1: TMenuItem;
Help1: TMenuItem;
About1: TMenuItem;
Panel2: TPanel;
Label3: TLabel;
CashLabel: TLabel;
BetLabel: TLabel;
HitBtn: TButton;
DealBtn: TButton;
HoldBtn: TButton;
ExitBtn: TButton;
BetEdit: TEdit;
DblBtn: TButton;
CheatPanel: TPanel;
DealLbl: TLabel;
PlayLbl: TLabel;
Label4: TLabel;
Label6: TLabel;
Cheat1: TMenuItem;
N2: TMenuItem;
procedure FormCreate(Sender: TObject);
procedure FormDestroy(Sender: TObject);
procedure About1Click(Sender: TObject);
procedure Cheat1Click(Sender: TObject);
procedure ExitBtnClick(Sender: TObject);
procedure DblBtnClick(Sender: TObject);
procedure DealBtnClick(Sender: TObject);
procedure HitBtnClick(Sender: TObject);
procedure HoldBtnClick(Sender: TObject);
private
CardDeck: TCardDeck;
CurCard: TPlayingCard;
NextPlayerPos: integer;
NextDealerPos: integer;
PlayerTotal: integer;
DealerTotal: integer;
PAceFlag: Boolean;
DAceFlag: Boolean;
PBJFlag: Boolean;
DBJFlag: Boolean;
DDFlag: Boolean;
Procedure Deal;
procedure DealerHit(CardVisible: Boolean);
```

LISTING 7.3 Continued

```
    procedure DoubleDown;
    procedure EnableMoves(Enable: Boolean);
    procedure FreeCards;
    procedure Hit;
    procedure Hold;
    procedure ShowFirstCard;
    procedure ShowWinner;
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

uses AboutU;

const
    PYPos = 175;           // starting y pos for player cards
    DYPos = 10;           // ditto for dealer's cards

procedure TMainForm.FormCreate(Sender: TObject);
begin
    CardDeck := TCardDeck.Create;
end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
    CardDeck.Free;
end;

procedure TMainForm.About1Click(Sender: TObject);
{ Creates and invokes about box }
begin
    with TAboutBox.Create(Self) do
        try
            ShowModal;
        finally
            Free;
        end;
end;

procedure TMainForm.Cheat1Click(Sender: TObject);
begin
```

```
Cheat1.Checked := not Cheat1.Checked;
CheatPanel.Visible := Cheat1.Checked;
end;

procedure TMainForm.ExitBtnClick(Sender: TObject);
begin
  Close;
end;

procedure TMainForm.DblBtnClick(Sender: TObject);
begin
  DoubleDown;
end;

procedure TMainForm.DealBtnClick(Sender: TObject);
begin
  Deal;
end;

procedure TMainForm.HitBtnClick(Sender: TObject);
begin
  Hit;
end;

procedure TMainForm.HoldBtnClick(Sender: TObject);
begin
  Hold;
end;

procedure TMainForm.Deal;
{ Deals a new hand for dealer and player }
begin
  FreeCards;           // remove any cards from screen
  BetEdit.Enabled := False; // disable bet edit ctrl
  BetLabel.Enabled := False; // disable bet label
  if CardDeck.Count < 11 then // reshuffle deck if < 11 cards
  begin
    Panel1.Caption := 'Reshuffling and dealing...';
    CardDeck.Shuffle;
  end
  else
    Panel1.Caption := 'Dealing...';
  Panel1.Show; // show "dealing" panel
  Panel1.Update; // make sure it's visible
  NextPlayerPos := 10; // set horiz position of cards
  NextDealerPos := 10;
```

LISTING 7.3 Continued

```

PlayerTotal := 0;           // reset card totals
DealerTotal := 0;
PAceFlag := False;        // reset flags
DAceFlag := False;
PBJFlag := False;
DBJFlag := False;
DDFlag := False;
Hit;                       // hit player
DealerHit(False);         // hit dealer
Hit;                       // hit player
DealerHit(True);          // hit dealer
Panel1.Hide;              // hide panel
if (PlayerTotal = 11) and PAceFlag then
  PBJFlag := True;         // check player blackjack
if (DealerTotal = 11) and DAceFlag then
  DBJFlag := True;         // check dealer blackjack
if PBJFlag or DBJFlag then // if a blackjack occurred
begin
  ShowFirstCard;           // flip dealer's card
  ShowMessage('Blackjack!');
  ShowWinner;              // determine winner
end
else
  EnableMoves(True);       // enable hit, hold double down
end;

procedure TMainForm.DealerHit(CardVisible: Boolean);
{ Dealer takes a hit }
begin
  CurCard := CardDeck.Draw; // dealer draws a card
  with TCardX.Create(Self) do // create the ActiveX control
  begin
    Left := NextDealerPos; // place card on form
    Top := DYPos;
    Suit := Ord(CurCard.Suit); // assign suit
    FaceUp := CardVisible;
    Value := Ord(CurCard.Face); // assign face
    Parent := Self; // assign parent for AX Ctl
    Inc(NextDealerPos, Width div 2); // track where to place next card
    Update; // show card
  end;
  if CurCard.Face = cvAce then DAceFlag := True; // set Ace flag
  Inc(DealerTotal, GetCardValue(CurCard)); // keep count
  DealLbl.Caption := IntToStr(DealerTotal); // cheat
  if DealerTotal > 21 then // track dealer bust

```

```

    ShowMessage('Dealer Busted!');
end;

procedure TMainForm.DoubleDown;
{ Called to double down on dealt hand }
begin
    DDFlag := True;           // set double down flag to adjust bet
    Hit;                       // take one card
    Hold;                       // let dealer take his cards
end;

procedure TMainForm.EnableMoves(Enable: Boolean);
{ Enables/disables moves buttons/menu items }
begin
    HitBtn.Enabled := Enable;   // Hit button
    HoldBtn.Enabled := Enable;  // Hold button
    DblBtn.Enabled := Enable;   // Double down button
    Hit1.Enabled := Enable;     // Hit menu item
    Hold1.Enabled := Enable;    // Hold menu item
    DoubleDown1.Enabled := Enable; // Double down menu item
end;

procedure TMainForm.FreeCards;
{ frees all AX Ctl cards on the screen }
var
    i: integer;
begin
    for i := ControlCount - 1 downto 0 do // go backward!
        if Controls[i] is TCardX then
            Controls[i].Free;
end;

procedure TMainForm.Hit;
{ Player hit }
begin
    CurCard := CardDeck.Draw;    // draw card
    with TCardX.Create(Self) do  // create card AX Ctl
        begin
            Left := NextPlayerPos; // set position
            Top := PYPos;
            Suit := Ord(CurCard.Suit); // set suit
            Value := Ord(CurCard.Face); // set value
            Parent := Self; // assign parent
            Inc(NextPlayerPos, Width div 2); // track position
            Update; // Display card
        end;
end;

```

LISTING 7.3 Continued

```
    Db1Btn.Enabled := False;           // hit disables double down
    if CurCard.Face = cvAce then PAceFlag := True; // set ace flag
    Inc(PlayerTotal, GetCardValue(CurCard));      // keep running total
    PlayLbl.Caption := IntToStr(PlayerTotal);    // cheat
    if PlayerTotal > 21 then                    // track bust
    begin
        ShowMessage('Busted!');
        ShowFirstCard;
        ShowWinner;
    end;
end;

procedure TMainForm.Hold;
{ Player holds. This procedure allows dealer to draw cards. }
begin
    EnableMoves(False);
    ShowFirstCard;           // show dealer card
    if PlayerTotal <= 21 then // if player hasn't busted...
    begin
        if DAceFlag then     // if dealer has an Ace...
        begin
            { Dealer must hit soft 17 }
            while (DealerTotal <= 7) or ((DealerTotal >= 11) and
                (DealerTotal < 17)) do
                DealerHit(True);
        end
        else
            // if no Ace, keep hitting until 17 is reached
            while DealerTotal < 17 do DealerHit(True);
        end;
        ShowWinner;           // Determine winner
    end;
end;

procedure TMainForm.ShowFirstCard;
var
    i: integer;
begin
    // make sure all cards are face-up
    for i := 0 to ControlCount - 1 do
        if Controls[i] is TCardX then
        begin
            TCardX(Controls[i]).FaceUp := True;
            TCardX(Controls[i]).Update;
        end;
    end;
end;
```

```

end;

procedure TMainForm.ShowWinner;
{ Determines winning hand }
var
  S: string;
begin
  if DAceFlag then // if dealer has an Ace...
  begin
    if DealerTotal + 10 <= 21 then // figure best hand
      inc(DealerTotal, 10);
    end;
  if PAceFlag then // if player has an Ace...
  begin
    if PlayerTotal + 10 <= 21 then // figure best hand
      inc(PlayerTotal, 10);
    end;
  if DealerTotal > 21 then // set score to 0 if busted
    DealerTotal := 0;
  if PlayerTotal > 21 then
    PlayerTotal := 0;
  if PlayerTotal > DealerTotal then // if player wins...
  begin
    S := 'You win!';
    if DDFlag then // pay 2:1 on double down
      CashLabel.Caption := IntToStr(StrToInt(CashLabel.Caption) +
        StrToInt(BetEdit.Text) * 2)
    else // pay 1:1 normally
      CashLabel.Caption := IntToStr(StrToInt(CashLabel.Caption) +
        StrToInt(BetEdit.Text));
    if PBJFlag then // pay 1.5:1 on blackjack
      CashLabel.Caption := IntToStr(StrToInt(CashLabel.Caption) +
        StrToInt(BetEdit.Text) div 2)
  end
  else if DealerTotal > PlayerTotal then // if dealer wins...
  begin
    S := 'Dealer wins!';
    if DDFlag then // lose 2x on double down
      CashLabel.Caption := IntToStr(StrToInt(CashLabel.Caption) -
        StrToInt(BetEdit.Text) * 2)
    else // normal loss
      CashLabel.Caption := IntToStr(StrToInt(CashLabel.Caption) -
        StrToInt(BetEdit.Text));
  end
  end
  else
    S := 'Push!'; // push, no one wins

```

LISTING 7.3 Continued

```
if MessageDlg(S + #13#10'Do you want to play again with the same bet?',
    mtConfirmation, [mbYes, mbNo], 0) = mrYes then
    Deal;
    BetEdit.Enabled := True;           // allow bet to change
    BetLabel.Enabled := True;
end;

end.
```

Invoking an ActiveX Control Method

In Listing 7.3, you might have noticed that the main form contains a method that creates and displays an About dialog box. Figure 7.7 shows what this About dialog box looks like when invoked.

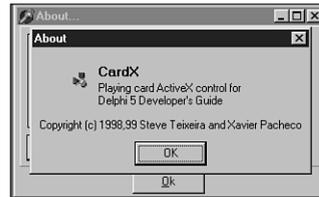
**FIGURE 7.7**

DDG BlackJack's About dialog box.

This About dialog box is special because it contains a button that, when selected, shows an About box for the CardX ActiveX control by calling its `AboutBox()` method. The About box for the CardX control is shown in Figure 7.8.

The code that accomplishes this task follows. Looking ahead, the same technique used to make `vTable` calls to OLE Automation servers in Chapter 23, “COM and ActiveX,” is used here.

```
procedure TAboutBox.CardBtnClick(Sender: TObject);
begin
    Card.AboutBox;
end;
```

**FIGURE 7.8**

The Cards ActiveX control About dialog box.

Summary

After reading this chapter, you should understand all the important aspects of using ActiveX controls in the Delphi environment. You learned about integrating an ActiveX control into Delphi, how the Object Pascal ActiveX control wrapper works, how to deploy an ActiveX control–equipped application, how to register an ActiveX control, and how to incorporate ActiveX controls into an application. Because of their market presence, ActiveX controls often can offer a blast of instant productivity. However, because ActiveX controls have some disadvantages, also remember to look for native VCL components when shopping for controls.

Advanced Techniques

PART



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Graphics Programming with GDI and Fonts

CHAPTER

8

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In previous chapters, you worked with a property called `Canvas`. `Canvas` is appropriately named because you can think of a window as an artist's blank canvas on which various Windows objects are painted. Each button, window, cursor, and so on is nothing more than a collection of pixels in which the colors have been set to give it some useful appearance. In fact, think of each individual window as a separate surface on which its separate components are painted. To take this analogy a bit further, imagine that you're an artist who requires various tools to accomplish your task. You need a palette from which to choose different colors. You'll probably use different styles of brushes, drawing tools, and special artist's techniques as well. Win32 makes use of similar tools and techniques—in the programming sense—to paint the various objects with which users interact. These tools are made available through the Graphics Device Interface, otherwise known as the *GDI*.

Win32 uses the GDI to paint or draw the images you see on your computer screen. Before Delphi, in traditional Windows programming, programmers worked directly with the GDI functions and tools. Now, the `TCanvas` object encapsulates and simplifies the use of these functions, tools, and techniques. This chapter teaches you how to use `TCanvas` to perform useful graphics functions. You'll also see how you can create advanced programming projects with Delphi 5 and Win32 GDI. We illustrate this by creating a paint program and animation program.

Delphi's Representation of Pictures: `TImage`

The `TImage` component represents a graphical image that can be displayed anywhere on a form and is available from Delphi 5's Component Palette. With `TImage`, you can load and display a bitmap file (`.bmp`), a 16-bit Windows metafile (`.wmf`), a 32-bit enhanced metafile (`.emf`), an icon file (`.ico`), a JPEG file (`.jpg`, `.jpeg`) or other file formats handled by add-in `TGraphic` classes. The image data actually is stored by `TImage`'s `Picture` property, which is of the type `TPicture`.

Graphic Images: Bitmaps, Metafiles, and Icons

Bitmaps

Win32 *bitmaps* are binary information arranged in a pattern of bits that represent a graphical image. More specifically, these bits store color information items called *pixels*. There are two types of bitmaps: device-dependent bitmaps (DDB) and device-independent bitmaps (DIB).

As a Win32 programmer, you probably won't be dealing much with DDBs because this format was kept solely for backward compatibility. Device-dependent bitmaps, as the name implies, are dependent on the device in which they're created. Bitmaps in this format, when saved, do not store information regarding the color palette they use nor do they store information regarding their resolution.

In contrast, device-independent bitmaps (DIBs) do store information to allow them to be displayed on any device without radically changing their appearance.

In memory, both DDBs and DIBs are represented with the same structures, for the most part. One key difference is that DDBs use the palette provided by the system, whereas DIBs provide their own palette. To take this explanation further, DDBs are simply native storage, handled by video driver routines and video hardware. DIBs are standardized pixel formats, handled by GDI generic routines and stored in global memory. Some video cards use DIB pixel formats as native storage, so you get DDB=DIB. In general, DIB gives you more flexibility and simplicity, sometimes at a slight performance cost. DDBs are always faster but not as convenient.

Metafiles

Unlike bitmaps, *metafiles* are vector-based graphical images. Metafiles are files in which a series of GDI routines are stored, enabling you to save GDI function calls to disk so that you can redisplay the image later. This also enables you to share your drawing routines with other programs without having to call the specific GDI functions in each program. Other advantages to metafiles are that they can be scaled to arbitrary dimensions and still retain their smooth lines and arcs—bitmaps don't do this as well. In fact, this is one of the reasons the Win32 printing engine is built around the enhanced metafile storage for print jobs.

There are two metafile formats: standard metafiles, typically stored in a file with a `.wmf` extension, and enhanced metafiles, typically stored in a file with an `.emf` extension.

Standard metafiles are a holdover from the Win16 system. Enhanced metafiles are more robust and accurate. Use EMFs if you're producing metafiles for your own applications. If you're exporting your metafiles to older programs that might not be able to use the enhanced format, use the 16-bit WMFs. Know, however, that by stepping down to the 16-bit WMFs, you'll also lose several GDI primitives that EMFs support but WMFs do not. Delphi 5's `TMetafile` class knows about both types of metafiles.

Icons

Icons are Win32 resources that usually are stored in an icon file with an `.ico` extension. They may also reside in a resource file (`.res`). There are two typical sizes of icons in Windows: large icons that are 32×32 pixels, and small icons that are 16×16 pixels. All Windows applications use both icon sizes. Small icons are displayed in the application's upper-left corner of the main window and also in the Windows List view control. Delphi's encapsulation of this control is the `TListView` component. This control appears on the Win32 page of the Component Palette.

Icons are made up of two bitmaps. One bitmap, referred to as the *image*, is the actual icon image as it is displayed. The other bitmap, referred to as the *mask*, makes it possible to achieve transparency when the icon is displayed. Icons are used for a variety of purposes. For example, icons appear on an application's taskbar and in message boxes where the question mark, exclamation point, or stop sign icons are used as attention grabbers.

TPicture is a container class for the TGraphic abstract class. A *container class* means that TPicture can hold a reference to and display a TBitmap, TMetafile, TIcon, or any other TGraphic type, without really caring which is which. You use TImage.Picture's properties and methods to load image files into a TImage component. For example, use the following statement:

```
MyImage.Picture.LoadFromFile('FileName.bmp');
```

Use a similar statement to load icon files or metafiles. For example, the following code loads a Win32 metafile:

```
MyImage.Picture.LoadFromFile('FileName.emf');
```

This code loads a Win32 icon file:

```
MyImage.Picture.LoadFromFile('FileName.ico');
```

In Delphi 5, TPicture can now load JPEG images using the same technique for loading bitmaps:

```
MyImage.Picture.LoadFromFile('FileName.jpeg');
```

Saving Images

To save an image use the SaveToFile() method:

```
MyImage.Picture.SaveToFile('FileName.bmp');
```

The TBitmap class encapsulates the Win32 bitmap and palette, and it provides the methods to load, store, display, save, and copy the bitmapped images. TBitmap also manages palette realization automatically. This means that the tedious task of managing bitmaps has been simplified substantially with Delphi 5's TBitmap class, which enables you to focus on using the bitmap and frees you from having to worry about all the underlying implementation details.

NOTE

TBitmap isn't the only object that manages palette realization. Components such as TImage, TMetafile, and every other TGraphic descendant also realize their bitmaps' palettes on request. If you build components that contain a TBitmap object that might have 256-color images, you'll need to override your component's GetPalette() method to return the color palette of the bitmap.

To create an instance of a TBitmap class and load a bitmap file, for example, you use the following commands:

```
MyBitmap := TBitmap.Create;  
MyBitmap.LoadFromFile('MyBMP.BMP');
```

CAUTION

Another method of loading bitmaps into an application is to load them from a resource file. We'll discuss this method shortly.

To copy one bitmap to another, you use the `TBitmap.Assign()` method, as in this example:

```
Bitmap1.Assign(Bitmap2);
```

You also can copy a portion of a bitmap from one `TBitmap` instance to another `TBitmap` instance or even to the form's canvas by using the `CopyRect()` method:

```
var
  R1: TRect;
begin
  with R1 do
  begin
    Top := 0;
    Left := 0;
    Right := Bitmap2.Width div 2;
    Bottom := Bitmap2.Height div 2;
  end;
  Bitmap1.Canvas.CopyRect(ClientRect, Bitmap2.Canvas, R1);
end;
```

In the preceding code, you first calculate the appropriate values in a `TRect` record and then use the `TCanvas.CopyRect()` method to copy a portion of the bitmap. A `TRect` is defined as follows:

```
TRect = record
  case Integer of
    0: (Left, Top, Right, Bottom: Integer);
    1: (TopLeft, BottomRight: TPoint);
  end;
```

This technique will be used in the paint program later in the chapter. `CopyRect()` automatically stretches the copied portion of the source canvas to fill the destination rectangle.

CAUTION

You should be aware of a significant difference in resource consumption for copying bitmaps in the previous two examples. The `CopyRect()` technique doubles the memory

continues

use in that two separate copies of the image exist in memory. The `Assign()` technique costs nothing because the two bitmap objects will share a reference to the same image in memory. If you happen to modify one of the bitmap objects, VCL will clone the image using a copy-on-write scheme.

Another method you can use to copy the entire bitmap to the form's canvas so that it shrinks or expands to fit inside the canvas's boundaries is the `StretchDraw()` method. Here's an example:

```
Canvas.StretchDraw(R1, MyBitmap);
```

We'll discuss `TCanvas`'s methods later in this chapter.

Using the TCanvas Properties

Higher-level classes such as `TForm` and `TGraphicControl` descendants have a `Canvas` property. The canvas serves as the painting surface for your form's other components. The tools that `Canvas` uses to do the drawing are pens, brushes, and fonts.

Using Pens

In this section, we first explain how to use the `TPen` properties and then show you some code in a sample project that uses these properties.

Pens enable you to draw lines on the canvas and are accessed from the `Canvas.Pen` property. You can change how lines are drawn by modifying the pen's properties: `Color`, `Width`, `Style`, and `Mode`.

The `Color` property specifies a pen's color. Delphi 5 provides predefined color constants that match many common colors. For example, the constants `clRed` and `clYellow` correspond to the colors red and yellow. Delphi 5 also defines constants to represent the Win32 system screen element colors such as `clActiveCaption` and `clHighlightText`, which correspond to the Win32 active captions and highlighted text. The following line assigns the color blue to the canvas's pen:

```
Canvas.Pen.color := clblue;
```

This line shows you how to assign a random color to `Canvas`'s `Pen` property:

```
Pen.Color := TColor( RGB(Random(255), Random(255), Random(255)) );
```

RGB() and TColor

Win32 represents colors as long integers in which the lowest three bytes each signify a red, green, and blue intensity level. The combination of the three values makes up a valid Win32 color. The `RGB(R, G, B)` function takes three parameters for the red,

green, and blue intensity levels. It returns a Win32 color as a long integer value. This is represented as a `TColor` Delphi type. There are 255 possible values for each intensity level and approximately 16 million colors that can be returned from the `RGB()` function. `RGB(0, 0, 0)`, for example, returns the color value for black, whereas `RGB(255, 255, 255)` returns the color value for white. `RGB(255, 0, 0)`, `RGB(0, 255, 0)`, and `RGB(0, 0, 255)` return the color values for red, green, and blue, respectively. By varying the values passed to `RGB()`, you can obtain a color anywhere within the color spectrum.

`TColor` is specific to VCL and refers to constants defined in the `Graphics.pas` unit. These constants map to either the closest matching color in the system palette or to a defined color in the Windows Control Panel. For example, `c1Blue` maps to the color blue whereas the `c1BtnFace` maps to the color specified for button faces. In addition to the three bytes to represent the color, `TColor`'s highest order byte specifies how a color is matched. Therefore, if the highest order byte is `$00`, the represented color is the closest matching color in the system palette. A value of `$01` represents the closest matching color in the currently realized palette. Finally, a color of `$02` matches with the nearest color in the logical palette of the current device context. You will find additional information in the Delphi help file under "`TColor` type."

TIP

Use the `ColorToRGB()` function to convert Win32 system colors, such as `c1Window`, to a valid RGB color. The function is described in Delphi 5's online help.

The pen can also draw lines with different drawing styles, as specified by its `Style` property. Table 8.1 shows the different styles you can set for `Pen.Style`.

TABLE 8.1 Pen Styles

<i>Style</i>	<i>Draws</i>
<code>psClear</code>	An invisible line
<code>psDash</code>	A line made up of a series of dashes
<code>psDashDot</code>	A line made up of alternating dashes and dots
<code>psDashDotDot</code>	A line made up of a series of dash-dot-dot combinations
<code>psDot</code>	A line made up of a series of dots
<code>psInsideFrame</code>	A line within a frame of closed shapes that specify a bounding rectangle
<code>psSolid</code>	A solid line

The following line shows how you would change the pen's drawing style:

```
Canvas.Pen.Style := psDashDot;
```

Figure 8.1 shows how the different pen styles appear when drawn on the form's canvas. One thing to note: The “in between” colors in the stippled lines come from the brush color. If you want to make a black dashed line run across a red square, you would need to set the `Canvas.Brush.Color` to `clRed` or set the `Canvas.Brush.Style` to `bsClear`. Setting both the pen and brush color is how you would draw, for example, a red and blue dashed line across a white square.

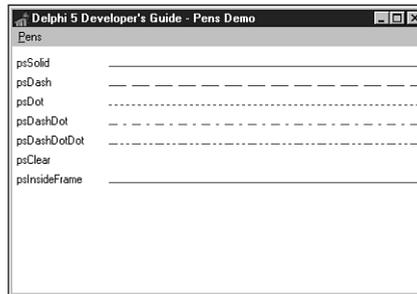


FIGURE 8.1

Different pen styles.

The `Pen.Width` property enables you to specify the width, in pixels, that the pen uses for drawing. When this property is set to a larger width, the pen draws with thicker lines.

NOTE

The stipple line style applies only to pens with a width of 1. Setting the pen width to 2 will draw a solid line. This is a holdover from the 16-bit GDI that Win32 emulates for compatibility. Windows 95/98 does not do fat stippled lines, but Windows NT/2000 can if you use only the extended GDI feature set.

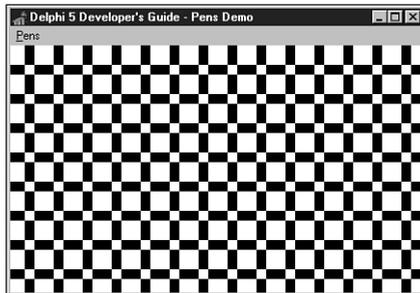
Three factors determine how Win32 draws pixels or lines to a canvas surface: the pen's color, the surface or destination color, and the bitwise operation that Win32 performs on the two-color values. This operation is known as a *raster operation* (ROP). The `Pen.Mode` property specifies the ROP to be used for a given canvas. Sixteen modes are predefined in Win32, as shown in Table 8.2.

TABLE 8.2 Win32 Pen Modes on Source Pen.Color (S) and Destination (D) Color

<i>Mode</i>	<i>Result Pixel Color</i>	<i>Boolean Operation</i>
pmBlack	Always black	0
pmWhite	Always white	1
pmNOP	Unchanged	D
pmNOT	Inverse of D color	not D
pmCopy	Color specified by S	S
pmNotCopy	Inverse of S	not S
pmMergePenNot	Combination S and inverse of D	S or not D
pmMaskPenNot	Combination of colors common to S and inverse of D	S and not D
pmMergeNotPen	Combination of D and inverse of S	not S or D
pmMaskNotPen	Combination of colors common to D and inverse of S	not S and D
pmMerge	Combination of S and D	S or D
pmNotMerge	Inverse of pmMerge operation on S and D	not (S or D)
pmMask	Combination of colors common to S and D	S and D
pmNotMask	Inverse of pmMask operation on S and D	not (S and D)
pmXor	Combination of colors in either S or D but not both	S XOR D
pmNotXor	Inverse of pmXOR operation on S and D	not (S XOR D)

Pen.mode is pmCopy by default. This means that the pen draws with the color specified by its Color property. Suppose that you want to draw black lines on a white background. If a line crosses over a previously drawn line, it should draw white rather than black.

One way to do this would be to check the color of the area you're going to draw to—if it's white, set pen.Color to black; if it is black, set pen.Color to white. Although this approach works, it would be cumbersome and slow. A better approach would be to set Pen.Color to c1Black and Pen.Mode to pmNot. This would result in the pen drawing the inverse of the merging operation with the pen and surface color. Figure 8.2 shows you the result of this operation when drawing with a black pen in a crisscross fashion.

**FIGURE 8.2**

The output of a pmNotMerge operation.

Listing 8.1 is an example of the project on the CD that illustrates the code that resulted in Figures 8.1 and 8.2. You'll find this demo on the CD.

LISTING 8.1 Illustration of Pen Operations

```
unit MainForm;  
  
interface  
  
uses  
    SysUtils, Windows, Messages, Classes, Graphics, Controls, Forms,  
    Dialogs, Menus, StdCtrls, Buttons, ExtCtrls;  
  
type  
    TMainForm = class(TForm)  
        mmMain: TMainMenu;  
        mmiPens: TMenuItem;  
        mmiStyles: TMenuItem;  
        mmiPenColors: TMenuItem;  
        mmiPenMode: TMenuItem;  
        procedure mmiStylesClick(Sender: TObject);  
        procedure mmiPenColorsClick(Sender: TObject);  
        procedure mmiPenModeClick(Sender: TObject);  
    private  
        { Private declarations }  
    public  
        { Public declarations }  
        procedure ClearCanvas;  
        procedure SetPenDefaults;  
    end;  
  
var
```

```
    MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.ClearCanvas;
var
    R: TRect;
begin
    // Clear the contents of the canvas
    with Canvas do
        begin
            Brush.Style := bsSolid;
            Brush.Color := clWhite;
            Canvas.FillRect(ClientRect);
        end;
end;

procedure TMainForm.SetPenDefaults;
begin
    with Canvas.Pen do
        begin
            Width := 1;
            Mode := pmCopy;
            Style := psSolid;
            Color := clBlack;
        end;
end;

procedure TMainForm.mmiStylesClick(Sender: TObject);
var
    yPos: integer;
    PenStyle: TPenStyle;
begin
    ClearCanvas;    // First clear Canvas's contents
    SetPenDefaults;
    // yPos represent the Y coordinate
    YPos := 20;
    with Canvas do
        begin
            for PenStyle := psSolid to psInsideFrame do
                begin
                    Pen.Color := clBlue;
                    Pen.Style := PenStyle;
                    MoveTo(100, yPos);
```

continues

LISTING 8.1 Continued

```
        LineTo(ClientWidth, yPos);
        inc(yPos, 20);
    end;

    // Write out titles for the various pen styles
    TextOut(1, 10, ' psSolid ');
    TextOut(1, 30, ' psDash ');
    TextOut(1, 50, ' psDot ');
    TextOut(1, 70, ' psDashDot ');
    TextOut(1, 90, ' psDashDotDot ');
    TextOut(1, 110, ' psClear ');
    TextOut(1, 130, ' psInsideFrame ');
end;
end;

procedure TMainForm.mmiPenColorsClick(Sender: TObject);
var
    i: integer;
begin
    ClearCanvas;    // Clear Canvas's contents
    SetPenDefaults;
    with Canvas do
    begin
        for i := 1 to 100 do
        begin
            // Get a random pen color draw a line using that color
            Pen.Color := RGB(Random(256),Random(256), Random(256));
            MoveTo(random(ClientWidth), Random(ClientHeight));
            LineTo(random(ClientWidth), Random(ClientHeight));
        end
    end;
end;

procedure TMainForm.mmiPenModeClick(Sender: TObject);
var
    x,y: integer;
begin
    ClearCanvas; // Clear the Canvas's contents
    SetPenDefaults;
    y := 10;
    canvas.Pen.Width := 20;
```

```
while y < ClientHeight do
begin
  canvas.MoveTo(0, y);
  // Draw a line and increment Y value
  canvas.LineTo(ClientWidth, y);
  inc(y, 30);
end;
x := 5;

canvas.pen.Mode := pmNot;
while x < ClientWidth do
begin
  Canvas.MoveTo(x, 0);
  canvas.LineTo(x, ClientHeight);
  inc(x, 30);
end;
end;

end.
```

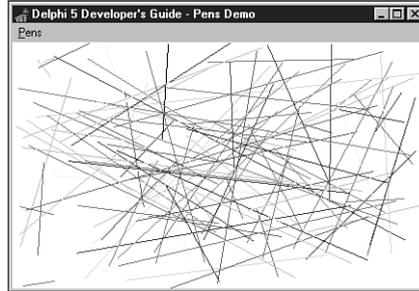
Listing 8.1 shows three examples of dealing with the canvas's pen. The two helper functions, `ClearCanvas()` and `SetPenDefaults()`, are used to clear the contents of the main form's canvas and to reset the `Canvas.Pen` properties to their default values as these properties are modified by each of the three event handlers.

`ClearCanvas()` is a useful technique for erasing the contents of any component containing a `Canvas` property. `ClearCanvas()` uses a solid white brush to erase whatever was previously painted on the `Canvas`. `FillRect()` is responsible for painting a rectangular area as specified by a `TRect` structure, `ClientRect`, which is passed to it.

The `mmiStylesClick()` method shows how to display the various `TPen` styles as shown in Figure 8.1 by drawing horizontal lines across the form's `Canvas` using a different `TPen` style. Both `TCanvas.MoveTo()` and `TCanvas.LineTo()` enable you to draw lines on the canvas.

The `mmiPenColorsClick()` method illustrates drawing lines using a different `TPen` color. Here you use the `RGB()` function to retrieve a color to assign to `TPen.Color`. The three values you pass to `RGB()` are each random values within range of 0 to 255. The output of this method is shown in Figure 8.3.

Finally, the `mmiPenModeClick()` method illustrates how to draw lines using a different pen mode. Here you use the `pmNot` mode to perform the actions previously discussed, resulting in the output shown in Figure 8.2.

**FIGURE 8.3**

Output from the `mmiPenColorsClick()` method.

Using TCanvas's Pixels

The `TCanvas.Pixels` property is a two-dimensional array in which each element represents a pixel's `TColor` value on the form's surface or client area. The upper-left corner of your form's painting surface is given by

```
Canvas.Pixels[0,0]
```

and the lower-right corner is

```
Canvas.Pixels[clientwidth, clientheight];
```

It's rare that you'll ever have to access individual pixels on your form. In general, you do not want to use the `Pixels` property because it's slow. Accessing this property uses the `GetPixel()/SetPixel()` GDI functions, which Microsoft has acknowledged are flawed and will never be efficient. This is because both functions rely on 24-bit RGB values. When not working with 24-bit RGB device contexts, these functions must perform serious color-matching gymnastics to convert the RGB into a device pixel format. For quick pixel manipulation, use the `TBitmap.ScanLine` array property instead. To fetch or set one or two pixels at a time, using `Pixels` is okay.

Using Brushes

This section discusses the `TBrush` properties and shows you some code in a sample project that uses these properties.

Using the TBrush Properties

A canvas's brush fills in areas and shapes drawn on the canvas. This differs from a `TPen` object, which enables you to draw lines to the canvas. A brush enables you to fill an area on the canvas using various colors, styles, and patterns.

Canvas's `TBrush` object has three important properties that specify how the brush paints on the canvas's surface: `Color`, `Style`, and `Bitmap`. `Color` specifies the brush's color, `Style` specifies

the pattern of the brush background, and `Bitmap` specifies a bitmap you can use to create custom patterns for the brush's background.

Eight brush options are specified by the `Style` property: `bsSolid`, `bsClear`, `bsHorizontal`, `bsVertical`, `bsFDiagonal`, `bsBDiagonal`, `bsCross`, and `bsDiagCross`. By default, the brush color is `clWhite` with a `bsSolid` style and no bitmap. You can change the color and style to fill an area with different patterns. The example in the following section illustrates using each of the `TBrush` properties.

TBrush Code Example

Listing 8.2 shows you the unit for a project that illustrates the use of the `TBrush` properties just discussed. You can load this project from the CD.

LISTING 8.2 TBrush Example

```
unit MainFrm;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls, Forms,
  Dialogs, Menus, ExtCtrls;

type
  TMainForm = class(TForm)
    mmMain: TMainMenu;
    mmiBrushes: TMenuItem;
    mmiPatterns: TMenuItem;
    mmiBitmapPattern1: TMenuItem;
    mmiBitmapPattern2: TMenuItem;
    procedure mmiPatternsClick(Sender: TObject);
    procedure mmiBitmapPattern1Click(Sender: TObject);
    procedure mmiBitmapPattern2Click(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
  private
    FBitmap: TBitmap;
  public
    procedure ClearCanvas;
  end;

var
  MainForm: TMainForm;

implementation
```

continues

LISTING 8.2 Continued

```
{ $R *.DFM }

procedure TMainForm.ClearCanvas;
var
  R: TRect;
begin
  // Clear the contents of the canvas
  with Canvas do
  begin
    Brush.Style := bsSolid;
    Brush.Color := clWhite;
    GetWindowRect(Handle, R);
    R.TopLeft := ScreenToClient(R.TopLeft);
    R.BottomRight := ScreenToClient(R.BottomRight);
    FillRect(R);
  end;
end;

procedure TMainForm.mmiPatternsClick(Sender: TObject);
begin
  ClearCanvas;
  with Canvas do
  begin
    // Write out titles for the various brush styles
    TextOut(120, 101, 'bsSolid');
    TextOut(10, 101, 'bsClear');
    TextOut(240, 101, 'bsCross');
    TextOut(10, 221, 'bsBDiagonal');
    TextOut(120, 221, 'bsFDiagonal');
    TextOut(240, 221, 'bsDiagCross');
    TextOut(10, 341, 'bsHorizontal');
    TextOut(120, 341, 'bsVertical');

    // Draw a rectangle with the various brush styles

    Brush.Style := bsClear;
    Rectangle(10, 10, 100, 100);
    Brush.Color := clBlack;

    Brush.Style := bsSolid;
    Rectangle(120, 10, 220, 100);

    { Demonstrate that the brush is transparent by drawing
      colored rectangle, over which the brush style rectangle will
      be drawn. }
  end;
end;
```

```
Brush.Style := bsSolid;
Brush.Color := clRed;
Rectangle(230, 0, 330, 90);

Brush.Style := bsCross;
Brush.Color := clBlack;
Rectangle(240, 10, 340, 100);

Brush.Style := bsBDiagonal;
Rectangle(10, 120, 100, 220);

Brush.Style := bsFDiagonal;
Rectangle(120, 120, 220, 220);

Brush.Style := bsDiagCross;
Rectangle(240, 120, 340, 220);

Brush.Style := bsHorizontal;
Rectangle(10, 240, 100, 340);

Brush.Style := bsVertical;
Rectangle(120, 240, 220, 340);

end;
end;

procedure TMainForm.mmiBitmapPattern1Click(Sender: TObject);
begin
  ClearCanvas;
  // Load a bitmap from the disk
  FBitMap.LoadFromFile('pattern.bmp');
  Canvas.Brush.Bitmap := FBitmap;
  try
    { Draw a rectangle to cover the form's entire
      client area using the bitmap pattern as the
      brush with which to paint. }
    Canvas.Rectangle(0, 0, ClientWidth, ClientHeight);
  finally
    Canvas.Brush.Bitmap := nil;
  end;
end;

procedure TMainForm.mmiBitmapPattern2Click(Sender: TObject);
begin
  ClearCanvas;
  // Load a bitmap from the disk
```

continues

LISTING 8.2 Continued

```
FBitmap.LoadFromFile('pattern2.bmp');
Canvas.Brush.Bitmap := FBitmap;
try
  { Draw a rectangle to cover the form's entire
    client area using the bitmap pattern as the
    brush with which to paint. }
  Canvas.Rectangle(0, 0, ClientWidth, ClientHeight);
finally
  Canvas.Brush.Bitmap := nil;
end;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
  FBitmap := TBitmap.Create;
end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
  FBitmap.Free;
end;

end.
```

TIP

The `ClearCanvas()` method that you use here is a handy routine for a utility unit. You can define `ClearCanvas()` to take `TCanvas` and `TRect` parameters to which the erase code will be applied:

```
procedure ClearCanvas(ACanvas: TCanvas; ARect: TRect);
begin
  // Clear the contents of the canvas
  with ACanvas do
  begin
    Brush.Style := bsSolid;
    Brush.Color := clWhite;
    FillRect(ARect);
  end;
end;
```

The `mmiPatternsClick()` method illustrates drawing with various `TBrush` patterns. First, you draw out the titles and then, using each of the available brush patterns, draw rectangles on the form's canvas. Figure 8.4 shows the output of this method.

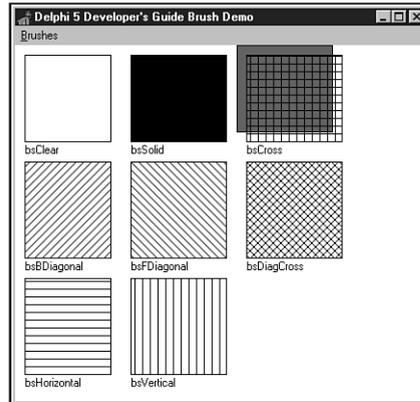


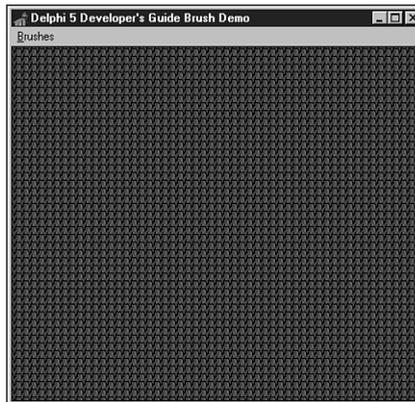
FIGURE 8.4

Brush patterns.

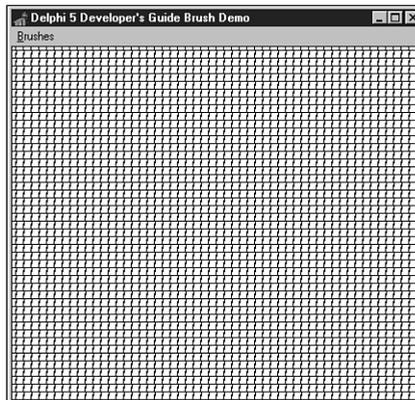
The `mmiBitmapPattern1Click()` and `mmiBitmapPattern2Click()` methods illustrate how to use a bitmap pattern as a brush. The `TCanvas.Brush` property contains a `TBitmap` property to which you can assign a bitmap pattern. This pattern will be used to fill the area painted by the brush instead of the pattern specified by the `TBrush.Style` property. There are a few rules for using this technique, however. First, you must assign a valid bitmap object to the property. Second, you must assign `nil` to the `Brush.Bitmap` property when you're finished with it because the brush does not take ownership of the bitmap object when you assign a bitmap to it. Figures 8.5 and 8.6 show the output of `mmiBitmapPattern1Click()` and `mmiBitmapPattern2Click()`, respectively.

NOTE

Windows limits the size of pattern brush bitmaps to 8×8 pixels, and they must be device-dependent bitmaps, not device-independent bitmaps. Windows will reject brush pattern bitmaps larger than 8×8; NT will accept larger but will only use the top-left 8×8 portion.

**FIGURE 8.5**

Output from mmiBitmapPattern1Click().

**FIGURE 8.6**

Output from mmiBitmapPattern2Click().

TIP

Using a bitmap pattern to fill an area on the canvas doesn't only apply to the form's canvas but also to any component that contains a Canvas property. Just access the methods and/or properties of the Canvas property of the component rather than the form. For example, here's how to perform pattern drawing on a TImage component:

```
Image1.Canvas.Brush.Bitmap := SomeBitmap;  
try
```

```
Image1.Canvas.Rectangle(0, 0, Image1.Width, Image1.Height);
finally
  Image1.Canvas.Brush.Bitmap := nil;
end;
```

Using Fonts

The `Canvas.Font` property enables you to draw text using any of the available Win32 fonts. You can change the appearance of text written to the canvas by modifying the font's `Color`, `Name`, `Size`, `Height`, or `Style` property.

You can assign any of Delphi 5's predefined colors to `Font.Color`. The following code, for example, assigns the color red to the canvas's font:

```
Canvas.Font.Color := clRed;
```

The `Name` property specifies the Window's font name. For example, the following two lines of code assign different typefaces to `Canvas's` font:

```
Canvas.Font.Name := 'New Times Roman';
```

`Canvas.Font.Size` specifies the font's size in points.

`Canvas.Font.Style` is a set composed of one style or a combination of the styles shown in Table 8.3.

TABLE 8.3 Font Styles

<i>Value</i>	<i>Style</i>
<code>fsBold</code>	Boldface
<code>fsItalic</code>	Italic
<code>fsUnderline</code>	Underlined
<code>fsStrikeOut</code>	A horizontal line through the font, giving it a strikethrough appearance

To combine two styles, use the syntax for combining multiple set values:

```
Canvas.Font.Style := [fsBold, fsItalic];
```

You can use `TFontDialog` to obtain a Win32 font and assign that font to the `TMemo.Font` property:

```
if FontDialog1.Execute then
  Memo1.Font.Assign(FontDialog1.Font);
```

The same can be done to assign the font selected in `TFontDialog` to the `Canvas's` font:

```
Canvas.Font.Assign(FontDialog1.Font);
```

CAUTION

Make sure to use the `Assign()` method when copying `TBitmap`, `TBrush`, `TIcon`, `TMetaFile`, `TPen`, and `TPicture` instance variables. A statement such as

```
MyBrush1 := MyBrush2
```

might seem valid, but it performs a direct pointer copy so that both instances point to the same brush object, which can result in a heap leak. By using `Assign()`, you ensure that previous resources are freed.

This is not so when assigning between two `TFont` properties. Therefore, a statement such as

```
Form1.Font := Form2.Font
```

is a valid statement because the `TForm.Font` is a property whose write method internally calls `Assign()` to copy the data from the given font object. Be careful, however; this is only valid with when assigning `TFont` properties, not `TFont` variables. As a general rule, always use `Assign()`.

Additionally, you can assign individual attributes from the selected font in `TFontDialog` to the Canvas's font:

```
Canvas.Font.Name := Font.Dialog1.Font.Name;  
Canvas.Font.Size := Font.Dialog1.Font.Size;
```

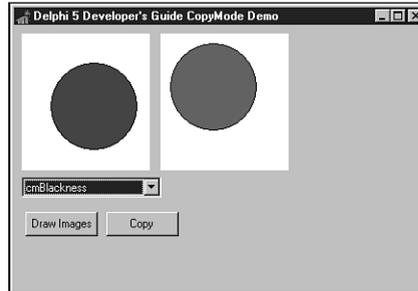
We've quickly brushed over fonts here. A more thorough discussion on fonts appears at the end of this chapter.

Using the CopyMode Property

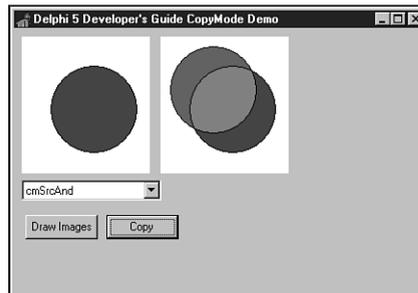
The `TCanvas.CopyMode` property determines how a canvas copies an image from another canvas onto itself. For example, when `CopyMode` holds the value `cmSrcCopy`, this means that the source image will be copied over the destination entirely. `cmSrcInvert`, however, causes the pixels of both the source and destination images to be combined using the bitwise XOR operator. `CopyMode` is used for achieving different effects when copying from one bitmap to another bitmap. A typical place where you would change the default value of `CopyMode` from `cmSrcCopy` to another value is when writing animation applications. You learn how to write animation later in this chapter.

To see how to use the `CopyMode` property, take a look at Figure 8.7.

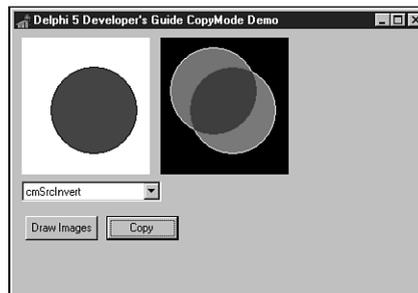
Figure 8.7 shows a form that contains two images, both of which have an ellipse drawn on them. You select a `CopyMode` setting from the `TComboBox` component, and you would get various results when copying the one image over the other by clicking the Copy button. Figures 8.8 and 8.9 show what the effects would be by copying `imgFromImage` to `imgToImage` using the `cmSrcAnd` and `cmSrcInvert` copy modes.

**FIGURE 8.7**

A form that contains two images to illustrate CopyMode.

**FIGURE 8.8**

A copy operation using the cmSrcAnd copy mode setting.

**FIGURE 8.9**

A copy operation using the cmSrcInvert copy mode setting.

Listing 8.3 shows the source code for the project, illustrating the various copy modes. You'll find this code on the CD.

LISTING 8.3 Project Illustrating CopyMode Usage

```
unit MainFrm;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls, ExtCtrls;

type

  TMainForm = class(TForm)
    imgCopyTo: TImage;
    imgCopyFrom: TImage;
    cbCopyMode: TComboBox;
    btnDrawImages: TButton;
    btnCopy: TButton;
    procedure FormShow(Sender: TObject);
    procedure btnCopyClick(Sender: TObject);
    procedure btnDrawImagesClick(Sender: TObject);
  private
    procedure DrawImages;
    procedure GetCanvasRect(AImage: TImage; var ARect: TRect);
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.GetCanvasRect(AImage: TImage; var ARect: TRect);
var
  R: TRect;
  R2: TRect;
begin
  R := AImage.Canvas.ClipRect;
  with AImage do begin
    ARect.TopLeft := Point(0, 0);
    ARect.BottomRight := Point(Width, Height);
  end;
  R2 := ARect;
  ARect := R2;
end;
```

```
procedure TMainForm.DrawImages;
var
  R: TRect;
begin
  // Draw an ellipse in img1
  with imgCopyTo.Canvas do
  begin
    Brush.Style := bsSolid;
    Brush.Color := clWhite;
    GetCanvasRect(imgCopyTo, R);
    FillRect(R);
    Brush.Color := clRed;
    Ellipse(10, 10, 100, 100);
  end;

  // Draw an ellipse in img2
  with imgCopyFrom.Canvas do
  begin
    Brush.Style := bsSolid;
    Brush.Color := clWhite;
    GetCanvasRect(imgCopyFrom, R);
    FillRect(R);
    Brush.Color := clBlue;
    Ellipse(30, 30, 120, 120);
  end;
end;

procedure TMainForm.FormShow(Sender: TObject);
begin
  // Initialize the combobox to the first item
  cbCopyMode.ItemIndex := 0;
  DrawImages;
end;

procedure TMainForm.btnCopyClick(Sender: TObject);
var
  cm: Longint;
  CopyToRect,
  CopyFromRect: TRect;
begin
  // Determine the copy mode based on the combo box selection
  case cbCopyMode.ItemIndex of
    0: cm := cmBlackNess;
    1: cm := cmDstInvert;
    2: cm := cmMergeCopy;
```

continues

LISTING 8.3 Continued

```
3: cm := cmMergePaint;
4: cm := cmNotSrcCopy;
5: cm := cmNotSrcErase;
6: cm := cmPatCopy;
7: cm := cmPatInvert;
8: cm := cmPatPaint;
9: cm := cmSrcAnd;
10: cm := cmSrcCopy;
11: cm := cmSrcErase;
12: cm := cmSrcInvert;
13: cm := cmSrcPaint;
14: cm := cmWhiteness;
    else
        cm := cmSrcCopy;
end;

// Assign the selected copymode to Image1's CopyMode property.
imgCopyTo.Canvas.CopyMode := cm;

GetCanvasRect(imgCopyTo, CopyToRect);
GetCanvasRect(imgCopyFrom, CopyFromRect);

// Now copy Image2 onto Image1 using Image1's CopyMode setting
imgCopyTo.Canvas.CopyRect(CopyToRect, imgCopyFrom.Canvas, CopyFromRect);
end;

procedure TMainForm.btnDrawImagesClick(Sender: TObject);
begin
    DrawImages;
end;

end.
```

This project initially paints an ellipse on the two `TImage` components: `imgFromImage` and `imgToImage`. When the Copy button is clicked, `imgFromImage` is copied onto `imgToImage1` using the `CopyMode` setting specified from `cbCopyMode`.

Other Properties

`TCanvas` has other properties that we'll discuss more as we illustrate how to use them in coding techniques. This section briefly discusses these properties.

`TCanvas.ClipRect` represents a drawing region of the canvas to which drawing can be performed. You can use `ClipRect` to limit the area that can be drawn for a given canvas.

CAUTION

Initially, `ClipRect` represents the entire Canvas drawing area. You might be tempted to use the `ClipRect` property to obtain the bounds of a canvas. However, this could get you into trouble. `ClipRect` will not always represent the total size of its component. It can be less than the Canvas's display area.

`TCanvas.Handle` gives you access to the actual device context that the `TCanvas` instance encapsulates. Device contexts are discussed later in this chapter.

`TCanvas.PenPos` is simply an X,Y coordinate location of the canvas's pen. You can change the pen's position by using the `TCanvas` methods—`MoveTo()`, `LineTo()`, `PolyLine()`, `TextOut()`, and so on.

Using the TCanvas Methods

The `TCanvas` class encapsulates many GDI drawing functions. With `TCanvas`'s methods, you can draw lines and shapes, write text, copy areas from one canvas to another, and even stretch an area on the canvas to fill a larger area.

Drawing Lines with TCanvas

`TCanvas.MoveTo()` changes `Canvas.Pen`'s drawing position on the Canvas's surface. The following code, for example, moves the drawing position to the upper-left corner of the canvas:

```
Canvas.MoveTo(0, 0);
```

`TCanvas.LineTo()` draws a line on the canvas from its current position to the position specified by the parameters passed to `LineTo()`. Use `MoveTo()` with `LineTo()` to draw lines anywhere on the canvas. The following code draws a line from the upper-left position of the form's client area to the form's lower-right corner:

```
Canvas.MoveTo(0, 0);  
Canvas.LineTo(ClientWidth, ClientHeight);
```

You already saw how to use the `MoveTo()` and `LineTo()` methods in the section covering the `TCanvas.Pen` property.

NOTE

Delphi now supports right-to-left-oriented text and control layouts; some controls (such as the grid) change the canvas coordinate system to flip the X axis. Therefore, if you're running Delphi on a Middle East version of Windows, `MoveTo(0,0)` may go to the top-right corner of the window.

Drawing Shapes with TCanvas

TCanvas offers various methods for rendering shapes to the canvas: `Arc()`, `Chord()`, `Ellipse()`, `Pie()`, `Polygon()`, `PolyLine()`, `Rectangle()`, and `RoundRect()`. To draw an ellipse in the form's client area, you would use Canvas's `Ellipse()` method, as shown in the following code:

```
Canvas.Ellipse(0, 0, ClientWidth, ClientHeight);
```

You also can fill an area on the canvas with a brush pattern specified in the `Canvas.Brush.Style` property. The following code draws an ellipse and fills the ellipse interior with the brush pattern specified by `Canvas.Brush.Style`:

```
Canvas.Brush.Style := bsCross;  
Canvas.Ellipse(0, 0, ClientWidth, ClientHeight);
```

Additionally, you saw how to add a bitmap pattern to the `TCanvas.Brush.Bitmap` property, which it uses to fill an area on the canvas. You can also use a bitmap pattern for filling in shapes. We'll demonstrate this later.

Some of Canvas's other shape-drawing methods take additional or different parameters to describe the shape being drawn. The `PolyLine()` method, for example, takes an array of `TPoint` records that specify positions, or pixel coordinates, on the canvas to be connected by a line—sort of like connect the dots. A `TPoint` is a record in Delphi 5 that signifies an X,Y coordinate. A `TPoint` is defined as

```
TPoint = record  
  X: Integer;  
  Y: Integer;  
end;
```

A Code Example for Drawing Shapes

Listing 8.4 illustrates using the various shape-drawing methods of TCanvas. You can find this project on the CD.

LISTING 8.4 An Illustration of Shape-Drawing Operations

```
unit MainForm;  
  
interface  
  
uses  
  SysUtils, Windows, Messages, Classes, Graphics,  
  Controls, Forms, Dialogs, Menus;  
  
type  
  TMainForm = class(TForm)
```

```
mmMain: TMainMenu;
mmiShapes: TMenuItem;
mmiArc: TMenuItem;
mmiChord: TMenuItem;
mmiEllipse: TMenuItem;
mmiPie: TMenuItem;
mmiPolygon: TMenuItem;
mmiPolyline: TMenuItem;
mmiRectangle: TMenuItem;
mmiRoundRect: TMenuItem;
N1: TMenuItem;
mmiFill: TMenuItem;
mmiUseBitmapPattern: TMenuItem;
mmiPolyBezier: TMenuItem;
procedure mmiFillClick(Sender: TObject);
procedure mmiArcClick(Sender: TObject);
procedure mmiChordClick(Sender: TObject);
procedure mmiEllipseClick(Sender: TObject);
procedure mmiUseBitmapPatternClick(Sender: TObject);
procedure mmiPieClick(Sender: TObject);
procedure mmiPolygonClick(Sender: TObject);
procedure mmiPolylineClick(Sender: TObject);
procedure mmiRectangleClick(Sender: TObject);
procedure mmiRoundRectClick(Sender: TObject);
procedure FormCreate(Sender: TObject);
procedure FormDestroy(Sender: TObject);
procedure mmiPolyBezierClick(Sender: TObject);
private
  FBitmap: TBitmap;
public
  procedure ClearCanvas;
  procedure SetFillPattern;
end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.ClearCanvas;
begin
  // Clear the contents of the canvas
  with Canvas do
```

continues

LISTING 8.4 Continued

```
begin
  Brush.Style := bsSolid;
  Brush.Color := clWhite;
  FillRect(ClientRect);
end;
end;

procedure TMainForm.SetFillPattern;
begin
  { Determine if shape is to be draw with a bitmap pattern in which
  case load a bitmap. Otherwise, use the brush pattern. }
  if mmiUseBitmapPattern.Checked then
    Canvas.Brush.Bitmap := FBitmap
  else
    with Canvas.Brush do
      begin
        Bitmap := nil;
        Color := clBlue;
        Style := bsCross;
      end;
    end;
end;

procedure TMainForm.mmiFillClick(Sender: TObject);
begin
  mmiFill.Checked := not mmiFill.Checked;
  { If mmiUseBitmapPattern was checked, uncheck it set the
  brush's bitmap to nil. }
  if mmiUseBitmapPattern.Checked then
    begin
      mmiUseBitmapPattern.Checked := not mmiUseBitmapPattern.Checked;
      Canvas.Brush.Bitmap := nil;
    end;
end;

procedure TMainForm.mmiUseBitmapPatternClick(Sender: TObject);
begin
  { Set mmiFill1.Checked mmiUseBitmapPattern.Checked. This will cause
  the SetFillPattern procedure to be called. However, if
  mmiUseBitmapPattern is being set, set Canvas.Brush.Bitmap to
  nil. }
  mmiUseBitmapPattern.Checked := not mmiUseBitmapPattern.Checked;
  mmiFill.Checked := mmiUseBitmapPattern.Checked;
  if not mmiUseBitmapPattern.Checked then
    Canvas.Brush.Bitmap := nil;
end;
```

```
procedure TMainForm.mmiArcClick(Sender: TObject);
begin
  ClearCanvas;
  with ClientRect do
    Canvas.Arc(Left, Top, Right, Bottom, Right, Top, Left, Top);
end;

procedure TMainForm.mmiChordClick(Sender: TObject);
begin
  ClearCanvas;
  with ClientRect do
    begin
      if mmiFill.Checked then
        SetFillPattern;
      Canvas.Chord(Left, Top, Right, Bottom, Right, Top, Left, Top);
    end;
end;

procedure TMainForm.mmiEllipseClick(Sender: TObject);
begin
  ClearCanvas;
  if mmiFill.Checked then
    SetFillPattern;
  Canvas.Ellipse(0, 0, ClientWidth, ClientHeight);
end;

procedure TMainForm.mmiPieClick(Sender: TObject);
begin
  ClearCanvas;
  if mmiFill.Checked then
    SetFillPattern;
  Canvas.Pie(0, 0, ClientWidth, ClientHeight, 50, 5, 300, 50);
end;

procedure TMainForm.mmiPolygonClick(Sender: TObject);
begin
  ClearCanvas;
  if mmiFill.Checked then
    SetFillPattern;
  Canvas.Polygon([Point(0, 0), Point(150, 20), Point(230, 130),
    Point(40, 120)]);
end;
procedure TMainForm.mmiPolylineClick(Sender: TObject);
begin
  ClearCanvas;
```

LISTING 8.4 Continued

```
Canvas.PolyLine([Point(0, 0), Point(120, 30), Point(250, 120),
    Point(140, 200), Point(80, 100), Point(30, 30)]);
end;

procedure TMainForm.mmiRectangleClick(Sender: TObject);
begin
    ClearCanvas;
    if mmiFill.Checked then
        SetFillPattern;
    Canvas.Rectangle(10 , 10, 125, 240);
end;

procedure TMainForm.mmiRoundRectClick(Sender: TObject);
begin
    ClearCanvas;
    if mmiFill.Checked then
        SetFillPattern;
    Canvas.RoundRect(15, 15, 150, 200, 50, 50);
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
    FBitmap := TBitmap.Create;
    FBitmap.LoadFromFile('Pattern.bmp');
    Canvas.Brush.Bitmap := nil;
end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
    FBitmap.Free;
end;

procedure TMainForm.mmiPolyBezierClick(Sender: TObject);
begin
    ClearCanvas;
    Canvas.PolyBezier([Point(0, 100), Point(100, 0), Point(200, 50),
        Point(300, 100)]);
end;

end.
```

The main menu event handlers perform the shape-drawing functions. Two public methods, `ClearCanvas()` and `SetFillPattern()`, serve as helper functions for the event handlers. The

first eight menu items result in a shape-drawing function being drawn on the form's canvas. The last two items, "Fill" and "Use Bitmap Pattern," specify whether the shape is to be filled with a brush pattern or a bitmap pattern, respectively.

You should already be familiar with the `ClearCanvas()` functionality. The `SetFillPattern()` method determines whether to use a brush pattern or a bitmap pattern to fill the shapes drawn by the other methods. If a bitmap is selected, it's assigned to the `Canvas.Brush.Bitmap` property.

All the shape-drawing event handlers call `ClearCanvas()` to erase what was previously drawn on the canvas. They then call `SetFillPattern()` if the `mmiFill.Checked` property is set to `True`. Finally, the appropriate `TCanvas` drawing routine is called. The comments in the source discuss the purpose of each function. One method worth mentioning here is `mmiPolylineClick()`.

When you're drawing shapes, an enclosed boundary is necessary for filling an area with a brush or bitmap pattern. Although it's possible to use `PolyLine()` and `FloodFill()` to create an enclosed boundary filled with a pattern, this method is highly discouraged. `PolyLine()` is used specifically for drawing lines. If you want to draw filled polygons, call the `TCanvas.Polygon()` method. A one-pixel imperfection in where the `PolyLine()` lines are drawn will allow the call to `FloodFill()` to leak out and fill the entire canvas. Drawing filled shapes with `Polygon()` uses math techniques that are immune to variations in pixel placement.

Painting Text with TCanvas

`TCanvas` encapsulates Win32 GDI routines for drawing text to a drawing surface. The following sections illustrate how to use these routines as well as how to use Win32 GDI functions that are not encapsulated by the `TCanvas` class.

Using the TCanvas Text-Drawing Routines

You used `Canvas's TextOut()` function to draw text to the form's client area in previous chapters. `Canvas` has some other useful methods for determining the size, in pixels, of text contained in a string using `Canvas's` rendered font. These functions are `TextWidth()` and `TextHeight()`. The following code determines the width and height for the string "Delphi 5 -- Yes!":

```
var
  S: String;
  w, h: Integer;
begin
  S := 'Delphi 5 -- Yes!';
  w := Canvas.TextWidth(S);
  h := Canvas.TextHeight(S);
end.
```

The `TextRect()` method also writes text to the form but only within a rectangle specified by a `TRect` structure. The text not contained within the `TRect` boundaries is clipped. In the line

```
Canvas.TextRect(R,0,0,'Delphi 3.0 Yes!');
```

the string "Delphi 5 Yes!" is written to the canvas at location `0,0`. However, the portion of the string that falls outside the coordinates specified by `R`, a `TRect` structure, gets clipped.

Listing 8.5 illustrates using some of the text-drawing routines.

LISTING 8.5 A Unit That Illustrates Text-Drawing Operations

```
unit MainFrm;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, Menus;

const
  DString = 'Delphi 5 YES!';
  DString2 = 'Delphi 5 Rocks!';

type

  TMainForm = class(TForm)
    mmMain: TMainMenu;
    mmiText: TMenuItem;
    mmiTextRect: TMenuItem;
    mmiTextSize: TMenuItem;
    mmiDrawTextCenter: TMenuItem;
    mmiDrawTextRight: TMenuItem;
    mmiDrawTextLeft: TMenuItem;
    procedure mmiTextRectClick(Sender: TObject);
    procedure mmiTextSizeClick(Sender: TObject);
    procedure mmiDrawTextCenterClick(Sender: TObject);
    procedure mmiDrawTextRightClick(Sender: TObject);
    procedure mmiDrawTextLeftClick(Sender: TObject);
  public
    procedure ClearCanvas;
  end;

var
  MainForm: TMainForm;

implementation
```

```
{SR *.DFM}

procedure TMainForm.ClearCanvas;
begin
  with Canvas do
    begin
      Brush.Style := bsSolid;
      Brush.Color := clWhite;
      FillRect(ClipRect);
    end;
end;

procedure TMainForm.mmiTextRectClick(Sender: TObject);
var
  R: TRect;
  TWidth, THeight: integer;
begin
  ClearCanvas;
  Canvas.Font.Size := 18;
  // Calculate the width/height of the text string
  TWidth := Canvas.TextWidth(DString);
  THeight := Canvas.TextHeight(DString);

  { Initialize a TRect structure. The height of this rectangle will
    be 1/2 the height of the text string height. This is to
    illustrate clipping the text by the rectangle drawn }
  R := Rect(1, THeight div 2, TWidth + 1, THeight+(THeight div 2));
  // Draw a rectangle based on the text sizes
  Canvas.Rectangle(R.Left-1, R.Top-1, R.Right+1, R.Bottom+1);
  // Draw the Text within the rectangle
  Canvas.TextRect(R,0,0,DString);
end;

procedure TMainForm.mmiTextSizeClick(Sender: TObject);
begin
  ClearCanvas;
  with Canvas do
    begin
      Font.Size := 18;
      TextOut(10, 10, DString);
      TextOut(50, 50, 'TextWidth = '+IntToStr(TextWidth(DString)));
      TextOut(100, 100, 'TextHeight = '+IntToStr(TextHeight(DString)));
    end;
end;

procedure TMainForm.mmiDrawTextCenterClick(Sender: TObject);
```

continues

LISTING 8.5 Continued

```
var
  R: TRect;
begin
  ClearCanvas;
  Canvas.Font.Size := 10;
  R := Rect(10, 10, 80, 100);
  // Draw a rectangle to surround the TRect boundaries by 2 pixels }
  Canvas.Rectangle(R.Left-2, R.Top-2, R.Right+2, R.Bottom+2);
  // Draw text centered by specifying the dt_Center option
  DrawText(Canvas.Handle, PChar(DString2), -1, R, dt_WordBreak or dt_Center);
end;

procedure TMainForm.mmiDrawTextRightClick(Sender: TObject);
var
  R: TRect;
begin
  ClearCanvas;
  Canvas.Font.Size := 10;
  R := Rect(10, 10, 80, 100);
  // Draw a rectangle to surround the TRect boundaries by 2 pixels
  Canvas.Rectangle(R.Left-2, R.Top-2, R.Right+2, R.Bottom+2);
  // Draw text right-aligned by specifying the dt_Right option
  DrawText(Canvas.Handle, PChar(DString2), -1, R, dt_WordBreak or dt_Right);
end;

procedure TMainForm.mmiDrawTextLeftClick(Sender: TObject);
var
  R: TRect;
begin
  ClearCanvas;
  Canvas.Font.Size := 10;
  R := Rect(10, 10, 80, 100);
  // Draw a rectangle to surround the TRect boundaries by 2 pixels
  Canvas.Rectangle(R.Left-2, R.Top-2, R.Right+2, R.Bottom+2);
  // Draw text left-aligned by specifying the dt_Left option
  DrawText(Canvas.Handle, PChar(DString2), -1, R, dt_WordBreak or dt_Left);
end;

end.
```

Like the other projects, this project contains the `ClearCanvas()` method to erase the contents of the form's canvas.

The various methods of the main form are event handlers to the form's main menu.

The `mmiTextRectClick()` method illustrates how to use the `TCanvas.TextRect()` method. It determines the text width and height and draws the text inside a rectangle the height of the original text size. Its output is shown in Figure 8.10.

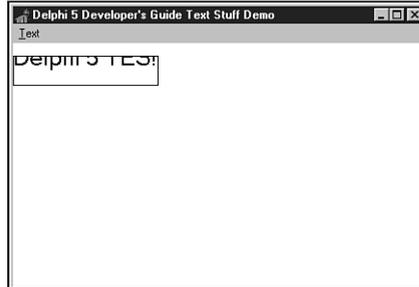


FIGURE 8.10

The output of `mmiTextRectClick()`.

`mmiTextSizeClick()` shows how to determine the size of a text string using the `TCanvas.TextWidth()` and `TCanvas.TextHeight()` methods. Its output is shown in Figure 8.11.

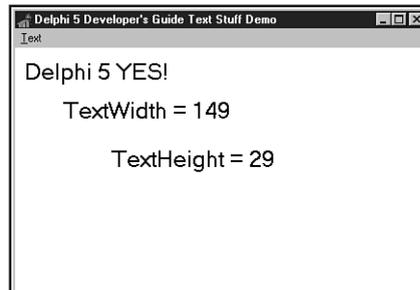


FIGURE 8.11

The output of `mmiTextSizeClick()`.

Using Non-TCanvas GDI Text Output Routines

In the sample project, the `mmiDrawTextCenter()`, `mmiDrawTextRight()`, and `mmiDrawTextLeft()` methods all illustrate using the Win32 GDI function `DrawText()`. `DrawText()` is a GDI function not encapsulated by the `TCanvas` class.

This code illustrates how Delphi 5's encapsulation of Win32 GDI through the `TCanvas` class doesn't prevent you from making use of the abundant Win32 GDI functions. Instead, `TCanvas` really just simplifies using the more common routines while still enabling you to call any Win32 GDI function you might need.

If you look at the various GDI functions such as `BitBlt()` and `DrawText()`, you'll find that one of the required parameters is a DC, or *device context*. The device context is accessible through the canvas's `Handle` property. `TCanvas.Handle` is the DC for that canvas.

Device Contexts

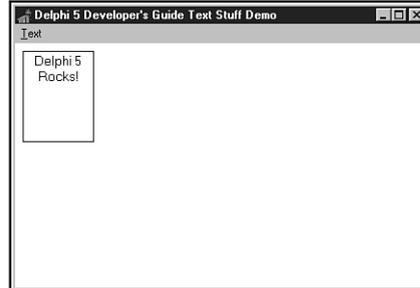
Device contexts (DCs) are handles provided by Win32 to identify a Win32 application's connection to an output device such as a monitor, printer, or plotter through a device driver. In traditional Windows programming, you're responsible for requesting a DC whenever you need to paint to a window's surface; then, when done, you have to return the DC back to Windows. Delphi 5 simplifies the management of DCs by encapsulating DC management in the `TCanvas` class. In fact, `TCanvas` even caches your DC, saving it for later so that requests to Win32 occur less often—thus, speeding up your program's overall execution.

To see how to use `TCanvas` with a Win32 GDI function, you used the GDI routine `DrawText()` to output text with advanced formatting capabilities. `DrawText` takes the following five parameters:

<i>Parameter</i>	<i>Description</i>
DC	Device context of the drawing surface.
Str	Pointer to a buffer containing the text to be drawn. This must be a null-terminated string if the <code>Count</code> parameter is <code>-1</code> .
Count	Number of bytes in <code>Str</code> . If this value is <code>-1</code> , <code>Str</code> is a pointer to a null-terminated string.
Rect	Pointer to a <code>TRect</code> structure containing the coordinates of the rectangle in which the text is formatted.
Format	A bit field that contains flags specifying the various formatting options for <code>Str</code> .

In the example, you initialize a `TRect` structure using the `Rect()` function. You'll use the structure to draw a rectangle around the text drawn with the `DrawText()` function. Each of the three methods passes a different set of formatting flags to the `DrawText()` function. The `dt_WordBreak` and `dt_Center` formatting flags are passed to the `DrawText()` function to center the text in the rectangle specified by the `TRect` variable `R`. `dt_WordBreak`, OR'ed with `dt_Right`, is used to right-justify the text in the rectangle. Likewise, `dt_WordBreak`, OR'ed with `dt_Left`, left-justifies the text. The `dt_WordBreak` specifier word-wraps the text within the width given by the rectangle parameter and modifies the rectangle height to bind the text after being word-wrapped.

The output of `mmiDrawTextCenterClick()` is shown in Figure 8.12.

**FIGURE 8.12**

The output of `mmiDrawTextCenterClick()`.

`TCanvas` also has the methods `Draw()`, `Copy()`, `CopyRect()`, and `StretchDraw()`, which enable you to draw, copy, expand, and shrink an image or a portion of an image to another canvas. You'll use `CopyRect()` when we show you how to create a paint program later in this chapter. Also, Chapter 16, "MDI Applications," shows you how to use the `StretchDraw()` method to stretch a bitmap image onto the client area of a form.

Coordinate Systems and Mapping Modes

Most GDI drawing routines require a set of coordinates that specify the location where drawing is to occur. These coordinates are based on a unit of measurement, such as the pixel. Additionally, GDI routines assume an orientation for the vertical and horizontal axis—that is, how increasing or decreasing the values of the X,Y coordinates moves the position at which drawing occurs. Win32 relies on two factors to perform drawing routines. These are the Win32 coordinates system and the mapping mode of the area that's being drawn to.

Win32 coordinates systems are, generally, no different from any other coordinates system. You define a coordinate for an X,Y axis, and Win32 plots that location to a point on your drawing surface based on a given orientation. Win32 uses three coordinates systems to plot areas on drawing surfaces called the *device*, *logical*, and *world* coordinates. Windows 95 doesn't support world transformations (bitmap rotation, shearing, twisting, and so on). We'll cover the first two modes in this chapter.

Device Coordinates

Device coordinates, as the name implies, refer to the device on which Win32 is running. Its measurements are in pixels, and the orientation is such that the horizontal and vertical axes increase from left to right and top to bottom. For example, if you're running Windows on a 640×480 pixel display, the coordinates at the top-left corner on your device are (0,0), whereas the bottom-right coordinates are (639,479).

Logical Coordinates

Logical coordinates refer to the coordinates system used by any area in Win32 that has a device context or DC such as a screen, a form, or a form's client area. The difference between device and logical coordinates is explained in a moment. The screen, form window, and form client-area coordinates are explained first.

Screen Coordinates

Screen coordinates refer to the display device; therefore, it follows that coordinates are based on pixel measurements. On a 640×480 display, `Screen.Width` and `Screen.Height` are also 640 and 480 pixels, respectively. To obtain a device context for the screen, use the Win32 API function `GetDC()`. You must match any function that retrieves a device context with a call to `ReleaseDC()`. The following code illustrates this:

```
var
  ScreenDC: HDC;
begin
  Screen DC := GetDC(0);
  try
    { Do whatever you need to do with ScreenDC }
  finally
    ReleaseDC(0, ScreenDC);
  end;
end;
```

Form Coordinates

Form coordinates are synonymous with the term *window coordinates* and refer to an entire form or window, including the caption bar and borders. Delphi 5 doesn't provide a DC to the form's drawing area through a form's property, but you can obtain one by using the Win32 API function `GetWindowDC()`, as follows:

```
MyDC := GetWindowDC(Form1.Handle);
```

This function returns the DC for the window handle passed to it.

NOTE

You can use a `TCanvas` object to encapsulate the device contexts obtained from the calls to `GetDC()` and `GetWindowDC()`. This enables you to use the `TCanvas` methods against those device contexts. You just need to create a `TCanvas` instance and then assign the result of `GetDC()` or `GetWindowDC()` to the `TCanvas.Handle` property. This

works because the `TCanvas` object takes ownership of the handle you assign to it, and it will release the DC when the canvas is freed. The following code illustrates this technique:

```
var
  c: TCanvas;
begin
  c := TCanvas.Create;
  try
    c.Handle := GetDC(0);
    c.TextOut(10, 10, 'Hello World');
  finally
    c.Free;
  end;
end;
```

A form's *client-area coordinates* refer to a form's client area whose DC is the `Handle` property of the form's `Canvas` and whose measurements are obtained from `Canvas.ClientWidth` and `Canvas.ClientHeight`.

Coordinate Mapping

So why not just use device coordinates instead of logical coordinates when performing drawing routines? Examine the following line of code:

```
Form1.Canvas.TextOut(0, 0, 'Upper Left Corner of Form');
```

This line places the string at the upper-left corner of the form. The coordinates (0,0) map to the position (0,0) in the form's device context—logical coordinates. However, the position (0,0) for the form is completely different in device coordinates and depends on where the form is located on your screen. If the form just happens to be located at the upper-left corner of your screen, the form's coordinates (0,0) may in fact map to (0,0) in device coordinates. However, as you move the form to another location, the form's position (0,0) will map to a completely different location on the device.

TIP

You can obtain a point based on device coordinates from the point as it's represented in logical coordinates, and vice versa, using the Win32 API functions `ClientToScreen()` and `ScreenToClient()`, respectively. These are also `TControl` methods. Note that this works only with screen DCs associated with a visible control.

continues

For printer or metafile DCs that are not screen based, convert logical pixels to device pixels by using the `LPtoDP()` Win32 function. Also see `DPtoLP()` in the Win32 online help.

Underneath the call to `Canvas.TextOut()`, Win32 does actually use device coordinates. For Win32 to do this, it must “map” the logical coordinates of the DC being drawn to, to device coordinates. It does this using the mapping mode associated with the DC.

Another reason for using logical coordinates is that you might not want to use pixels to perform drawing routines. Perhaps you want to draw using inches or millimeters. Win32 enables you to change the unit with which you perform your drawing routines by changing its mapping mode, as you’ll see in a moment.

Mapping modes define two attributes for the DC: the translation that Win32 uses to convert logical units to device units, and the orientation of the X,Y axis for the DC.

NOTE

It might not seem apparent that drawing routines, mapping modes, orientation, and so on are associated with a DC because, in Delphi 5, you use the canvas to draw. Remember that `TCanvas` is a wrapper for a DC. This becomes obvious when comparing Win32 GDI routines to their equivalent `Canvas` routines. Here are examples:

Canvas routine: `Canvas.Rectangle(0, 0, 50, 50);`

GDI routine: `Rectangle(ADC, 0, 0, 50, 50);`

When you’re using the GDI routine, a DC is passed to the function, whereas the canvas’s routine uses the DC that it encapsulates.

Win32 enables you to define the mapping mode for a DC or `TCanvas.Handle`. In fact, Win32 defines eight mapping modes you can use. These mapping modes, along with their attributes, are shown in Table 8.4. The sample project in the next section illustrates more about mapping modes.

TABLE 8.4 Win32 Mapping Modes

<i>Mapping Mode</i>	<i>Logical Unit Size</i>	<i>Orientation (X,Y)</i>
MM_ANISOTROPIC	Arbitrary ($x \neq y$) or ($x = y$)	Definable/definable
MM_HIENGLISH	0.001 inch	Right/up

<i>Mapping Mode</i>	<i>Logical Unit Size</i>	<i>Orientation (X,Y)</i>
MM_HIMETRIC	0.01 mm	Right/up
MM_ISOTROPIC	arbitrary (x = y)	Definable/definable
MM_LOENGLISH	0.01 inch	Right/up
MM_LOMETRIC	0.1 mm	Right/up
MM_TEXT	1 pixel	Right/down
MM_TWIPS	1/1440 inch	Right/up

Win32 defines a few functions that enable you to change or retrieve information about the mapping modes for a given DC. Here's a summary of these functions:

- `SetMapMode()`. Sets the mapping mode for a given device context.
- `GetMapMode()`. Gets the mapping mode for a given device context.
- `SetWindowOrgEx()`. Defines a window origin (point 0,0) for a given DC.
- `SetViewportOrgEx()`. Defines a viewport origin (point 0,0) for a given DC.
- `SetWindowExtEx()`. Defines the X,Y extents for a given window DC. These values are used in conjunction with the viewport X,Y extents to perform translation from logical units to device units.
- `SetViewportExtEx()`. Defines the X,Y extents for a given viewport DC. These values are used in conjunction with the window X,Y extents to perform translation from logical units to device units.

Notice that these functions contain either the word `Window` or `ViewPort`. The window or viewport is simply a means by which Win32 GDI can perform the translation from logical to device units. The functions with `Window` refer to the logical coordinate system, whereas those with `ViewPort` refer to the device coordinates system. With the exception of the `MM_ANISOTROPIC` and `MM_ISOTROPIC` mapping modes, you don't have to worry about this much. In fact, Win32 uses the `MM_TEXT` mapping mode by default.

NOTE

`MM_TEXT` is the default mapping mode, and it maps logical coordinates 1:1 with device coordinates. So, you're always using device coordinates on all DCs, unless you change the mapping mode. There are some API functions where this is significant: Font heights, for example, are always specified in device pixels, not logical pixels.

Setting the Mapping Mode

You'll notice that each mapping mode uses a different logical unit size. In some cases, it might be convenient to use a different mapping mode for that reason. For example, you might want to display a line 2 inches wide, regardless of the resolution of your output device. In this instance, `MM_LOENGLISH` would be a good candidate for a mapping mode to use.

As an example of drawing a 1-inch rectangle to the form, you first change the mapping mode for `Form1.Canvas.Handle` to `MM_HIENGLISH` or `MM_LOENGLISH`:

```
SetMapMode(Canvas.Handle, MM_LOENGLISH);
```

Then you draw the rectangle using the appropriate units of measurement for a 1-inch rectangle. Because `MM_LOENGLISH` uses $\frac{1}{100}$ inch, you simply pass the value `100`, as follows (this will be illustrated further in a later example):

```
Canvas.Rectangle(0, 0, 100, 100);
```

Because `MM_TEXT` uses pixels as its unit of measurement, you can use the Win32 API function `GetDeviceCaps()` to retrieve the information you need to perform translation from pixels to inches or millimeters. Then you can do your own calculations if you want. This is demonstrated in Chapter 10, "Printing in Delphi 5." Mapping modes are a way to let Win32 do the work for you. Note, however, that you'll most likely never be able to get exact measurements for screen displays. There are a few reasons for this: Windows cannot record the display size of the screen—it must guess. Also, Windows typically inflates display scales to improve text readability on relatively chunky monitors. So, for example, a 10-point font on a screen is about as tall as a 12- to 14-point font on paper.

Setting the Window/Viewport Extents

The `SetWindowExtEx()` and `SetViewportExtEx()` functions enable you to define how Win32 translates logical units to device units. These functions have an effect only when the window's mapping mode is either `MM_ANISOTROPIC` or `MM_ISOTROPIC`. They are ignored otherwise. Therefore, the following lines of code mean that one logical unit requires two device units (pixels):

```
SetWindowExtEx(Canvas.Handle, 1, 1, nil)  
SetViewportExtEx(Canvas.Handle, 2, 2, nil);
```

Likewise, these lines of code mean that five logical units require 10 device units:

```
SetWindowExtEx(Canvas.Handle, 5, 5, nil)  
SetViewportExtEx(Canvas.Handle, 10, 10, nil);
```

Notice that this is exactly the same as the previous example. Both have the same effect of having a 1:2 ratio of logical to device units. Here's an example of how this may be used to change the units for a form:

```
SetWindowExtEx(Canvas.Handle, 500, 500, nil)  
SetViewportExtEx(Canvas.Handle, ClientWidth, ClientHeight, nil);
```

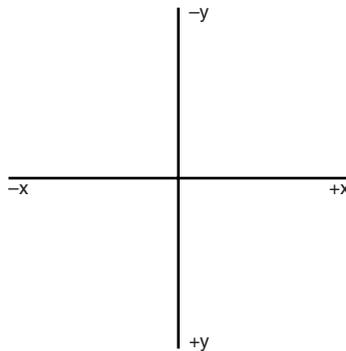
NOTE

Changing the mapping mode for a device context represented by a VCL canvas is not “sticky,” which means that it may revert back to its original mode. Generally, the map mode must be set within the handler doing the actual drawing.

This enables you to work with a form whose client width and height are 500×500 units (not pixels) despite any resizing of the form.

The `SetWindowOrgEx()` and `SetViewportOrgEx()` functions enable you to relocate the origin or position (0,0), which, by default, is at the upper-left corner of a form’s client area in the `MM_TEXT` mapping mode. Typically, you just modify the viewport origin. For example, the following line sets up a four-quadrant coordinate system like the one illustrated in Figure 8.13:

```
SetViewportOrgEx(Canvas.Handle, ClientWidth div 2, ClientHeight div 2, nil);
```

**FIGURE 8.13**

A four-quadrant coordinate system.

Notice that we pass a `nil` value as the last parameter in the `SetWindowOrgEx()`, `SetViewportOrgEx()`, `SetWindowExtEx()`, and `SetViewportExtEx()` functions. The `SetWindowOrgEx()` and `SetViewportOrgEx()` functions take a `TPoint` variable that gets assigned the last origin value so that you can restore the origin for the DC, if necessary. The `SetWindowExtEx()` and `SetViewportExtEx()` functions take a `TSize` structure to store the original extents for the DC for the same reason.

Mapping Mode Example Project

Listing 8.6 shows you the unit for a project. This project illustrates how to set mapping modes, window and viewport origins, and windows and viewport extents. It also illustrates how to draw various shapes using TCanvas methods. You can load this project from the CD.

LISTING 8.6 An Illustration of Mapping Modes

```
unit MainFrm;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, Menus, DB, DBCGrids, DBTables;

type
  TMainForm = class(TForm)
    mmMain: TMainMenu;
    mmiMappingMode: TMenuItem;
    mmiMM_ISOTROPIC: TMenuItem;
    mmiMM_ANSITROPIC: TMenuItem;
    mmiMM_LOENGLISH: TMenuItem;
    mmiMM_HIINGLISH: TMenuItem;
    mmiMM_LOMETRIC: TMenuItem;
    mmiMM_HIMETRIC: TMenuItem;
    procedure FormCreate(Sender: TObject);
    procedure mmiMM_ISOTROPICClick(Sender: TObject);
    procedure mmiMM_ANSITROPICClick(Sender: TObject);
    procedure mmiMM_LOENGLISHClick(Sender: TObject);
    procedure mmiMM_HIINGLISHClick(Sender: TObject);
    procedure mmiMM_LOMETRICClick(Sender: TObject);
    procedure mmiMM_HIMETRICClick(Sender: TObject);
  public
    MappingMode: Integer;
    procedure ClearCanvas;
    procedure DrawMapMode(Sender: TObject);
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.ClearCanvas;
begin
```

```
with Canvas do
begin
  Brush.Style := bsSolid;
  Brush.Color := clWhite;
  FillRect(ClipRect);
end;
end;

procedure TMainForm.DrawMapMode(Sender: TObject);
var
  PrevMapMode: Integer;
begin
  ClearCanvas;
  Canvas.TextOut(0, 0, (Sender as TMenuItem).Caption);

  // Set mapping mode to MM_LOENGLISH and save the previous mapping mode
  PrevMapMode := SetMapMode(Canvas.Handle, MappingMode);
  try
    // Set the viewport org to left, bottom
    SetViewPortOrgEx(Canvas.Handle, 0, ClientHeight, nil);
    { Draw some shapes to illustrate drawing shapes with different
      mapping modes specified by MappingMode }
    Canvas.Rectangle(0, 0, 200, 200);
    Canvas.Rectangle(200, 200, 400, 400);
    Canvas.Ellipse(200, 200, 400, 400);
    Canvas.MoveTo(0, 0);
    Canvas.LineTo(400, 400);
    Canvas.MoveTo(0, 200);
    Canvas.LineTo(200, 0);
  finally
    // Restore previous mapping mode
    SetMapMode(Canvas.Handle, PrevMapMode);
  end;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
  MappingMode := MM_TEXT;
end;

procedure TMainForm.mmiMM_ISOTROPICClick(Sender: TObject);
var
  PrevMapMode: Integer;
begin
  ClearCanvas;
  // Set mapping mode to MM_ISOTROPIC and save the previous mapping mode
  PrevMapMode := SetMapMode(Canvas.Handle, MM_ISOTROPIC);
```

continues

LISTING 8.6 Continued

```
try
  // Set the window extent to 500 x 500
  SetWindowExtEx(Canvas.Handle, 500, 500, nil);
  // Set the Viewport extent to the Window's client area
  SetViewportExtEx(Canvas.Handle, ClientWidth, ClientHeight, nil);
  // Set the ViewPortOrg to the center of the client area
  SetViewportOrgEx(Canvas.Handle, ClientWidth div 2,
    ClientHeight div 2, nil);
  // Draw a rectangle based on current settings
  Canvas.Rectangle(0, 0, 250, 250);
  { Set the viewport extent to a different value, and
    draw another rectangle. continue to do this three
    more times so that a rectangle is draw to represent
    the plane in a four-quadrant square }
  SetViewportExtEx(Canvas.Handle, ClientWidth, -ClientHeight, nil);
  Canvas.Rectangle(0, 0, 250, 250);

  SetViewportExtEx(Canvas.Handle, -ClientWidth, -ClientHeight, nil);
  Canvas.Rectangle(0, 0, 250, 250);

  SetViewportExtEx(Canvas.Handle, -ClientWidth, ClientHeight, nil);
  Canvas.Rectangle(0, 0, 250, 250);
  // Draw an ellipse in the center of the client area
  Canvas.Ellipse(-50, -50, 50, 50);
finally
  // Restore the previous mapping mode
  SetMapMode(Canvas.Handle, PrevMapMode);
end;
end;

procedure TMainForm.mmiMM_ANSITROPICClick(Sender: TObject);
var
  PrevMapMode: Integer;
begin
  ClearCanvas;
  // Set the mapping mode to MM_ANISOTROPIC and save the
  // previous mapping mode
  PrevMapMode := SetMapMode(Canvas.Handle, MM_ANISOTROPIC);
  try
    // Set the window extent to 500 x 500
    SetWindowExtEx(Canvas.Handle, 500, 500, nil);
    // Set the Viewport extent to that of the Window's client area
    SetViewportExtEx(Canvas.Handle, ClientWidth, ClientHeight, nil);
    // Set the ViewPortOrg to the center of the client area
    SetViewportOrgEx(Canvas.Handle, ClientWidth div 2,
      ClientHeight div 2, nil);
```

```
// Draw a rectangle based on current settings
Canvas.Rectangle(0, 0, 250, 250);
{ Set the viewport extent to a different value, and
  draw another rectangle. continue to do this three
  more times so that a rectangle is draw to represent
  the plane in a four-quadrant square }
SetViewportExtEx(Canvas.Handle, ClientWidth, -ClientHeight, nil);
Canvas.Rectangle(0, 0, 250, 250);

SetViewportExtEx(Canvas.Handle, -ClientWidth, -ClientHeight, nil);
Canvas.Rectangle(0, 0, 250, 250);

SetViewportExtEx(Canvas.Handle, -ClientWidth, ClientHeight, nil);
Canvas.Rectangle(0, 0, 250, 250);
// Draw an ellipse in the center of the client area
Canvas.Ellipse(-50, -50, 50, 50);
finally
  //Restore the previous mapping mode
  SetMapMode(Canvas.Handle, PrevMapMode);
end;
end;

procedure TMainForm.mmiMM_LOENGLISHClick(Sender: TObject);
begin
  MappingMode := MM_LOENGLISH;
  DrawMapMode(Sender);
end;

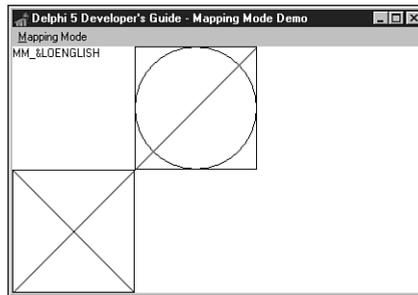
procedure TMainForm.mmiMM_HIENGLISHClick(Sender: TObject);
begin
  MappingMode := MM_HIENGLISH;
  DrawMapMode(Sender);
end;

procedure TMainForm.mmiMM_LOMETRICClick(Sender: TObject);
begin
  MappingMode := MM_LOMETRIC;
  DrawMapMode(Sender);
end;

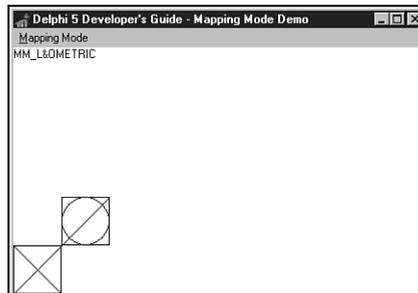
procedure TMainForm.mmiMM_HIMETRICClick(Sender: TObject);
begin
  MappingMode := MM_HIMETRIC;
  DrawMapMode(Sender);
end;

end.
```

The main form's field `MappingMode` is used to hold the current mapping mode that's initialized in the `FormCreate()` method to `MM_TEXT`. This variable gets set whenever the `MMLOENGLISH1Click()`, `MMHIENGLISH1Click()`, `MMLOMETRIC1Click()`, and `MMHIMETRIC1Click()` methods are invoked from their respective menus. These methods then call the method `DrawMapMode()`, which sets the main form's mapping mode to that specified by `MappingMode`. It then draws some shapes and lines using constant values to specify their sizes. When different mapping modes are used when drawing the shapes, they'll be sized differently on the form because the measurements used are used in the context of the specified mapping mode. Figures 8.14 and 8.15 illustrate `DrawMapMode()`'s output for the `MM_LOENGLISH` and `MM_LOMETRIC` mapping modes.

**FIGURE 8.14**

`DrawMapMode()` output using `MM_LOENGLISH` mapping mode.

**FIGURE 8.15**

`DrawMapMode()` output using `MM_LOMETRIC` mapping mode.

The `mmiMM_ISOTROPIC1Click()` method illustrates drawing with the form's canvas in the `MM_ISOTROPIC` mode. This method first sets the mapping mode and then sets the canvas's view-port extent to that of the form's client area. The origin is then set to the center of the form's client area, which allows all four quadrants of the coordinate system to be viewed.

The method then draws a rectangle in each plane and an ellipse in the center of the client area. Notice how you can use the same values in the parameters passed to `Canvas.Rectangle()` yet draw to different areas of the canvas. This is accomplished by passing negative values to the X parameter, Y parameter, or both parameters passed to `SetViewportExt()`.

The `mmiMM_ANISOTROPICClick()` method performs the same operations except it uses the `MM_ANISOTROPIC` mode. The purpose of showing both is to illustrate the principle difference between the `MM_ISOTROPIC` and `MM_ANISOTROPIC` mapping modes.

Using the `MM_ISOTROPIC` mode, Win32 ensures that the two axes use the same physical size and makes the necessary adjustments to see this is the case. The `MM_ANISOTROPIC` mode, however, uses physical dimensions that might not be equal. Figures 8.16 and 8.17 illustrate this more clearly. You can see that the `MM_ISOTROPIC` mode ensures equality with the two axes, whereas the same code using the `MM_ANISOTROPIC` mode does not ensure equality. In fact, the `MM_ISOTROPIC` mode further guarantees that the square logical coordinates will be mapped to device coordinates such that squareness will be preserved, even if the device coordinates system is not square.

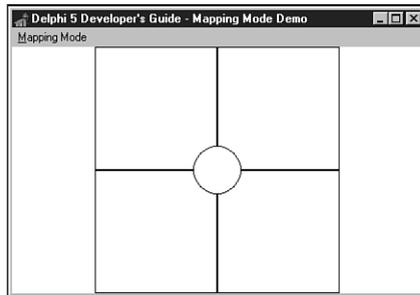


FIGURE 8.16

MM_ISOTROPIC mapping mode output.

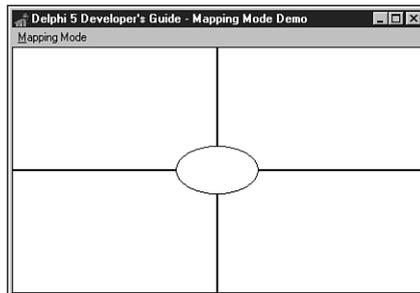


FIGURE 8.17

MM_ANISOTROPIC mapping mode output.

Creating a Paint Program

The paint program shown here uses several advanced techniques in working with GDI and graphics images. You can find this project on the CD as `DDGPaint.dpr`. Listing 8.7 shows the source code for this project.

LISTING 8.7 The Paint Program: `DDGPaint`

```
unit MainFrm;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, Buttons, ExtCtrls, ColorGrd, StdCtrls, Menus,
  ComCtrls;

const
  crMove = 1;
type

  TDrawType = (dtLineDraw, dtRectangle, dtEllipse, dtRoundRect,
               dtClipRect, dtCrooked);

  TMainForm = class(TForm)
    sbxMain: TScrollBar;
    imgDrawingPad: TImage;
    pnlToolBar: TPanel;
    sbLine: TSpeedButton;
    sbRectangle: TSpeedButton;
    sbEllipse: TSpeedButton;
    sbRoundRect: TSpeedButton;
    pnlColors: TPanel;
    cgDrawingColors: TColorGrid;
    pnlFgBgBorder: TPanel;
    pnlFgBgInner: TPanel;
    Bevel1: TBevel;
    mmMain: TMainMenu;
    mmiFile: TMenuItem;
    mmiExit: TMenuItem;
    N2: TMenuItem;
    mmiSaveAs: TMenuItem;
    mmiSaveFile: TMenuItem;
    mmiOpenFile: TMenuItem;
    mmiNewFile: TMenuItem;
    mmiEdit: TMenuItem;
```

```

mmiPaste: TMenuItem;
mmiCopy: TMenuItem;
mmiCut: TMenuItem;
sbRectSelect: TSpeedButton;
SaveDialog: TSaveDialog;
OpenDialog: TOpenDialog;
stbMain: TStatusBar;
pbPasteBox: TPaintBox;
sbFreeForm: TSpeedButton;
RgGrpFillOptions: TRadioGroup;
cbxBorder: TCheckBox;
procedure FormCreate(Sender: TObject);
procedure sbLineClick(Sender: TObject);
procedure imgDrawingPadMouseDown(Sender: TObject; Button:
    TMouseButton; Shift: TShiftState; X, Y: Integer);
procedure imgDrawingPadMouseMove(Sender: TObject;
    Shift: TShiftState; X, Y: Integer);
procedure imgDrawingPadMouseUp(Sender: TObject; Button: TMouseButton;
    Shift: TShiftState; X, Y: Integer);
procedure cgDrawingColorsChange(Sender: TObject);
procedure mmiExitClick(Sender: TObject);
procedure mmiSaveFileClick(Sender: TObject);
procedure mmiSaveAsClick(Sender: TObject);
procedure FormCloseQuery(Sender: TObject; var CanClose: Boolean);
procedure mmiNewFileClick(Sender: TObject);
procedure mmiOpenFileClick(Sender: TObject);
procedure mmiEditClick(Sender: TObject);
procedure mmiCutClick(Sender: TObject);
procedure mmiCopyClick(Sender: TObject);
procedure mmiPasteClick(Sender: TObject);
procedure pbPasteBoxMouseDown(Sender: TObject; Button: TMouseButton;
    Shift: TShiftState; X, Y: Integer);
procedure pbPasteBoxMouseMove(Sender: TObject; Shift: TShiftState; X,
    Y: Integer);
procedure pbPasteBoxMouseUp(Sender: TObject; Button: TMouseButton;
    Shift: TShiftState; X, Y: Integer);
procedure pbPasteBoxPaint(Sender: TObject);
procedure FormDestroy(Sender: TObject);
procedure RgGrpFillOptionsClick(Sender: TObject);
public
{ Public declarations }
MouseOrg: TPoint; // Stores mouse information
NextPoint: TPoint; // Stores mouse information
Drawing: Boolean; // Drawing is being performed flag
DrawType: TDrawType; // Holds the draw type information: TDrawType
FillSelected, // Fill shapes flag

```

LISTING 8.7 Continued

```

BorderSelected: Boolean; // Draw Shapes with no border flag
EraseClipRect: Boolean; // Specifies whether or not to erase the
                        // clipping rectangle
Modified: Boolean; // Image modified flag
FileName: String; // Holds the filename of the image
OldClipViewHwnd: Hwnd; // Holds the old clipboard view window
{ Paste Image variables }
PBoxMoving: Boolean; // PasteBox is moving flag
PBoxMouseOrg: TPoint; // Stores mouse coordinates for PasteBox
PasteBitMap: TBitmap; // Stores a bitmap image of the pasted data
Pasted: Boolean; // Data pasted flag
LastDot: TPoint; // Hold the TPoint coordinate for performing
                // free line drawing
procedure DrawToImage(TL, BR: TPoint; PenMode: TPenMode);
{ This procedure paints the image specified by the DrawType field
  to imgDrawingPad }
procedure SetDrawingStyle;
{ This procedure sets various Pen/Brush styles based on values
  specified by the form's controls. The Panels and color grid is
  used to set these values }
procedure CopyPasteBoxToImage;
{ This procedure copies the data pasted from the Windows clipboard
  onto the main image component imgDrawingPad }
procedure WMDrawClipboard(var Msg: TWMDrawClipboard);
  message WM_DRAWCLIPBOARD;
{ This message handler captures the WM_DRAWCLIPBOARD messages
  which is sent to all windows that have been added to the clipboard
  viewer chain. An application can add itself to the clipboard viewer
  chain by using the SetClipboardViewer() Win32 API function as
  is done in FormCreate() }
procedure CopyCut(Cut: Boolean);
{ This method copies a portion of the main image, imgDrawingPad,
  to the Window's clipboard. }
end;

var
  MainForm: TMainForm;

implementation
uses ClipBrd, Math;

{$R *.DFM}

procedure TMainForm.FormCreate(Sender: TObject);
{ This method sets the form's field to their default values. It then

```

```

creates a bitmap for the imgDrawingPad. This is the image on which
drawing is done. Finally, it adds this application as part of the
Windows clipboard viewer chain by using the SetClipboardViewer()
function. This makes enables the form to get WM_DRAWCLIPBOARD messages
which are sent to all windows in the clipboard viewer chain whenever
the clipboard data is modified. }
begin
Screen.Cursors[crMove] := LoadCursor(hInstance, 'MOVE');

FillSelected := False;
BorderSelected := True;

Modified := False;
FileName := '';
Pasted := False;
pbPasteBox.Enabled := False;

// Create a bitmap for imgDrawingPad and set its boundaries
with imgDrawingPad do
begin
SetBounds(0, 0, 600, 400);
Picture.Graphic := TBitmap.Create;
Picture.Graphic.Width := 600;
Picture.Graphic.Height := 400;
end;
// Now create a bitmap image to hold pasted data
PasteBitmap := TBitmap.Create;
pbPasteBox.BringToFront;
{ Add the form to the Windows clipboard viewer chain. Save the handle
of the next window in the chain so that it may be restored by the
ChangeClipboardChange() Win32 API function in this form's
FormDestroy() method. }
OldClipViewHwnd := SetClipboardViewer(Handle);
end;

procedure TMainForm.WMDrawClipBoard(var Msg: TWMDrawClipBoard);
begin
{ This method will be called whenever the clipboard data
has changed. Because the main form was added to the clipboard
viewer chain, it will receive the WM_DRAWCLIPBOARD message
indicating that the clipboard's data was changed. }
inherited;
{ Make sure that the data contained on the clipboard is actually
bitmap data. }
if Clipboard.HasFormat(CF_BITMAP) then
mmiPaste.Enabled := True

```

LISTING 8.7 Continued

```
    else
        mmiPaste.Enabled := False;
    Msg.Result := 0;
end;

procedure TMainForm.DrawToImage(TL, BR: TPoint; PenMode: TPenMode);
{ This method performs the specified drawing operation. The
  drawing operation is specified by the DrawType field }
begin
    with imgDrawingPad.Canvas do
        begin
            Pen.Mode := PenMode;

            case DrawType of
                dtLineDraw:
                    begin
                        MoveTo(TL.X, TL.Y);
                        LineTo(BR.X, BR.Y);
                    end;
                dtRectangle:
                    Rectangle(TL.X, TL.Y, BR.X, BR.Y);
                dtEllipse:
                    Ellipse(TL.X, TL.Y, BR.X, BR.Y);
                dtRoundRect:
                    RoundRect(TL.X, TL.Y, BR.X, BR.Y,
                        (TL.X - BR.X) div 2, (TL.Y - BR.Y) div 2);
                dtClipRect:
                    Rectangle(TL.X, TL.Y, BR.X, BR.Y);
            end;
        end;
end;

procedure TMainForm.CopyPasteBoxToImage;
{ This method copies the image pasted from the Windows clipboard onto
  imgDrawingPad. It first erases any bounding rectangle drawn by PaintBox
  component, pbPasteBox. It then copies the data from pbPasteBox onto
  imgDrawingPad at the location where pbPasteBox has been dragged
  over imgDrawingPad. The reason we don't copy the contents of
  pbPasteBox's canvas and use PasteBitmap's canvas instead, is because
  when a portion of pbPasteBox is dragged out of the viewable area,
  Windows does not paint the portion pbPasteBox not visible. Therefore,
  it is necessary to the pasted bitmap from the off-screen bitmap }
var
```

```

    SrcRect, DestRect: TRect;
begin
    // First, erase the rectangle drawn by pbPasteBox
    with pbPasteBox do
    begin
        Canvas.Pen.Mode := pmNotXOR;
        Canvas.Pen.Style := psDot;
        Canvas.Brush.Style := bsClear;
        Canvas.Rectangle(0, 0, Width, Height);
        DestRect := Rect(Left, Top, Left+Width, Top+Height);
        SrcRect := Rect(0, 0, Width, Height);
    end;
    { Here we must use the PasteBitmap instead of the pbPasteBox because
      pbPasteBox will clip anything outside if the viewable area. }
    imgDrawingPad.Canvas.CopyRect(DestRect, PasteBitmap.Canvas, SrcRect);
    pbPasteBox.Visible := false;
    pbPasteBox.Enabled := false;
    Pasted := False; // Pasting operation is complete
end;

procedure TMainForm.imgDrawingPadMouseDown(Sender: TObject;
    Button: TMouseButton; Shift: TShiftState; X, Y: Integer);
begin
    Modified := True;
    // Erase the clipping rectangle if one has been drawn
    if (DrawType = dtClipRect) and EraseClipRect then
        DrawToImage(MouseOrg, NextPoint, pmNotXOR)
    else if (DrawType = dtClipRect) then
        EraseClipRect := True; // Re-enable cliprect erasing

    { If an bitmap was pasted from the clipboard, copy it to the
      image and remove the PaintBox. }
    if Pasted then
        CopyPasteBoxToImage;

    Drawing := True;
    // Save the mouse information
    MouseOrg := Point(X, Y);
    NextPoint := MouseOrg;
    LastDot := NextPoint; // Lastdot is updated as the mouse moves
    imgDrawingPad.Canvas.MoveTo(X, Y);
end;

procedure TMainForm.imgDrawingPadMouseMove(Sender: TObject;
    Shift: TShiftState; X, Y: Integer);
{ This method determines the drawing operation to be performed and

```

LISTING 8.7 Continued

```
    either performs free form line drawing, or calls the
    DrawToImage method which draws the specified shape }
begin
  if Drawing then
  begin
    if DrawType = dtCrooked then
    begin
      imgDrawingPad.Canvas.MoveTo(LastDot.X, LastDot.Y);
      imgDrawingPad.Canvas.LineTo(X, Y);
      LastDot := Point(X,Y);
    end
    else begin
      DrawToImage(MouseOrg, NextPoint, pmNotXor);
      NextPoint := Point(X, Y);
      DrawToImage(MouseOrg, NextPoint, pmNotXor)
    end;
  end;
  // Update the status bar with the current mouse location
  stbMain.Panels[1].Text := Format('X: %d, Y: %D', [X, Y]);
end;

procedure TMainForm.imgDrawingPadMouseUp(Sender: TObject;
  Button: TMouseButton; Shift: TShiftState; X, Y: Integer);
begin
  if Drawing then
  { Prevent the clipping rectangle from destroying the images already
  on the image }
  if not (DrawType = dtClipRect) then
    DrawToImage(MouseOrg, Point(X, Y), pmCopy);
  Drawing := False;
end;

procedure TMainForm.sbLineClick(Sender: TObject);
begin
  // First erase the cliprect if current drawing type
  if DrawType = dtClipRect then
    DrawToImage(MouseOrg, NextPoint, pmNotXOR);

  { Now set the DrawType field to that specified by the TSpeedButton
  invoking this method. The TSpeedButton's Tag values match a
  specific TDrawType value which is why the typecasting below
  successfully assigns a valid TDrawType value to the DrawType field. }
  if Sender is TSpeedButton then
    DrawType := TDrawType(TSpeedButton(Sender).Tag);
```

```
// Now make sure the dtClipRect style doesn't erase previous drawings
if DrawType = dtClipRect then begin
    EraseClipRect := False;
end;
// Set the drawing style
SetDrawingStyle;
end;
```

```
procedure TMainForm.cgDrawingColorsChange(Sender: TObject);
{ This method draws the rectangle representing fill and border colors
  to indicate the users selection of both colors. pnlFgBgInner and
  pnlFgBgBorder are TPanel arranged one on top of the other for the
  desired effect }
begin
    pnlFgBgBorder.Color := cgDrawingColors.ForegroundColor;
    pnlFgBgInner.Color := cgDrawingColors.BackgroundColor;
    SetDrawingStyle;
end;
```

```
procedure TMainForm.SetDrawingStyle;
{ This method sets the various drawing styles based on the selections
  on the pnlFillStyle TPanel for Fill and Border styles }
begin
    with imgDrawingPad do
        begin
            if DrawType = dtClipRect then
                begin
                    Canvas.Pen.Style := psDot;
                    Canvas.Brush.Style := bsClear;
                    Canvas.Pen.Color := clBlack;
                end

            else if FillSelected then
                Canvas.Brush.Style := bsSolid
            else
                Canvas.Brush.Style := bsClear;

            if BorderSelected then
                Canvas.Pen.Style := psSolid
            else
                Canvas.Pen.Style := psClear;

            if FillSelected and (DrawType <> dtClipRect) then
                Canvas.Brush.Color := pnlFgBgInner.Color;
```

LISTING 8.7 Continued

```
        if DrawType <> dtClipRect then
            Canvas.Pen.Color := pnIFgBgBorder.Color;
        end;
    end;

procedure TMainForm.mmiExitClick(Sender: TObject);
begin
    Close; // Terminate application
end;

procedure TMainForm.mmiSaveFileClick(Sender: TObject);
{ This method saves the image to the file specified by FileName. If
  FileName is blank, however, SaveAs1Click is called to get a filename.}
begin
    if FileName = '' then
        mmiSaveAsClick(nil)
    else begin
        imgDrawingPad.Picture.SaveToFile(FileName);
        stbMain.Panels[0].Text := FileName;
        Modified := False;
    end;
end;

procedure TMainForm.mmiSaveAsClick(Sender: TObject);
{ This method launches SaveDialog to get a file name to which
  the image's contents will be saved. }
begin
    if SaveDialog.Execute then
    begin
        FileName := SaveDialog.FileName; // Store the filename
        mmiSaveFileClick(nil)
    end;
end;

procedure TMainForm.FormCloseQuery(Sender: TObject;
    var CanClose: Boolean);
{ If the user attempts to close the form before saving the image, they
  are prompted to do so in this method. }
var
    Rslt: Word;
begin
    CanClose := False; // Assume fail.
    if Modified then begin
        Rslt := MessageDlg('File has changed, save?',
            mtConfirmation, mbYesNOCancel, 0);
```

```

    case Rslt of
        mrYes: mmiSaveFileClick(nil);
        mrNo: ; // no need to do anything.
        mrCancel: Exit;
    end
end;
CanClose := True; // Allow use to close application
end;

procedure TMainForm.mmiNewFileClick(Sender: TObject);
{ This method erases any drawing on the main image after prompting the
  user to save it to a file in which case the mmiSaveFileClick event handler
  is called. }
var
    Rslt: Word;
begin
    if Modified then begin
        Rslt := MessageDlg('File has changed, save?', mtConfirmation,
mbYesNOCancel, 0);
        case Rslt of
            mrYes: mmiSaveFileClick(nil);
            mrNo: ; // no need to do anything.
            mrCancel: Exit;
        end
    end;

    with imgDrawingPad.Canvas do begin
        Brush.Style := bsSolid;
        Brush.Color := clWhite; // clWhite erases the image
        FillRect(ClipRect); // Erase the image
        FileName := '';
        stbMain.Panels[0].Text := FileName;
    end;
    SetDrawingStyle; // Restore the previous drawing style
    Modified := False;
end;

procedure TMainForm.mmiOpenFileClick(Sender: TObject);
{ This method opens a bitmap file specified by OpenFileDialog.FileName. If
  a file was already created, the user is prompted to save
  the file in which case the mmiSaveFileClick event is called. }
var
    Rslt: Word;
begin
    if OpenFileDialog.Execute then

```

continues

LISTING 8.7 Continued

```
begin

    if Modified then begin
        Rslt := MessageDlg('File has changed, save?',
            mtConfirmation, mbYesNOCancel, 0);
        case Rslt of
            mrYes: mmiSaveFileClick(nil);
            mrNo: ; // no need to do anything.
            mrCancel: Exit;
        end
    end;

    imgDrawingPad.Picture.LoadFromFile(OpenDialog.FileName);
    FileName := OpenDialog.FileName;
    stbMain.Panels[0].Text := FileName;
    Modified := false;
end;

end;

procedure TMainForm.mmiEditClick(Sender: TObject);
{ The timer is used to determine if an area on the main image is
  surrounded by a bounding rectangle. If so, then the Copy and Cut
  menu items are enabled. Otherwise, they are disabled. }
var
    IsRect: Boolean;
begin
    IsRect := (MouseOrg.X <> NextPoint.X) and (MouseOrg.Y <> NextPoint.Y);
    if (DrawType = dtClipRect) and IsRect then
    begin
        mmiCut.Enabled := True;
        mmiCopy.Enabled := True;
    end
    else begin
        mmiCut.Enabled := False;
        mmiCopy.Enabled := False;
    end;
end;

procedure TMainForm.CopyCut(Cut: Boolean);
{ This method copies a portion of the main image to the clipboard.
  The portion copied is specified by a bounding rectangle
  on the main image. If Cut is true, the area in the bounding rectangle
  is erased. }
var
```

```

CopyBitMap: TBitmap;
DestRect, SrcRect: TRect;
OldBrushColor: TColor;
begin
CopyBitMap := TBitmap.Create;
try
  { Set CopyBitmap's size based on the coordinates of the
    bounding rectangle }
CopyBitMap.Width := Abs(NextPoint.X - MouseOrg.X);
CopyBitMap.Height := Abs(NextPoint.Y - MouseOrg.Y);
DestRect := Rect(0, 0, CopyBitMap.Width, CopyBitMap.Height);
SrcRect := Rect(Min(MouseOrg.X, NextPoint.X)+1,
                Min(MouseOrg.Y, NextPoint.Y)+1,
                Max(MouseOrg.X, NextPoint.X)-1,
                Max(MouseOrg.Y, NextPoint.Y)-1);
  { Copy the portion of the main image surrounded by the bounding
    rectangle to the Windows clipboard }
CopyBitMap.Canvas.CopyRect(DestRect, imgDrawingPad.Canvas, SrcRect);
  { Previous versions of Delphi required the bitmap's Handle property
    to be touched for the bitmap to be made available. This was due to
    Delphi's caching of bitmapped images. The step below may not be
    required. }
CopyBitMap.Handle;
  // Assign the image to the clipboard.
Clipboard.Assign(CopyBitMap);
  { If cut was specified the erase the portion of the main image
    surrounded by the bounding Rectangle }
if Cut then
  with imgDrawingPad.Canvas do
  begin
    OldBrushColor := Brush.Color;
    Brush.Color := clWhite;
    try
      FillRect(SrcRect);
    finally
      Brush.Color := OldBrushColor;
    end;
  end;
finally
  CopyBitMap.Free;
end;
end;

procedure TMainForm.mmiCutClick(Sender: TObject);
begin
  CopyCut(True);

```

continues

LISTING 8.7 Continued

```
end;

procedure TMainForm.mmiCopyClick(Sender: TObject);
begin
  CopyCut(False);
end;

procedure TMainForm.mmiPasteClick(Sender: TObject);
{ This method pastes the data contained in the clipboard to the
  paste bitmap. The reason it is pasted to the PasteBitmap, an off-
  image elsewhere on to the main image. This is done by having the pbPasteBox,
  a TPaintBox component, draw the contents of PasteImage. When the
  user if done positioning the pbPasteBox, the contents of TPasteBitmap
  is drawn to imgDrawingPad at the location specified by pbPasteBox's
  location.}
begin
  { Clear the bounding rectangle }

  pbPasteBox.Enabled := True;
  if DrawType = dtClipRect then
  begin
    DrawToImage(MouseOrg, NextPoint, pmNotXOR);
    EraseClipRect := False;
  end;

  PasteBitmap.Assign(ClipBoard); // Grab the data from the clipboard
  Pasted := True;
  // Set position of pasted image to top left
  pbPasteBox.Left := 0;
  pbPasteBox.Top := 0;
  // Set the size of pbPasteBox to match the size of PasteBitmap
  pbPasteBox.Width := PasteBitmap.Width;
  pbPasteBox.Height := PasteBitmap.Height;

  pbPasteBox.Visible := True;
  pbPasteBox.Invalidate;
end;

procedure TMainForm.pbPasteBoxMouseDown(Sender: TObject;
  Button: TMouseButton; Shift: TShiftState; X, Y: Integer);
{ This method set's up pbPasteBox, a TPaintBox for being moved by the
  user when the left mouse button is held down }
begin
  if Button = mbLeft then
```

```

begin
  PBoxMoving := True;
  Screen.Cursor := crMove;
  PBoxMouseOrg := Point(X, Y);
end
else
  PBoxMoving := False;
end;

procedure TMainForm.pbPasteBoxMouseMove(Sender: TObject; Shift: TShiftState;
  X, Y: Integer);
{ This method moves pbPasteBox if the PBoxMoving flag is true indicating
  that the user is holding down the left mouse button and is dragging
  PaintBox }
begin
  if PBoxMoving then
    begin
      pbPasteBox.Left := pbPasteBox.Left + (X - PBoxMouseOrg.X);
      pbPasteBox.Top := pbPasteBox.Top + (Y - PBoxMouseOrg.Y);
    end;
end;

procedure TMainForm.pbPasteBoxMouseUp(Sender: TObject; Button: TMouseButton;
  Shift: TShiftState; X, Y: Integer);
begin
{ This method disables moving of pbPasteBox when the user lifts the left
  mouse button }
  if PBoxMoving then
    begin
      PBoxMoving := False;
      Screen.Cursor := crDefault;
    end;
  pbPasteBox.Refresh; // Redraw the pbPasteBox.
end;

procedure TMainForm.pbPasteBoxPaint(Sender: TObject);
{ The paintbox is drawn whenever the user selects the Paste option
  from the menu. pbPasteBox draws the contents of PasteBitmap which
  holds the image gotten from the clipboard. The reason for drawing
  PasteBitmap's contents in pbPasteBox, a TPaintBox class, is so that
  the user can also move the object around on top of the main image.
  In other words, pbPasteBox can be moved, and hidden when necessary. }
var
  DestRect, SrcRect: TRect;
begin
  // Display the paintbox only if a pasting operation occurred.

```

LISTING 8.7 Continued

```
if Pasted then
begin
  { First paint the contents of PasteBitmap using canvas's CopyRect
    but only if the paintbox is not being moved. This reduces
    flicker }
  if not PBoxMoving then
  begin
    DestRect := Rect(0, 0, pbPasteBox.Width, pbPasteBox.Height);
    SrcRect := Rect(0, 0, PasteBitmap.Width, PasteBitmap.Height);
    pbPasteBox.Canvas.CopyRect(DestRect, PasteBitmap.Canvas, SrcRect);
  end;
  { Now copy a bounding rectangle to indicate that pbPasteBox is
    a moveable object. We use a pen mode of pmNotXOR because we
    must erase this rectangle when the user copies PaintBox's
    contents to the main image and we must preserve the original
    contents. }
  pbPasteBox.Canvas.Pen.Mode := pmNotXOR;
  pbPasteBox.Canvas.Pen.Style := psDot;
  pbPasteBox.Canvas.Brush.Style := bsClear;
  pbPasteBox.Canvas.Rectangle(0, 0, pbPasteBox.Width,
    pbPasteBox.Height);
end;
end;

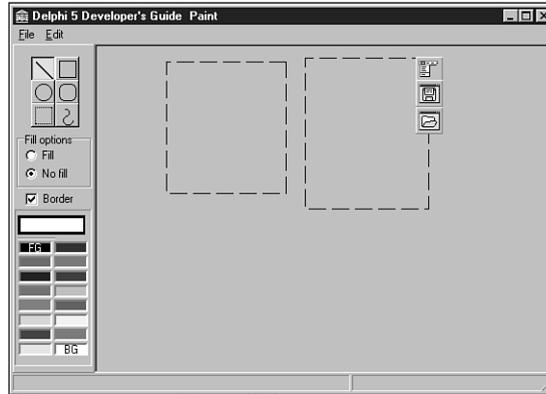
procedure TMainForm.FormDestroy(Sender: TObject);
begin
  // Remove the form from the clipboard chain
  ChangeClipboardChain(Handle, OldClipViewHwnd);
  PasteBitmap.Free; // Free the PasteBitmap instance
end;

procedure TMainForm.RgGrpFillOptionsClick(Sender: TObject);
begin
  FillSelected := RgGrpFillOptions.ItemIndex = 0;
  BorderSelected := cbxBorder.Checked;
  SetDrawingStyle;
end;

end.
```

How the Paint Program Works

The paint program is actually quite a bit of code. Because it would be difficult to explain how it works outside of the code, we've added ample comments to the source. We'll describe the general functionality of the paint program here. The main form is shown in Figure 8.18.

**FIGURE 8.18**

The main form for the paint program.

NOTE

Notice that a `TImage` component is used as a drawing surface for the paint program. Keep in mind that this can only be the case if the image uses a `TBitmap` object.

The main form contains a main image component, `imgDrawingPad`, which is placed on a `TScrollBox` component. `imgDrawingPad` is where the user performs drawing. The selected speed button on the form's toolbar specifies the type of drawing that the user performs.

The user can draw lines, rectangles, ellipses, and rounded rectangles as well as perform free-form drawing. Additionally, a portion of the main image can be selected and copied to the Windows Clipboard so that it can be pasted into another application that can handle bitmap data. Likewise, the paint program can accept bitmap data from the Windows Clipboard.

TPanel Techniques

The fill style and border type are specified by the Fill Options radio group. The fill and border colors are set using the color grid in the `ColorPanel` shown in Figure 8.18.

Clipboard Pasting of Bitmap Data

To paste data from the Clipboard, you use an offscreen bitmap, `PasteBitmap`, to hold the pasted data. A `TPaintBox` component, `PasteBox`, then draws the data from `PasteBitmap`. The reason for using a `TPaintBox` component for drawing the contents of `PasteBitmap` is so the user can move `PasteBox` to any location on the main image to designate where the pasted data is to be copied to the main image.

Attaching to the Win32 Clipboard Viewer Chain

Another technique shown by the paint program is how an application can attach itself to the Win32 Clipboard viewer chain. This is done in the `FormCreate()` method by the call to the Win32 API function `SetClipboardViewer()`. This function takes the handle of the window attaching itself to the chain and returns the handle to the next window in the chain. The return value must be stored so that when the application shuts down, it can restore the previous state of the chain using `ChangeClipboardChain()`, which takes the handle being removed and the saved handle. The paint program restores the chain in the main form's `FormDestroy()` method. When an application is attached to the Clipboard viewer chain, it receives the `WM_DRAWCLIPBOARD` messages whenever the data on the Clipboard is modified. You take advantage of this by capturing this message and enabling the Paste menu item if the changed data in the Clipboard is bitmap data. This is done in the `WMDrawClipboard()` method.

Bitmap Copying

Bitmap copy operations are performed in the `CopyCut()`, `PbPasteBoxPaint()`, and `CopyPasteBoxToImage()` methods. The `CopyCut()` method copies a portion of the main image selected by a bounding rectangle to the Clipboard and then erases the bounded area if the `Cut` parameter passed to it is `True`. Otherwise, it leaves the area intact.

`PbPasteBoxPaint()` copies the contents of the offscreen bitmap to `PbPasteBox.Canvas` but only when `PbPasteBox` is not being moved. This helps reduce flicker as the user moves `PbPasteBox`.

`CopyPasteBoxToImage()` copies the contents of the offscreen bitmap to the main image `imgDrawingPad` at the location specified by `PbPasteBox`.

Paint Program Comments

As mentioned earlier, much of the functionality of the paint program is documented in the code's commentary. It would be a good idea to read through the source and comments and step through the code so that you can gain a good understanding of what's happening in the program.

Performing Animation with Graphics Programming

This section demonstrates how you can achieve simple sprite animation by mixing Delphi 5 classes with Win32 GDI functions. The animation project resides on the CD as `Animate.dpr`. Listing 8.8 shows the main form, which contains the main form functionality.

LISTING 8.8 The Animation Project's Main Form

```
unit MainFrm;  
  
interface
```

```
uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, Menus, StdCtrls, AppEvnts;

{$R SPRITES.RES } // Link in the bitmaps

type

  TSprite = class
  private
    FWidth: integer;
    FHeight: integer;
    FLeft: integer;
    FTop: integer;
    FAndImage, FOrImage: TBitmap;
  public
    property Top: Integer read FTop write FTop;
    property Left: Integer read FLeft write FLeft;
    property Width: Integer read FWidth write FWidth;
    property Height: Integer read FHeight write FHeight;
    constructor Create;
    destructor Destroy; override;
  end;

  TMainForm = class(TForm)
    mmMain: TMainMenu;
    mmiFile: TMenuItem;
    mmiSlower: TMenuItem;
    mmiFaster: TMenuItem;
    N1: TMenuItem;
    mmiExit: TMenuItem;
    appevMain: TApplicationEvents;
    procedure FormCreate(Sender: TObject);
    procedure FormPaint(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
    procedure mmiExitClick(Sender: TObject);
    procedure mmiSlowerClick(Sender: TObject);
    procedure mmiFasterClick(Sender: TObject);
    procedure appevMainIdle(Sender: TObject; var Done: Boolean);
  private
    BackGnd1, BackGnd2: TBitmap;
    Sprite: TSprite;
    GoLeft, GoRight, GoUp, GoDown: boolean;
    FSpeed, FSpeedIndicator: Integer;
    procedure DrawSprite;
  end;
```

continues

LISTING 8.8 Continued

```
const

    BackGround = 'BACK2.BMP';

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

constructor TSprite.Create;
begin
    inherited Create;
    { Create the bitmaps to hold the sprite images that will
      be used for performing the AND/OR operation to create animation }
    FAndImage := TBitmap.Create;
    FAndImage.LoadFromResourceName(hInstance, 'AND');

    FOrImage := TBitmap.Create;
    FOrImage.LoadFromResourceName(hInstance, 'OR');

    Left := 0;
    Top := 0;
    Height := FAndImage.Height;
    Width := FAndImage.Width;

end;

destructor TSprite.Destroy;
begin
    FAndImage.Free;
    FOrImage.Free;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
    // Create the original background image
    BackGnd1 := TBitmap.Create;
    with BackGnd1 do
    begin
        LoadFromResourceName(hInstance, 'BACK');
        Parent := nil;
        SetBounds(0, 0, Width, Height);
    end;
end;
```

```
// Create a copy of the background image
BackGnd2 := TBitmap.Create;
BackGnd2.Assign(BackGnd1);

// Create a sprite image
Sprite := TSprite.Create;

// Initialize the direction variables
GoRight := true;
GoDown := true;
GoLeft := false;
GoUp := false;

FSpeed := 0;
FSpeedIndicator := 0;

{ Set the application's OnIdle event to MyIdleEvent which will start
the sprite moving }

// Adjust the form's client width/height
ClientWidth := BackGnd1.Width;
ClientHeight := BackGnd1.Height;

end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
    // Free all objects created in the form's create constructor
    BackGnd1.Free;
    BackGnd2.Free;
    Sprite.Free;
end;

procedure TMainForm.DrawSprite;
var
    OldBounds: TRect;
begin
    // Save the sprite's bounds in OldBounds
    with OldBounds do
    begin
        Left := Sprite.Left;
        Top := Sprite.Top;
        Right := Sprite.Width;
```

continues

LISTING 8.8 Continued

```
    Bottom := Sprite.Height;
end;

{ Now change the sprites bounds so that it moves in one direction
  or changes direction when it comes in contact with the form's
  boundaries }
with Sprite do
begin
  if GoLeft then
    if Left > 0 then
      Left := Left - 1
    else begin
      GoLeft := false;
      GoRight := true;
    end;

  if GoDown then
    if (Top + Height) < self.ClientHeight then
      Top := Top + 1
    else begin
      GoDown := false;
      GoUp := true;
    end;

  if GoUp then
    if Top > 0 then
      Top := Top - 1
    else begin
      GoUp := false;
      GoDown := true;
    end;

  if GoRight then
    if (Left + Width) < self.ClientWidth then
      Left := Left + 1
    else begin
      GoRight := false;
      GoLeft := true;
    end;
end;

{ Erase the original drawing of the sprite on BackGnd2 by copying
  a rectangle from BackGnd1 }
with OldBounds do
  BitBlt(BackGnd2.Canvas.Handle, Left, Top, Right, Bottom,
        BackGnd1.Canvas.Handle, Left, Top, SrcCopy);
```

```

{ Now draw the sprite onto the off-screen bitmap. By performing the
  drawing in an off-screen bitmap, the flicker is eliminated. }
with Sprite do
begin
  { Now create a black hole where the sprite first existed by And-ing
    the FAndImage onto BackGnd2 }
  BitBlt(BackGnd2.Canvas.Handle, Left, Top, Width, Height,
    FAndImage.Canvas.Handle, 0, 0, SrcAnd);
  // Now fill in the black hole with the sprites original colors
  BitBlt(BackGnd2.Canvas.Handle, Left, Top, Width, Height,
    FOrImage.Canvas.Handle, 0, 0, SrcPaint);
end;

{ Copy the sprite at its new location to the form's Canvas. A
  rectangle slightly larger than the sprite is needed
  to effectively erase the sprite by over-writing it, and draw the
  new sprite at the new location with a single BitBlt call }
with OldBounds do
  BitBlt(Canvas.Handle, Left - 2, Top - 2, Right + 2, Bottom + 2,
    BackGnd2.Canvas.Handle, Left - 2, Top - 2, SrcCopy);

end;

procedure TMainForm.FormPaint(Sender: TObject);
begin
  // Draw the background image whenever the form gets painted
  BitBlt(Canvas.Handle, 0, 0, ClientWidth, ClientHeight,
    BackGnd1.Canvas.Handle, 0, 0, SrcCopy);
end;

procedure TMainForm.mmiExitClick(Sender: TObject);
begin
  Close;
end;

procedure TMainForm.mmiSlowerClick(Sender: TObject);
begin
  Inc(FSpeedIndicator, 100);
end;

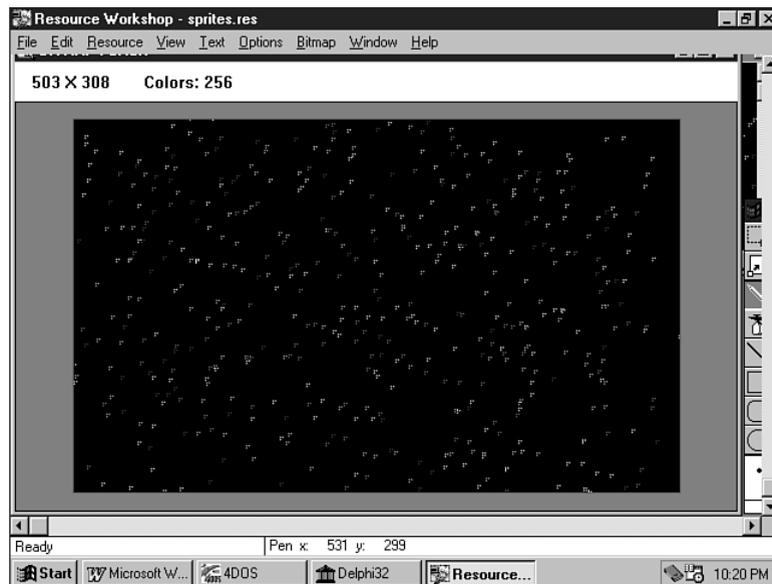
procedure TMainForm.mmiFasterClick(Sender: TObject);
begin
  if FSpeedIndicator >= 100 then
    Dec(FSpeedIndicator, 100)
  else
    FSpeedIndicator := 0;
end;

```

LISTING 8.8 Continued

```
end;  
  
procedure TMainForm.appexMainIdle(Sender: TObject; var Done: Boolean);  
begin  
  if FSpeed >= FSpeedIndicator then  
  begin  
    DrawSprite;  
    FSpeed := 0;  
  end  
  else  
    inc(FSpeed);  
  
Done := False;  
end;  
  
end.
```

The animation project consists of a background image on which a sprite, a flying saucer, is drawn and moved about the background's client area. The background is represented by a bitmap consisting of scattered stars (see Figure 8.19).

**FIGURE 8.19**

The background of the animation project.

The sprite is made up of two 64×32 bitmaps. More on these bitmaps later; for now, we'll discuss what goes on in the source code.

The unit defines a `TSprite` class. `TSprite` contains the fields that hold the sprite's location on the background image and two `TBitmap` objects to hold each of the sprite bitmaps. The `TSprite.Create` constructor creates both `TBitmap` instances and loads them with the actual bitmaps. Both the sprite bitmaps and the background bitmap are kept in a resource file that you link to the project by including the following statement in the main unit:

```
{ $R SPRITES.RES }
```

After the bitmap is loaded, the sprite's boundaries are set. The `TSprite.Done` destructor frees both bitmap instances.

The main form contains two `TBitmap` objects, a `TSprite` object, and direction indicators to specify the direction of the sprite's motion. Additionally, the main form defines another method, `DrawSprite()`, which has the sprite-drawing functionality. The `TApplicationEvents` component is a new Delphi 5 component that allows you to hook into the Application-level events. Prior to Delphi 5, you had to do this by adding Application-level events at runtime. Now, with this component, you can do all event management for `TApplication` at design time. We will use this component to provide an `OnIdle` event for the `TApplication` object.

Note that two private variables are used to control the speed of the animation: `FSpeed` and `FSpeedIndicator`. These are used in the `DrawSprite()` method for slowing down the animation on faster machines.

The `FormCreate()` event handler creates both `TBitmap` instances and loads each with the same background bitmap. (The reason you use two bitmaps will be discussed in a moment.) It then creates a `TSprite` instance, and sets the direction indicators. Finally `FormCreate()` resizes the form to the background image's size.

The `FormPaint()` method paints the `BackGnd1` to its canvas, and the `FormDestroy()` frees the `TBitmap` and `TSprite` instances.

The `appvMainIdle()` method calls `DrawSprite()`, which moves and draws the sprite on the background. The bulk of the work is done in the `DrawSprite()` method. `appvMainIdle()` will be invoked whenever the application is in an idle state. That is, whenever there are no actions from the user for the application to respond to.

The `DrawSprite()` method repositions the sprite on the background image. A series of steps is required to erase the old sprite on the background and then draw it at its new location while preserving the background colors around the actual sprite image. Additionally, `DrawSprite()` must perform these steps without producing flickering while the sprite is moving.

To accomplish this, drawing is performed on the offscreen bitmap, `BackGnd2`. `BackGnd2` and `BackGnd1` are exact copies of the background image. However, `BackGnd1` is never modified, so it's a clean copy of the background. When drawing is complete on `BackGnd2`, the modified area of `BackGnd2` is copied to the form's canvas. This allows for only one `BitBlt()` operation to the

form's canvas to both erase and draw the sprite at its new location. The drawing operations performed on BackGnd2 are as follows.

First, a rectangular region is copied from BackGnd1 to BackGnd2 over the area occupied by the sprite. This effectively erases the sprite from BackGnd2. Then the FAndImage bitmap is copied to BackGnd2 at its new location using the bitwise AND operation. This effectively creates a black hole in BackGnd2 where the sprite exists and still preserves the colors on BackGnd2 surrounding the sprite. Figure 8.20 shows FAndImage.

In Figure 8.20, the sprite is represented by black pixels, and the rest of the image surrounding it consists of white pixels. The color black has a value of 0, and the color white has the value of 1. Tables 8.5, and 8.6 show the results of performing the AND operation with black and white colors.

TABLE 8.5 AND Operation with Black Color

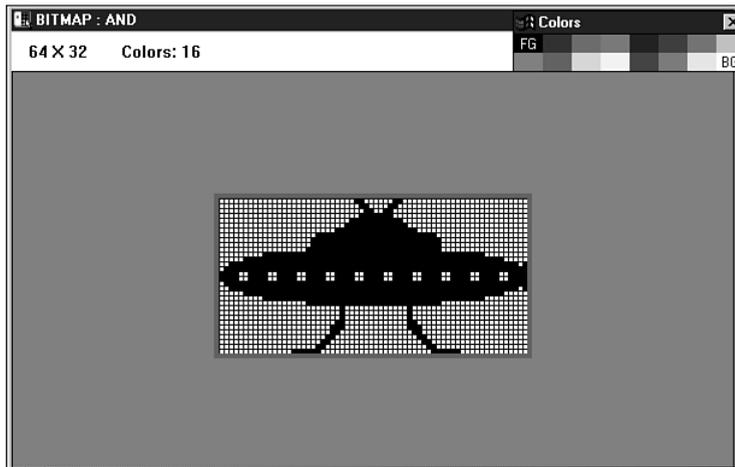
<i>Background</i>	<i>Value</i>	<i>Color</i>
BackGnd2	1001	Some color
FAndImage	0000	Black
Result	0000	Black

TABLE 8.6 AND Operation with White Color<\$AND operation; with white color>

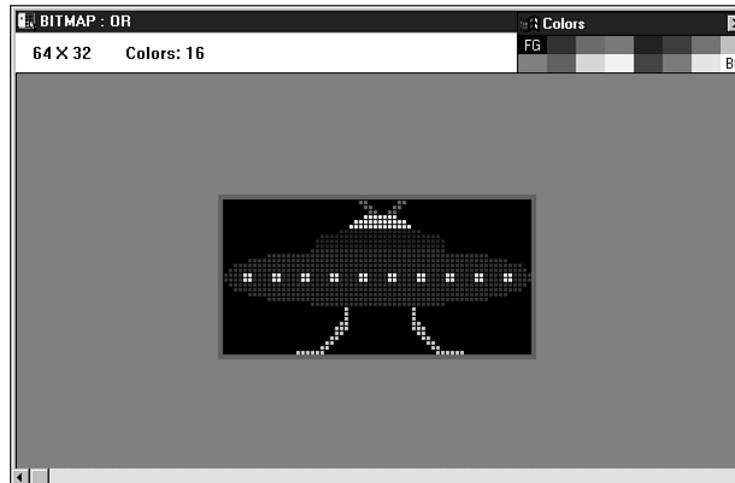
<i>Background</i>	<i>Value</i>	<i>Color</i>
BackGnd2	1001	Some color
FAndImage	1111	White
Result	1001	Some color

These tables show how performing the AND operation results in blacking out the area where the sprite exists on BackGnd2. In Table 8.5, Value represents a pixel color. If a pixel on BackGnd2 contains some arbitrary color, combining this color with the color black using the AND operator results in that pixel becoming black. Combining this color with the color white using the AND operator results in the color being the same as the arbitrary color, as shown in Table 8.6. Because the color surrounding the sprite in FAndImage is white, the pixels on BackGnd2 where this portion of FAndImage is copied retain their colors.

After copying FAndImage to BackGnd2, FOrImage must be copied to the same location on BackGnd2 to fill in the black hole created by FAndImage with the actual sprite colors. FOrImage also has a rectangle surrounding the actual sprite image. Again, you're faced with getting the sprite colors to BackGnd2 while preserving BackGnd2's colors surrounding the sprite. This is accomplished by combining FOrImage with BackGnd2 using the OR operation. FOrImage is shown in Figure 8.21.

**FIGURE 8.20**

FAndImage for a sprite.

**FIGURE 8.21**

FOrImage.

Notice that the area surrounding the sprite image is black. Table 8.7 shows the results of performing the OR operation on *FOrImage* and *BackGnd2*.

TABLE 8.7 An OR Operation with the Color Black

<i>Background</i>	<i>Value</i>	<i>Color</i>
BackGnd2	1001	Some color
FAndImage	0000	Black
Result	1001	Black

Table 8.7 shows that if BackGnd2 contains an arbitrary color, using the OR operation to combine it with black will result in BackGnd2's color.

Recall that all this drawing is performed on the offscreen bitmap. When the drawing is complete, a single `BitBlt()` is made to the form's canvas to erase and copy the sprite.

The technique shown here is a fairly common method for performing animation. You might consider extending the functionality of the `TSprite` class to move and draw itself on a parent canvas.

Advanced Fonts

Although the VCL enables you to manipulate fonts with relative ease, it doesn't provide the vast font-rendering capabilities provided by the Win32 API. This section gives you a background on Win32 fonts and shows you how to manipulate them.

Types of Win32 Fonts

There are basically two types of fonts in Win32: GDI fonts and device fonts. GDI fonts are stored in font resource files and have an extension of `.fon` (for raster and vector fonts) or `.tot` and `.ttf` (for TrueType fonts). Device fonts are specific to a particular device, such as a printer. Unlike with the GDI fonts, when Win32 uses a device font for printing text, it only needs to send the ASCII character to the device, and the device takes care of printing the character in the specified font. Otherwise, Win32 converts the font to a bitmap or performs the GDI function to draw the font. Drawing the font using bitmaps or GDI functions generally takes longer, as is the case with GDI fonts. Although device fonts are faster, they are device-specific and often very limiting in what fonts a particular device supports.

Basic Font Elements

Before you learn how to use the various fonts in Win32, you should know the various terms and elements associated with Win32 fonts.

A Font's Typeface, Family, and Measurements

Think of a font as just a picture or *glyph* representing a character. Each character has two characteristics: a typeface and a size.

In Win32, a font's *typeface* refers to the font's style and its size. Probably the best definition of typeface and how it relates to a font is in the Win32 help file. This definition says, "A typeface

is a collection of characters that share design characteristics; for example, Courier is a common typeface. A font is a collection of characters that have the same typeface and size.”

Win32 categorizes these different typefaces into five font families: Decorative, Modern, Roman, Script, and Swiss. The distinguishing font features in these families are the font’s serifs and stroke widths.

A *serif* is a small line at the beginning or end of a font’s main strokes that give the font a finished appearance. A *stroke* is the primary line that makes up the font. Figure 8.22 illustrates these two features.



FIGURE 8.22

Serifs and strokes.

Some of the typical fonts you’ll find in the different font families are listed in Table 8.8.

TABLE 8.8 Font Families and Typical Fonts

<i>Font Family</i>	<i>Typical Fonts</i>
Decorative	Novelty fonts: Old English
Modern	Fonts with constant strike widths that may or may not have serifs: Pica, Elite, and Courier New
Roman	Fonts with variable stroke widths and serifs: Times New Roman and New Century SchoolBook
Script	Fonts that look like handwriting: Script and Cursive
Swiss	Fonts with variable stroke widths without serifs: Arial and Helvetica

A font’s size is represented in points (a *point* is $\frac{1}{72}$ of an inch). A font’s height consists of its *ascender* and *descender*. The ascender and descender are represented by the `tmAscent` and `tmDescent` values as shown in Figure 8.23. Figure 8.23 shows other values essential to the character measurement as well.

Characters reside in a character *cell*, an area surrounding the character that consists of white space. When referring to character measurements, keep in mind that the measurement may include both the character glyph (the character’s visible portion) and the character cell. Others may refer to only one or the other.

Table 8.9 explains the meaning of the various character measurements.

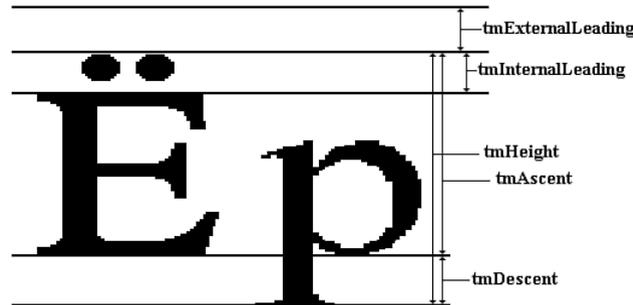


FIGURE 8.23

Character measurement values.

TABLE 8.9 Character Measurements

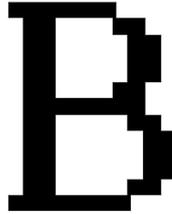
<i>Measurement</i>	<i>Meaning</i>
External leading	The space between text lines
Internal leading	The difference between the character's glyph height and the font's cell height
Ascent	Measurement from the baseline to the top of the character cell
Descent	Measurement from the baseline to the bottom of the character cell
Point size	The character height minus <code>tmInternalLeading</code>
Height	The sum of ascent, descent, and internal leading
Baseline	The line on which characters sit

GDI Font Categories

There are essentially three separate categories of GDI fonts: raster fonts, vector fonts (also referred to as *stroke fonts*), and TrueType fonts. The first two existed in older versions of Win32, whereas the latter was introduced in Windows 3.1.

Raster Fonts Explained

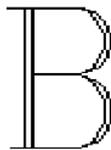
Raster fonts are basically bitmaps provided for a specific resolution or *aspect ratio* (ratio of the pixel height and width of a given device) and font size. Because these fonts are provided in specific sizes, Win32 can synthesize the font to generate a new font in the requested size, but it can do so only to produce a larger font from a smaller font. The reverse is not possible because the technique Win32 uses to synthesize the fonts is to duplicate the rows and columns that make up the original font bitmap. Raster fonts are convenient when the size requested is available. They're fast to display and look good when used at the intended size. The disadvantage is that they tend to look a bit sloppy when scaled to larger sizes, as shown in Figure 8.24, which displays the Win32 System font.

**FIGURE 8.24**

A raster font.

Vector Fonts Explained

Vector fonts are generated by Win32 with a series of lines created by GDI functions as opposed to bitmaps. These fonts offer better scalability than do raster fonts, but they have a much lower density when displayed, which may or may not be desired. Also, the performance of vector fonts is slow compared to raster fonts. Vector fonts lend themselves best to use with plotters but aren't recommended for designing appealing user interfaces. Figure 8.25 shows a typical vector font.

**FIGURE 8.25**

A vector font.

TrueType Fonts Explained

TrueType fonts are probably the most preferred of the three font types. The advantage to using TrueType fonts is that they can represent virtually any style of font in any size and look pleasing to the eye. Win32 displays TrueType fonts by using a collection of points and hints that describe the font outline. *Hints* are simply algorithms to distort a scaled font's outline to improve its appearance at different resolutions. Figure 8.26 shows a TrueType font.

**FIGURE 8.26**

A TrueType font.

Displaying Different Font Types

So far, we've given you the general concepts surrounding Windows's font technology. If you're interested in getting down to the many nuts and bolts of fonts, take a look at the Win32 online help file on "Fonts Overview," which provides you with a vast amount of information on the topic. Now, you'll learn how to use the Win32 API and Win32 structures to create and display fonts of any shape and size.

A Font-Creation Sample Project

The example to follow illustrates the process of instantiating different font types in Windows. The project also illustrates how to obtain information about a rendered font. This project is located in on the CD as `MakeFont.dpr`.

How the Project Works

Through the main form, you select various font attributes to be used in creating the font. The font then gets drawn to a `TPaintBox` component whenever you change the value of one of the font's attributes. (All components are attached to the `FontChanged()` event handler through their `OnChange` or `OnClick` events.) You also can view information about a font by clicking the Font Information button. Figure 8.27 shows the main form for this project. Listing 8.9 shows the unit defining the main form.

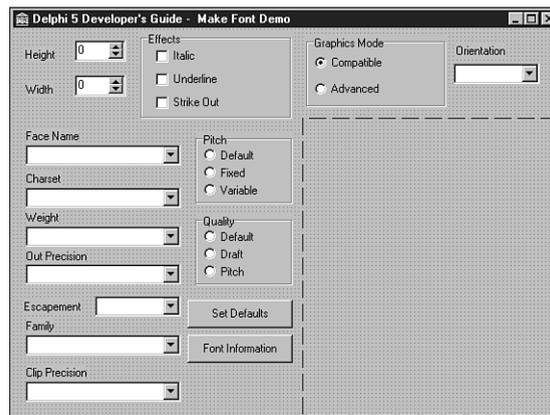


FIGURE 8.27

The main form for the font-creation project.

LISTING 8.9 The Font-Creation Project

```
unit MainFrm;  
  
interface
```

```
uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, ExtCtrls, Mask, Spin;

const

  // Array to represent the TLOGFONT.lfCharSet values
  CharSetArray: array[0..4] of byte = (ANSI_CHARSET, DEFAULT_CHARSET,
    SYMBOL_CHARSET, SHIFTJIS_CHARSET, OEM_CHARSET);

  // Array to represent the TLOGFONT.lfWeight values
  WeightArray: array[0..9] of integer =
    (FW_DONTCARE, FW_THIN, FW_EXTRALIGHT, FW_LIGHT, FW_NORMAL, FW_MEDIUM,
    FW_SEMIBOLD, FW_BOLD, FW_EXTRABOLD, FW_HEAVY);

  // Array to represent the TLOGFONT.lfOutPrecision values
  OutPrecArray: array[0..7] of byte = (OUT_DEFAULT_PRECIS,
    OUT_STRING_PRECIS, OUT_CHARACTER_PRECIS, OUT_STROKE_PRECIS,
    OUT_TT_PRECIS, OUT_DEVICE_PRECIS, OUT_RASTER_PRECIS,
    OUT_TT_ONLY_PRECIS);

  // Array to represent the TLOGFONT.lfPitchAndFamily higher four-bit
  // values
  FamilyArray: array[0..5] of byte = (FF_DONTCARE, FF_ROMAN,
    FF_SWISS, FF_MODERN, FF_SCRIPT, FF_DECORATIVE);

  // Array to represent the TLOGFONT.lfPitchAndFamily lower two-bit values
  PitchArray: array[0..2] of byte = (DEFAULT_PITCH, FIXED_PITCH,
    VARIABLE_PITCH);

  // Array to represent the TLOGFONT.lfClipPrecision values
  ClipPrecArray: array[0..6] of byte = (CLIP_DEFAULT_PRECIS,
    CLIP_CHARACTER_PRECIS, CLIP_STROKE_PRECIS, CLIP_MASK, CLIP_LH_ANGLES,
    CLIP_TT_ALWAYS, CLIP_EMBEDDED);

  // Array to represent the TLOGFONT.lfQuality values
  QualityArray: array[0..2] of byte = (DEFAULT_QUALITY, DRAFT_QUALITY,
    PROOF_QUALITY);

type

  TMainForm = class(TForm)
    lblHeight: TLabel;
    lblWidth: TLabel;
    gbEffects: TGroupBox;
    cbxItalic: TCheckBox;
```

continues

LISTING 8.9 Continued

```
    cbxUnderline: TCheckBox;
    cbxStrikeOut: TCheckBox;
    cbWeight: TComboBox;
    lblWeight: TLabel;
    lblEscapement: TLabel;
    cbEscapement: TComboBox;
    pbxFont: TPaintBox;
    cbCharSet: TComboBox;
    lblCharSet: TLabel;
    cbOutPrec: TComboBox;
    lblOutPrecision: TLabel;
    cbFontFace: TComboBox;
    rgPitch: TRadioGroup;
    cbFamily: TComboBox;
    lblFamily: TLabel;
    lblClipPrecision: TLabel;
    cbClipPrec: TComboBox;
    rgQuality: TRadioGroup;
    btnSetDefaults: TButton;
    btnFontInfo: TButton;
    lblFaceName: TLabel;
    rgGraphicsMode: TRadioGroup;
    lblOrientation: TLabel;
    cbOrientation: TComboBox;
    seHeight: TSpinEdit;
    seWidth: TSpinEdit;
    procedure pbxFontPaint(Sender: TObject);
    procedure FormActivate(Sender: TObject);
    procedure btnFontInfoClick(Sender: TObject);
    procedure btnSetDefaultsClick(Sender: TObject);
    procedure rgGraphicsModeClick(Sender: TObject);
    procedure cbEscapementChange(Sender: TObject);
    procedure FontChanged(Sender: TObject);
private
    { Private declarations }
    FLogFont: TLogFont;
    FFont: HFont;
    procedure MakeFont;
    procedure SetDefaults;
public
    { Public declarations }
end;

var
```

```
    MainForm: TMainForm;

implementation
uses FontInfoFrm;

{$R *.DFM}

procedure TMainForm.MakeFont;
begin
    // Clear the contents of FLogFont
    FillChar(FLogFont, sizeof(TLogFont), 0);
    // Set the TLOGFONT's fields
    with FLogFont do
    begin
        lfHeight      := StrToInt(seHeight.Text);
        lfWidth       := StrToInt(seWidth.Text);
        lfEscapement  :=
            StrToInt(cbEscapement.Items[cbEscapement.ItemIndex]);
        lfOrientation :=
            StrToInt(cbOrientation.Items[cbOrientation.ItemIndex]);
        lfWeight      := WeightArray[cbWeight.ItemIndex];
        lfItalic      := ord(cbxItalic.Checked);
        lfUnderline   := ord(cbxUnderLine.Checked);
        lfStrikeOut   := ord(cbxStrikeOut.Checked);
        lfCharSet     := CharSetArray[cbCharSet.ItemIndex];
        lfOutPrecision := OutPrecArray[cbOutPrec.ItemIndex];
        lfClipPrecision := ClipPrecArray[cbClipPrec.ItemIndex];
        lfQuality     := QualityArray[rgQuality.ItemIndex];
        lfPitchAndFamily := PitchArray[rgPitch.ItemIndex] or
            FamilyArray[cbFamily.ItemIndex];
        StrPCopy(lfFaceName, cbFontFace.Items[cbFontFace.ItemIndex]);
    end;
    // Retrieve the requested font
    FHFont := CreateFontIndirect(FLogFont);
    // Assign to the Font.Handle
    pbxFont.Font.Handle := FHFont;
    pbxFont.Refresh;
end;

procedure TMainForm.SetDefaults;
begin
    // Set the various controls to default values for ALogFont
    seHeight.Text      := '0';
    seWidth.Text       := '0';
    cbxItalic.Checked  := false;
    cbxStrikeOut.Checked := false;
```

LISTING 8.9 Continued

```
    cbxUnderline.Checked    := false;
    cbWeight.ItemIndex     := 0;
    cbEscapement.ItemIndex := 0;
    cbOrientation.ItemIndex := 0;
    cbCharset.ItemIndex    := 1;
    cbOutPrec.ItemIndex    := 0;
    cbFamily.ItemIndex     := 0;
    cbClipPrec.ItemIndex   := 0;
    rgPitch.ItemIndex      := 0;
    rgQuality.ItemIndex    := 0;
    // Fill CBFontFace TComboBox with the screen's fonts
    cbFontFace.Items.Assign(Screen.Fonts);
    cbFontFace.ItemIndex := cbFontFace.Items.IndexOf(Font.Name);
end;

procedure TMainForm.pbxFontPaint(Sender: TObject);
begin
    with pbxFont do
    begin
        { Note that in Windows 95, the graphics mode will always
          be GM_COMPATIBLE as GM_ADVANCED is recognized only by Windows NT.}
        case rgGraphicsMode.ItemIndex of
            0: SetGraphicsMode(pbxFont.Canvas.Handle, GM_COMPATIBLE);
            1: SetGraphicsMode(pbxFont.Canvas.Handle, GM_ADVANCED);
        end;
        Canvas.Rectangle(2, 2, Width-2, Height-2);
        // Write the fonts name
        Canvas.TextOut(Width div 2, Height div 2, CBFontFace.Text);
    end;
end;

procedure TMainForm.FormActivate(Sender: TObject);
begin
    SetDefaults;
    MakeFont;
end;

procedure TMainForm.btnFontInfoClick(Sender: TObject);
begin
    FontInfoForm.ShowModal;
end;

procedure TMainForm.btnSetDefaultsClick(Sender: TObject);
begin
    SetDefaults;
```

```
    MakeFont;
end;

procedure TMainForm.rgGraphicsModeClick(Sender: TObject);
begin
    cbOrientation.Enabled := rgGraphicsMode.ItemIndex = 1;
    if not cbOrientation.Enabled then
        cbOrientation.ItemIndex := cbEscapement.ItemIndex;
    MakeFont;
end;

procedure TMainForm.cbEscapementChange(Sender: TObject);
begin
    if not cbOrientation.Enabled then
        cbOrientation.ItemIndex := cbEscapement.ItemIndex;
end;

procedure TMainForm.FontChanged(Sender: TObject);
begin
    MakeFont;
end;

end.
```

In MAINFORM.PAS, you'll see several array definitions that will be explained shortly. For now, notice that the form has two private variables: FLogFont and FHFont. FLogFont is of type TLOGFONT, a record structure used to describe the font to create. FHFont is the handle to the font that gets created. The private method MakeFont() is where you create the font by first filling the FLogFont structure with values specified from the main form's components and then passing that structure to CreateFontIndirect(), a Win32 GDI function that returns a font handle to the new font. Before you go on, however, you need to understand the TLOGFONT structure.

The TLOGFONT Structure

As stated earlier, you use the TLOGFONT structure to define the font you want to create. This structure is defined in the WINDOWS unit as follows:

```
TLogFont = record
    lfHeight: Integer;
    lfWidth: Integer;
    lfEscapement: Integer;
    lfOrientation: Integer;
    lfWeight: Integer;
    lfItalic: Byte;
```

```

lfUnderline: Byte;
lfStrikeOut: Byte;
lfCharSet: Byte;
lfOutPrecision: Byte;
lfClipPrecision: Byte;
lfQuality: Byte;
lfPitchAndFamily: Byte;
lfFaceName: array[0..lf_FaceSize - 1] of Char;
end;

```

You place values in the `TLOGFONT`'s fields that specify the attributes you want your font to have. Each field represents a different type of attribute. By default, most of the fields can be set to zero, which is what the Set Defaults button on the main form does. In this instance, Win32 chooses the attributes for the font and returns whatever it pleases. The general rule is this: The more fields you fill in, the more you can fine-tune your font style. The following list explains what each `TLOGFONT` field represents. Some of the fields may be assigned constant values that are predefined in the `WINDOWS` unit. Refer to Win32 help for a detailed description of these values; we show you only the most commonly used ones here:

<i>Field Value</i>	<i>Description</i>
<code>lfHeight</code>	The font height. A value greater than zero indicates a cell height. A value less than zero indicates the glyph height (the cell height minus the internal leading). Set this field to zero to let Win32 decide a height for you.
<code>lfWidth</code>	The average font width. Set this field to zero to let Win32 choose a font width for you.
<code>lfEscapement</code>	The angle (in tenths of degrees) of rotation of the font's baseline (the line along which characters are drawn). In Windows 95/98, the text string and individual characters are drawn using the same angle. That is, <code>lfEscapement</code> and <code>lfOrientation</code> are the same. In Windows NT, text is drawn independently of the orientation angle of each character in the text string. To achieve the latter, you must set the graphics mode for the device to <code>GM_ADVANCED</code> using the <code>SetGraphicsMode()</code> Win32 GDI function. By default, the graphics mode is <code>GM_COMPATIBLE</code> , which makes the Windows NT behavior like Windows 95. This font-rotation effect is only available with TrueType fonts.
<code>lfOrientation</code>	Enables you to specify an angle at which to draw individual characters. In Windows 95/98, this has the same value as <code>lfEscapement</code> . In Windows NT, the values may be different. (See <code>lfEscapement</code> .)

<code>lfWeight</code>	This affects the font density. The WINDOWS unit defines several constants for this field, such as <code>FW_BOLD</code> and <code>FW_NORMAL</code> . Set this field to <code>FW_DONTCARE</code> to let Win32 choose a weight for you.
<code>lfItalic</code>	Nonzero means <i>italic</i> ; zero means <i>nonitalic</i> .
<code>lfUnderline</code>	Nonzero means <i>underlined</i> ; zero means <i>not underlined</i> .
<code>lfStrikeOut</code>	Nonzero means that a line gets drawn through the font, whereas a value of zero does not draw a line through the font.
<code>lfCharSet</code>	Win32 defines the character sets: <code>ANSI_CHARSET=0</code> , <code>DEFAULT_CHARSET=1</code> , <code>SYMBOL_CHARSET=2</code> , <code>SHIFTJIS_CHARSET=128</code> , and <code>OEM_CHARSET = 255</code> . Use the <code>DEFAULT_CHARSET</code> by default.
<code>lfOutPrecision</code>	Specifies how Win32 should match the requested font's size and characteristics to an actual font. Use <code>TT_ONLY_PRECIS</code> to specify only TrueType fonts. Other types are defined in the WINDOWS unit.
<code>lfClipPrecision</code>	Specifies how Win32 clips characters outside a clipping region. Use <code>CLIP_DEFAULT_PRECIS</code> to let Win32 choose.
<code>lfQuality</code>	Defines the font's output quality as GDI will draw it. Use <code>DEFAULT_QUALITY</code> to let Win32 decide, or you may specify <code>PROOF_QUALITY</code> or <code>DRAFT_QUALITY</code> .
<code>lfPitchAndFamily</code>	Defines the font's pitch in the two low-order bits. Specifies the family in the higher four high-order bits. Table 8.8 displays these families.
<code>lfFaceName</code>	The typeface name of the font.

The `MakeFont()` procedure uses the values defined in the constant section of `MainForm.pas`. These array constants contain the various predefined constant values for the `TLOGFONT` structure. These values are placed in the same order as the choices in the main form's `TComboBox` components. For example, the choices for the font family in the `CBFamily` combo box are in the same order as the values in `FamilyArray`. We used this technique to reduce the code required to fill in the `TLOGFONT` structure. The first line in the `MakeFont()` function

```
fillChar(FLogFont, sizeof(TLogFont), 0);
```

clears the `FLogFont` structure before any values are set. When `FLogFont` has been set, the line

```
FHFont := CreateFontIndirect(FLogFont);
```

calls the Win32 API function `CreateFontIndirect()`, which accepts the `TLOGFONT` structure as a parameter and returns a handle to the requested font. This handle is then set to the `TPaintBox.Font`'s handle property. Delphi 5 takes care of destroying the `TPaintBox`'s previous font before making the assignment. After the assignment is made, you redraw `pbxFont` by calling its `Refresh()` method.

The `SetDefaults()` method initializes the `TLOGFONT` structure with default values. This method is called when the main form is created and whenever the user clicks the Set Defaults button. Experiment with the project to see the different effects you can get with fonts, as shown in Figure 8.28.

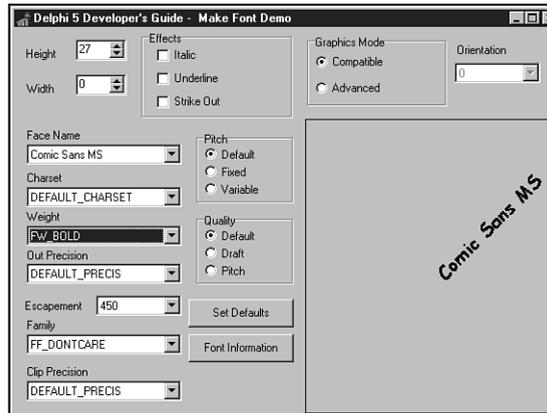


FIGURE 8.28

A rotated font.

Displaying Information About Fonts

The main form's Font Information button invokes the form `FontInfoForm`, which displays information about the selected font. When you specify font attributes in the `TLOGFONT` structure, Win32 attempts to provide you with a font that best resembles your requested font. It's entirely possible that the font you get back from the `CreateFontIndirect()` function has completely different attributes than what you requested. `FontInfoForm` lets you inspect your selected font's attributes. It uses the Win32 API function `GetTextMetrics()` to retrieve the font information.

`GetTextMetrics()` takes two parameters: the handle to the device context whose font you want to examine and a reference to another Win32 structure, `TTEXTMETRIC`. `GetTextMetrics()` then updates the `TTEXTMETRIC` structure with information about the given font. The `WINDOWS` unit defines the `TTEXTMETRIC` record as follows:

```
TTextMetric = record
    tmHeight: Integer;
    tmAscent: Integer;
    tmDescent: Integer;
    tmInternalLeading: Integer;
    tmExternalLeading: Integer;
    tmAveCharWidth: Integer;
```

```
tmMaxCharWidth: Integer;  
tmWeight: Integer;  
tmItalic: Byte;  
tmUnderlined: Byte;  
tmStruckOut: Byte;  
tmFirstChar: Byte;  
tmLastChar: Byte;  
tmDefaultChar: Byte;  
tmBreakChar: Byte;  
tmPitchAndFamily: Byte;  
tmCharSet: Byte;  
tmOverhang: Integer;  
tmDigitizedAspectX: Integer;  
tmDigitizedAspectY: Integer;  
end;
```

The TTEXTMETRIC record's fields contain much of the same information we've already discussed about fonts. For example, it shows a font's height, average character width, and whether the font is underlined, italicized, struck out, and so on. Refer to the Win32 API online help for detailed information on the TTEXTMETRIC structure. Listing 8.10 shows the code for the font information form.

LISTING 8.10 Source to the Font Information Form

```
unit FontInfoFrm;  
  
interface  
  
uses  
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,  
  Forms, Dialogs, ExtCtrls, StdCtrls;  
  
type  
  
  TFontInfoForm = class(TForm)  
    lbFontInfo: TListBox;  
    procedure FormActivate(Sender: TObject);  
  private  
    { Private declarations }  
  public  
    { Public declarations }  
  end;
```

continues

LISTING 8.10 Continued

```
var
    FontInfoForm: TFontInfoForm;

implementation
uses MainFrm;

{$R *.DFM}

procedure TFontInfoForm.FormActivate(Sender: TObject);
const
    PITCH_MASK: byte = $0F; // Set the lower order four bits
    FAMILY_MASK: byte = $F0; // Set to higher order four bits
var
    TxMetric: TTextMetric;
    FaceName: String;
    PitchTest, FamilyTest: byte;
begin

    // Allocate memory for FaceName string
    SetLength(FaceName, lf_FaceSize+1);

    // First get the font information
    with MainForm.pbxFont.Canvas do
    begin
        GetTextFace(Handle, lf_faceSize-1, PChar(FaceName));
        GetTextMetrics(Handle, TxMetric);
    end;

    // Now add the font information to the listbox from
    // the TTEXTMETRIC structure.
    with lbFontInfo.Items, TxMetric do
    begin
        Clear;
        Add('Font face name:      '+FaceName);
        Add('tmHeight:           '+IntToStr(tmHeight));
        Add('tmAscent:           '+IntToStr(tmAscent));
        Add('tmDescent:           '+IntToStr(tmDescent));
        Add('tmInternalLeading:    '+IntToStr(tmInternalLeading));
        Add('tmExternalLeading:     '+IntToStr(tmExternalLeading));
        Add('tmAveCharWidth:       '+IntToStr(tmAveCharWidth));
        Add('tmMaxCharWidth:       '+IntToStr(tmMaxCharWidth));
```

```
Add('tmWeight:      '+IntToStr(tmWeight));

if tmItalic <> 0 then
  Add('tmItalic: YES')
else
  Add('tmItalic: NO');

if tmUnderlined <> 0 then
  Add('tmUnderlined: YES')
else
  Add('tmUnderlined: NO');

if tmStruckOut <> 0 then
  Add('tmStruckOut: YES')
else
  Add('tmStruckOut: NO');

// Check the font's pitch type
PitchTest := tmPitchAndFamily and PITCH_MASK;
if (PitchTest and TMPF_FIXED_PITCH) = TMPF_FIXED_PITCH then
  Add('tmPitchAndFamily-Pitch: Fixed Pitch');
if (PitchTest and TMPF_VECTOR) = TMPF_VECTOR then
  Add('tmPitchAndFamily-Pitch: Vector');
if (PitchTest and TMPF_TRUETYPE) = TMPF_TRUETYPE then
  Add('tmPitchAndFamily-Pitch: True type');
if (PitchTest and TMPF_DEVICE) = TMPF_DEVICE then
  Add('tmPitchAndFamily-Pitch: Device');
if PitchTest = 0 then
  Add('tmPitchAndFamily-Pitch: Unknown');

// Check the fonts family type
FamilyTest := tmPitchAndFamily and FAMILY_MASK;
if (FamilyTest and FF_ROMAN) = FF_ROMAN then
  Add('tmPitchAndFamily-Family: FF_ROMAN');
if (FamilyTest and FF_SWISS) = FF_SWISS then
  Add('tmPitchAndFamily-Family: FF_SWISS');
if (FamilyTest and FF_MODERN) = FF_MODERN then
  Add('tmPitchAndFamily-Family: FF_MODERN');
if (FamilyTest and FF_SCRIPT) = FF_SCRIPT then
  Add('tmPitchAndFamily-Family: FF_SCRIPT');
if (FamilyTest and FF_DECORATIVE) = FF_DECORATIVE then
  Add('tmPitchAndFamily-Family: FF_DECORATIVE');
```

continues

LISTING 8.10 Continued

```

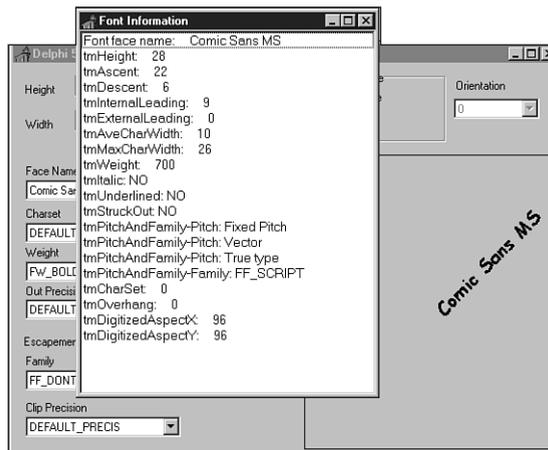
if FamilyTest = 0 then
    Add('tmPitchAndFamily-Family: Unknown');

Add('tmCharSet:      '+IntToStr(tmCharSet));
Add('tmOverhang:    '+IntToStr(tmOverhang));
Add('tmDigitizedAspectX:  '+IntToStr(tmDigitizedAspectX));
Add('tmDigitizedAspectY:  '+IntToStr(tmDigitizedAspectY));
end;
end;

end.

```

The `FormActive()` method first retrieves the font's name with the Win32 API function `GetTextFace()`, which takes a device context, a buffer size, and a null-terminated character buffer as parameters. `FormActivate()` then uses `GetTextMetrics()` to fill `TxMetric`, a `TTEXT-METRIC` record structure, for the selected font. The event handler then adds the values in `TxMetric` to the list box as strings. For the `tmPitchAndFamily` value, you mask out the high- or low-order bit, depending on the value you're testing for, and add the appropriate values to the list box. Figure 8.29 shows `FontInfoForm` displaying information about a font.

**FIGURE 8.29**

The font information form.

Summary

This chapter presented you with a lot of information about the Win32 Graphics Device Interface. We discussed Delphi 5's `TCanvas`, its properties, and its drawing methods. We also discussed Delphi 5's representation of images with its `TImage` component as well as mapping modes and Win32 coordinates systems. You saw how you can use graphics programming techniques to build a paint program and perform simple animation. Finally, we discussed fonts—how to create them and how to display information about them. One of the nice things about the GDI is that working with it can be a lot of fun. Entire books have been written on this subject alone. Take some time to experiment with the drawing routines, create your own fonts, or just fool around with the mapping modes to see what type of effects you can get.

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This chapter discusses Win32 dynamic link libraries, otherwise known as *DLLs*. DLLs are a key component to writing any Windows application. This chapter discusses several aspects of using and creating DLLs. It gives you an overview of how DLLs work and discusses how to create and use DLLs. You learn different methods of loading DLLs and linking to the procedures and functions they export. This chapter also covers the use of callback functions and illustrates how to share DLL data among different calling processes.

What Exactly Is a DLL?

Dynamic link libraries are program modules that contain code, data, or resources that can be shared among many Windows applications. One of the primary uses of DLLs is to enable applications to load code to execute at runtime instead of linking that code to the application at compile time. Therefore, multiple applications can simultaneously use the same code provided by the DLL. In fact, the files `Kerne132.d11`, `User32.d11`, and `GDI32.d11` are three DLLs on which Win32 relies heavily. `Kerne132.d11` is responsible for memory, process, and thread management. `User32.d11` contains routines for the user interface that deal with the creation of windows and the handling of Win32 messages. `GDI32.d11` deals with graphics. You'll also hear of other system DLLs, such as `AdvAPI32.d11` and `ComDlg32.d11`, which deal with object security/Registry manipulation and common dialog boxes, respectively.

Another advantage to using DLLs is that your applications become modular. This simplifies updating your applications because you need to replace only DLLs instead of replacing the entire application. The Windows environment presents a typical example of this type of modularity. Each time you install a new device, you also install a device driver DLL to enable that device to communicate with Windows. The advantage to modularity becomes obvious when you imagine having to reinstall Windows each time you install a new device to your system.

On disk, a DLL is basically the same as a Windows EXE file. One major difference is that a DLL isn't an independently executable file, although it may contain executable code. The most common DLL file extension is `.d11`. Other file extensions are `.drv` for device drivers, `.sys` for system files, and `.fon` for font resources, which contain no executable code.

NOTE

Delphi introduces a special-purpose DLL known as a *package*, which is used in the Delphi and C++Builder environments. We'll go into greater depth on packages in Chapter 21, "Writing Delphi Custom Components."

DLLs share their code with other applications through a process called *dynamic linking*, which is discussed later in this chapter. In general, when an application uses a DLL, the Win32 system ensures that only one copy of that DLL resides in memory. It does this by using *memory-mapped files*. The DLL is first loaded into the Win32 system's global heap. It's then mapped

into the address space of the calling process. In the Win32 system, each process is given its own 32-bit linear address space. When the DLL is loaded by multiple processes, each process receives its own image of the DLL. Therefore, processes don't share the same physical code, data, or resources, as was the case in 16-bit Windows. In Win32, the DLL appears as though it's actually code belonging to the calling process. For more information on Win32 constructs, you can refer to Chapter 3, "The Win32 API."

This doesn't mean that when multiple processes load a DLL, the physical memory is consumed by each usage of the DLL. The DLL image is placed into each process's address space by mapping its image from the system's global heap to the address space of each process that uses the DLL, at least in the ideal scenario (see the sidebar "Setting a DLL's Preferred Base Address").

Setting a DLL's Preferred Base Address

DLL code is only shared between processes if the DLL can be loaded into the process address space of all interested clients at the DLL's preferred base address. If the preferred base address and range of the DLL overlaps with something already allocated in a process, the Win32 loader has to relocate the entire DLL image to some other base address. When that happens, none of the relocated DLL image is shared with any other process in the system—each relocated DLL instance consumes its own chunk of physical memory and swap file space.

It's critical that you set the base address of every DLL you produce to a value that doesn't conflict with or overlap other address ranges used by your application by using the `$IMAGEBASE` directive.

If your DLL will be used by multiple applications, choose a unique base address that's unlikely to collide with application addresses at the low end of the process virtual address range or common DLLs (such as VCL packages) at the high end of the address range. The default base address for all executable files (EXEs and DLLs) is `$400000`, which means unless you change your DLL base address, it will always collide with the base address of its host EXE and therefore never be shared between processes.

There's another side benefit to base address loading. Because the DLL doesn't require relocation or fixes (which is usually the case) and because it's stored on a local disk drive, the DLL's memory pages are mapped directly onto the DLL file on disk. The DLL code does not consume any space in the system's page file (as called a *swap file*). This is why the system's total committed page count and size statistics can be much larger than the system swap file plus RAM.

You'll find detailed information on using the `$IMAGEBASE` directive by looking up "Image Base Address" in the Delphi 5 online help.

Following are some terms you'll need to know in regard to DLLs:

- *Application*. A Windows program residing in an .exe file.
- *Executable*. A file containing executable code. Executable files include .dll and .exe files.
- *Instance*. When referring to applications and DLLs, an *instance* is the occurrence of an executable. Each instance can be referred to by an *instance handle*, which is assigned by the Win32 system. When an application is run twice, for example, there are two instances of that application and, therefore, two instance handles. When a DLL is loaded, there's an instance of that DLL as well as a corresponding instance handle. The term *instance*, as used here, should not be confused with the instance of a class.
- *Module*. In 32-bit Windows, *module* and *instance* can be used synonymously. This differs from 16-bit Windows, in which the system maintains a database to manage modules and provides a module handle for each module. In Win32, each instance of an application gets its own address space; therefore, there's no need for a separate module identifier. However, Microsoft still uses the term in its own documentation. Just be aware that *module* and *instance* are one and the same.
- *Task*. Windows is a multitasking (or task-switching) environment. It must be able to allocate system resources and time to the various instances running under it. It does this by maintaining a task database that maintains instance handles and other necessary information to enable it to perform its task-switching functions. The *task* is the element to which Windows grants resources and time blocks.

Static Linking Versus Dynamic Linking

Static linking refers to the method by which the Delphi compiler resolves a function or procedure call to its executable code. The function's code can exist in the application's .dpr file or in a unit. When linking your applications, these functions and procedures become part of the final executable file. In other words, on disk, each function will reside at a specific location in the program's .exe file.

A function's location also is predetermined at a location relative to where the program is loaded in memory. Any calls to that function cause program execution to jump to where the function resides, execute the function, and then return to the location from which it was called. The relative address of the function is resolved during the linking process.

This is a loose description of a more complex process that the Delphi compiler uses to perform static linking. However, for the purpose of this book, you don't need to understand the underlying operations that the compiler performs to use DLLs effectively in your applications.

NOTE

Delphi implements a *smart linker* that automatically removes functions, procedures, variables, and typed constants that never get referenced in the final project. Therefore, functions that reside in large units that never get used don't become a part of your EXE file.

Suppose you have two applications that use the same function that resides in a unit. Both applications, of course, would have to include the unit in their `uses` statements. If you ran both applications simultaneously in Windows, the function would exist twice in memory. If you had a third application, there would be a third instance of the function in memory, and you would be using up three times its memory space. This small example illustrates one of the primary reasons for dynamic linking. Through dynamic linking, this function resides in a DLL. Then, when an application loads the function into memory, all other applications that need to reference it can share its code by mapping the image of the DLL into their own process memory space. The end result is that the DLL's function exists only once in memory—theoretically.

With *dynamic linking*, the link between a function call and its executable code is resolved at runtime by using an external reference to the DLL's function. These references can be declared in the application, but usually they're placed in a separate `import` unit. The `import` unit declares the imported functions and procedures and defines the various types required by DLL functions.

For example, suppose you have a DLL named `MaxLib.dll` that contains a function:

```
function Max(i1, I2: integer): integer;
```

This function returns the higher of the two integers passed to it. A typical `import` unit would look like this:

```
unit MaxUnit;
interface
function Max(I1, I2: integer): integer;
implementation
function Max; external 'MAXLIB';
end.
```

You'll notice that although this looks somewhat like a typical unit, it doesn't define the function `Max()`. The keyword `external` simply says that the function resides in the DLL of the name that follows it. To use this unit, an application would simply place `MaxUnit` in its `uses` statement. When the application runs, the DLL is loaded into memory automatically, and any calls to `Max()` are linked to the `Max()` function in the DLL.

This illustrates one of two ways to load a DLL; it's called *implicit loading*, which causes Windows to automatically load the DLL when the application loads. Another method is to *explicitly load* the DLL; this is discussed later in this chapter.

Why Use DLLs?

There are several reasons for using DLLs, some of which were mentioned earlier. In general, you use DLLs to share code or system resources, to hide your code implementation or low-level system routines, or to design custom controls. We discuss these topics in the following sections.

Sharing Code, Resources, and Data with Multiple Applications

Earlier in this chapter, you learned that the most common reason for creating a DLL is to share code. Unlike units, which enable you to share code with different Delphi applications, DLLs enable you to share code with any Windows application that can call functions from DLLs.

Additionally, DLLs provide a way for you to share resources such as bitmaps, fonts, icons, and so on that you normally would put into a resource file and link directly into your application. If you place these resources into a DLL, many applications can make use of them without using up the memory required to load them more often.

Back in 16-bit Windows, DLLs had their own data segment, so all applications that used a DLL could access the same data-global and static variables. In the Win32 system, this is a different story. Because the DLL image is mapped to each process's address space, all data in the DLL belongs to that process. One thing worth mentioning here is that although the DLL's data isn't shared between different processes, it's shared by multiple threads within the same process. Because threads execute independently of one another, you must take precautions not to cause conflicts when accessing a DLL's global data.

This doesn't mean that there aren't ways to make multiple processes share data made accessible through a DLL. One technique would be to create a shared memory area (using a memory-mapped file) from within the DLL. Each application using that DLL would be able to read the data stored in the shared memory area. This technique is shown later in the chapter.

Hiding Implementation

In some cases, you might want to hide the details of the routines that you make available from a DLL. Regardless of your reason for deciding to hide your code's implementation, a DLL provides a way for you to make your functions available to the public and not give away your source code in doing so. All you need to do is provide an interface unit to enable others to access your DLL. If you're thinking that this is already possible with Delphi compiled units (DCUs), consider that DCUs apply only to other Delphi applications that are created with the same version of Delphi. DLLs are language-independent, so you can create a DLL that can be used by C++, VB, or any other language that supports DLLs.

The Windows unit is the interface unit to the Win32 DLLs. The Win32 API unit source files are included with Delphi 5. One of the files you get is `Windows.pas`, the source to the Windows unit. In `Windows.pas`, you find function definitions such as the following in the interface section:

```
function ClientToScreen(Hwnd: HWND; var lpPoint: TPoint): BOOL; stdcall;
```

The corresponding link to the DLL is in the implementation section, as in the following example:

```
function ClientToScreen; external user32 name 'ClientToScreen';
```

This basically says that the procedure `ClientToScreen()` exists in the dynamic link library `User32.dll`, and its name is `ClientToScreen`.

Custom Controls

Custom controls usually are placed in DLLs. These controls aren't the same as Delphi custom components. Custom controls are registered under Windows and can be used by any Windows development environment. These types of custom controls are placed in DLLs to conserve memory by having only one copy of the control's code in memory when multiple copies of the control are being used.

NOTE

The old custom control DLL mechanism is extremely crude and inflexible, which is why Microsoft now uses OLE and ActiveX controls. These older forms of custom controls are rare.

Creating and Using DLLs

The following sections take you through the process of actually creating a DLL with Delphi. You'll see how to create an interface unit so that you can make your DLLs available to other programs. You'll also learn how to incorporate Delphi forms into DLLs before going on to using DLLs in Delphi.

Counting Your Pennies (A Simple DLL)

The following DLL example illustrates placing a routine that's a favorite of many computer science professors into a DLL. The routine converts a monetary amount in pennies to the minimum number of nickels, dimes, or quarters needed to match the total number of pennies.

A Basic DLL

The library contains the `PenniesToCoins()` method. Listing 9.1 shows the complete DLL project.

LISTING 9.1 PenniesLib.dpr, a DLL to Convert Pennies to Other Coins

```
library PenniesLib;
{$DEFINE PENNIESLIB}
uses
  SysUtils,
  Classes,
  PenniesInt;

function PenniesToCoins(TotPennies: word;
  CoinsRec: PCoinsRec): word; StdCall;
begin
  Result := TotPennies; // Assign value to Result
  { Calculate the values for quarters, dimes, nickels, pennies }
  with CoinsRec^ do
  begin
    Quarters := TotPennies div 25;
    TotPennies := TotPennies - Quarters * 25;
    Dimes := TotPennies div 10;
    TotPennies := TotPennies - Dimes * 10;
    Nickels := TotPennies div 5;
    TotPennies := TotPennies - Nickels * 5;
    Pennies := TotPennies;
  end;
end;

{ Export the function by name }
exports
  PenniesToCoins;
end.
```

Notice that this library uses the unit `PenniesInt`. We'll discuss this in more detail momentarily.

The `exports` clause specifies which functions or procedures in the DLL get exported and made available to calling applications.

Defining an Interface Unit

Interface units enable users of your DLL to statically import your DLL's routines into their applications by just placing the `import` unit's name in their module's `uses` statement. Interface units also allow the DLL writer to define common structures used by both the library and the calling application. We demonstrate that here with the `interface` unit. Listing 9.2 shows the source code to `PenniesInt.pas`.

LISTING 9.2 PenniesInt.pas, the interface Unit for PenniesLib.Dll

```
unit PenniesInt;
{ Interface routine for PENNIES.DLL }

interface
type

    { This record will hold the denominations after the conversions have
      been made }
    PCoinsRec = ^TCoinsRec;
    TCoinsRec = record
        Quarters,
        Dimes,
        Nickels,
        Pennies: word;
    end;

{$IFDEF PENNIESLIB}
{ Declare function with export keyword }

function PenniesToCoins(TotPennies: word;
    CoinsRec: PCoinsRec): word; StdCall;
{$ENDIF}

implementation

{$IFDEF PENNIESLIB}
{ Define the imported function }
function PenniesToCoins; external 'PENNIESLIB.DLL' name 'PenniesToCoins';
{$ENDIF}

end.
```

In the type section of this project, you declare the record `TCoinsRec` as well as a pointer to this record. This record will hold the denominations that will make up the penny amount passed into the `PenniesToCoins()` function. The function takes two parameters—the total amount of money in pennies and a pointer to a `TCoinsRec` variable. The result of the function is the amount of pennies passed in.

`PenniesInt.pas` declares the function that the `PenniesLib.dll` exports in its interface section. The definition of the `PenniesToCoins()` function is placed in the implementation section. This definition specifies that the function is an external function existing in the DLL file

PenniesLib.d11. It links to the DLL function by the name of the function. Notice that you used a compiler directive PENNIESLIB to conditionally compile the declaration of the PenniesToCoins() function. You do this because it's not necessary to link this declaration when compiling the interface unit for the library. This allows you to share the interface unit's type definitions with both the library and any applications that intend to use the library. Any changes to the structures used by both only have to be made in the interface unit.

TIP

To define an application-wide conditional directive, specify the conditional in the Directories/Conditionals page of the Project, Options dialog box. Note that you must rebuild your project for changes to conditional defines to take effect because Make logic doesn't reevaluate conditional defines.

NOTE

The following definition shows one of two ways to import a DLL function:

```
function PenniesToCoins; external 'PENNIESLIB.DLL' index 1;
```

This method is called *importing by ordinal*. The other method by which you can import DLL functions is *by name*:

```
function PenniesToCoins; external 'PENNIESLIB.DLL' name 'PenniesToCoins';
```

The by-name method uses the name specified after the name keyword to determine which function to link to in the DLL.

The by-ordinal method reduces the DLL's load time because it doesn't have to look up the function name in the DLL's name table. However, this method isn't the preferred method in Win32. Importing by name is the preferred technique so that applications won't be hypersensitive to relocation of DLL entry points as DLLs get updated over time. When you import by ordinal, you are binding to a place in the DLL. When you import by name, you're binding to the function name, regardless of where it happens to be placed in the DLL.

If this were an actual DLL that you planned to deploy, you would provide both PenniesLib.d11 and PenniesInt.pas to your users. This would enable them to use the DLL by defining the types and functions in PenniesInt.pas that PenniesLib.d11 requires. Additionally, programmers using different languages, such as C++, could convert PenniesInt.pas to their languages, thus enabling them to use your DLL in their development environments. You'll find a sample project that uses PenniesLib.d11 on the CD that accompanies this book.

Displaying Modal Forms from DLLs

This section shows you how to make modal forms available from a DLL. One reason why placing commonly used forms in a DLL is beneficial is that it enables you to extend your forms for use with any Windows application or development environment, such as C++ and Visual Basic.

To do this, you remove your DLL-based form from the list of autocreated forms.

We've created such a form that contains a `TCalendar` component on the main form. The calling application will call a DLL function that will invoke this form. When the user selects a day on the calendar, the date will be returned to the calling application.

Listing 9.3 shows the source for `CalendarLib.dpr`, the DLL project file. Listing 9.4, in the section, "Displaying Modeless Forms from DLLs," shows the source code for `DllFrm.pas`, the DLL form's unit, which illustrates how to encapsulate the form into a DLL.

LISTING 9.3 Library Project Source—CalendarLib.dpr

```
unit DLLFrm;

interface

uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, Grids, Calendar;

type

  TDLLForm = class(TForm)
    calDllCalendar: TCalendar;
    procedure calDllCalendarDb1Click(Sender: TObject);
  end;

{ Declare the export function }
function ShowCalendar(AHandle: THandle; ACaption: String):
  TDateTime; StdCall;

implementation
{$R *.DFM}

function ShowCalendar(AHandle: THandle; ACaption: String): TDateTime;
var
  DLLForm: TDllForm;
```

LISTING 9.3 Continued

```
begin
  // Copy application handle to DLL's TApplication object
  Application.Handle := AHandle;
  DLLForm := TDLLForm.Create(Application);
  try
    DLLForm.Caption := ACaption;
    DLLForm.ShowModal;
    // Pass the date back in Result
    Result := DLLForm.calDLLCalendar.CalendarDate;
  finally
    DLLForm.Free;
  end;
end;

procedure TDLLForm.calDllCalendarDb1Click(Sender: TObject);
begin
  Close;
end;

end.
```

The main form in this DLL is incorporated into the exported function. Notice that the `DLLForm` declaration was removed from the interface section and declared inside the function instead.

The first thing that the DLL function does is to assign the `AHandle` parameter to the `Application.Handle` property. Recall from Chapter 4, “Application Frameworks and Design Concepts,” that Delphi projects, including library projects, contain a global `Application` object. In a DLL, this object is separate from the `Application` object that exists in the calling application. For the form in the DLL to truly act as a modal form for the calling application, you must assign the handle of the calling application to the DLL’s `Application.Handle` property, as has been illustrated. Not doing so will result in erratic behavior, especially when you start minimizing the DLL’s form. Also, as shown, you must make sure not to pass `nil` as the owner of the DLL’s form.

After the form is created, you assign the `ACaption` string to the `Caption` of the DLL form. It’s then displayed modally. When the form closes, the date selected by the user in the `TCalendar` component is passed back to the calling function. The form closes after the user double-clicks the `TCalendar` component.

CAUTION

ShareMem must be the first unit in your library's uses clause and your project's (select View, Project Source) uses clause if your DLL exports any procedures or functions that pass strings or dynamic arrays as parameters or function results. This applies to all strings passed to and from your DLL—even those nested in records and classes. ShareMem is the interface unit to the Bor1ndmm.dll shared memory manager, which must be deployed along with your DLL. To avoid using Bor1ndmm.dll, pass string information using PChar or ShortString parameters.

ShareMem is only required when heap-allocated strings or dynamic arrays are passed between modules, and such transfers also transfer ownership of that string memory. Typcasting an internal string to a PChar and passing it to another module as a PChar does not transfer ownership of the string memory to the calling module, so ShareMem is not required.

Note that this ShareMem issue applies only to DelphiC++Builder DLLs that pass strings or dynamic arrays to other Delphi/BCB DLLs or EXEs. You should never expose Delphi strings or dynamic arrays (as parameters or function results of DLL exported functions) to non-Delphi DLLs or host apps. They won't know how to dispose of the Delphi items correctly.

Also, ShareMem is never required between modules built with packages. The memory allocator is implicitly shared between packaged modules.

This is all that's required when encapsulating a modal form into a DLL. In the next section, we'll discuss displaying a modeless form in a DLL.

Displaying Modeless Forms from DLLs

To illustrate placing modeless forms in a DLL, we'll use the same calendar form as the previous section.

When displaying modeless forms from a DLL, the DLL must provide two routines. The first routine must take care of creating and displaying the form. A second routine is required to free the form. Listing 9.4 displays the source code for the illustration of a modeless form in a DLL.

LISTING 9.4 A Modeless Form in a DLL

```
unit DLLFrm;  
  
interface  
  
uses
```

continues

LISTING 9.4 Continued

```
SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
Forms, Dialogs, Grids, Calendar;

type

  TDLLForm = class(TForm)
    calDllCalendar: TCalendar;
  end;

{ Declare the export function }
function ShowCalendar(AHandle: THandle; ACaption: String):
  Longint; stdCall;
procedure CloseCalendar(AFormRef: Longint); stdcall;

implementation
{$R *.DFM}

function ShowCalendar(AHandle: THandle; ACaption: String): Longint;
var
  DLLForm: TDllForm;
begin
  // Copy application handle to DLL's TApplication object
  Application.Handle := AHandle;
  DLLForm := TDLLForm.Create(Application);
  Result := Longint(DLLForm);
  DLLForm.Caption := ACaption;
  DLLForm.Show;
end;

procedure CloseCalendar(AFormRef: Longint);
begin
  if AFormRef > 0 then
    TDLLForm(AFormRef).Release;
end;

end.
```

This listing displays the routines `ShowCalendar()` and `CloseCalendar()`. `ShowCalendar()` is similar to the same function in the modal form example in that it makes the assignment of the calling application's application handle to the DLL's application handle and creates the form.

Instead of calling `ShowModal()`, however, this routine calls `Show()`. Notice that it doesn't free the form. Also, notice that the function returns a `longint` value to which you assign the `DLLForm` instance. This is because a reference of the created form must be maintained, and it's best to have the calling application maintain this instance. This would take care of any issues regarding other applications calling this DLL and creating another instance of the form.

In the `CloseCalendar()` procedure, you simply check for a valid reference to the form and invoke its `Release()` method. Here, the calling application should pass back the same reference that was returned to it from `ShowCalendar()`.

When using such a technique, you must be careful that your DLL never frees the form independently of the host. If it does (for example, returning `caFree` in `CanClose()`), the call to `CloseCalendar()` will crash.

Demos of both the modal and modeless forms are on the CD that accompanies this book.

Using DLLs in Your Delphi Applications

Earlier in this chapter, you learned that there are two ways to load or import DLLs: implicitly and explicitly. Both techniques are illustrated in this section with the DLLs just created.

The first DLL created in this chapter included an `interface` unit. You'll use this `interface` unit in the following example to illustrate implicit linking of a DLL. The sample project's main form has a `TMaskEdit`, `TButton`, and nine `TLabel` components.

In this application, the user enters an amount of pennies. Then, when the user clicks the button, the labels will show the breakdown of denominations of change adding up to that amount. This information is obtained from the `PenniesLib.dll` exported function `PenniesToCoins()`.

The main form is defined in the unit `MainFrm.pas` shown in Listing 9.5.

LISTING 9.5 Main Form for the Pennies Demo

```
unit MainFrm;

interface

uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, Mask;

type

  TMainForm = class(TForm)
    lblTotal: TLabel;
    lblQ1lbl: TLabel;
```

LISTING 9.5 Continued

```
    lblD1b1: TLabel;  
    lblN1b1: TLabel;  
    lblP1b1: TLabel;  
    lblQuarters: TLabel;  
    lblDimes: TLabel;  
    lblNickels: TLabel;  
    lblPennies: TLabel;  
    btnMakeChange: TButton;  
    meTotalPennies: TMaskEdit;  
    procedure btnMakeChangeClick(Sender: TObject);  
end;  
  
var  
    MainForm: TMainForm;  
  
implementation  
uses PenniesInt; // Use an interface unit  
  
{$R *.DFM}  
  
procedure TMainForm.btnMakeChangeClick(Sender: TObject);  
var  
    CoinsRec: TCoinsRec;  
    TotPennies: word;  
begin  
    { Call the DLL function to determine the minimum coins required  
      for the amount of pennies specified. }  
    TotPennies := PenniesToCoins(StrToInt(meTotalPennies.Text), @CoinsRec);  
    with CoinsRec do  
    begin  
        { Now display the coin information }  
        lblQuarters.Caption := IntToStr(Quarters);  
        lblDimes.Caption := IntToStr(Dimes);  
        lblNickels.Caption := IntToStr(Nickels);  
        lblPennies.Caption := IntToStr(Pennies);  
    end  
end;  
  
end.
```

Notice that `MainFrm.pas` uses the unit `PenniesInt`. Recall that `PenniesInt.pas` includes the external declarations to the functions existing in `PenniesLib.dpr`. When this application runs, the Win32 system automatically loads `PenniesLib.dll` and maps it to the process address space for the calling application.

Usage of an `import` unit is optional. You can remove `PenniesInt` from the `uses` statement and place the external declaration to `PenniesToCoins()` in the implementation section of `MainFrm.pas`, as in the following code:

```
implementation
```

```
function PenniesToCoins(TotPennies: word; ChangeRec: PChangeRec): word;  
    ↪StdCall external 'PENNIESLIB.DLL';
```

You also would have to define `PChangeRec` and `TChangeRec` again in `MainFrm.pas`, or you can compile your application using the compiler directive `PENNIESLIB`. This technique is fine in the case where you only need access to a few routines from a DLL. In many cases, you'll find that you require not only the external declarations to the DLL's routines but also access to the types defined in the interface unit.

NOTE

Many times, when using another vendor's DLL, you won't have a Pascal interface unit; instead, you'll have a C/C++ import library. In this case, you have to translate the library to a Pascal equivalent interface unit.

You'll find this demo on the accompanying CD.

Loading DLLs Explicitly

Although loading DLLs implicitly is convenient, it isn't always the most desired method. Suppose you have a DLL that contains many routines. If it's likely that your application will never call any of the DLL's routines, it would be a waste of memory to load the DLL every time your application runs. This is especially true when using multiple DLLs with one application. Another example is when using DLLs as large objects: a standard list of functions that are implemented by multiple DLLs but do slightly different things, such as printer drivers and file format readers. In this situation, it would be beneficial to load the DLL when specifically requested to do so by the application. This is referred to as *explicitly loading* a DLL.

To illustrate explicitly loading a DLL, we return to the sample DLL with a modal form. Listing 9.6 shows the code for the main form of the application that demonstrates explicitly loading this DLL. The project file for this application is on the accompanying CD.

LISTING 9.6 Main Form for Calendar DLL Demo Application

```
unit MainFfm;

interface

uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls;

type
  { First, define a procedural data type, this should reflect the
    procedure that is exported from the DLL. }
  TShowCalendar = function (AHandle: THandle; ACaption: String):
    TDateTime; StdCall;

  { Create a new exception class to reflect a failed DLL load }
  EDLLLoadError = class(Exception);

  TMainForm = class(TForm)
    lblDate: TLabel;
    btnGetCalendar: TButton;
    procedure btnGetCalendarClick(Sender: TObject);
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.btnGetCalendarClick(Sender: TObject);
var
  LibHandle : THandle;
  ShowCalendar: TShowCalendar;
begin
  { Attempt to load the DLL }
  LibHandle := LoadLibrary('CALENDARLIB.DLL');
  try
    { If the load failed, LibHandle will be zero.
      If this occurs, raise an exception. }
  end;
end;
```

```
if LibHandle = 0 then
    raise EDLLLoadError.Create('Unable to Load DLL');
{ If the code makes it here, the DLL loaded successfully, now obtain
  the link to the DLL's exported function so that it can be called. }
@ShowCalendar := GetProcAddress(LibHandle, 'ShowCalendar');
{ If the function is imported successfully, then set
  lblDate.Caption to reflect the returned date from
  the function. Otherwise, show the return raise an exception. }
if not (@ShowCalendar = nil) then
    lblDate.Caption := DateToStr(ShowCalendar(Application.Handle, Caption))
else
    RaiseLastWin32Error;
finally
    FreeLibrary(LibHandle); // Unload the DLL.
end;
end;

end.
```

This unit first defines a procedural data type, `TShowCalendar`, that reflects the definition of the function it will be using from `CalendarLib.dll`. It then defines a special exception, which is raised when there's a problem loading the DLL. In the `btnGetCalendarClick()` event handler, you'll notice the use of three Win32 API functions: `LoadLibrary()`, `FreeLibrary()`, and `GetProcAddress()`.

`LoadLibrary()` is defined this way:

```
function LoadLibrary(lpLibFileName: PChar): HMODULE; stdcall;
```

This function loads the DLL module specified by `lpLibFileName` and maps it into the address space of the calling process. If this function succeeds, it returns a handle to the module. If it fails, it returns the value `0`, and an exception is raised. You can look up `LoadLibrary()` in the online help for detailed information on its functionality and possible return error values.

`FreeLibrary()` is defined like this:

```
function FreeLibrary(hLibModule: HMODULE): BOOL; stdcall;
```

`FreeLibrary()` decrements the instance count of the library specified by `LibModule`. It removes the library from memory when the library's instance count is zero. The instance count keeps track of the number of tasks using the DLL.

Here's how `GetProcAddress()` is defined:

```
function GetProcAddress(hModule: HMODULE; lpProcName: LPCSTR):
    FARPROC; stdcall
```

`GetProcAddress()` returns the address of a function within the module specified in its first parameter, `hModule`. `hModule` is the `THandle` returned from a call to `LoadLibrary()`. If `GetProcAddress()` fails, it returns `nil`. You must call `GetLastError()` for extended error information.

In `Button1`'s `OnClick` event handler, `LoadLibrary()` is called to load `CALDLL`. If it fails to load, an exception is raised. If the call is successful, a call to the window's `GetProcAddress()` is made to get the address of the function `ShowCalendar()`. Prepending the procedural data type variable `ShowCalendar` with the address of operator (`@`) character prevents the compiler from issuing a type mismatch error due to its strict type-checking. After obtaining the address of `ShowCalendar()`, you can use it as defined by `TShowCalendar`. Finally, `FreeLibrary()` is called within the `finally` block to ensure that the library is freed from memory when no longer required.

You can see that the library is loaded and freed each time this function is called. If this function was called only once during the run of an application, it becomes apparent how explicit loading can save much-needed and often limited memory resources. On the other hand, if this function were called frequently, the DLL loading and unloading would add a lot of overhead.

The Dynamically Linked Library Entry/Exit Function

You can provide optional entry and exit code for your DLLs when required under various initialization and shutdown operations. These operations can occur during process or thread initialization/termination.

Process/Thread Initialization and Termination Routines

Typical initialization operations include registering Windows classes, initializing global variables, and initializing an entry/exit function. This occurs during the method of entry for the DLL, which is referred to as the `DLLEntryPoint` function. This function is actually represented by the `begin...end` block of the DLL project file. This is the location where you would set up an entry/exit procedure. This procedure must take a single parameter of the type `DWord`.

The global `DLLProc` variable is a procedural pointer to which you can assign the entry/exit procedure. This variable is initially `nil` unless you set up your own procedure. By setting up an entry/exit procedure, you can respond to the events listed in Table 9.1.

TABLE 9.1 DLL Entry/Exit Events

<i>Event</i>	<i>Purpose</i>
<code>DLL_PROCESS_ATTACH</code>	The DLL is attaching to the address space of the current process when the process starts up or when a call to <code>LoadLibrary()</code> is made. DLLs initialize any instance data during this event.

<i>Event</i>	<i>Purpose</i>
DLL_PROCESS_DETACH	The DLL is detaching from the address space of the calling process. This occurs during a clean process exit or when a call to <code>FreeLibrary()</code> is made. The DLL can uninitialized any instance data during this event.
DLL_THREAD_ATTACH	This event occurs when the current process creates a new thread. When this occurs, the system calls the entry-point function of any DLLs attached to the process. This call is made in the context of the new thread and can be used to allocate any thread-specific data.
DLL_THREAD_DETACH	This event occurs when the thread is exiting. During this event, the DLL can free any thread-specific initialized data.

CAUTION

Threads terminated abnormally—by calling `TerminateThread()`—are not guaranteed to call `DLL_THREAD_DETACH`.

DLL Entry/Exit Example

Listing 9.7 illustrates how you would install an entry/exit procedure to the DLL's `DLLProc` variable.

LISTING 9.7 The Source Code for `DllEntry.dpr`

```
library DllEntry;
uses
  SysUtils,
  Windows,
  Dialogs,
  Classes;
procedure DLLEntryPoint(dwReason: DWord);
begin
  case dwReason of
    DLL_PROCESS_ATTACH: ShowMessage('Attaching to process');
    DLL_PROCESS_DETACH: ShowMessage('Detaching from process');
    DLL_THREAD_ATTACH:  MessageBeep(0);
    DLL_THREAD_DETACH:  MessageBeep(0);
  end;
end;
```

LISTING 9.7 Continued

```
end;
begin
  { First, assign the procedure to the DLLProc variable }
  DllProc := @DLLEntryPoint;
  { Now invoke the procedure to reflect that the DLL is attaching to the
    process }
  DLLEntryPoint(DLL_PROCESS_ATTACH);
end.
```

The entry/exit procedure is assigned to the DLL's `DLLProc` variable in the `begin..end` block of the DLL project file. This procedure, `DLLEntryPoint()`, evaluates its word parameter to determine which event is being called. These events correspond to the events listed in Table 9.1. For illustration purposes, we have each event display a message box when the DLL is being loaded or destroyed. When a thread in the calling application is being created or destroyed, a message beep occurs.

To illustrate the use of this DLL, examine the code shown in Listing 9.8.

LISTING 9.8 Sample Code for DLL Entry/Exit Demo

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, ComCtrls, Gauges;

type
  { Define a TThread descendant }

  TTestThread = class(TThread)
    procedure Execute; override;
    procedure SetCaptionData;
  end;

  TMainForm = class(TForm)
    btnLoadLib: TButton;
    btnFreeLib: TButton;
    btnCreateThread: TButton;
```

```
    btnFreeThread: TButton;
    lblCount: TLabel;
    procedure btnLoadLibClick(Sender: TObject);
    procedure btnFreeLibClick(Sender: TObject);
    procedure btnCreateThreadClick(Sender: TObject);
    procedure btnFreeThreadClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
private
    LibHandle    : THandle;
    TestThread   : TTestThread;
    Counter      : Integer;
    GoThread     : Boolean;
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TTestThread.Execute;
begin
    while MainForm.GoThread do
        begin
            Synchronize(SetCaptionData);
            Inc(MainForm.Counter);
        end;
end;

procedure TTestThread.SetCaptionData;
begin
    MainForm.lblCount.Caption := IntToStr(MainForm.Counter);
end;

procedure TMainForm.btnLoadLibClick(Sender: TObject);
{ This procedure loads the library DllEntryLib.DLL }
begin
    if LibHandle = 0 then
        begin
            LibHandle := LoadLibrary('DLENTRYLIB.DLL');
            if LibHandle = 0 then
```

LISTING 9.8 Continued

```
        raise Exception.Create('Unable to Load DLL');
    end
    else
        MessageDlg('Library already loaded', mtWarning, [mbok], 0);
    end;

procedure TMainForm.btnFreeLibClick(Sender: TObject);
{ This procedure frees the library }
begin
    if not (LibHandle = 0) then
        begin
            FreeLibrary(LibHandle);
            LibHandle := 0;
        end;
    end;
end;

procedure TMainForm.btnCreateThreadClick(Sender: TObject);
{ This procedure creates the TThread instance. If the DLL is loaded a
  message beep will occur. }
begin
    if TestThread = nil then
        begin
            GoThread := True;
            TestThread := TTestThread.Create(False);
        end;
    end;
end;

procedure TMainForm.btnFreeThreadClick(Sender: TObject);
{ In freeing the TThread a message beep will occur if the DLL is loaded. }
begin
    if not (TestThread = nil) then
        begin
            GoThread := False;
            TestThread.Free;
            TestThread := nil;
            Counter := 0;
        end;
    end;
end;
end;
```

```
procedure TMainForm.FormCreate(Sender: TObject);
begin
    LibHandle := 0;
    TestThread := nil;
end;

end.
```

This project consists of a main form with four `TButton` components. `BtnLoadLib` loads the DLL `DllEntryLib.dll`. `BtnFreeLib` frees the library from the process. `BtnCreateThread` creates a `TThread` descendant object, which in turn creates a thread. `BtnFreeThread` destroys the `TThread` object. The `lblCount` is used just to show the thread execution.

The `btnLoadLibClick()` event handler calls `LoadLibrary()` to load `DllEntryLib.dll`. This causes the DLL to load and be mapped to the process's address space. Additionally, the initialization code in the DLL gets executed. Again, this is the code that appears in the `begin..end` block of the DLL, which performs the following to set up an entry/exit procedure for the DLL:

```
begin
    { First, assign the procedure to the DLLProc variable }
    DllProc := @DllEntryPoint;
    { Now invoke the procedure to reflect that the DLL is attaching to the
      process }
    DllEntryPoint(DLL_PROCESS_ATTACH);
end.
```

This initialization section will only be called once per process. If another process loads this DLL, this section will be called again, except in the context of the separate process—processes don't share DLL instances.

The `btnFreeLibClick()` event handler unloads the DLL by calling `FreeLibrary()`. When this happens, the procedure to which the `DLLProc` points, `DllEntryProc()`, gets called with the value of `DLL_PROCESS_DETACH` passed as the parameter.

The `btnCreateThreadClick()` event handler creates the `TThread` descendant object. This causes the `DllEntryProc()` to get called, and the `DLL_THREAD_ATTACH` value is passed as the parameter. The `btnFreeThreadClick()` event handler invokes `DllEntryProc` again but passes `DLL_THREAD_DETACH` as the value to the procedure.

Although you invoke only a message box when the events occur, you'll use these events to perform any process or thread initialization or cleanup that might be necessary for your application. Later, you'll see an example of using this technique to set up sharable DLL global data. You can look at the demo of this DLL in the project `DllEntryTest.dpr` on the CD.

Exceptions in DLLs

This section discusses issues regarding DLLs and Win32 exceptions.

Capturing Exceptions in 16-Bit Delphi

Back in the 16-bit days with Delphi 1, Delphi exceptions were language specific. Therefore, if exceptions were raised in a DLL, you were required to capture the exception before it escaped from the DLL so that it wouldn't creep up the calling modules stack, causing it to crash. You had to wrap every DLL entry point with an exception handler, like this:

```
procedure SomeDLLProc;  
begin  
  try  
    { Do your stuff }  
  except  
    on Exception do  
      { Don't let it get away, handle it and don't re-raise it }  
    end;  
end;
```

This is no longer the case as of Delphi 2. Delphi 5 exceptions map themselves to Win32 exceptions. Exceptions raised in DLLs are no longer a compiler/language feature of Delphi but rather a feature of the Win32 system.

For this to work, however, you must make sure that `SysUtils` is included in the DLL's `uses` clause. Not including `SysUtils` disables Delphi's exception support inside the DLL.

CAUTION

Most Win32 applications are not designed to handle exceptions, so even though Delphi language exceptions get turned into Win32 exceptions, exceptions that you let escape from a DLL into the host application are likely to shut down the application.

If the host application is built with Delphi or C++Builder, this shouldn't be much of an issue, but there's still a lot of raw C and C++ code out there that doesn't like exceptions.

Therefore, to make your DLLs bulletproof, you might still consider using the 16-bit method of protecting DLL entry points with `try..except` blocks to capture exceptions raised in your DLLs.

NOTE

When a non-Delphi application uses a DLL written in Delphi, it won't be able to utilize the Delphi language-specific exception classes. However, it can be handled as a Win32 system exception given the exception code of \$0EEDFACE. The exception address will be the first entry in the `ExceptionInformation` array of the Win32 system `EXCEPTION_RECORD`. The second entry contains a reference to the Delphi exception object. Look up `EXCEPTION_RECORD` in the Delphi online help for additional information.

Exceptions and the Safecall Directive

`Safecall` functions are used for COM and exception handling. They guarantee that any exception will propagate to the caller of the function. A `Safecall` function converts an exception into an `HResult` return value. `Safecall` also implies the `StdCall` calling convention. Therefore, a `Safecall` function declared as

```
function Foo(i: integer): string; Safecall;
```

really looks like this according to the compiler:

```
function Foo(i: integer): string; HResult; StdCall;
```

The compiler then inserts an implicit `try..except` block that wraps the entire function contents and catches any exceptions raised. The `except` block invokes a call to `SafecallExceptionHandler()` to convert the exception into an `HResult`. This is somewhat similar to the 16-bit method of capturing exceptions and passing back error values.

Callback Functions

A *callback function* is a function in your application called by Win32 DLLs or other DLLs. Basically, Windows has several API functions that require a callback function. When calling these functions, you pass in an address of a function defined by your application that Windows can call. If you're wondering how this all relates to DLLs, remember that the Win32 API is really several routines exported from system DLLs. Essentially, when you pass a callback function to a Win32 function, you're passing this function to a DLL.

One such function is the `EnumWindows()` API function, which enumerates through all top-level windows. This function passes the handle of each window in the enumeration to your application-defined callback function. You're required to define and pass the callback function's address to the `EnumWindows()` function. The callback function that you must provide to `EnumWindows()` is defined this way:

```
function EnumWindowsProc(Hw: HWND; lp: LPARAM): Boolean; stdcall;
```

We illustrate the use of the `EnumWindows()` function in the `CallBack.dpr` project on the CD accompanying this book and shown in Listing 9.9.

LISTING 9.9 MainForm.pas, Source to Callback Example

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, ComCtrls;

type

  { Define a record/class to hold the window name and class name for
    each window. Instances of this class will get added to ListBox1 }
  TWindowInfo = class
    WindowName,           // The window name
    WindowClass: String; // The window's class name
  end;

  TMainForm = class(TForm)
    lbWinInfo: TListBox;
    btnGetWinInfo: TButton;
    hdWinInfo: THeaderControl;
    procedure btnGetWinInfoClick(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
    procedure lbWinInfoDrawItem(Control: TWinControl; Index: Integer;
      Rect: TRect; State: TOwnerDrawState);
    procedure hdWinInfoSectionResize(HeaderControl: THeaderControl;
      Section: THeaderSection);
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

function EnumWindowsProc(Hw: HWND; AMainForm: TMainForm):
  Boolean; stdcall;
```

```
{ This procedure is called by the User32.DLL library as it enumerates
  through windows active in the system. }
var
  WinName, CName: array[0..144] of char;
  WindowInfo: TWindowInfo;
begin
  { Return true by default which indicates not to stop enumerating
    through the windows }
  Result := True;
  GetWindowText(Hw, WinName, 144); // Obtain the current window text
  GetClassName(Hw, CName, 144);   // Obtain the class name of the window
  { Create a TWindowInfo instance and set its fields with the values of
    the window name and window class name. Then add this object to
    ListBox1's Objects array. These values will be displayed later by
    the listbox }
  WindowInfo := TWindowInfo.Create;
  with WindowInfo do
  begin
    SetLength(WindowName, strlen(WinName));
    SetLength(WindowClass, StrLen(CName));
    WindowName := StrPas(WinName);
    WindowClass := StrPas(CName);
  end;
  // Add to Objects array
  MainForm.lbWinInfo.Items.AddObject('', WindowInfo); end;

procedure TMainForm.btnGetWinInfoClick(Sender: TObject);
begin
  { Enumerate through all top-level windows being displayed. Pass in the
    call back function EnumWindowsProc which will be called for each
    window }
  EnumWindows(@EnumWindowsProc, 0);
end;

procedure TMainForm.FormDestroy(Sender: TObject);
var
  i: integer;
begin
  { Free all instances of TWindowInfo }
  for i := 0 to lbWinInfo.Items.Count - 1 do
    TWindowInfo(lbWinInfo.Items.Objects[i]).Free
  end;
end;
```

LISTING 9.9 Continued

```
procedure TMainForm.lbWinInfoDrawItem(Control: TWinControl;
  Index: Integer; Rect: TRect; State: TOwnerDrawState);
begin
  { First, clear the rectangle to which drawing will be performed }
  lbWinInfo.Canvas.FillRect(Rect);
  { Now draw the strings of the TWindowInfo record stored at the
    Index'th position of the listbox. The sections of HeaderControl
    will give positions to which to draw each string }
  with TWindowInfo(lbWinInfo.Items.Objects[Index]) do
  begin
    DrawText(lbWinInfo.Canvas.Handle, PChar(WindowName),
      Length(WindowName), Rect, dt_Left or dt_VCenter);
    { Shift the drawing rectangle over by using the size
      HeaderControl1's sections to determine where to draw the next
      string }
    Rect.Left := Rect.Left + hdWinInfo.Sections[0].Width;
    DrawText(lbWinInfo.Canvas.Handle, PChar(WindowClass),
      Length(WindowClass), Rect, dt_Left or dt_VCenter);
  end;
end;

procedure TMainForm.hdWinInfoSectionResize(HeaderControl:
  THeaderControl; Section: THeaderSection);
begin
  lbWinInfo.Invalidate; // Force ListBox1 to redraw itself.
end;

end.
```

This application uses the `EnumWindows()` function to extract the window name and class name of all top-level windows and adds them to the owner-draw list box on the main form. The main form uses an owner-draw list box to make both the window name and window class name appear in a columnar fashion. First we'll explain the use of the callback function. Then we'll explain how we created the columnar list box.

Using the Callback Function

You saw in Listing 9.9 that we defined a procedure, `EnumWindowsProc()`, that takes a window handle as its first parameter. The second parameter is user-defined data, so you may pass whatever data you deem necessary as long as its size is the equivalent to an integer data type.

`EnumWindowsProc()` is the callback procedure that you'll pass to the `EnumWindows()` Win32 API function. It must be declared with the `stdcall` directive to specify that it uses the Win32 calling convention. When passing this procedure to `EnumWindows()`, it will get called for each top-level window whose window handle gets passed as the first parameter. You use this window handle to obtain both the window name and class name of each window. You then create an instance of the `TWindowInfo` class and set its fields with this information. The `TWindowInfo` class instance is then added to the `lbWinInfo.Objects` array. The data in this list box will be used when the list box is drawn to show this data in a columnar fashion.

Notice that, in the main form's `OnDestroy` event handler, you make sure to clean up any allocated instances of the `TWindowInfo` class.

The `btnGetWinInfoClick()` event handler calls the `EnumWindows()` procedure and passes `EnumWindowsProc()` as its first parameter.

When you run the application and click the button, you'll see that the information is obtained from each window and is shown in the list box.

Drawing an Owner-Draw List Box

The window names and class names of top-level windows are drawn in a columnar fashion in `lbWinInfo` from the previous project. This was done by using a `TListBox` with its `Style` property set to `lbOwnerDraw`. When this style is set as such, the `TListBox.OnDrawItem` event is called each time the `TListBox` is to draw one of its items. You're responsible for drawing the items as illustrated in the example.

In Listing 9.9, the event handler `lbWinInfoDrawItem()` contains the code that performs the drawing of list box items. Here, you draw the strings contained in the `TWindowInfo` class instances, which are stored in the `lbWinInfo.Objects` array. These values are obtained from the callback function `EnumWindowsProc()`. You can refer to the code commentary to determine what this event handler does.

Calling Callback Functions from Your DLLs

Just as you can pass callback functions to DLLs, you can also have your DLLs call callback functions. This section illustrates how you can create a DLL whose exported function takes a callback procedure as a parameter. Then, based on whether the user passes in a callback procedure, the procedure gets called. Listing 9.10 contains the source code to this DLL.

LISTING 9.10 Calling a Callback Demo: Source Code for `StrSrchLib.dll`

```
library StrSrchLib;
```

```
uses
```

```
  Wintypes,  
  WinProcs,
```

continues

LISTING 9.10 Continued

```
    SysUtils,
    Dialogs;

type
  { declare the callback function type }
  TFoundStrProc = procedure(StrPos: PChar); StdCall;

function SearchStr(ASrcStr, ASearchStr: PChar; AProc: TFarProc):
  Integer; StdCall;
{ This function looks for ASearchStr in ASrcStr. When found ASearchStr,
  the callback procedure referred to by AProc is called if one has been
  passed in. The user may pass nil as this parameter. }
var
  FindStr: PChar;
begin
  FindStr := ASrcStr;
  FindStr := StrPos(FindStr, ASearchStr);
  while FindStr <> nil do
  begin
    if AProc <> nil then
      TFoundStrProc(AProc)(FindStr);
    FindStr := FindStr + 1;
    FindStr := StrPos(FindStr, ASearchStr);
  end;
end;

exports
  SearchStr;
begin
end.
```

The DLL also defines a procedural type, `TFoundStrProc`, for the callback function, which will be used to typecast the callback function when it's called.

The exported procedure `SearchStr()` is where the callback function is called. The commentary in the listing explains what this procedure does.

An example of this DLL's usage is given in the project `CallBackDemo.dpr` in the `\DLLCallBack` directory on the CD. The source for the main form of this demo is shown in Listing 9.11.

LISTING 9.11 The Main Form for the DLL Callback Demo

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls;

type
  TMainForm = class(TForm)
    btnCallDLLFunc: TButton;
    edtSearchStr: TEdit;
    lblSrchWrd: TLabel;
    memStr: TMemo;
    procedure btnCallDLLFuncClick(Sender: TObject);
  end;

var
  MainForm: TMainForm;
  Count: Integer;

implementation

{$R *.DFM}

{ Define the DLL's exported procedure }
function SearchStr(ASrcStr, ASearchStr: PChar; AProc: TFarProc):
  Integer; StdCall external
  'STRSRCHLIB.DLL';

{ Define the callback procedure, make sure to use the StdCall directive }
procedure StrPosProc(AStrPsn: PChar); StdCall;
begin
  inc(Count); // Increment the Count variable.
end;

procedure TMainForm.btnCallDLLFuncClick(Sender: TObject);
var
  S: String;
  S2: String;
begin
```

LISTING 9.11 Continued

```
Count := 0; // Initialize Count to zero.
{ Retrieve the length of the text on which to search. }
SetLength(S, memStr.GetTextLen);
{ Now copy the text to the variable S }
memStr.GetTextBuf(PChar(S), memStr.GetTextLen);
{ Copy Edit1's Text to a string variable so that it can be passed to
  the DLL function }
S2 := edtSearchStr.Text;
{ Call the DLL function }
SearchStr(PChar(S), PChar(S2), @StrPosProc);
{ Show how many times the word occurs in the string. This has been
  stored in the Count variable which is used by the callback function }
ShowMessage(Format('%s %s %d %s', [edtSearchStr.Text,
  'occurs', Count, 'times.']));
end;

end.
```

This application contains a TMemo control. `EdtSearchStr.Text` contains a string that will be searched for in `memStr`'s contents. `memStr`'s contents are passed as the source string to the DLL function `SearchStr()`, and `edtSearchStr.Text` is passed as the search string.

The function `StrPosProc()` is the actual callback function. This function increments the value of the global variable `Count`, which you use to hold the number of times the search string occurs in `memStr`'s text.

Sharing DLL Data Across Different Processes

Back in the world of 16-bit Windows, DLL memory was handled differently than it is in the 32-bit world of Win32. One often-used trait of 16-bit DLLs is that they share global memory among different applications. In other words, if you declare a global variable in a 16-bit DLL, any application that uses that DLL will have access to that variable, and changes made to that variable by an application will be seen by other applications.

In some ways, this behavior can be dangerous because one application can overwrite data on which another application is dependent. In other ways, developers have made use of this characteristic.

In Win32, this sharing of DLL global data no longer exists. Because each application process maps the DLL to its own address space, the DLL's data also gets mapped to that same address space. This results in each application getting its own instance of DLL data. Changes made to the DLL global data by one application won't be seen from another application.

If you're planning on porting a 16-bit application that relies on the sharable behavior of DLL global data, you can still provide a means for applications to share data in a DLL with other applications. The process isn't automatic, and it requires the use of memory-mapped files to store the shared data. Memory-mapped files are covered in Chapter 12, "Working with Files." We'll use them here to illustrate this method; however, you'll probably want to return to and review this section when you have a more thorough understanding of memory-mapped files after reading Chapter 12.

Creating a DLL with Shared Memory

Listing 9.12 shows a DLL project file that contains the code to allow applications using this DLL to share its global data. This global data is stored in the variable appropriately named `GlobalData`.

LISTING 9.12 ShareLib: A DLL That Illustrates Sharing Global Data

```
library ShareLib;

uses
  ShareMem,
  Windows,
  SysUtils,
  Classes;
const

  cMMFileName: PChar = 'SharedMapData';

{$I DLLDATA.INC}

var
  GlobalData : PGlobalDLLData;
  MapHandle  : THandle;

{ GetDLLData will be the exported DLL function }
procedure GetDLLData(var AGlobalData: PGlobalDLLData); StdCall;
begin
  { Point AGlobalData to the same memory address referred to by GlobalData. }
  AGlobalData := GlobalData;
end;

procedure OpenSharedData;
var
  Size: Integer;
```

LISTING 9.12 Continued

```
begin
  { Get the size of the data to be mapped. }
  Size := SizeOf(TGlobalDLLData);

  { Now get a memory-mapped file object. Note the first parameter passes
    the value $FFFFFFFF or DWord(-1) so that space is allocated from
    the system's paging file. This requires that a name for the memory-mapped
    object get passed as the last parameter. }

  MapHandle := CreateFileMapping(DWord(-1), nil, PAGE_READWRITE, 0,
    Size, cMMFileName);

  if MapHandle = 0 then
    RaiseLastWin32Error;
  { Now map the data to the calling process's address space and get a
    pointer to the beginning of this address }
  GlobalData := MapViewOfFile(MapHandle, FILE_MAP_ALL_ACCESS, 0, 0, Size);
  { Initialize this data }
  GlobalData^.S := 'ShareLib';
  GlobalData^.I := 1;
  if GlobalData = nil then
    begin
      CloseHandle(MapHandle);
      RaiseLastWin32Error;
    end;
end;

procedure CloseSharedData;
{ This procedure un-maps the memory-mapped file and releases the memory-mapped
  file handle }
begin
  UnmapViewOfFile(GlobalData);
  CloseHandle(MapHandle);
end;

procedure DLLEntryPoint(dwReason: DWord);
begin
  case dwReason of
    DLL_PROCESS_ATTACH: OpenSharedData;
    DLL_PROCESS_DETACH: CloseSharedData;
  end;
```

```
end;

exports
  GetDLLData;

begin
  { First, assign the procedure to the DLLProc variable }
  DllProc := @DLLEntryPoint;
  { Now invoke the procedure to reflect that the DLL is attaching
    to the process }
  DLLEntryPoint(DLL_PROCESS_ATTACH);
end.
```

GlobalData is of the type PGlobalDLLData, which is defined in the include file DllData.inc. This include file contains the following type definition (note that the include file is linked by using the include directive \$I):

```
type

  PGlobalDLLData = ^TGlobalDLLData;
  TGlobalDLLData = record
    S: String[50];
    I: Integer;
  end;
```

In this DLL, you use the same process discussed earlier in the chapter to add entry and exit code to the DLL in the form of an entry/exit procedure. This procedure is called `DLLEntryPoint()`, as shown in the listing. When a process loads the DLL, the `OpenSharedData()` method gets called. When a process detaches from the DLL, the `CloseSharedData()` method is called.

We won't go into too much detail here about memory-mapped file usage because we cover it in more detail in Chapter 12, "Working with Files." However, we'll explain the basics of what's going on so that you understand the purpose of this DLL.

Memory-mapped files provide a means for you to reserve a region of address space in the Win32 system to which physical storage gets committed. This is similar to allocating memory and referring to that memory with a pointer. With memory-mapped files, however, you can map a disk file to this address space and refer to the space within the file as though you were just referencing an area of memory with a pointer.

With memory-mapped files, you must first get a handle to an existing file on disk to which a memory-mapped object will be mapped. You then map the memory-mapping object to that file. At the beginning of the chapter, we told you how the system shares DLLs with multiple applications by first loading the DLL into memory and then giving each application its own image of the DLL so that it appears that each application has loaded a separate instance of the DLL.

In reality, however, the DLL exists in memory only once. This is done by using memory-mapped files. You can use the same process to give access to data files. You just make necessary Win32 API calls that deal with creating and accessing memory-mapped files.

Now, consider this scenario: Suppose an application, which we'll call App1, creates a memory-mapped file that gets mapped to a file on disk, `MyFile.dat`. App1 can now read and write data in that file. If, while App1 is running, App2 also maps to that same file, changes made to the file by App1 will be seen by App2. Actually, it's a bit more complex; certain flags must be set so that changes to the file are immediately set and so forth. For this discussion, it suffices to say that changes will be realized by both applications because this is possible.

One of the ways in which memory-mapped files can be used is to create a file mapping from the Win32 paging file rather than an existing file. This means that instead of mapping to an existing file on disk, you can reserve an area of memory to which you can refer as though it were a disk file. This prevents you from having to create and destroy a temporary file if all you want to do is to create an address space that can be accessed by multiple processes. The Win32 system manages its paging file, so when memory is no longer required of the paging file, this memory gets released.

In the preceding paragraphs, we presented a scenario that illustrated how two applications can access the same file data by using a memory-mapped file. The same can be done between an application and a DLL. In fact, if the DLL creates the memory-mapped file when it's loaded by an application, it will use the same memory-mapped file when loaded by another application. There will be two images of the DLL, one for each calling application, both of which use the same memory-mapped file instance. The DLL can make the data referred to by the file mapping available to its calling application. When one application makes changes to this data, the second application will see these changes because they're referring to the same data, mapped by two different memory-mapped object instances. We use this technique in the example.

In Listing 9.12, `OpenSharedData()` is responsible for creating the memory-mapped file. It uses the `CreateFileMapping()` function to first create the file-mapping object, which it then passes to the `MapViewOfFile()` function. The `MapViewOfFile()` function maps a view of the file into the address space of the calling process. The return value of this function is the beginning of that address space. Now remember, this is the address space of the calling process. For two different applications using this DLL, this address location might be different, although the data to which they refer will be the same.

NOTE

The first parameter to `CreateFileMapping()` is a handle to a file to which the memory-mapped file gets mapped. However, if you're mapping to an address space of the system paging file, pass the value `$FFFFFFFF` (which is the same as `DWord(-1)`) as this parameter value. You must also supply a name for the file-mapping object as the last

parameter to `CreateFileMapping()`. This is the name that the system uses to refer to this file mapping. If multiple processes create a memory-mapped file using the same name, the mapping objects will refer to the same system memory.

After the call to `MapViewOfFile()`, the variable `GlobalData` refers to the address space for the memory-mapped file. The exported function `GetDLLData()` assigns that memory to which `GlobalData` refers to the `AGlobalData` parameter. `AGlobalData` is passed in from the calling application; therefore, the calling application has read/write access to this data.

The `CloseSharedData()` procedure is responsible for unmapping the view of the file from the calling process and releasing the file-mapping object. This doesn't affect other file-mapping objects or file mappings from other applications.

Using a DLL with Shared Memory

To illustrate the use of the shared memory DLL, we've created two applications that make use of it. The first application, `App1.dpr`, allows you to modify the DLL's data. The second application, `App2.dpr`, also refers to the DLL's data and continually updates a couple of `TLabel` components by using a `TTimer` component. When you run both applications, you'll be able to see the sharable access to the DLL data—`App2` will reflect changes made by `App1`.

Listing 9.13 shows the source code for the `APP1` project.

LISTING 9.13 The Main Form for `App1.dpr`

```
unit MainFrmA1;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, ExtCtrls, Mask;

{$I DLLDATA.INC}

type

  TMainForm = class(TForm)
    edtGlobDataStr: TEdit;
    btnGetDllData: TButton;
    meGlobDataInt: TMaskEdit;
    procedure btnGetDllDataClick(Sender: TObject);
```

LISTING 9.13 Continued

```
    procedure edtGlobDataStrChange(Sender: TObject);
    procedure meGlobDataIntChange(Sender: TObject);
    procedure FormCreate(Sender: TObject);
public
    GlobalData: PGlobalDLLData;
end;

var
    MainForm: TMainForm;

{ Define the DLL's exported procedure }
procedure GetDLLData(var AGlobalData: PGlobalDLLData);
    StdCall External 'SHARELIB.DLL';

implementation

{$R *.DFM}

procedure TMainForm.btnGetDllDataClick(Sender: TObject);
begin
    { Get a pointer to the DLL's data }
    GetDLLData(GlobalData);
    { Now update the controls to reflect GlobalData's field values }
    edtGlobDataStr.Text := GlobalData^.S;
    meGlobDataInt.Text := IntToStr(GlobalData^.I);
end;

procedure TMainForm.edtGlobDataStrChange(Sender: TObject);
begin
    { Update the DLL data with the changes }
    GlobalData^.S := edtGlobDataStr.Text;
end;

procedure TMainForm.meGlobDataIntChange(Sender: TObject);
begin
    { Update the DLL data with the changes }
    if meGlobDataInt.Text = EmptyStr then
        meGlobDataInt.Text := '0';
    GlobalData^.I := StrToInt(meGlobDataInt.Text);
end;
```

```
procedure TMainForm.FormCreate(Sender: TObject);
begin
  btnGetDllDataClick(nil);
end;

end.
```

This application also links in the include file `DllData.inc`, which defines the `TGlobalDLLData` data type and its pointer. The `btnGetDllDataClick()` event handler gets a pointer to the DLL's data, which is accessed by a memory-mapped file in the DLL. It does this by calling the DLL's `GetDLLData()` function. It then updates its controls with the value of this pointer, `GlobalData`. The `OnChange` event handlers for the edit controls change the values of `GlobalData`. Because `GlobalData` refers to the DLL's data, it modifies the data referred to by the DLL's memory-mapped file.

Listing 9.14 shows the source code for the main form for `App2.dpr`.

LISTING 9.14 The Source Code for Main Form for `App2.dpr`

```
unit MainFrmA2;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  ExtCtrls, StdCtrls;

{$I DLLDATA.INC}

type

  TMainForm = class(TForm)
    lblGlobDataStr: TLabel;
    tmTimer: TTimer;
    lblGlobDataInt: TLabel;
    procedure tmTimerTimer(Sender: TObject);
  public
    GlobalData: PGlobalDLLData;
  end;

{ Define the DLL's exported procedure }
procedure GetDLLData(var AGlobalData: PGlobalDLLData);
```

LISTING 9.14 Continued

```
StdCall External 'SHARELIB.DLL';

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.tmTimerTimer(Sender: TObject);
begin
  GetDllData(GlobalData); // Get access to the data
  { Show the contents of GlobalData's fields.}
  lblGlobDataStr.Caption := GlobalData^.S;
  lblGlobDataInt.Caption := IntToStr(GlobalData^.I);
end;

end.
```

This form contains two `TLabel` components, which get updated during the `tmTimer`'s `OnTimer` event. When the user changes the values of the DLL's data from `App1`, `App2` will reflect these changes.

You can run both applications to experiment with them. You'll find them on this book's CD.

Exporting Objects from DLLs

It's possible to access an object and its methods even if that object is contained within a DLL. There are some requirements, however, to how that object is defined within the DLL as well as some limitations as to how the object can be used. The technique we illustrate here is useful in very specific situations. Typically, you can achieve the same functionality by using packages or interfaces.

The following list summarizes the conditions and limitations to exporting an object from a DLL:

- The calling application can only use methods of the object that have been declared as virtual.
- The object instances must be created only within the DLL.
- The object must be defined in both the DLL and calling application with methods defined in the same order.
- You cannot create a descendant object from the object contained within the DLL.

Some additional limitations might exist, but the ones listed are the primary limitations.

To illustrate this technique, we've created a simple, yet illustrative example of an object that we export. This object contains a function that returns the uppercase or lowercase value of a string based on the value of a parameter indicating either uppercase or lowercase. This object is defined in Listing 9.15.

LISTING 9.15 Object to Be Exported from a DLL

```

type

    TConvertType = (ctUpper, ctLower);

    TStringConvert = class(TObject)
{$IFDEF STRINGCONVERTLIB}
    private
        FPrepend: String;
        FAppend : String;
{$ENDIF}
    public
        function ConvertString(AConvertType: TConvertType; AString: String):
String;
            virtual; stdcall; {$IFDEF STRINGCONVERTLIB} abstract; {$ENDIF}
{$IFDEF STRINGCONVERTLIB}
        constructor Create(APrepend, AAppend: String);
        destructor Destroy; override;
{$ENDIF}
    end;

{ For any application using this class, STRINGCONVERTLIB is not defined and
therefore, the class definition will be equivalent to:

    TStringConvert = class(TObject)
    public
        function ConvertString(AConvertType: TConvertType; AString: String):
String;
            virtual; stdcall; abstract;
    end;
}

```

Listing 9.15 is actually an include file named `StrConvert.inc`. The reason for placing this object in an include file is to meet the third requirement in the preceding list—that the object be equally defined in both the DLL and in the calling application. By placing the object in an

include file, both the calling application and DLL can include this file. If changes are made to the object, you only have to compile both projects instead of typing the changes twice—once in the calling application and once in the DLL—which is error prone.

Observe the following definition of the `ConvertString()` method:

```
function ConvertString(AConvertType: TConvertType; AString: String):  
    ↪String; virtual; stdcall;
```

The reason you declare this method as `virtual` is not so that one can create a descendant object that can then override the `ConvertString()` method. Instead, it's declared as `virtual` so that an entry to the `ConvertString()` method is made in the Virtual Method Table (VMT). We won't go into detail on the VMT here; it's discussed in Chapter 13, "Hard-Core Techniques." For now, think of the VMT as a block of memory that holds pointers to virtual methods of an object. Because of the VMT, the calling application can obtain a pointer to the method of the object. Without declaring the method as `virtual`, the VMT would not have an entry for the method, and the calling application would have no way of obtaining the pointer to the method. So really, what you have in the calling application is a pointer to the function. Because you've based this pointer on a method type defined in an object, Delphi automatically handles any fix-ups, such as passing the implicit `self` parameter to the method.

Note the conditional define `STRINGCONVERTLIB`. When you're exporting the object, the only methods that need redefinition in the calling application are the methods to be accessed externally from the DLL. Also, these methods can be defined as abstract methods to avoid generating a compile-time error. This is valid because at runtime, these methods will be implemented in the DLL code. The commentary shows what the `TStringConvert` object looks like on the application side.

Listing 9.16 shows the implementation of the `TStringConvert` object.

LISTING 9.16 Implementation of the `TStringConvert` Object

```
unit StringConvertImp;  
{$DEFINE STRINGCONVERTLIB}  
  
interface  
uses SysUtils;  
{$I StrConvert.inc}  
  
function InitStrConvert(APrepend, AAppend: String): TStringConvert; stdcall;  
  
implementation  
  
constructor TStringConvert.Create(APrepend, AAppend: String);  
begin
```

```
    inherited Create;
    FPrepend := APrepend;
    FAppend  := AAppend;
end;

destructor TStringConvert.Destroy;
begin
    inherited Destroy;
end;

function TStringConvert.ConvertString(AConvertType:
    TConvertType; AString: String): String;
begin
    case AConvertType of
        ctUpper: Result := Format('%s%s%s', [FPrepend, UpperCase(AString),
            FAppend]);
        ctLower: Result := Format('%s%s%s', [FPrepend, LowerCase(AString),
            FAppend]);
    end;
end;

function InitStrConvert(APrepend, AAppend: String): TStringConvert;
begin
    Result := TStringConvert.Create(APrepend, AAppend);
end;

end.
```

As stated in the conditions, the object must be created in the DLL. This is done in a standard DLL exported function `InitStrConvert()`, which takes two parameters that are passed to the constructor. We added this to illustrate how you would pass information to an object's constructor through an interface function.

Also, notice that in this unit you declare the conditional directive `STRINGCONVERTLIB`. The rest of this unit is self-explanatory. Listing 9.17 shows the DLL's project file.

LISTING 9.17 The Project File for `StringConvertLib.dll`

```
library StringConvertLib;
uses
    ShareMem,
    SysUtils,
    Classes,
```

continues

LISTING 9.17 Continued

```
StringConvertImp in 'StringConvertImp.pas';

exports
  InitStrConvert;
end.
```

Generally, this library doesn't contain anything we haven't already covered. Do note, however, that you used the `ShareMem` unit. This unit must be the first unit declared in the library project file as well as in the calling application's project file. This is an extremely important thing to remember.

Listing 9.18 shows an example of how to use the exported object to convert a string to both uppercase and lowercase. You'll find this demo project on the CD as `StrConvertTest.dpr`.

LISTING 9.18 The Demo Project for the String Conversion Object

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls;

{$I strconvert.inc}

type

  TMainForm = class(TForm)
    btnUpper: TButton;
    edtConvertStr: TEdit;
    btnLower: TButton;
    procedure btnUpperClick(Sender: TObject);
    procedure btnLowerClick(Sender: TObject);
  private
  public
  end;
```

```
var
    MainForm: TMainForm;

function InitStrConvert(APrepend, AAppend: String): TStringConvert; stdcall;
    external 'STRINGCONVERTLIB.DLL';

implementation

{$R *.DFM}

procedure TMainForm.btnUpperClick(Sender: TObject);
var
    ConvStr: String;
    FStrConvert: TStringConvert;
begin
    FStrConvert := InitStrConvert('Upper ', ' end');
    try
        ConvStr := edtConvertStr.Text;
        if ConvStr <> EmptyStr then
            edtConvertStr.Text := FStrConvert.ConvertString(ctUpper, ConvStr);
    finally
        FStrConvert.Free;
    end;
end;

procedure TMainForm.btnLowerClick(Sender: TObject);
var
    ConvStr: String;
    FStrConvert: TStringConvert;
begin
    FStrConvert := InitStrConvert('Lower ', ' end');
    try
        ConvStr := edtConvertStr.Text;
        if ConvStr <> EmptyStr then
            edtConvertStr.Text := FStrConvert.ConvertString(ctLower, ConvStr);
    finally
        FStrConvert.Free;
    end;
end;

end.
```

Summary

DLLs are an essential part of creating Windows applications while focusing in on code reusability. This chapter covered the reasons for creating or using DLLs. The chapter illustrated how to create and use DLLs in your Delphi applications and showed different methods of loading DLLs. The chapter discussed some of the special considerations you must take when using DLLs with Delphi and showed you how to make DLL data sharable with different applications.

With this knowledge under your belt, you should be able to create DLLs with Delphi and use them in your Delphi applications with ease. You'll learn more about DLLs in other chapters.

IN THIS CHAPTER

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- **TPrinter.Canvas 421**
- **Simple Printing 422**
- **Printing a Form 425**
- **Advanced Printing 425**
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Printing in Windows has been the bane of many a Windows programmer. However, don't be discouraged; Delphi simplifies most of what you need to know for printing. You can write simple printing routines to output text or bitmapped images with little effort. For more complex printing, a few concepts and techniques are all you really need to enable you to perform any type of custom printing. When you have that, printing isn't so difficult.

NOTE

You'll find a set of reporting components by QuSoft on the QReport page of the Component Palette. The documentation for this tool is located in the help file `QuickRpt.hlp`.

QuSoft's tools are suitable for applications that generate complex reports. However, they limit you from getting to the nuts and bolts of printing at the source-code level, where you have more control over what gets printed. This chapter doesn't cover QuickReports; instead, it covers creating your own reports in Delphi.

Delphi's `TPrinter` object, which encapsulates the Windows printing engine, does a great deal for you that you would otherwise have to handle yourself.

This chapter teaches you how to perform a whole range of printing operations by using `TPrinter`. You learn the simple tasks that Delphi has made much easier for generating print-outs. You also learn the techniques for creating advanced printing routines that should start you on your way to becoming a printing guru.

The TPrinter Object

The `TPrinter` object encapsulates the Windows printing interface, making most of the printing management invisible to you. `TPrinter`'s methods and properties enable you to print onto its canvas as though you were drawing your output to a form's surface. The function `Printer()` returns a global `TPrinter` instance the first time it's called. `TPrinter`'s properties and methods are listed in Tables 10.1 and 10.2.

TABLE 10.1 `TPrinter` Properties

<i>Property</i>	<i>Purpose</i>
<code>Aborted</code>	Boolean variable that determines whether the user has aborted the print job.
<code>Canvas</code>	The printing surface for the current page.
<code>Fonts</code>	Contains a list of fonts supported by the printer.
<code>Handle</code>	A unique number representing the printer's device handle. See the sidebar "Handles" in Chapter 20, "Key Elements of the Visual Component Library."

<i>Property</i>	<i>Purpose</i>
Orientation	Determines horizontal (poLandscape) or vertical (poPortrait) printing.
PageHeight	Height, in pixels, of the printed page's surface.
PageNumber	Indicates the page being printed. This is incremented with each subsequent call to TPrinter.NewPage().
PageWidth	Width, in pixels, of the printed page's surface.
PrinterIndex	Indicates the selected printer from the available printers on the user's system.
Printers	A list of the available printers on the system.
Printing	Determines whether a print job is printing.
Title	Text appearing in the Print Manager and on networked pages.

TABLE 10.2 TPrinter Methods

<i>Method</i>	<i>Purpose</i>
Abort	Terminates a print job.
BeginDoc	Begins a print job.
EndDoc	Ends a print job. (EndDoc ends a print job when printing is finished; Abort can terminate the job before printing is complete.)
GetPrinter	Retrieves the current printer.
NewPage	Forces the printer to start printing on a new page and increments the PageCount property.
SetPrinter	Specifies a printer as a current printer.

TPrinter.Canvas

TPrinter.Canvas is much like the canvas for your form; it represents the drawing surface on which text and graphics are drawn. The difference is that TPrinter.Canvas represents the drawing surface for your printed output as opposed to your screen. Most of the routines you use to draw text, to draw shapes, and to display images are used in the same manner for printed output. When printing, however, you must take into account some differences:

- Drawing to the screen is *dynamic*—you can erase what you've placed on the screen's output. Drawing to the printer isn't so flexible. What's drawn to the TPrinter.Canvas is printed to the printer.
- Drawing text or graphics to the screen is nearly instantaneous, whereas drawing to the printer is slow, even on some high-performance laser printers. You therefore must allow

users to abort a print job either by using an Abort dialog box or by some other method that enables them to terminate the print job.

- Because your users are running Windows, you can assume that their display supports graphics output. However, you can't assume the same for their printers. Different printers have different capabilities. Some printers may be high-resolution printers; other printers may be very low resolution and may not support graphics printing at all. You must take this into account in your printing routines.

- You'll never see an error message like this:

```
Display ran out of screen space,  
please insert more screen space into your display.
```

But you can bet that you'll see an error telling you that the printer ran out of paper. Windows NT/2000 and Windows 95/98 both provide error handling when this occurs. However, you should provide a way for the user to cancel the printout when this occurs.

- Text and graphics on your screen don't look the same on hard copy. Printers and displays have very different resolutions. That 300×300 bitmap might look spectacular on a 640×480 display, but it's a mere 1×1-inch square blob on your 300 dpi (dots per inch) laser printer. You're responsible for making adjustments to your drawing routines so that your users won't need a magnifying glass to read their printed output.

Simple Printing

In many cases, you want to send a stream of text to your printer without any regard for special formatting or placement of the text. Delphi facilitates simple printing, as the following sections illustrate.

Printing the Contents of a TMemo Component

Printing lines of text is actually quite simple using the `AssignPrn()` procedure. The `AssignPrn()` procedure enables you to assign a text file variable to the current printer. It's used with the `Rewrite()` and `CloseFile()` procedures. The following lines of code illustrate this syntax:

```
var  
  f: TextFile;  
begin  
  AssignPrn(f);  
  try  
    Rewrite(f);  
    writeln(f, 'Print the output');  
  finally
```

```
    CloseFile(f);
  end;
end;
```

Printing a line of text to the printer is the same as printing a line of text to a file. You use this syntax:

```
writeln(f, 'This is my line of text');
```

In Chapter 16, “MDI Applications,” you add menu options for printing the contents of the `TMdiEditForm` form. Listing 10.1 shows you how to print the contents from `TMdiEditForm`. You’ll use this same technique for printing text from just about any source.

LISTING 10.1 Printing Code for `TMdiEditForm`

```
procedure TMdiEditForm.mmiPrintClick(Sender: TObject);
var
  i: integer;
  PText: TextFile;
begin
  inherited;
  if PrintDialog.Execute then
  begin
    AssignPrn(PText);
    Rewrite(PText);
    try
      Printer.Canvas.Font := memMainMemo.Font;
      for i := 0 to memMainMemo.Lines.Count - 1 do
        writeln(PText, memMainMemo.Lines[i]);
    finally
      CloseFile(PText);
    end;
  end;
end;
```

Notice that the memo’s font also was assigned to the Printer’s font, causing the output to print with the same font as `memMainMemo`.

CAUTION

Be aware that the printer will print with the font specified by `Printer.Font` only if the printer supports that font. Otherwise, the printer will use a font that approximates the characteristics of the specified font.

Printing a Bitmap

Printing a bitmap is simple as well. The `MdiApp` example in Chapter 16, “MDI Applications,” shows how to print the contents of a bitmap in `TMdiBmpForm`. This event handler is shown in Listing 10.2.

LISTING 10.2 Printing Code for `TMdiBmpForm`

```
procedure TMdiBMPForm.mmiPrintClick(Sender: TObject);
begin
    inherited;

    with ImgMain.Picture.Bitmap do
    begin
        Printer.BeginDoc;
        Printer.Canvas.StretchDraw(Canvas.ClipRect, imgMain.Picture.Bitmap);
        Printer.EndDoc;
    end; { with }
end;
```

Only three lines of code are needed to print the bitmap using the `TCanvas.StretchDraw()` method. This vast simplification of printing a bitmap is made possible by the fact that since Delphi 3, bitmaps are in DIB format by default, and DIBs are what the printer driver requires. If you happen to have a handle to a bitmap that isn't in DIB format, you can copy (Assign) it into a temporary `TBitmap`, force the temporary bitmap into DIB format by assigning `bmDIB` to the `TBitmap.HandleType` property, and then print from the new DIB.

NOTE

One of the keys to printing is to be able to print images as they appear onscreen at approximately the same size. A 3×3-inch image on a 640×480 pixel screen uses fewer pixels than it would on a 300 dpi printer, for example. Therefore, stretch the image to `TPrinter`'s canvas as was done in the example in the call to `StretchDIBits()`. Another technique is to draw the image using a different mapping mode, as described in Chapter 8, “Graphics Programming with GDI and Fonts.” Keep in mind that some older printers may not support the stretching of images. You can obtain valuable information about the printer's capabilities by using the Win32 API function `GetDeviceCaps()`.

Printing Rich Text–Formatted Data

Printing the contents of a `TRichEdit` component is a matter of one method call. The following code shows how to do this (this is also the code for printing `TMdiRtfForm` in the `MdiApp` example in Chapter 16, “MDI Applications”):

```
procedure TMdiRtfForm.mmiPrintClick(Sender: TObject);
begin
    inherited;
    reMain.Print(Caption);
end;
```

Printing a Form

Conceptually, printing a form can be one of the more difficult tasks to perform. However, this task has been simplified greatly thanks to VCL’s `Print()` method of `TForm`. The following one-line procedure prints your form’s client areas as well as all components residing in the client area:

```
procedure TForm1.PrintMyForm(Sender: TObject);
begin
    Print;
end;
```

NOTE

Printing your form is a quick-and-dirty way to print graphical output. However, only what’s visible onscreen will be printed, due to Windows’ clipping. Also, the bitmap is created at screen pixel density and then stretched to printer resolution. Text on the form is not drawn at printer resolution; it’s drawn at screen resolution and stretched, so overall the form will be noticeably jagged and blocky. You must use more elaborate techniques to print complex graphics; these techniques are discussed later in this chapter.

Advanced Printing

Often you need to print something very specific that isn’t facilitated by the development tool you’re using or a third-party reporting tool. In this case, you need to perform the low-level printing tasks yourself. The next several sections show you how to write such printing routines and present a methodology you can apply to all your printing tasks.

NOTE

Although this section covers printing, you should know that at the time of this writing, several third-party printing components are available that should handle most of your printing needs. You'll find demos of some of these tools on the CD with this book.

Printing a Columnar Report

Many applications, particularly those using databases, print some type of report. One common report style is the columnar report.

The next project prints a columnar report from one of the tables in Delphi's demo directories. Each page contains a header, column titles, and then the record list. Each subsequent page also has the header and column titles preceding the record list.

Figure 10.1 shows the main form for this project. The TEdit/TUpDown pairs enable the user to specify the column widths in tenths of inches. By using the TUpDown components, you can specify minimum and maximum values. The TEdit1 control, edtHeaderFont, contains a header that can be printed using a font that differs from the one used for the rest of the report.

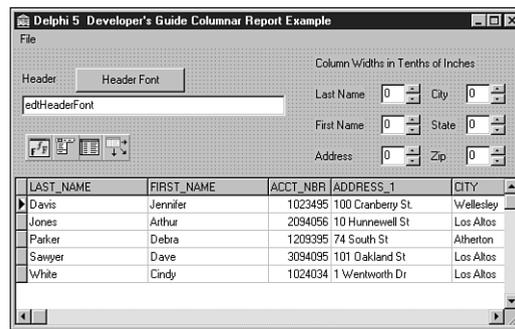


FIGURE 10.1

Columnar report main form.

Listing 10.3 shows the source code for the project. The `mmiPrintClick()` event handler basically performs the following steps:

1. Initiates a print job.
2. Prints a header.
3. Prints column names.

4. Prints a page.
5. Continues steps 2, 3, and 4 until printing finishes.
6. Ends the print job.

LISTING 10.3 Columnar Report Demo

```
unit MainFrm;
interface

uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, Grids, DBGrids, DB, DBTables, Menus, StdCtrls, Spin,
  Gauges, ExtCtrls, ComCtrls;

type
  TMainForm = class(TForm)
  { components not included in listing,
    please refer to CD source }
  procedure mmiPrintClick(Sender: TObject);
  procedure btnHeaderFontClick(Sender: TObject);
  private
    PixelsInInchx: integer;
    LineHeight: Integer;
  { Keeps track of vertical space in pixels, printed on a page }
    AmountPrinted: integer;
  { Number of pixels in 1/10 of an inch. This is used for line spacing }
    TenthsOfInchPixelsY: integer;
  procedure PrintLine(Items: TStringList);
  procedure PrintHeader;
  procedure PrintColumnNames;
  end;

var
  MainForm: TMainForm;

implementation
uses printers, AbortFrm;

{$R *.DFM}

procedure TMainForm.PrintLine(Items: TStringList);
var
  OutRect: TRect;
  Inches: double;
  i: integer;
```

continues

LISTING 10.3 Continued

```

begin
  // First position the print rect on the print canvas
  OutRect.Left := 0;
  OutRect.Top := AmountPrinted;
  OutRect.Bottom := OutRect.Top + LineHeight;
  With Printer.Canvas do
    for i := 0 to Items.Count - 1 do
      begin
        Inches := longint(Items.Objects[i]) * 0.1;
        // Determine Right edge
        OutRect.Right := OutRect.Left + round(PixelsInInchx*Inches);
        if not Printer.Aborted then
          // Print the line
          TextRect(OutRect, OutRect.Left, OutRect.Top, Items[i]);
          // Adjust right edge
          OutRect.Left := OutRect.Right;
        end;
      { As each line prints, AmountPrinted must increase to reflect how
        much of a page has been printed on based on the line height. }
      AmountPrinted := AmountPrinted + TenthsOfInchPixelsY*2;
    end;

procedure TMainForm.PrintHeader;
var
  SaveFont: TFont;
begin
  { Save the current printer's font, then set a new print font based
  on the selection for Edit1 }
  SaveFont := TFont.Create;
  try
    Savefont.Assign(Printer.Canvas.Font);
    Printer.Canvas.Font.Assign(edtHeaderFont.Font);
    // First print out the Header
    with Printer do
      begin
        if not Printer.Aborted then
          Canvas.TextOut((PageWidth div 2) - (Canvas.TextWidth(edtHeaderFont.Text)
            div 2), 0, edtHeaderFont.Text);
          // Increment AmountPrinted by the LineHeight
          AmountPrinted := AmountPrinted + LineHeight + TenthsOfInchPixelsY;
        end;
        // Restore the old font to the Printer's Canvas property
        Printer.Canvas.Font.Assign(SaveFont);
      finally
        SaveFont.Free;

```

```
end;
end;

procedure TMainForm.PrintColumnNames;
var
  ColNames: TStringList;
begin
  { Create a TStringList to hold the column names and the
    positions where the width of each column is based on values
    in the TEdit controls. }
  ColNames := TStringList.Create;
  try
    // Print the column headers using a bold/underline style
    Printer.Canvas.Font.Style := [fsBold, fsUnderline];

    with ColNames do
      begin
        // Store the column headers and widths in the TStringList object
        AddObject('LAST NAME', pointer(StrToInt(edtLastName.Text)));
        AddObject('FIRST NAME', pointer(StrToInt(edtFirstName.Text)));
        AddObject('ADDRESS', pointer(StrToInt(edtAddress.Text)));
        AddObject('CITY', pointer(StrToInt(edtCity.Text)));
        AddObject('STATE', pointer(StrToInt(edtState.Text)));
        AddObject('ZIP', pointer(StrToInt(edtZip.Text)));
      end;

      PrintLine(ColNames);
      Printer.Canvas.Font.Style := [];
    finally
      ColNames.Free; // Free the column name TStringList instance
    end;
end;

procedure TMainForm.mmiPrintClick(Sender: TObject);
var
  Items: TStringList;
begin
  { Create a TStringList instance to hold the fields and the widths
    of the columns in which they'll be drawn based on the entries in
    the edit controls }
  Items := TStringList.Create;
  try
    // Determine pixels per inch horizontally
    PixelsInInchX := GetDeviceCaps(Printer.Handle, LOGPIXELSX);
    TenthsOfInchPixelsY := GetDeviceCaps(Printer.Handle,
      LOGPIXELSY) div 10;
```

continues

LISTING 10.3 Continued

```
AmountPrinted := 0;
MainForm.Enabled := False; // Disable the parent form
try
  Printer.BeginDoc;
  AbortForm.Show;
  Application.ProcessMessages;
  { Calculate the line height based on text height using the
    currently rendered font }
  LineHeight := Printer.Canvas.TextHeight('X')+TenthsOfInchPixelsY;
  if edtHeaderFont.Text <> '' then
    PrintHeader;
  PrintColumnNames;
  tblClients.First;
  { Store each field value in the TStringList as well as its
    column width }
  while (not tblClients.Eof) or Printer.Aborted do
  begin

    Application.ProcessMessages;
    with Items do
    begin
      AddObject(tblClients.FieldName('LAST_NAME').AsString,
        pointer(StrToInt(edtLastName.Text)));
      AddObject(tblClients.FieldName('FIRST_NAME').AsString,
        pointer(StrToInt(edtFirstName.Text)));
      AddObject(tblClients.FieldName('ADDRESS_1').AsString,
        pointer(StrToInt(edtAddress.Text)));
      AddObject(tblClients.FieldName('CITY').AsString,
        pointer(StrToInt(edtCity.Text)));
      AddObject(tblClients.FieldName('STATE').AsString,
        pointer(StrToInt(edtState.Text)));
      AddObject(tblClients.FieldName('ZIP').AsString,
        pointer(StrToInt(edtZip.Text)));
    end;
    PrintLine(Items);
    { Force print job to begin a new page if printed output has
      exceeded page height }
    if AmountPrinted + LineHeight > Printer.PageHeight then
    begin
      AmountPrinted := 0;
      if not Printer.Aborted then
        Printer.NewPage;
      PrintHeader;
      PrintColumnNames;
```

```
        end;
        Items.Clear;
        tblClients.Next;
    end;
    AbortForm.Hide;
    if not Printer.Aborted then
        Printer.EndDoc;
    finally
        MainForm.Enabled := True;
    end;
finally
    Items.Free;
end;
end;

procedure TMainForm.btnHeaderFontClick(Sender: TObject);
begin
    { Assign the font selected with FontDialog1 to Edit1. }
    FontDialog.Font.Assign(edtHeaderFont.Font);
    if FontDialog.Execute then
        edtHeaderFont.Font.Assign(FontDialog.Font);
end;

end.
```

`mmiPrintClick()` first creates a `TStringList` instance to hold the strings for a line to be printed. Then the number of pixels per inch along the vertical axis is determined in `PixelsPerInchX`, which is used to calculate column widths. `TenthsOfInchPixelsY` is used to space each line by 0.1 inch. `AmountPrinted` holds the total amount of pixels along the printed surface's vertical axis for each line printed. This is required to determine whether to start a new page when `AmountPrinted` exceeds `Printer.PageHeight`.

If a header exists in `edtHeaderFont.Text`, it's printed in `PrintHeader()`. `PrintColumnNames()` prints the names of the columns for each field to be printed. (These two procedures are discussed later in this section.) Finally, the table's records are printed.

The following loop increments through `tblClients` records and prints selected fields within each of the records:

```
while (not tblClients.Eof) or Printer.Aborted do begin
```

Within the loop, the field values are added to the `TStringList` using the `AddObject()` method. Here, you store both the string and the column width. The column width is added to the `Items.Objects` array property. `Items` is then passed to the `PrintLine()` procedure, which prints the strings in a columnar format.

In much of the previous code, you saw references to `Printer.Aborted`. This is a test to determine whether the user has aborted the print job, which is covered in the next section.

TIP

The `TStrings` and `TStringList`'s `Objects` array properties are a convenient place to store integer values. Using `AddObject()` or `InsertObject()`, you can hold any number up to `MaxLongInt`. Because `AddObject()` expects a `TObject` reference as its second parameter, you must typecast that parameter as a pointer, as shown in the following code:

```
MyList.AddObject('SomeString', pointer(SomeInteger));
```

To retrieve the value, use a `Longint` typecast:

```
MyInteger := Longint(MyList.Objects[Index]);
```

The event handler then determines whether printing a new line will exceed the page height:

```
if AmountPrinted + LineHeight > Printer.PageHeight then
```

If this evaluates to `True`, `AmountPrinted` is set back to `0`, `Printer.NewPage` is invoked to print a new page, and the header and column names are printed again. `Printer.EndDoc` is called to end the print job after the `tblClients` records have printed.

The `PrintHeader()` procedure prints the header centered at the top of the report using `edtHeaderFont.Text` and `edtHeaderFont.Font`. `AmountPrinted` is then incremented and `Printer`'s font is restored to its original style.

As the name implies, `PrintColumnNames()` prints the column names of the report. In this method, names are added to a `TStringList` object, `ColNames`, which then is passed to `PrintLine()`. Notice that the column names are printed in a bold, underlined font. Setting `Printer.Canvas.Font` accordingly does this.

The `PrintLine()` procedure takes a `TStringList` argument called `Items` and prints each string in `Items` on a single line in a columnar manner. The variable `OutRect` holds values for a binding rectangle at a location on `Printer`'s canvas to which the text is drawn. `OutRect` is passed to `TextRect()`, along with the text to draw. By multiplying `Items.Object[i]` by `0.1`, `OutRect.Right`'s value is obtained because `Items.Objects[i]` is in tenths of inches. Inside the `for` loop, `OutRect` is recalculated along the same X-axis to position it to the next column and draw the next text value. Finally, `AmountPrinted` is incremented by `LineHeight + TenthsOfInchPixelsY`.

Although this report is fully functional, you might consider extending it to include a footer, page numbers, and even margin settings.

Aborting the Printing Process

Earlier in this chapter, you learned that your users need a way to terminate printing after they've initiated it. The `TPrinter.Abort()` procedure and the `Aborted` property help you do this. The code in Listing 10.3 contains such logic. To add abort logic to your printing routines, your code must meet these three conditions:

- You must establish an event that, when activated, calls `Printer.Abort`, thus aborting the printing process.
- You must check for `TPrinter.Aborted = True` before calling any of `TPrinter`'s print functions, such as `TextOut()`, `NewPage()`, and `EndDoc()`.
- You must end your printing logic by checking the value of `TPrinter.Aborted` for `True`.

A simple Abort dialog box can satisfy the first condition. You used such a dialog box in the preceding example. This dialog box should contain a button that will invoke the abort process.

This button's event handler should simply call `TPrinter.Abort`, which terminates the print job and cancels any printing requests made to `TPrinter`.

In the unit `MainForm.pas`, examine the code to show `AbortForm` shortly after calling `TPrinter.BeginDoc()`:

```
Printer.BeginDoc;  
AbortForm.Show;  
Application.ProcessMessages;
```

Because `AbortForm` is shown as a modeless dialog box, the call to `Application.ProcessMessages` ensures that it's drawn properly before any processing of the printing logic continues.

To satisfy the second condition, the test for `Printer.Aborted = True` is performed before calling any `TPrinter` methods. The `Aborted` property is set to `True` when the `Abort()` method is called from `AbortForm`. As an example, before you call `Printer.TextRect`, check for `Aborted = True`:

```
if not Printer.Aborted then  
    TextRect(OutRect, OutRect.Left, OutRect.Top, Items[i]);
```

Also, you shouldn't call `EndDoc()` or any of `TPrinter.Canvas`'s drawing routines after calling `Abort()`, because the printer has been effectively closed.

To satisfy the third condition in this example, `while not Table.Eof` also checks whether the value of `Printer.Aborted` is `True`, which causes execution to jump out of the loop where the print logic is executed.

Printing Envelopes

The preceding example showed you a method for printing a columnar report. Although this technique was somewhat more complicated than sending a series of `writeln()` calls to the printer, it's still, for the most part, a line-by-line print. Printing envelopes introduces a few factors that complicate things a bit further and are common to most types of printing you'll do in Windows. First, the objects (items) you must print probably need to be positioned at some specific location on the printed surface. Second, the items' *metrics*, or units of measurement, can be completely different from those of the printer canvas. Taking these two factors into account, printing becomes much more than just printing a line and keeping track of how much print space you've used.

This envelope-printing example shows you a step-by-step process you can use to print just about anything. Keep in mind that everything drawn on the printer's canvas is drawn within some bounding rectangle on the canvas or to specific points on the printer canvas.

Printing in the Abstract

Think of the printing task in a more abstract sense for a moment. In all cases, two things are certain: You have a surface on which to print, and you have one or more elements to plot onto that surface. Take a look at Figure 10.2.

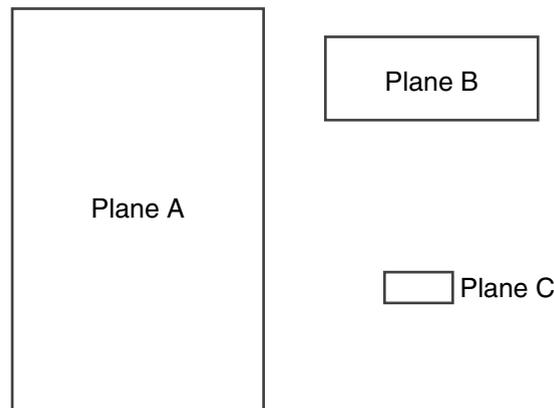


FIGURE 10.2

Three planes.

In Figure 10.2, Plane A is your destination surface. Planes B and C are the elements you want to superimpose (print) onto Plane A. Assume a coordinate system for each plane where the unit of measurement increases as you travel east along the X-axis and south along the Y-axis—that is, unless you live in Australia. Figure 10.3 depicts this coordinate system. The result of combining the planes is shown in Figure 10.4.

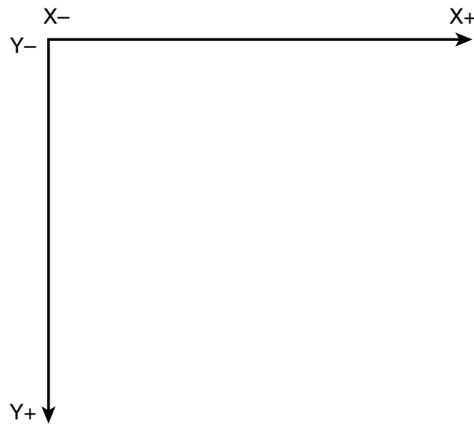


FIGURE 10.3

The Plane A, B, and C coordinate system.

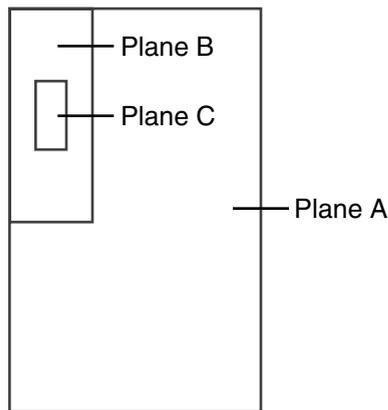


FIGURE 10.4

Planes B and C superimposed on Plane A.

Notice that Planes B and C were rotated by 90 degrees to achieve the final result. So far, this doesn't appear to be too bad. Given that your planes are measured using the same unit of measurement, you can easily draw out these rectangles to achieve the final result with some simple geometry. But what if they're not the same unit of measurement?

Suppose that Plane A represents a surface for which the measurements are given in pixels. Its dimensions are 2,550×3,300 pixels. Plane B is measured in inches: 6½×3¾ inches. Suppose

that you don't know the dimensions for Plane C; you do know, however, that it's measured in pixels, and you'll know its measurements later. These measurements are illustrated in Figure 10.5.

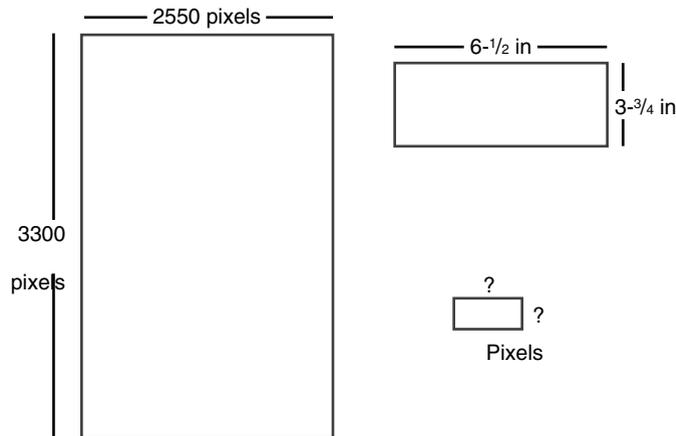


FIGURE 10.5

Plane measurements.

This abstraction illustrates the problem associated with printing. In fact, it illustrates the very task of printing an envelope. Plane A represents a printer's page size on a 300 dpi printer (at 300 dpi, 8 1/2 × 11 inches equals 2,550 × 3,300 pixels). Plane B represents the envelope's size in inches, and Plane C represents the bounding rectangle for the text making up the address. Keep in mind, however, that this abstraction isn't tied to just envelopes. Planes B and C might represent TImage components measured in millimeters.

By looking at this task in its abstraction, you've achieved the first three steps to printing in Windows: Identify each element to print, identify the unit of measurement for the destination surface, and identify the units of measurement for each individual element to be plotted onto the destination surface.

Now consider another twist—literally. When you're printing an envelope in a vertical fashion, the text must rotate vertically.

A Step-by-Step Process for Printing

The following list summarizes the process you should follow when laying out your printed output in code:

1. Identify each element to be printed to the destination surface.
2. Identify the unit of measurement for the destination surface or printer canvas.

3. Identify the units of measurement for each individual element to be plotted onto the destination surface.
4. Decide on the common unit of measurement with which to perform all drawing routines. Almost always, this will be the printer canvas's units—pixels.
5. Write the translation routines to convert the other units of measurement to that of the common unit of measurement.
6. Write the routines to calculate the size for each element to print in the common unit of measurement. In Object Pascal, this can be represented by a `TPoint` structure. Keep in mind dependencies on other values. For example, the address's bounding rectangle is dependent on the envelope's position. Therefore, the envelope's data must be calculated first.
7. Write the routines to calculate the position of each element as it will appear on the printer canvas, based on the printer canvas's coordinate system and the sizes obtained from step 6. In Object Pascal, this can be represented by a `TRect` structure. Again, keep dependencies in mind.
8. Write your printing function, using the data gathered from the previous steps, to position items on the printed surface.

NOTE

Steps 5 and 6 can be achieved by using a technique of performing all drawing in a specific mapping mode. Mapping modes are discussed in Chapter 8, "Graphics Programming with GDI and Fonts."

Getting Down to Business

Given the step-by-step process, your task of printing an envelope should be much clearer. You'll see this in the envelope-printing project. The first step is to identify the elements to print or represent. The elements for the envelope example are the envelope, itself, and the address.

In this example, you learn how to print two standard envelope sizes: a size 10 and a size 6 $\frac{3}{4}$.

The following record holds the envelope sizes:

type

```
TEnvelope = record
  Kind: string; // Stores the envelope type's name
  Width: double; // Holds the width of the envelope
  Height: double; // Holds the height of the envelope
end;
```

```

const
  // This constant array stores envelope types
  EnvArray: array[1..2] of TEnvelope =
    ((Kind: 'Size 10';Width:9.5;Height:4.125),    // 9-1/2 x 4-1/8
     (Kind: 'Size 6-3/4';Width:6.5;Height:3.625)); // 6-1/2 x 3-3/4

```

Steps 2 and 3 are covered: You know that the destination surface is the `TPrinter.Canvas`, which is represented in pixels. The envelopes are represented in inches, and the address is represented in pixels. Step 4 requires you to select a common unit of measurement. For this project, you use pixels as the common unit of measurement.

For step 5, the only units you need to convert are from inches to pixels. The `GetDeviceCaps()` Win32 API function can return the amount of pixels per one inch along the horizontal and vertical axis for `Printer.Canvas`:

```

PixPerInX := GetDeviceCaps(Printer.Handle, LOGPIXELSX);
PixPerInY := GetDeviceCaps(Printer.Handle, LOGPIXELSY);

```

To convert the envelope's size to pixels, you just multiply the number of inches by `PixPerInX` or `PixPerInY` to get the horizontal or vertical measurement in pixels:

```

EnvelopeWidthInPixels := trunc(EnvelopeWidthValue * PixPerInX);
EnvelopeHeightInPixels := trunc(EnvelopeHeightValue * PixPerInY);

```

Because the envelope width or height can be a fractional value, it's necessary to use the `Trunc()` function to return the integer portion of the floating-point type rounded toward zero.

The sample project demonstrates how you would implement steps 6 and 7. The main form for this project is shown in Figure 10.6; Listing 10.4 shows the source code for the envelope-printing project.

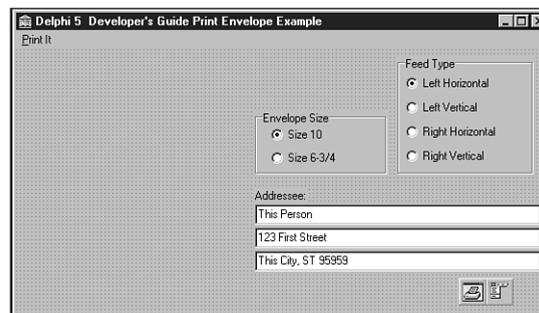


FIGURE 10.6

The main form for the envelope demo.

LISTING 10.4 Envelope Printing Demo

```
unit MainFrm;

interface

uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, printers, StdCtrls, ExtCtrls, Menus, ComCtrls;

type

  TEnvelope = record
    Kind: string; // Stores the envelope type's name
    Width: double; // Holds the width of the envelope
    Height: double; // Holds the height of the envelope
  end;

const
  // This constant array stores envelope types
  EnvArray: array[1..2] of TEnvelope =
    ((Kind:'Size 10';Width:9.5;Height:4.125), // 9-1/2 x 4-1/8
     (Kind:'Size 6-3/4';Width:6.5;Height:3.625)); // 6-1/2 x 3-3/4

type

  // This enumerated type represents printing positions.
  TFeedType = (epLHorz, epLVert, epRHorz, epRVert);

  TPrintPrevPanel = class(TPanel)
  public
    property Canvas; // Publicize the Canvas property
  end;

  TMainForm = class(TForm)
    gbEnvelopeSize: TGroupBox;
    rbSize10: TRadioButton;
    rbSize6: TRadioButton;
    mmMain: TMainMenu;
    mmiPrintIt: TMenuItem;
    lblAddressee: TLabel;
    edtName: TEdit;
    edtStreet: TEdit;
    edtCityState: TEdit;
    rgFeedType: TRadioGroup;
    PrintDialog: TPrintDialog;
```

continues

LISTING 10.4 Continued

```
    procedure FormCreate(Sender: TObject);
    procedure rgFeedTypeClick(Sender: TObject);
    procedure mmiPrintItClick(Sender: TObject);
private
    PrintPrev: TPrintPrevPanel; // Print preview panel
    EnvSize: TPoint;           // Stores the envelope's size
    EnvPos: TRect;            // Stores the envelope's position
    ToAddrPos: TRect;        // Stores the address's position
    FeedType: TFeedType; // Stores the feed type from TEnvPosition
    function GetEnvelopeSize: TPoint;
    function GetEnvelopePos: TRect;
    function GetToAddrSize: TPoint;
    function GetToAddrPos: TRect;
    procedure DrawIt;
    procedure RotatePrintFont;
    procedure SetCopies(Copies: Integer);
end;

var
    MainForm: TMainForm;

implementation
{$R *.DFM}

function TMainForm.GetEnvelopeSize: TPoint;
// Gets the envelope's size represented by a TPoint
var
    EnvW, EnvH: integer;
    PixPerInX,
    PixPerInY: integer;
begin
    // Pixels per inch along the horizontal axis
    PixPerInX := GetDeviceCaps(Printer.Handle, LOGPIXELSX);
    // Pixels per inch along the vertical axis
    PixPerInY := GetDeviceCaps(Printer.Handle, LOGPIXELSY);

    // Envelope size differs depending on the user's selection
    if RBSize10.Checked then
    begin
        EnvW := trunc(EnvArray[1].Width * PixPerInX);
        EnvH := trunc(EnvArray[1].Height * PixPerInY);
    end
    else begin
        EnvW := trunc(EnvArray[2].Width * PixPerInX);
```

```
    EnvH := trunc(EnvArray[2].Height * PixPerInY);
end;

// return Result as a TPoint record
Result := Point(EnvW, EnvH)
end;

function TMainForm.GetEnvelopePos: TRect;
{ Returns the envelope's position relative to its feed type. This
  function requires that the variable EnvSize be initialized }
begin
    // Determine feed type based on user's selection.
    FeedType := TFeedType(rgFeedType.ItemIndex);

    { Return a TRect structure indicating the envelope's
      position as it is ejected from the printer. }
    case FeedType of
        epLHorz:
            Result := Rect(0, 0, EnvSize.X, EnvSize.Y);
        epLVert:
            Result := Rect(0, 0, EnvSize.Y, EnvSize.X);
        epRHorz:
            Result := Rect(Printer.PageWidth - EnvSize.X, 0,
                Printer.PageWidth, EnvSize.Y);
        epRVert:
            Result := Rect(Printer.PageWidth - EnvSize.Y, 0,
                Printer.PageWidth, EnvSize.X);
    end; // Case
end;

function MaxLn(V1, V2: Integer): Integer;
// Returns the larger of the two. If equal, returns the first
begin
    Result := V1;    // Default result to V1 }
    if V1 < V2 then
        Result := V2
    end;
end;

function TMainForm.GetToAddrSize: TPoint;
var
    TempPoint: TPoint;
begin
    // Calculate the size of the longest line using the MaxLn() function
    TempPoint.x := Printer.Canvas.TextWidth(edtName.Text);
    TempPoint.x := MaxLn(TempPoint.x, Printer.Canvas.TextWidth(edtStreet.Text));
    TempPoint.x := MaxLn(TempPoint.x,
```

continues

LISTING 10.4 Continued

```

Printer.Canvas.TextWidth(edtCityState.Text))+10;

// Calculate the height of all the address lines
TempPoint.y := Printer.Canvas.TextHeight(edtName.Text)+
  ▶Printer.Canvas.TextHeight(edtStreet.Text)+
  ▶Printer.Canvas.TextHeight(edtCityState.Text)+10;
Result := TempPoint;
end;

function TMainForm.GetToAddrPos: TRect;
// This function requires that EnvSize, and EnvPos be initialized
Var
  TempSize: TPoint;
  LT, RB: TPoint;
begin
  // Determine the size of the Address bounding rectangle
  TempSize := GetToAddrSize;
  { Calculate two points, one representing the Left Top (LT) position
    and one representing the Right Bottom (RB) position of the
    address's bounding rectangle. This depends on the FeedType }
  case FeedType of
    epLHorz:
      begin
        LT := Point((EnvSize.x div 2) - (TempSize.x div 2),
          ((EnvSize.y div 2) - (TempSize.y div 2)));
        RB := Point(LT.x + TempSize.x, LT.y + TempSize.Y);
      end;
    epLVert:
      begin
        LT := Point((EnvSize.y div 2) - (TempSize.y div 2),
          ((EnvSize.x div 2) - (TempSize.x div 2)));
        RB := Point(LT.x + TempSize.y, LT.y + TempSize.x);
      end;
    epRHorz:
      begin
        LT := Point((EnvSize.x div 2) - (TempSize.x div 2) + EnvPos.Left,
          ((EnvSize.y div 2) - (TempSize.y div 2)));
        RB := Point(LT.x + TempSize.x, LT.y + TempSize.Y);
      end;
    epRVert:
      begin
        LT := Point((EnvSize.y div 2) - (TempSize.y div 2) + EnvPos.Left,
          ((EnvSize.x div 2) - (TempSize.x div 2)));
        RB := Point(LT.x + TempSize.y, LT.y + TempSize.x);
      end;
  end;
end;

```

```

end; // End Case

Result := Rect(LT.x, LT.y, RB.x, RB.y);
end;

procedure TMainForm.DrawIt;
// This procedure assumes that EnvPos and EnvSize have been initialized
begin
  PrintPrev.Invalidate; // Erase contents of Panel
  PrintPrev.Update;
  // Set the mapping mode for the panel to MM_ISOTROPIC
  SetMapMode(PrintPrev.Canvas.Handle, MM_ISOTROPIC);
  // Set the TPanel's extent to match that of the printer boundaries.
  SetWindowExtEx(PrintPrev.Canvas.Handle,
    Printer.PageWidth, Printer.PageHeight, nil);
  // Set the viewport extent to that of the PrintPrev TPanel size.
  SetViewPortExtEx(PrintPrev.Canvas.Handle,
    PrintPrev.Width, PrintPrev.Height, nil);
  // Set the origin to the position at 0, 0
  SetViewportOrgEx(PrintPrev.Canvas.Handle, 0, 0, nil);
  PrintPrev.Brush.Style := bsSolid;

  with EnvPos do
    // Draw a rectangle to represent the envelope
    PrintPrev.Canvas.Rectangle(Left, Top, Right, Bottom);

  with ToAddrPos, PrintPrev.Canvas do
    case FeedType of
      epLHorz, epRHorz:
        begin
          Rectangle(Left, Top, Right, Top+2);
          Rectangle(Left, Top+(Bottom-Top) div 2, Right,
            Top+(Bottom-Top) div 2+2);
          Rectangle(Left, Bottom, Right, Bottom+2);
        end;
      epLVert, epRVert:
        begin
          Rectangle(Left, Top, Left+2, Bottom);
          Rectangle(Left + (Right-Left)div 2, Top,
            Left + (Right-Left)div 2+2, Bottom);
          Rectangle(Right, Top, Right+2, Bottom);
        end;
    end; // case
end;

procedure TMainForm.FormCreate(Sender: TObject);

```

continues

LISTING 10.4 Continued

```
var
  Ratio: double;
begin
  // Calculate a ratio of PageWidth to PageHeight
  Ratio := Printer.PageHeight / Printer.PageWidth;

  // Create a new TPanel instance
  with TPanel.Create(self) do
    begin
      SetBounds(15, 15, 203, trunc(203*Ratio));
      Color := clBlack;
      BevelInner := bvNone;
      BevelOuter := bvNone;
      Parent := self;
    end;

  // Create a Print preview panel
  PrintPrev := TPrintPrevPanel.Create(self);

  with PrintPrev do
    begin
      SetBounds(10, 10, 200, trunc(200*Ratio));
      Color := clWhite;
      BevelInner := bvNone;
      BevelOuter := bvNone;
      BorderStyle := bsSingle;
      Parent := self;
    end;
  end;

  end;

  procedure TMainForm.rgFeedTypeClick(Sender: TObject);
  begin
    EnvSize := GetEnvelopeSize;
    EnvPos := GetEnvelopePos;
    ToAddrPos := GetToAddrPos;
    DrawIt;
  end;

  procedure TMainForm.SetCopies(Copies: Integer);
  var
    ADevice, ADriver, APort: String;
    ADeviceMode: THandle;
    DevMode: PDeviceMode;
```

```
begin
  SetLength(ADevice, 255);
  SetLength(ADriver, 255);
  SetLength(APort, 255);

  { If ADeviceMode is zero, a printer driver is not loaded. Therefore,
    setting PrinterIndex forces the driver to load. }
  if ADeviceMode = 0 then
  begin
    Printer.PrinterIndex := Printer.PrinterIndex;
    Printer.GetPrinter(PChar(ADevice), PChar(ADriver),
    PChar(APort), ADeviceMode);
  end;

  if ADeviceMode <> 0 then
  begin
    DevMode := GlobalLock(ADeviceMode);
    try
      DevMode^.dmFields := DevMode^.dmFields or DM_Copies;
      DevMode^.dmCopies := Copies;
    finally
      GlobalUnlock(ADeviceMode);
    end;
  end
  else
    raise Exception.Create('Could not set printer copies');
end;

procedure TMainForm.mmiPrintItClick(Sender: TObject);
var
  TempHeight: integer;
  SaveFont: TFont;
begin
  if PrintDialog.Execute then
  begin
    // Set the number of copies to print
    SetCopies(PrintDialog.Copies);
    Printer.BeginDoc;
    try
      // Calculate a temporary line height
      TempHeight := Printer.Canvas.TextHeight(edtName.Text);
      with ToAddrPos do
      begin
        { When printing vertically, rotate the font such that it paints
          at a 90 degree angle. }
        if (FeedType = eplVert) or (FeedType = epRVert) then
```

continues

LISTING 10.4 Continued

```

begin
  SaveFont := TFont.Create;
  try
    // Save the original font
    SaveFont.Assign(Printer.Canvas.Font);
    RotatePrintFont;
    // Write out the address lines to the printer's Canvas
    Printer.Canvas.TextOut(Left, Bottom, edtName.Text);
    Printer.Canvas.TextOut(Left+TempHeight+2, Bottom,
↳edtStreet.Text);
    Printer.Canvas.TextOut(Left+TempHeight*2+2, Bottom,
↳edtCityState.Text);
    // Restore the original font
    Printer.Canvas.Font.Assign(SaveFont);
  finally
    SaveFont.Free;
  end;
end
else begin
  { If the envelope is not printed vertically, then
  just draw the address lines normally. }
  Printer.Canvas.TextOut(Left, Top, edtName.Text);
  Printer.Canvas.TextOut(Left, Top+TempHeight+2, edtStreet.Text);
  Printer.Canvas.TextOut(Left, Top+TempHeight*2+2,
↳edtCityState.Text);
  end;
end;
finally
  Printer.EndDoc;
end;
end;

procedure TMainForm.RotatePrintFont;
var
  LogFont: TLogFont;
begin
  with Printer.Canvas do
    begin
      with LogFont do
        begin
          lfHeight := Font.Height; // Set to Printer.Canvas.font.height
          lfWidth := 0;           // let font mapper choose width

```

```

lfEscapement := 900;          // tenths of degrees so 900 = 90 degrees
lfOrientation := lfEscapement; // Always set to value of lfEscapement
lfWeight := FW_NORMAL;      // default
lfItalic := 0;              // no italics
lfUnderline := 0;           // no underline
lfStrikeOut := 0;           // no strikethrough
lfCharSet := ANSI_CHARSET; // default
StrPCopy(lfFaceName, Font.Name); // Printer.Canvas's font's name
lfQuality := PROOF_QUALITY;
lfOutPrecision := OUT_TT_ONLY_PRECIS; // force TrueType fonts
lfClipPrecision := CLIP_DEFAULT_PRECIS; // default
lfPitchAndFamily := Variable_Pitch; // default
end;
end;
Printer.Canvas.Font.Handle := CreateFontIndirect(LogFont);
end;

end.

```

When the user clicks one of the radio buttons in `gbEnvelopeSize` or `gbFeedType`, the `FeedTypeClick()` event handler is called. This event handler calls the routines to calculate the envelope's size and position based on the radio button choices.

The address rectangle's size and position also are calculated in these event handlers. This rectangle's width is based on the longest text width of the text in each of the three `TEdit` components. The rectangle's height consists of the combined height of the three `TEdit` components.

All calculations are based on `Printer.Canvas`'s pixels. `mmiPrintItClick()` contains logic to print the envelope based on the choices selected. Additional logic to handle font rotation when the envelope is positioned vertically is also provided. Additionally, a pseudo-print preview is created in the `FormCreate()` event handler. This print preview is updated as the user selects the radio buttons.

The `TFeedType` enumerated type represents each position of the envelope as it may feed out of the printer:

```
TFeedType = (epLHorz, epLVert, epRHorz, epRVert);
```

`TMainForm` contains variables to hold the envelope's size and position, the address's `TRect` size and position, and the current `TFeedType`.

`TMainForm` declares the methods `GetEnvelopeSize()`, `GetEnvelopePos()`, `GetToAddrSize()`, and `GetToAddrPos()` to determine the various measurements for elements to be printed, as specified in steps 6 and 7 of this chapter's model.

In `GetEnvelopeSize()`, the `GetDeviceCaps()` function is used to convert the envelope size in inches to pixels, based on the selection from `gbEnvelopeSize`. `GetEnvelopePos()` determines the position of the envelope on `TPrinter.Canvas`, based on `Printer.Canvas`'s coordinate system.

`GetToAddrSize()` calculates the size of the address's bounding rectangle, based on the measurements of text contained in the three `TEdit` components. Here, `Printer.Canvas`'s `TextHeight()` and `TextWidth()` methods are used to determine these sizes. The function `MaxLn()` is a helper function used to determine the longest text line of the three `TEdit` components, which is used as the rectangle's width. You can also use the `Max()` function from the `Math.pas` unit to determine the longest text line.

`GetToAddrPos()` calls `GetToAddrSize()` and uses the returned value to calculate the address's bounding rectangle's position on `Printer.Canvas`. Note that the envelope's size and placement are needed for this function to position the address rectangle properly.

The `mmiPrintItClick()` event handler performs the actual printing logic. First, it initializes printing with the `BeginDoc()` method. Then it calculates a temporary line height used for text positioning. It determines the `TFeedType`, and if it's one of the vertical types, saves the printer's font and calls the method `RotatePrintFont()`, which rotates the font 90 degrees. When it returns from `RotatePrintFont()`, it restores `Printer.Canvas`'s original font. If the `TFeedType` is one of the horizontal types, it performs the `TextOut()` calls to print the address. Finally, `mmiPrintItClick()` ends printing with the `EndDoc()` method.

`RotatePrintFont()` creates a `TLogFont` structure and initializes its various values obtained from `Printer.Canvas` and other default values. Notice the assignment to its `lfEscapement` member. Remember from Chapter 8, "Graphics Programming with GDI and Fonts," that `lfEscapement` specifies an angle in tenths of degrees at which the font is to be drawn. Here, you specify to print the font at a 90-degree angle by assigning `900` to `lfEscapement`. One thing to note here is that only TrueType fonts can be rotated.

A Simple Print Preview

Often, a good way to help your users not make a mistake by choosing the wrong selection is to enable them to view what the printed output would look like before actually printing. The project in this section contains a print preview panel. You did this by constructing a descendant class of `TPanel` and publicizing its `Canvas` property:

```
TPrintPrevPanel = class(TPanel)
public
    property Canvas; // Publicize this property
end;
```

The `FormCreate()` event handler performs the logic to instantiate a `TPrintPrevPanel`. The following line determines the ratio of the printer's width to its height:

```
Ratio := Printer.PageHeight / Printer.PageWidth;
```

This ratio is used to calculate the width and height for the `TPrintPrevPanel` instance.

Before the `TPrintPrevPanel` is created, however, a regular `TPanel` with a black color is created to serve as a shadow to the `TPrintPrevPanel` instance, `PrintPrev`. Its boundaries are adjusted so that they're slightly to the right of and below the `PrintPrev`'s boundaries. The effect is that it gives `PrintPrev` a three-dimensional look with a shadow behind it. `PrintPrev` is used primarily to show how the envelope would be printed. The routine `DrawIt()` performs this logic.

`TEnvPrintForm.DrawIt()` calls `PrintPrev.Invalidate` to erase its previous contents. Then it calls `PrintPrev.Update()` to ensure that the paint message is processed before executing the remaining code. It then sets `PrintPrev`'s mapping mode to `MM_ISOTROPIC` to allow it to accept arbitrary extents along the X- and Y-axes. `SetWindowExt()` sets `PrintPrev`'s windows' extents to those of `Printer.Canvas`, and `SetViewportExt()` sets `PrintPrev`'s viewport extents to its own height and width (see Chapter 8, "Graphics Programming with GDI and Fonts," for a discussion on mapping modes).

This enables `DrawIt()` to use the same metric values used for the `Printer.Canvas`, the envelope, the address rectangle, and the `PrintPrev` panel. This routine also uses rectangles to represent text lines. The effect is shown in Figure 10.7.

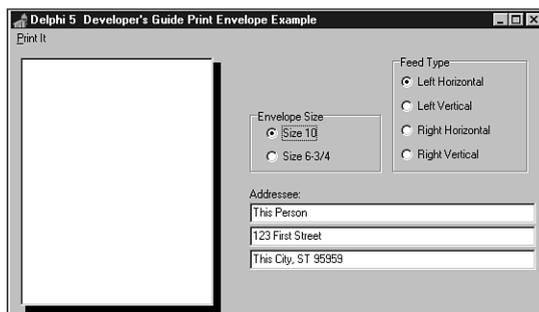


FIGURE 10.7

An envelope-printing form with a print preview feature.

NOTE

An alternative and better print preview can be created with metafiles. Create the metafile using the printer handle as the reference device, then draw into the metafile canvas just as you would the printer canvas, and then draw the metafile on the screen. No scaling or viewport extent tweaking is required.

Miscellaneous Printing Tasks

Occasionally, you'll need to perform a printing task that isn't available through the `TPrinter` object, such as specifying the print quality of your print job. To perform these tasks, you must resort to the Win32 API method. However, this isn't too difficult. First, you must understand the `TDeviceMode` structure. The next section discusses this. The following sections show you how to use this structure to perform these various printing tasks.

The TDeviceMode Structure

The `TDeviceMode` structure contains information about a printer driver's initialization and environment data. Programmers use this structure to retrieve information about or set various attributes of the current printer. This structure is defined in the `Windows.pas` file.

You'll find definitions for each of the fields in Delphi's online help. The following sections cover some of the more common fields of this structure, but it would be a good idea to take a look at the online help and read what some of the other fields are used for. In some cases, you might need to refer to these fields, and some of them are used differently in Windows NT/2000 than in Windows 95/98.

To obtain a pointer to the current printer's `TDeviceMode` structure, you can first use `TPrinter.GetPrinter()` to obtain a handle to the memory block that the structure occupies. Then use the `GlobalLock()` function to retrieve a pointer to this structure. Listing 10.5 illustrates how to get the pointer to the `TDeviceMode` structure.

LISTING 10.5 Obtaining a Pointer to a TDeviceMode Structure

```
var
  ADevice, ADriver, APort: array [0..255] of Char;
  DeviceHandle: THandle;
  DevMode: PDeviceMode; // A Pointer to a TDeviceMode structure
begin
  { First obtain a handle to the TPrinter's DeviceMode structure }
  Printer.GetPrinter(ADevice, ADriver, APort, DeviceHandle);
  { If DeviceHandle is still 0, then the driver was not loaded. Set
    the printer index to force the printer driver to load making the
    handle available }
  if DeviceHandle = 0 then
  begin
    Printer.PrinterIndex := Printer.PrinterIndex;
    Printer.GetPrinter(ADevice, ADriver, APort, DeviceHandle);
  end;
  { If DeviceHandle is still 0, then an error has occurred. Otherwise,
    use GlobalLock() to get a pointer to the TDeviceMode structure }
```

```

if DeviceHandle = 0 then
  Raise Exception.Create('Could Not Initialize TDeviceMode structure')
else
  DevMode := GlobalLock(DeviceHandle);
  { Code to use the DevMode structure goes here }
  { !!!! }
  if not DeviceHandle = 0 then
    GlobalUnlock(DeviceHandle);
end;

```

The comments in the preceding listing explain the steps required to obtain the pointer to the TDeviceMode structure. After you've obtained this pointer, you can perform various printer routines, as illustrated in the following sections. First, however, notice this comment in the preceding listing:

```

{ Code to use the DevMode structure goes here }
{ !!!! }

```

It's here that you place the code examples to follow.

Before you can initialize any of the members of the TDeviceMode structure, however, you must specify which member you're initializing by setting the appropriate bit in the dmFields bit flags. Table 10.3 lists the various bit flags of dmFields and also specifies to which TDeviceMode member they pertain.

TABLE 10.3 TDeviceMode.dmFields Bit Flags

<i>dmField Value</i>	<i>Corresponding Field</i>
DM_ORIENTATION	dmOrientation
DM_PAPERSIZE	dmPaperSize
DM_PAPERLENGTH	dmPaperLength
DM_PAPERWIDTH	dmPaperWidth
DM_SCALE	dmScale
DM_COPIES	dmCopies
DM_DEFAULTSOURCE	dmDefaultSource
DM_PRINTQUALITY	dmPrintQuality
DM_COLOR	dmColor
DM_DUPLEX	dmDuplex
DM_YRESOLUTION	dmYResolution
DM_TTOPTION	dmTTOption
DM_COLLATE	dmCollate

continues

TABLE 10.3 Continued

<i>dmField Value</i>	<i>Corresponding Field</i>
DM_FORMNAME	dmFormName
DM_LOGPIXELS	dmLogPixels
DM_BITSPERPEL	dmBitsPerPel
DM_PELSWIDTH	dmPelsWidth
DM_PELSHEIGHT	dmPelsHeight
DM_DISPLAYFLAGS	dmDisplayFlags
DM_DISPLAYFREQUENCY	dmDisplayFrequency
DM_ICMMETHOD	dmICMMethod (Windows 95 only)
DM_ICMINTENT	dmICMIntent (Windows 95 only)
DM_MEDIATYPE	dmMediaType (Windows 95 only)
DM_DITHERTYPE	dmDitherType (Windows 95 only)

In the examples that follow, you'll see how to set the appropriate bit flag as well as the corresponding `TDeviceMode` member.

Specifying Copies to Print

You can tell a print job how many copies to print by specifying the number of copies in the `dmCopies` field of the `TDeviceMode` structure. The following code illustrates how to do this:

```
with DevMode^ do
begin
    dmFields := dmFields or DM_COPIES;
    dmCopies := Copies;
end;
```

First, you must set the appropriate bit flag of the `dmFields` field to indicate which member of the `TDeviceMode` structure has been initialized. The preceding code is what you would insert into the code in Listing 10.6 where specified. Then, whenever you start your print job, the number of copies specified should be sent to the printer. It's worth mentioning that although this examples illustrates how to set the copies to print using the `TDeviceMode` structure, the `TPrinter.Copies` property does the same.

Specifying Printer Orientation

Specifying printer orientation is similar to specifying copies except that you initialize a different `TDeviceMode` structure:

```
with DevMode^ do
begin
  dmFields := dmFields or DM_ORIENTATION;
  dmOrientation := DMORIENT_LANDSCAPE;
end;
```

The two options for `dmOrientation` are `DMORIENT_LANDSCAPE` and `DMORIENT_PORTRAIT`. You might also look at the `TPrinter.Orientation` property.

Specifying Paper Size

To specify a paper size, you initialize `TDeviceMode`'s `dmPaperSize` member:

```
with DevMode^ do
begin
  dmFields := dmFields or DM_PAPERSIZE;
  dmPaperSize := DMPAPER_LETTER; // Letter, 8-1/2 by 11 inches
end;
```

Several predefined values exist for the `dmPaperSize` member, which you can look up in the online help under `TDeviceMode`. The `dmPaperSize` member can be set to zero if the paper size is specified by the `dmPaperWidth` and `dmPaperHeight` members.

Specifying Paper Length

You can specify the paper length in tenths of a millimeter for the printed output by setting the `dmPaperLength` field. This overrides any settings applied to the `dmPaperSize` field. The following code illustrates setting the paper length:

```
with DevMode^ do
begin
  dmFields := dmFields or DM_PAPERLENGTH;
  dmPaperLength := SomeLength;
end;
```

Specifying Paper Width

Paper width is also specified in tenths of a millimeter. To set the paper width, you must initialize the `dmPaperWidth` field of the `TDeviceMode` structure. The following code illustrates this setting:

```
with DevMode^ do
begin
  dmFields := dmFields or DM_PAPERWIDTH;
  dmPaperWidth := SomeWidth;
end;
```

This also overrides the settings for the `dmPaperSize` field.

Specifying Print Scale

The *print scale* is the factor by which the printed output is scaled. Therefore, the resulting page size is scaled from the physical page size by a factor of `TDeviceMode.dmScale` divided by 100. Therefore, to shrink the printed output (graphics and text) by half their original size, you would assign the value of 50 to the `dmScale` field. The following code illustrates how to set the print scale:

```
with DevMode^ do
begin
    dmFields := dmFields or DM_SCALE;
    dmScale := 50;
end;
```

Specifying Print Color

For printers that support color printing, you can specify whether the printer is to render color or monochrome printing by initializing the `dmColor` field, as shown here:

```
with DevMode^ do
begin
    dmFields := dmFields or DM_COLOR;
    dmColor := DMCOLOR_COLOR;
end;
```

Another value that can be assigned to the `dmColor` field is `DMCOLOR_MONOCHROME`.

Specifying Print Quality

Print quality is the resolution at which the printer prints its output. Four predefined values exist for setting the print quality, as shown in the following list:

- `DMRES_HIGH`. High-resolution printing
- `DMRES_MEDIUM`. Medium-resolution printing
- `DMRES_LOW`. Low-resolution printing
- `DMRES_DRAFT`. Draft-resolution printing

To change the quality of print, you initialize the `dmPrintQuality` field of the `TDeviceMode` structure:

```
with DevMode^ do
begin
    dmFields := dmFields or DM_PRINTQUALITY;
    dmPrintQuality := DMRES_DRAFT;
end;
```

Specifying Duplex Printing

Some printers are capable of duplex printing—printing on both sides of the paper. You can tell the printer to perform double-sided printing by initializing the `dmDuplex` field of the `TDeviceMode` structure to one of these values:

- `DMDUP_SIMPLEX`
- `DMDUP_HORIZONTAL`
- `DMDUP_VERTICAL`

Here's an example:

```
with DevMode^ do
begin
  dmFields := dmFields or DM_DUPLEX;
  dmDuplex := DMDUP_HORIZONTAL;
end;
```

Changing the Default Printer

Although it's possible to change the default printer by launching the printer folder, you might want to change the default printer at runtime. This is possible as illustrated in the sample project shown in Listing 10.6.

LISTING 10.6 Changing the Default Printer

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls;

type
  TMainForm = class(TForm)
    cbPrinters: TComboBox;
    lblPrinter: TLabel;
    procedure FormCreate(Sender: TObject);
    procedure cbPrintersChange(Sender: TObject);
  private
    { Private declarations }
  public
    { Public declarations }
  end;
```

continues

LISTING 10.6 Continued

```
var
    MainForm: TMainForm;

implementation
uses IniFiles, Printers;

{$R *.DFM}

procedure TMainForm.FormCreate(Sender: TObject);
begin
    { Copy the printer names to the combobox and set the combobox to
      show the currently selected default printer }
    cbPrinters.Items.Assign(Printer.Printers);
    cbPrinters.Text := Printer.Printers[Printer.PrinterIndex];
    // Update the label to reflect the default printer
    lblPrinter.Caption := Printer.Printers[Printer.PrinterIndex];
end;

procedure TMainForm.cbPrintersChange(Sender: TObject);
var
    IniFile: TIniFile;
    TempStr1, TempStr2: String;
begin
    with Printer do
    begin
        // Set the new printer based on the ComboBox's selected printer
        PrinterIndex := cbPrinters.ItemIndex;
        // Store the printer name into a temporary string
        TempStr1 := Printers[PrinterIndex];
        // Delete the unnecessary portion of the printer name
        System.Delete(TempStr1, Pos(' on ', TempStr1), Length(TempStr1));
        // Create a TIniFile class
        IniFile := TIniFile.Create('WIN.INI');
        try
            // Retrieve the device name of the selected printer
            TempStr2 := IniFile.ReadString('Devices', TempStr1, '');
            // Change the default printer to that chosen by the user
            IniFile.WriteString('windows', 'device', TempStr1 + ',' + TempStr2);
        finally
            IniFile.Free;
        end;
    end;
    // Update the label to reflect the new printer selection
    lblPrinter.Caption := Printer.Printers[Printer.PrinterIndex];
end;

end.
```

The preceding project consists of a main form with a `TComboBox` and a `TLabel` component. Upon form creation, the `TComboBox` component is initialized with the string list of printer names obtained from the `Printer.Printers` property. The `TLabel` component is then updated to reflect the currently selected printer. The `cbPrintersChange()` event handler is where we placed the code to modify the system-wide default printer. What this entails is changing the `[device]` entry in the `[windows]` section of the `WIN.INI` file, located in the `Windows` directory. The comments in the preceding code go on to explain the process of making these modifications.

Obtaining Printer Information

This section illustrates how you can retrieve information about a printer device such as physical characteristics (number of bins, paper sizes supported, and so on) as well as the printer's text- and graphics-drawing capabilities.

You might want to get information about a particular printer for several reasons. For example, you might need to know whether the printer supports a particular capability. A typical example is to determine whether the current printer supports banding. *Banding* is a process that can improve printing speed and disk space requirements for printers with memory limitations. To use banding, you must make API calls specific to this capability. On a printer that doesn't support this capability, these calls wouldn't function. Therefore, you can first determine whether the printer will support banding (and use it, if so); otherwise, you can avoid the banding API calls.

GetDeviceCaps() and DeviceCapabilities()

The Win32 API function `GetDeviceCaps()` allows you to obtain information about devices such as printers, plotters, screens, and so on. Generally, these are devices that have a device context. You use `GetDeviceCaps()` by supplying it a handle to a device context and an index that specifies the information you want to retrieve.

`DeviceCapabilities()` is specific to printers. In fact, the information obtained from `DeviceCapabilities()` is provided by the printer driver for a specified printer.

Use `DeviceCapabilities()` by supplying it with strings identifying the printer device as well as an index specifying the data you want to retrieve. Sometimes two calls to `DeviceCapabilities()` are required to retrieve certain data. The first call is made to determine how much memory you must allocate for the data to be retrieved. The second call stores the data in the memory block you've allocated. This section illustrates how to do this.

One thing you should know is that most of the drawing capabilities that aren't supported by a particular printer will still work if you use them. For example, when `GetDeviceCaps()` or `DeviceCapabilities()` indicates that `BitBlt()`, `StretchBlt()`, or printing TrueType fonts isn't supported, you can still use any of these functions; GDI will simulate these functions for you. Note, however, that GDI cannot simulate `BitBlt()` on a device that doesn't support raster scanline pixels; `BitBlt()` will always fail on a pen plotter, for example.

Printer Information Sample Program

Figure 10.8 shows the main form for the sample program. This program contains eight pages, each of which lists different printer capabilities for the printer selected in the combo box.

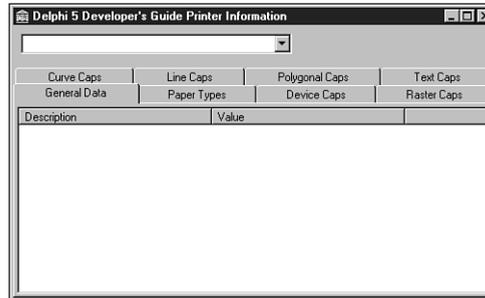


FIGURE 10.8

The main form for the printer information example.

Declaring the DeviceCapabilitiesA Function

If you attempt to use the function `DeviceCapabilities()` defined in `Windows.pas`, you won't be able to run your program because this function isn't defined in `GDI32.DLL` as `Windows.pas` indicates. Instead, this function in `GDI32.DLL` is `DeviceCapabilitiesEx()`. However, even if you define this function's prototype as follows, the function won't work as expected and returns erroneous results:

```
function DeviceCapabilitiesEx(pDevice, pPort: Pchar; fwCapability: Word;
    pOutput: Pchar; DevMode: PdeviceMode):
    Integer; stdcall; external 'Gdi32.dll';
```

It turns out that two functions—`DeviceCapabilitiesA()` for ANSI strings and `DeviceCapabilitiesW()` for wide strings—are defined in `WINSPOOL.DRV`, which is the Win32 print spooler interface. This function is the correct one to use as indicated in the Microsoft Developer's Network CD (MSDN). The correct definition for the function prototype that's used in the sample program in Listing 10.8 (shown in the following section) is as follows:

```
function DeviceCapabilitiesA(pDevice, pPort: Pchar; fwCapability: Word;
    pOutput: Pchar; DevMode: PdeviceMode):
    Integer; stdcall; external 'winspool.drv';
```

Note that the preceding declaration can be found in `WINSPOOL.PAS` in Delphi 5.

Sample Program Functionality

Listing 10.8 (shown at the end of this section) contains the source for the Printer Information sample program. The main form's `OnCreate` event handler simply populates the combo box

with the list of available printers on the system. The `OnChange` event handler for the combo box is the central point of the application where the methods to retrieve the printer information are called.

The first page on the form `General Data` contains general information about the printer device. You'll see that the printer's device name, driver, and port location are obtained by calling the `TPrinter.GetPrinter()` method. This method also retrieves a handle to a `TDeviceMode` structure for the currently selected printer. This information is then added to the `General Data` page. To retrieve the printer driver version, you use the `DeviceCapabilitiesA()` function and pass the `DC_DRIVER` index. The rest of the `PrinterComboBoxChange` event handler calls the various routines to populate the list boxes on the various pages of the main form.

The `GetBinNames()` method illustrates how to use the `DeviceCapabilitiesA()` function to retrieve the bin names for the selected printer. This method first gets the number of bin names available by calling `DeviceCapabilitiesA()`, passing the `DC_BINNAMES` index, and passing `nil` as the `pOutput` and `DevMode` parameters. The result of this function call specifies how much memory must be allocated to hold the bin names. According to the documentation on `DeviceCapabilitiesA()`, each bin name is defined as an array of 24 characters. We defined a `TBinName` data type like this:

```
TBinName = array[0..23] of char;
```

We also defined an array of `TBinName`:

```
TBinNames = array[0..0] of TBinName;
```

This type is used to typecast a pointer as an array of `TBinName` data types. To access an element at some index into the array, you must disable range checking, because this array is defined to have a range of `0..0`, as illustrated in the `GetBinNames()` method. The bin names are added to the appropriate list box.

This same technique of determining the amount of memory required and allocating this memory dynamically is also used in the methods `GetDevCapsPaperNames()` and `GetResolutions()`.

The methods `GetDuplexSupport()`, `GetCopies()`, and `GetEMFStatus()` all use the `DeviceCapabilitiesA()` function to return a value of the requested information. For example, the following code determines whether the selected printer supports duplex printing by returning a value of 1 if duplex printing is supported or 0 if not:

```
DeviceCapabilitiesA(Device, Port, DC_DUPLEX, nil, nil);
```

Also, the following statement returns the maximum number of copies the device can print:

```
DeviceCapabilitiesA(Device, Port, DC_COPIES, nil, nil);
```

The remaining methods use the `GetDeviceCaps()` function to determine the various capabilities of the selected device. In some cases, `GetDeviceCaps()` returns the specific value requested. For example, the following statement returns the width, in millimeters, of the printer device:

```
GetDeviceCaps(Printer.Handle, HORZSIZE);
```

In other cases, `GetDeviceCaps()` returns an integer value whose bits are masked to determine a particular capability. For example, the `GetRasterCaps()` method first retrieves the integer value that contains the bitmasked fields:

```
RCaps := GetDeviceCaps(Printer.Handle, RASTERCAPS);
```

Then, to determine whether the printer supports banding, you must mask out the `RC_BANDING` field by performing an AND operation whose result should equal the value of `RC_BANDING`:

```
(RCaps and RC_BANDING) = RC_BANDING
```

This evaluation is passed to one of the helper functions, `BoolToYesNoStr()`, which returns the string `Yes` or `No`, based on the result of the evaluation. Other fields are masked in the same manner. This same technique is used in other areas where bitmasked fields are returned from `GetDeviceCaps()` as well as from the `DeviceCapabilitiesA()` function, such as in the `GetTrueTypeInfo()` method.

You'll find both functions, `DeviceCapabilities()` and `GetDeviceCaps()`, well documented in the online Win32 API help.

LISTING 10.7 Printer Information Sample Program

```
unit MainFrm;  
  
interface  
  
uses  
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,  
  StdCtrls, ComCtrls, ExtCtrls;  
  
type  
  TMainForm = class(TForm)  
    pgcPrinterInfo: TPageControl;  
    tbsPaperTypes: TTabSheet;  
    tbsGeneralData: TTabSheet;  
    lbPaperTypes: TListBox;  
    tbsDeviceCaps: TTabSheet;  
    tbsRasterCaps: TTabSheet;  
    tbsCurveCaps: TTabSheet;  
    tbsLineCaps: TTabSheet;  
    tbsPolygonalCaps: TTabSheet;
```

```
tbsTextCaps: TTabSheet;
lvGeneralData: TListView;
lvCurveCaps: TListView;
Splitter1: TSplitter;
lvDeviceCaps: TListView;
lvRasterCaps: TListView;
pnlTop: TPanel;
cbPrinters: TComboBox;
lvLineCaps: TListView;
lvPolyCaps: TListView;
lvTextCaps: TListView;
procedure FormCreate(Sender: TObject);
procedure cbPrintersChange(Sender: TObject);
private
  Device, Driver, Port: array[0..255] of char;
  ADevMode: THandle;
public
  procedure GetBinNames;
  procedure GetDuplexSupport;
  procedure GetCopies;
  procedure GetEMFStatus;
  procedure GetResolutions;
  procedure GetTrueTypeInfo;
  procedure GetDevCapsPaperNames;
  procedure GetDevCaps;
  procedure GetRasterCaps;
  procedure GetCurveCaps;
  procedure GetLineCaps;
  procedure GetPolyCaps;
  procedure GetTextCaps;
end;

var
  MainForm: TMainForm;

implementation
uses
  Printers, WinSpool;

const
  NoYesArray: array[Boolean] of String = ('No', 'Yes');
type
  // Types for holding bin names
  TBinName = array[0..23] of char;
  // Where used set $R- to prevent error
```

continues

LISTING 10.7 Continued

```
TBinNames = array[0..0] of TBinName;

// Types for holding paper names
TPName = array[0..63] of char;

// Where used set $R- to prevent error
TPNames = array[0..0] of TPName;

// Types for holding resolutions
TResolution = array[0..1] of integer;
// Where used set $R- to prevent error
TResolutions = array[0..0] of TResolution;

// Type for holding array of pages sizes (word types)
TPageSizeArray = Array[0..0] of word;

var
  Rslt: Integer;

{$R *.DFM}
(*)
function BoolToYesNoStr(aVal: Boolean): String;
// Returns the string "YES" or "NO" based on the boolean value
begin
  if aVal then
    Result := 'Yes'
  else
    Result := 'No';
end;
*)
procedure AddListViewItem(const aCaption, aValue: String; aLV: TListView);
// This method is used to add a TListItem to the TListView, aLV
var
  NewItem: TListItem;
begin
  NewItem := aLV.Items.Add;
  NewItem.Caption := aCaption;
  NewItem.SubItems.Add(aValue);
end;

procedure TMainForm.GetBinNames;
var
  BinNames: Pointer;
  i: integer;
```

```

begin
{$R-} // Range checking must be turned off here.
// First determine how many bin names are available.
Rslt := DeviceCapabilitiesA(Device, Port, DC_BINNAMES, nil, nil);
if Rslt > 0 then
begin
{ Each bin name is 24 bytes long. Therefore, allocate Rslt*24 bytes to hold
the bin names. }
GetMem(BinNames, Rslt*24);
try
// Now retrieve the bin names in the allocated block of memory.
if DeviceCapabilitiesA(Device, Port, DC_BINNAMES, BinNames, nil) = -1
then
raise Exception.Create('DevCap Error');
//{ Add the information to the appropriate list box.
AddListViewItem('BIN NAMES', EmptyStr, lvGeneralData);
for i := 0 to Rslt - 1 do
begin
AddListViewItem(Format(' Bin Name %d', [i]),
StrPas(TBinNames(BinNames^)[i]), lvGeneralData);
end;
finally
FreeMem(BinNames, Rslt*24);
end;
end;
{$R+} // Turn range checking back on.
end;

procedure TMainForm.GetDuplexSupport;
begin
{ This function uses DeviceCapabilitiesA to determine whether or not the
printer device supports duplex printing. }
Rslt := DeviceCapabilitiesA(Device, Port, DC_DUPLEX, nil, nil);
AddListViewItem('Duplex Printing', NoYesArray[Rslt = 1], lvGeneralData);
end;

procedure TMainForm.GetCopies;
begin
{ This function determines how many copies the device can be set to print.
If the result is not greater than 1 then the print logic must be
executed multiple times }
Rslt := DeviceCapabilitiesA(Device, Port, DC_COPIES, nil, nil);
AddListViewItem('Copies that printer can print',
InttoStr(Rslt), lvGeneralData);

end;

```

continues

LISTING 10.7 Continued

```
procedure TMainForm.GetEMFStatus;
begin
    // This function determines if the device supports the enhanced metafiles.
    Rslt := DeviceCapabilitiesA(Device, Port, DC_EMF_COMPLIANT, nil, nil);
    AddListViewItem('EMF Compliant', NoYesArray[Rslt=1], lvGeneralData);
end;

procedure TMainForm.GetResolutions;
var
    Resolutions: Pointer;
    i: integer;
begin
    {$R-} // Range checking must be turned off.
    // Determine how many resolutions are available.
    Rslt := DeviceCapabilitiesA(Device, Port, DC_ENUMRESOLUTIONS, nil, nil);
    if Rslt > 0 then begin
        { Allocate the memory to hold the different resolutions which are
          represented by integer pairs, ie: 300, 300 }
        GetMem(Resolutions, (SizeOf(Integer)*2)*Rslt);
        try
            // Retrieve the different resolutions.
            if DeviceCapabilitiesA(Device, Port, DC_ENUMRESOLUTIONS,
                Resolutions, nil) = -1 then
                Raise Exception.Create('DevCaps Error');
            // Add the resolution information to the appropriate list box.
            AddListViewItem('RESOLUTION CONFIGURATIONS', EmptyStr, lvGeneralData);

            for i := 0 to Rslt - 1 do
                begin
                    AddListViewItem(' Resolution Configuration',
                        IntToStr(TResolutions(Resolutions^)[i][0])+
                        ' '+IntToStr(TResolutions(Resolutions^)[i][1]), lvGeneralData);
                end;
            finally
                FreeMem(Resolutions, SizeOf(Integer)*Rslt*2);
            end;
        end;
    end;
    {$R+} // Turn range checking back on.
end;

procedure TMainForm.GetTrueTypeInfo;
begin
    // Get the TrueType font capabilities of the device represented as bitmasks
    Rslt := DeviceCapabilitiesA(Device, Port, DC_TRUETYPE, nil, nil);
    if Rslt <> 0 then
```

```

{ Now mask out the individual TrueType capabilities and indicate the
  result in the appropriate list box. }
AddListViewItem('TRUE TYPE FONTS', EmptyStr, lvGeneralData);
with lvGeneralData.Items do
begin
  AddListViewItem('  Prints TrueType fonts as graphics',
    NoYesArray[(Rslt and DCTT_BITMAP) = DCTT_BITMAP], lvGeneralData);

  AddListViewItem('  Downloads TrueType fonts',
    NoYesArray[(Rslt and DCTT_DOWNLOAD) = DCTT_DOWNLOAD],
  ↪lvGeneralData);

  AddListViewItem('  Downloads outline TrueType fonts',
    NoYesArray[(Rslt and DCTT_DOWNLOAD_OUTLINE) =
  ↪DCTT_DOWNLOAD_OUTLINE],
    lvGeneralData);

  AddListViewItem('  Substitutes device for TrueType fonts',
    NoYesArray[(Rslt and DCTT_SUBDEV) = DCTT_SUBDEV], lvGeneralData);
end;
end;

procedure TMainForm.GetDevCapsPaperNames;
{ This method gets the paper types available on a selected printer from the
  DeviceCapabilitiesA function. }
var
  PaperNames: Pointer;
  i: integer;
begin
  {$R-} // Range checking off.
  lbPaperTypes.Items.Clear;
  // First get the number of paper names available.
  Rslt := DeviceCapabilitiesA(Device, Port, DC_PAPERNAME, nil, nil);
  if Rslt > 0 then begin
    { Now allocate the array of paper names. Each paper name is 64 bytes.
      Therefore, allocate Rslt*64 of memory. }
    GetMem(PaperNames, Rslt*64);
    try
      // Retrieve the list of names into the allocated memory block.
      if DeviceCapabilitiesA(Device, Port, DC_PAPERNAME,
        PaperNames, nil) = - 1 then
        raise Exception.Create('DevCap Error');
      // Add the paper names to the appropriate list box.
      for i := 0 to Rslt - 1 do
        lbPaperTypes.Items.Add(StrPas(TPNAMES(PaperNames^)[i]));
    finally

```

continues

LISTING 10.7 Continued

```

        FreeMem(PaperNames, Rslt*64);
    end;
end;
{$R+} // Range checking back on.
end;

procedure TMainForm.GetDevCaps;
{ This method retrieves various capabilities of the selected printer device by
  using the GetDeviceCaps function. Refer to the Online API help for the
  meaning of each of these items. }
begin
    with lvDeviceCaps.Items do
    begin
        Clear;
        AddListViewItem('Width in millimeters',
            IntToStr(GetDeviceCaps(Printer.Handle, HORZSIZE)), lvDeviceCaps);
        AddListViewItem('Height in millimeter',
            IntToStr(GetDeviceCaps(Printer.Handle, VERTSIZE)), lvDeviceCaps);
        AddListViewItem('Width in pixels',
            IntToStr(GetDeviceCaps(Printer.Handle, HORZRES)), lvDeviceCaps);
        AddListViewItem('Height in pixels',
            IntToStr(GetDeviceCaps(Printer.Handle, VERTRES)), lvDeviceCaps);
        AddListViewItem('Pixels per horizontal inch',
            IntToStr(GetDeviceCaps(Printer.Handle, LOGPIXELSX)), lvDeviceCaps);
        AddListViewItem('Pixels per vertical inch',
            IntToStr(GetDeviceCaps(Printer.Handle, LOGPIXELSY)), lvDeviceCaps);
        AddListViewItem('Color bits per pixel',
            IntToStr(GetDeviceCaps(Printer.Handle, BITSPIXEL)), lvDeviceCaps);
        AddListViewItem('Number of color planes',
            IntToStr(GetDeviceCaps(Printer.Handle, PLANES)), lvDeviceCaps);
        AddListViewItem('Number of brushes',
            IntToStr(GetDeviceCaps(Printer.Handle, NUMBRUSHES)), lvDeviceCaps);
        AddListViewItem('Number of pens',
            IntToStr(GetDeviceCaps(Printer.Handle, NUMPENS)), lvDeviceCaps);
        AddListViewItem('Number of fonts',
            IntToStr(GetDeviceCaps(Printer.Handle, NUMFONTS)), lvDeviceCaps);
        Rslt := GetDeviceCaps(Printer.Handle, NUMCOLORS);
        if Rslt = -1 then
            AddListViewItem('Number of entries in color table', '> 8', lvDeviceCaps)
        else AddListViewItem('Number of entries in color table',
            IntToStr(Rslt), lvDeviceCaps);
        AddListViewItem('Relative pixel drawing width',
            IntToStr(GetDeviceCaps(Printer.Handle, ASPECTX)), lvDeviceCaps);
        AddListViewItem('Relative pixel drawing height',

```

```

    IntToStr(GetDeviceCaps(Printer.Handle, ASPECTY)), lvDeviceCaps);
AddListViewItem('Diagonal pixel drawing width',
    IntToStr(GetDeviceCaps(Printer.Handle, ASPECTXY)), lvDeviceCaps);
if GetDeviceCaps(Printer.Handle, CLIPCAPS) = 1 then
    AddListViewItem('Clip to rectangle', 'Yes', lvDeviceCaps)
else AddListViewItem('Clip to rectangle', 'No', lvDeviceCaps);
end;
end;

procedure TMainForm.GetRasterCaps;
{ This method gets the various raster capabilities of the selected printer
  device by using the GetDeviceCaps function with the RASTERCAPS index. Refer
  to the online help for information on each capability. }
var
    RCaps: Integer;
begin
    with lvRasterCaps.Items do
        begin
            Clear;
            RCaps := GetDeviceCaps(Printer.Handle, RASTERCAPS);
            AddListViewItem('Banding',
                NoYesArray[(RCaps and RC_BANDING) = RC_BANDING], lvRasterCaps);
            AddListViewItem('BitBlt Capable',
                NoYesArray[(RCaps and RC_BITBLT) = RC_BITBLT], lvRasterCaps);
            AddListViewItem('Supports bitmaps > 64K',
                NoYesArray[(RCaps and RC_BITMAP64) = RC_BITMAP64], lvRasterCaps);
            AddListViewItem('DIB support',
                NoYesArray[(RCaps and RC_DI_BITMAP) = RC_DI_BITMAP], lvRasterCaps);
            AddListViewItem('Floodfill support',
                NoYesArray[(RCaps and RC_FLOODFILL) = RC_FLOODFILL], lvRasterCaps);
            AddListViewItem('Windows 2.0 support',
                NoYesArray[(RCaps and RC_GDI20_OUTPUT) = RC_GDI20_OUTPUT],
                lvRasterCaps);
            AddListViewItem('Palette based device',
                NoYesArray[(RCaps and RC_PALETTE) = RC_PALETTE], lvRasterCaps);
            AddListViewItem('Scaling support',
                NoYesArray[(RCaps and RC_SCALING) = RC_SCALING], lvRasterCaps);
            AddListViewItem('StretchBlt support',
                NoYesArray[(RCaps and RC_STRETCHBLT) = RC_STRETCHBLT],
                lvRasterCaps);
            AddListViewItem('StretchDIBits support',
                NoYesArray[(RCaps and RC_STRETCHDIB) = RC_STRETCHDIB],
                lvRasterCaps);
        end;
    end;
end;

```

continues

LISTING 10.7 Continued

```
procedure TMainForm.GetCurveCaps;
{ This method gets the various curve capabilities of the selected printer
  device by using the GetDeviceCaps function with the CURVECAPS index. Refer
  to the online help for information on each capability. }
var
  CCaps: Integer;
begin
  with lvCurveCaps.Items do
  begin
    Clear;
    CCaps := GetDeviceCaps(Printer.Handle, CURVECAPS);

    AddListViewItem('Curve support',
      NoYesArray[(CCaps and CC_NONE) = CC_NONE], lvCurveCaps);

    AddListViewItem('Circle support',
      NoYesArray[(CCaps and CC_CIRCLES) = CC_CIRCLES], lvCurveCaps);

    AddListViewItem('Pie support',
      NoYesArray[(CCaps and CC_PIE) = CC_PIE], lvCurveCaps);

    AddListViewItem('Chord arc support',
      NoYesArray[(CCaps and CC_CHORD) = CC_CHORD], lvCurveCaps);

    AddListViewItem('Ellipse support',
      NoYesArray[(CCaps and CC_ELLIPSES) = CC_ELLIPSES], lvCurveCaps);

    AddListViewItem('Wide border support',
      NoYesArray[(CCaps and CC_WIDE) = CC_WIDE], lvCurveCaps);

    AddListViewItem('Styled border support',
      NoYesArray[(CCaps and CC_STYLED) = CC_STYLED], lvCurveCaps);

    AddListViewItem('Round rectangle support',
      NoYesArray[(CCaps and CC_ROUNDRECT) = CC_ROUNDRECT], lvCurveCaps);

  end;
end;

procedure TMainForm.GetLineCaps;
{ This method gets the various line drawing capabilities of the selected
  printer device by using the GetDeviceCaps function with the LINECAPS index.
  Refer to the online help for information on each capability. }
var
  LCaps: Integer;
```

```
begin
  with lvLineCaps.Items do
  begin
    Clear;
    LCaps := GetDeviceCaps(Printer.Handle, LINECAPS);

    AddListViewItem('Line support',
      NoYesArray[(LCaps and LC_NONE) = LC_NONE], lvLineCaps);

    AddListViewItem('Polyline support',
      NoYesArray[(LCaps and LC_POLYLINE) = LC_POLYLINE], lvLineCaps);

    AddListViewItem('Marker support',
      NoYesArray[(LCaps and LC_MARKER) = LC_MARKER], lvLineCaps);

    AddListViewItem('Multiple marker support',
      NoYesArray[(LCaps and LC_POLYMARKER) = LC_POLYMARKER], lvLineCaps);

    AddListViewItem('Wide line support',
      NoYesArray[(LCaps and LC_WIDE) = LC_WIDE], lvLineCaps);

    AddListViewItem('Styled line support',
      NoYesArray[(LCaps and LC_STYLED) = LC_STYLED], lvLineCaps);

    AddListViewItem('Wide and styled line support',
      NoYesArray[(LCaps and LC_WIDESTYLED) = LC_WIDESTYLED], lvLineCaps);

    AddListViewItem('Interior support',
      NoYesArray[(LCaps and LC_INTERIORS) = LC_INTERIORS], lvLineCaps);
  end;
end;

procedure TMainForm.GetPolyCaps;
{ This method gets the various polygonal capabilities of the selected printer
  device by using the GetDeviceCaps function with the POLYGONALCAPS index.
  Refer to the online help for information on each capability. }
var
  PCaps: Integer;
begin
  with lvPolyCaps.Items do
  begin
    Clear;
    PCaps := GetDeviceCaps(Printer.Handle, POLYGONALCAPS);

    AddListViewItem('Polygon support',
      NoYesArray[(PCaps and PC_NONE) = PC_NONE], lvPolyCaps);
```

continues

LISTING 10.7 Continued

```
AddListViewItem('Alternate fill polygon support',
  NoYesArray[(PCaps and PC_POLYGON) = PC_POLYGON], lvPolyCaps);

AddListViewItem('Rectangle support',
  NoYesArray[(PCaps and PC_RECTANGLE) = PC_RECTANGLE], lvPolyCaps);

AddListViewItem('Winding-fill polygon support',
  NoYesArray[(PCaps and PC_WINDPOLYGON) = PC_WINDPOLYGON], lvPolyCaps);

AddListViewItem('Single scanline support',
  NoYesArray[(PCaps and PC_SCANLINE) = PC_SCANLINE], lvPolyCaps);

AddListViewItem('Wide border support',
  NoYesArray[(PCaps and PC_WIDE) = PC_WIDE], lvPolyCaps);

AddListViewItem('Styled border support',
  NoYesArray[(PCaps and PC_STYLED) = PC_STYLED], lvPolyCaps);

AddListViewItem('Wide and styled border support',
  NoYesArray[(PCaps and PC_WIDESTYLED) = PC_WIDESTYLED], lvPolyCaps);

AddListViewItem('Interior support',
  NoYesArray[(PCaps and PC_INTERIORS) = PC_INTERIORS], lvPolyCaps);
end;
end;

procedure TMainForm.GetTextCaps;
{ This method gets the various text drawing capabilities of the selected
  printer device by using the GetDeviceCaps function with the TEXTCAPS index.
  Refer to the online help for information on each capability. }
var
  TCaps: Integer;
begin
  with lvTextCaps.Items do
  begin
    Clear;
    TCaps := GetDeviceCaps(Printer.Handle, TEXTCAPS);

    AddListViewItem('Character output precision',
      NoYesArray[(TCaps and TC_OP_CHARACTER) = TC_OP_CHARACTER], lvTextCaps);

    AddListViewItem('Stroke output precision',
      NoYesArray[(TCaps and TC_OP_STROKE) = TC_OP_STROKE], lvTextCaps);

    AddListViewItem('Stroke clip precision',
```

```
NoYesArray[(TCaps and TC_CP_STROKE) = TC_CP_STROKE], lvTextCaps);

AddListViewItem('90 degree character rotation',
  NoYesArray[(TCaps and TC_CR_90) = TC_CR_90], lvTextCaps);

AddListViewItem('Any degree character rotation',
  NoYesArray[(TCaps and TC_CR_ANY) = TC_CR_ANY], lvTextCaps);

AddListViewItem('Independent scale in X and Y direction',
  NoYesArray[(TCaps and TC_SF_X_YINDEP) = TC_SF_X_YINDEP], lvTextCaps);

AddListViewItem('Doubled character for scaling',
  NoYesArray[(TCaps and TC_SA_DOUBLE) = TC_SA_DOUBLE], lvTextCaps);

AddListViewItem('Integer multiples only for character scaling',
  NoYesArray[(TCaps and TC_SA_INTEGER) = TC_SA_INTEGER], lvTextCaps);

AddListViewItem('Any multiples for exact character scaling',
  NoYesArray[(TCaps and TC_SA_CONTIN) = TC_SA_CONTIN], lvTextCaps);

AddListViewItem('Double weight characters',
  NoYesArray[(TCaps and TC_EA_DOUBLE) = TC_EA_DOUBLE], lvTextCaps);

AddListViewItem('Italicized characters',
  NoYesArray[(TCaps and TC_IA_ABLE) = TC_IA_ABLE], lvTextCaps);

AddListViewItem('Underlined characters',
  NoYesArray[(TCaps and TC_UA_ABLE) = TC_UA_ABLE], lvTextCaps);

AddListViewItem('Strikeout characters',
  NoYesArray[(TCaps and TC_SO_ABLE) = TC_SO_ABLE], lvTextCaps);

AddListViewItem('Raster fonts',
  NoYesArray[(TCaps and TC_RA_ABLE) = TC_RA_ABLE], lvTextCaps);

AddListViewItem('Vector fonts',
  NoYesArray[(TCaps and TC_VA_ABLE) = TC_VA_ABLE], lvTextCaps);

AddListViewItem('Scrolling using bit-block transfer',
  NoYesArray[(TCaps and TC_SCROLLBLT) = TC_SCROLLBLT], lvTextCaps);
end;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
```

continues

LISTING 10.7 Continued

```
// Store the printer names in the combo box.
cbPrinters.Items.Assign(Printer.Printers);
// Display the default printer in the combo box.
cbPrinters.ItemIndex := Printer.PrinterIndex;
// Invoke the combo's OnChange event
cbPrintersChange(nil);
end;

procedure TMainForm.cbPrintersChange(Sender: TObject);
begin
  Screen.Cursor := crHourGlass;
  try
    // Populate combo with available printers
    Printer.PrinterIndex := cbPrinters.ItemIndex;
    with Printer do
      GetPrinter(Device, Driver, Port, ADevMode);
    // Fill the general page with printer information
    with lvGeneralData.Items do
      begin
        Clear;
        AddListViewItem('Port', Port, lvGeneralData);
        AddListViewItem('Device', Device, lvGeneralData);

        Rslt := DeviceCapabilitiesA(Device, Port, DC_DRIVER, nil, nil);
        AddListViewItem('Driver Version', IntToStr(Rslt), lvGeneralData);
      end;

    // The functions below make use of the GetDeviceCapabilitiesA function.
    GetBinNames;
    GetDuplexSupport;
    GetCopies;
    GetEMFStatus;
    GetResolutions;
    GetTrueTypeInfo;

    // The functions below make use of the GetDeviceCaps function.
    GetDevCapsPaperNames;
    GetDevCaps; // Fill Device Caps page.
    GetRasterCaps; // Fill Raster Caps page.
    GetCurveCaps; // Fill Curve Caps page.
    GetLineCaps; // Fill Line Caps page.
    GetPolyCaps; // Fill Polygonal Caps page.
    GetTextCaps; // Fill Text Caps page.
  finally
```

```
    Screen.Cursor := crDefault;  
end;  
end;  
  
end.
```

Summary

This chapter teaches the techniques you need to know in order to program any type of custom printing, from simple printing to more advanced techniques. You also learned a methodology that you can apply to any printing task. Additionally, you learned about the `TDeviceMode` structure and how to perform common printing tasks. You'll use more of this knowledge in upcoming chapters, where you build even more powerful printing methods.

Writing Multithreaded Applications

CHAPTER

11

IN THIS CHAPTER

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The Win32 operating system provides you with the capability to have multiple threads of execution in your applications. Arguably the single most important benefit Win32 has over 16-bit Windows, this feature provides the means for performing different types of processing simultaneously in your application. This is one of the primary reasons for upgrading to a 32-bit version of Delphi, and this chapter gives you all the details on how to get the most out of threads in your applications.

Threads Explained

As discussed in Chapter 3, “The Win32 API,” a *thread* is an operating system object that represents a path of code execution within a particular process. Every Win32 application has at least one thread—often called the *primary thread* or *default thread*—but applications are free to create other threads to perform other tasks.

Threads provide a means for running many distinct code routines simultaneously. Of course, unless you have more than one CPU in your computer, two threads can’t truly run simultaneously. However, each thread is scheduled in fractions of seconds of time by the operating system in such a way as to give the feeling that many threads are running simultaneously.

TIP

Threads are not and never will be supported under 16-bit Windows. This means that any 32-bit Delphi code you write using threads will never be backward-compatible to Delphi 1.0. Keep this in mind if you develop applications for both platforms.

A New Type of Multitasking

The notion of *threads* is much different from the style of multitasking supported under 16-bit Windows platforms. You might hear people talk about Win32 as a *preemptive multitasking* operating system, whereas Windows 3.1 is a *cooperative multitasking* environment.

The key difference here is that under a preemptive multitasking environment the operating system is responsible for managing which thread executes when. When execution of thread one is stopped in order for thread two to receive some CPU cycles, thread one is said to have been *preempted*. If the code that one thread is executing happens to put itself into an infinite loop, it’s usually not a tragic situation because the operating system will continue to schedule time for all the other threads.

Under Windows 3.1, the application developer is responsible for giving control back to Windows at points during the application’s execution. Failure of an application to do so causes the operating environment to appear locked up, and we all know what a painful experience that

can be. If you take a moment to think about it, it's slightly amusing that the very foundation of 16-bit Windows depends on all applications behaving themselves and not putting themselves into infinite loops, a recursion, or any other unneighborly situation. It's because all applications must cooperate for Windows to work correctly that this type of multitasking is referred to as *cooperative*.

Using Multiple Threads in Delphi Applications

It's no secret that threads represent a serious boon for Windows programmers. You can create secondary threads in your applications anywhere that it's appropriate to do some sort of background processing. Calculating cells in a spreadsheet or spooling a word processing document to the printer are examples of situations where a thread would commonly be used. The goal of the developer will most often be to perform necessary background processing while still providing the best possible response time for the user interface.

Most of VCL has a built-in assumption that it's being accessed by only one thread at any given time. While this limitation is especially apparent in the user interface portions of VCL, it's important to note that even many non-UI portions of VCL are not thread-safe.

Non-UI VCL

There are actually very few areas of VCL that are guaranteed to be thread-safe. Perhaps the most notable among these thread-safe areas is VCL's property streaming mechanism, which ensures that component streams can be effectively read and written by multiple threads. Remember that even very basic classes in VCL, such as TList, are not designed to be manipulated from multiple simultaneous threads. In some cases, VCL provides thread-safe alternatives that you can use in cases where you need them. For example, use a TThreadList in place of a TList when the list will be subject to manipulation by multiple threads.

UI VCL

VCL requires that all user-interface control happens within the context of an application's primary thread (the exception is the thread-safe TCanvas, which is explained later in this chapter). Of course, techniques are available to update the user interface from a secondary thread (which we discuss later), but this limitation essentially forces you to use threads a bit more judiciously than you might do otherwise. The examples given in this chapter show some ideal uses for multiple threads in Delphi applications.

Misuse of Threads

Too much of a good thing can be bad, and that's definitely true in the case of threads. Even though threads can help to solve some of the problems you may have from an application design standpoint, they do introduce a whole new set of problems. For example, suppose you're writing an integrated development environment, and you want the compiler to execute

in its own thread so the programmer will be free to continue work on the application while the program compiles. The problem here is this: What if the programmer changes a file that the compiler is in the middle of compiling? There are a number of solutions to this problem, such as making a temporary copy of the file while the compile continues or preventing the user from editing not-yet-compiled files. The point is simply that threads are not a panacea; although they solve some development problems, they invariably introduce others. What's more, bugs due to threading problems are also much, much harder to debug because threading problems are often time-sensitive. Designing and implementing thread-safe code is also more difficult because you have a lot more factors to consider.

The TThread Object

Delphi encapsulates the API thread object into an Object Pascal object called `TThread`. Although `TThread` encapsulates almost all the commonly used thread API functions into one discrete object, there are some points—particularly those dealing with thread synchronization—where you have to use the API. In this section, you learn how the `TThread` object works and how to use it in your applications.

TThread Basics

The `TThread` object is found in the `Classes` unit and is defined as follows:

```
type
  TThread = class
  private
    FHandle: THandle;
    FThreadID: THandle;
    FTerminated: Boolean;
    FSuspended: Boolean;
    FFreeOnTerminate: Boolean;
    FFinished: Boolean;
    FReturnValue: Integer;
    FOnTerminate: TNotifyEvent;
    FMethod: TThreadMethod;
    FSynchronizeException: TObject;
    procedure CallOnTerminate;
    function GetPriority: TThreadPriority;
    procedure SetPriority(Value: TThreadPriority);
    procedure SetSuspended(Value: Boolean);
  protected
    procedure DoTerminate; virtual;
    procedure Execute; virtual; abstract;
    procedure Synchronize(Method: TThreadMethod);
    property ReturnValue: Integer read FReturnValue write FReturnValue;
    property Terminated: Boolean read FTerminated;
  public
```

```
constructor Create(CreateSuspended: Boolean);
destructor Destroy; override;
procedure Resume;
procedure Suspend;
procedure Terminate;
function WaitFor: Integer;
property FreeOnTerminate: Boolean read FFreeOnTerminate
    write FFreeOnTerminate;
property Handle: THandle read FHandle;
property Priority: TThreadPriority read GetPriority write
    SetPriority;
property Suspended: Boolean read FSuspended write SetSuspended;
property ThreadID: THandle read FThreadID;
property OnTerminate: TNotifyEvent read FOnTerminate write
    FOnTerminate;
end;
```

As you can tell from the declaration, `TThread` is a direct descendant of `TObject` and is therefore not a component. You might also notice that the `TThread.Execute()` method is abstract. This means that the `TThread` class itself is abstract, meaning that you will never create an instance of `TThread` itself. You will only create instances of `TThread` descendants. Speaking of which, the most straightforward way to create a `TThread` descendant is to select Thread Object from the New Items dialog box provided by the File, New menu option. The New Items dialog box is shown in Figure 11.1.

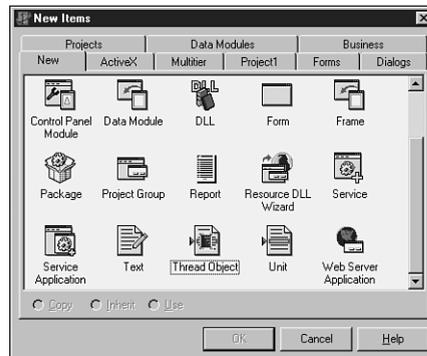


FIGURE 11.1

The Thread Object item in the New Items dialog box.

After choosing Thread Object from the New Items dialog box, you'll be presented with a dialog box that prompts you to enter a name for the new object. You could enter `TTestThread`, for example. Delphi will then create a new unit that contains your object. Your object will initially be defined as follows:

```
type
  TTestThread = class(TThread)
  private
    { Private declarations }
  protected
    procedure Execute; override;
  end;
```

As you can see, the only method that you *must* override in order to create a functional descendant of `TThread` is the `Execute()` method. Suppose, for example, that you want to perform a complex calculation within `TTestThread`. In that case, you could define its `Execute()` method as follows:

```
procedure TTestThread.Execute;
var
  i: integer;
begin
  for i := 1 to 2000000 do
    inc(Answer, Round(Abs(Sin(Sqrt(i)))));
end;
```

Admittedly, the equation is contrived, but it still illustrates the point in this case because the sole purpose of this equation is to take a relatively long time to execute.

You can now execute this sample thread by calling its `Create()` constructor. For now, you can do this from a button click in the main form, as shown in the following code (remember to include the unit containing `TTestThread` in the `uses` clause of the unit containing `TForm1` to avoid a compiler error):

```
procedure TForm1.Button1Click(Sender: TObject);
var
  NewThread: TTestThread;
begin
  NewThread := TTestThread.Create(False);
end;
```

If you run the application and click the button, you'll notice that you can still manipulate the form by moving it or resizing it while the calculation goes on in the background.

NOTE

The single Boolean parameter passed to `TThread`'s `Create()` constructor is called `CreateSuspended`, and it indicates whether to start the thread in a suspended state. If this parameter is `False`, the object's `Execute()` method will automatically be called following `Create()`. If this parameter is `True`, you must call `TThread`'s `Resume()`

method at some point to actually start the thread running. This will cause the `Execute()` method to be invoked at that time. You would set `CreateSuspended` to `True` if you need to set additional properties on your thread object before allowing it to run. Setting the properties after the thread is running would be asking for trouble.

To go a little deeper, the constructor of `Create()` calls the `BeginThread()` Delphi Runtime Library (RTL) function, which calls the `CreateThread()` API function in order to create the new thread. The value of the `CreateSuspended` parameter indicates whether to pass the `CREATE_SUSPENDED` flag to `CreateThread()`.

Thread Instances

Going back to the `Execute()` method for the `TTestThread` object, notice that it contains a local variable called `i`. Consider what might happen to `i` if you create two instances of `TTestThread`. Does the value for one thread overwrite the value for the other? Does the first thread take precedence? Does it blow up? The answers are no, no, and no. Win32 maintains a separate stack for each thread executing in the system. This means that as you create multiple instances of the `TTestThread` object, each one keeps its own copy of `i` on its own stack. Therefore, all the threads will operate independently of one another in that respect.

An important distinction to make, however, is that this notion of the same variable operating independently in each thread doesn't carry over to global variables. This topic is explored in detail in the "Thread-Local Storage" and "Thread Synchronization" sections, later in this chapter.

Thread Termination

A `TThread` is considered terminated when the `Execute()` method has finished executing. At that point, the `EndThread()` Delphi standard procedure is called, which in turn calls the `ExitThread()` API procedure. `ExitThread()` properly disposes of the thread's stack and de-allocates the API thread object. This cleans up the thread as far as the API is concerned.

You also need to ensure that the Object Pascal object is destroyed when you're finished using a `TThread` object. This will ensure that all memory occupied by that object has been properly disposed of. Although this will automatically happen when your process terminates, you might want to dispose of the object earlier so that your application doesn't leak memory as it runs. The easiest way to ensure that the `TThread` object is disposed of is to set its `FreeOnTerminate` property to `True`. This can be done any time before the `Execute()` method finishes executing. For example, you could do this for the `TTestThread` object by setting the property in the `Execute()` method as follows:

```
procedure TTestThread.Execute;
var
  i: integer;
begin
  FreeOnTerminate := True;
  for i := 1 to 2000000 do
    inc(Answer, Round(Abs(Sin(Sqrt(i)))));
  end;
```

The TThread object also has an OnTerminate event that's called when the thread terminates. It's also acceptable to free the TThread object from within a handler for this event.

TIP

The OnTerminate event of TThread is called from the context of your application's main thread. This means that you can feel free to access VCL properties and methods from within a handler for this event without using the Synchronize() method, as described in the following section.

It's also important to note that your thread's Execute() method is responsible for checking the status of the Terminated property to determine the need to make an earlier exit. Although this means one more thing that you must worry about when working with threads, the flip side is that this type of architecture ensures that the rug isn't pulled out from under you, and that you'll be able to perform any necessary cleanup on thread termination. To add this code to the Execute() method of TTestThread is rather simple, and the addition is shown here:

```
procedure TTestThread.Execute;
var
  i: integer;
begin
  FreeOnTerminate := True;
  for i := 1 to 2000000 do begin
    if Terminated then Break;
    inc(Answer, Round(Abs(Sin(Sqrt(i)))));
  end;
end;
```

CAUTION

In case of emergency, you can also use the Win32 API TerminateThread() function to terminate an executing thread. You should do this only when no other options exist, such as when a thread gets caught in an endless loop and stops responding. This function is defined as follows:

```
function TerminateThread(hThread: THandle; dwExitCode: DWORD);
```

The `Handle` property of `TThread` provides the API thread handle, so you could call this function with syntax similar to that shown here:

```
TerminateThread(MyHosedThread.Handle, 0);
```

If you choose to use this function, you should be wary of the negative side effects it will cause. First, this function behaves differently under Windows NT/2000 and Windows 95/98. Under Windows 95/98, `TerminateThread()` disposes of the stack associated with the thread; under Windows NT/2000, the stack sticks around until the process is terminated. Second, on all Win32 operating systems, `TerminateThread()` simply halts the execution, wherever it may be, and does not allow `try..finally` blocks to clean up resources. This means that files opened by the thread would not be closed, memory allocated by the thread would not be freed, and so forth. Also, DLLs loaded by your process won't be notified when a thread destroyed with `TerminateThread()` goes away, and this may cause problems when the DLL closes. See Chapter 9, "Dynamic Link Libraries," for more information on thread notifications in DLLs.

Synchronizing with VCL

As mentioned several times earlier in this chapter, you should only access VCL properties or methods from the application's primary thread. This means that any code that accesses or updates your application's user interface should be executed from the context of the primary thread. The disadvantages of this architecture are obvious, and this requirement might seem rather limiting on the surface, but it actually has some redeeming advantages that you should know about.

Advantages of a Single-Threaded User Interface

First, it greatly reduces the complexity of your application to have only one thread accessing the user interface. Win32 requires that each thread that creates a window have its own message loop using the `GetMessage()` function. As you might imagine, having messages coming into your application from a variety of sources can make it extremely difficult to debug. Because an application's message queue provides a means for serializing input—fully processing one condition before moving on to the next—you can depend in most cases on certain messages coming before or after others. Adding another message loop throws this serialization of input out the door, thereby opening you up to potential synchronization problems and possibly introducing a need for complex synchronization code.

Additionally, because VCL can depend on the fact that it will be accessed by only one thread at any given time, the need for code to synchronize multiple threads inside VCL is obviated.

The net result of this is better overall performance of your application due to a more streamlined architecture.

The Synchronize() Method

TThread provides a method called `Synchronize()` that allows for some of its own methods to be executed from the application's primary thread. `Synchronize()` is defined as follows:

```
procedure Synchronize(Method: TThreadMethod);
```

Its `Method` parameter is of type `TThreadMethod` (which means a procedural method that takes no parameter), which is defined as follows:

```
type  
  TThreadMethod = procedure of object;
```

The method you pass as the `Method` parameter is the one that's then executed from the application's primary thread. Going back to the `TTestThread` example, suppose you want to display the result in an edit control on the main form. You could do this by introducing to `TTestThread` a method that makes the necessary change to the edit control's `Text` property and calling that method by using `Synchronize()`.

In this case, suppose this method is called `GiveAnswer()`. Listing 11.1 shows the complete source code for this unit, called `ThrdU`, which includes the code to update the edit control on the main form.

LISTING 11.1 The *ThrdU.PAS* Unit

```
unit ThrdU;  
  
interface  
  
uses  
  Classes;  
  
type  
  TTestThread = class(TThread)  
  private  
    Answer: integer;  
  protected  
    procedure GiveAnswer;  
    procedure Execute; override;  
  end;  
  
implementation
```

```
uses SysUtils, Main;

{ TTestThread }

procedure TTestThread.GiveAnswer;
begin
    MainForm.Edit1.Text := InttoStr(Answer);
end;

procedure TTestThread.Execute;
var
    I: Integer;
begin
    FreeOnTerminate := True;
    for I := 1 to 2000000 do
        begin
            if Terminated then Break;
            Inc(Answer, Round(Abs(Sin(Sqrt(I)))));
            Synchronize(GiveAnswer);
        end;
    end;
end.

```

You already know that the `Synchronize()` method enables you to execute methods from the context of the primary thread, but up to this point you've treated `Synchronize()` as sort of a mysterious black box. You don't know *how* it works—you only know that it does. If you'd like to take a peek at the man behind the curtain, read on.

The first time you create a secondary thread in your application, VCL creates and maintains a hidden *thread window* from the context of its primary thread. The sole purpose of this window is to serialize procedure calls made through the `Synchronize()` method.

The `Synchronize()` method stores the method specified in its `Method` parameter in a private field called `FMethod` and sends a VCL-defined `CM_EXECPROC` message to the thread window, passing `Self` (`Self` being the `TThread` object in this case) as the `lParam` of the message. When the thread window's window procedure receives this `CM_EXECPROC` message, it calls the method specified in `FMethod` through the `TThread` object instance passed in the `lParam`. Remember, because the thread window was created from the context of the primary thread, the window procedure for the thread window is also executed by the primary thread. Therefore, the method specified in the `FMethod` field is also executed by the primary thread.

To see a more visual illustration of what goes on inside `Synchronize()`, look at Figure 11.2.

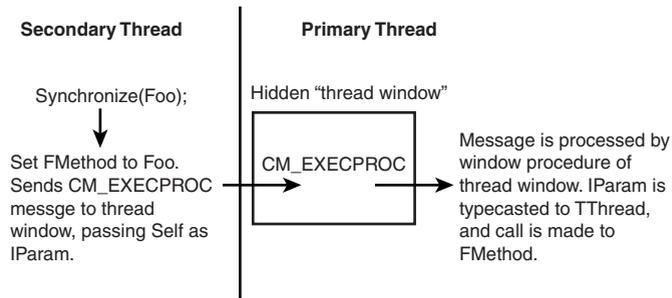


FIGURE 11.2

A road map of the `Synchronize()` method.

Using Messages for Synchronization

As an alternative to the `TThread.Synchronize()` method, another technique for thread synchronization is to use messages to communicate between threads. You can use the `SendMessage()` or `PostMessage()` API function to send or post messages to windows operating in the context of another thread. For example, the following code could be used to set the text in an edit control residing in another thread:

```
var
  S: string;
begin
  S := 'hello from threadland';
  SendMessage(SomeEdit.Handle, WM_SETTEXT, 0, Integer(PChar(S)));
end;
```

A Demo Application

To fully illustrate how multithreading in Delphi works, you can save the current project as `EZThrd`. Then you can also put a memo control on the main form so that it resembles what's shown in Figure 11.3.

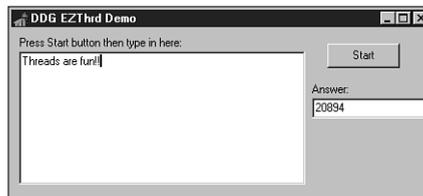


FIGURE 11.3

The main form of the `EZThrd` demo.

The source code for the main unit is shown in Listing 11.2.

LISTING 11.2 The *MAIN.PAS* Unit for the *EZThrd* Demo

```
unit Main;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls, ThrdU;

type
  TMainForm = class(TForm)
    Edit1: TEdit;
    Button1: TButton;
    Memo1: TMemo;
    Label1: TLabel;
    Label2: TLabel;
    procedure Button1Click(Sender: TObject);
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.Button1Click(Sender: TObject);
var
  NewThread: TTestThread;
begin
  NewThread := TTestThread.Create(False);
end;

end.
```

Notice that after you click the button to invoke the secondary thread, you can still type in the memo control as if the secondary thread doesn't exist. When the calculation is completed, the result will be displayed in the edit control.

Priorities and Scheduling

As mentioned earlier, the operating system is in charge of scheduling each thread some CPU cycles in which it may execute. The amount of time scheduled for a particular thread depends on the priority assigned to the thread. An individual thread's overall priority is determined by a combination of the priority of the process that created the thread—called the *priority class*—and the priority of the thread itself—called the *relative priority*.

Process Priority Class

The *process priority class* describes the priority of a particular process running on the system. Win32 supports four distinct priority classes: Idle, Normal, High, and Realtime. The default priority class for any process, of course, is Normal. Each of these priority classes has a corresponding flag defined in the Windows unit. You can or any of these flags with the `dwCreationFlags` parameter of `CreateProcess()` in order to spawn a process with a specific priority. Additionally, you can use these flags to dynamically adjust the priority class of a given process, as shown in a moment. Furthermore, each priority class can also be represented by a numeric priority level, which is a value between 4 and 24 (inclusive).

NOTE

Modifying a process's priority class requires special process privileges under Windows NT/2000. The default settings allow processes to set their priority classes, but these can be turned off by system administrators, particularly on high-load Windows NT/2000 servers.

Table 11.1 shows each priority class and its corresponding flag and numeric value.

TABLE 11.1 Process Priority Classes

<i>Class</i>	<i>Flag</i>	<i>Value</i>
Idle	IDLE_PRIORITY_CLASS	\$40
Below normal*	BELOW_NORMAL_PRIORITY_CLASS	\$4000
Normal	NORMAL_PRIORITY_CLASS	\$20Above normal*
	ABOVE_NORMAL_PRIORITY_CLASS	\$8000
High	HIGH_PRIORITY_CLASS	\$80
Realtime	REALTIME_PRIORITY_CLASS	\$100

*Available only on Windows 2000, and flag constant is not present in the Delphi 5 version of `Windows.pas`.

To get and set the priority class of a given process dynamically, Win32 provides the `GetPriorityClass()` and `SetPriorityClass()` functions, respectively. These functions are defined as follows:

```
function GetPriorityClass(hProcess: THandle): DWORD; stdcall;

function SetPriorityClass(hProcess: THandle; dwPriorityClass: DWORD): BOOL;
    stdcall;
```

The `hProcess` parameter in both cases represents a handle to a process. In most cases, you'll be calling these functions in order to access the priority class of your own process. In that case, you can use the `GetCurrentProcess()` API function. This function is defined as follows:

```
function GetCurrentProcess: THandle; stdcall;
```

The return value of these functions is a pseudo-handle for the current process. We say *pseudo* because the function doesn't create a new handle, and the return value doesn't have to be closed with `CloseHandle()`. It merely provides a handle that can be used to reference an existing handle.

To set the priority class of your application to `High`, use code similar to the following:

```
if not SetPriorityClass(GetCurrentProcess, HIGH_PRIORITY_CLASS) then
    ShowMessage('Error setting priority class.');
```

CAUTION

In almost all cases, you should avoid setting the priority class of any process to `Realtime`. Because most of the operating system threads run in a priority class lower than `Realtime`, your thread will receive more CPU time than the OS itself, and that could cause some unexpected problems.

Even bumping the priority class of the process to `High` can cause problems if the threads of the process don't spend most of their time idle or waiting for external events (such as file I/O). One high-priority thread is likely to drain all CPU time away from lower-priority threads and processes until it blocks on an event, goes idle, or processes messages. Preemptive multitasking can easily be defeated by abusing scheduler priorities.

Relative Priority

The other thing that goes into determining the overall priority of a thread is the *relative priority* of a particular thread. The important distinction to make is that the priority class is associated with a process and the relative priority is associated with individual threads within a process. A thread can have any one of seven possible relative priorities: `Idle`, `Lowest`, `Below Normal`, `Normal`, `Above Normal`, `Highest`, or `Time Critical`.

TThread exposes a Priority property of an enumerated type TThreadPriority. There's an enumeration in this type for each relative priority:

type

```
TThreadPriority = (tpIdle, tpLowest, tpLower, tpNormal, tpHigher,
    tpHighest, tpTimeCritical);
```

You can get and set the priority of any TThread object simply by reading from or writing to its Priority property. The following code sets the priority of a TThread descendant instance called MyThread to Highest:

```
MyThread.Priority := tpHighest.
```

Like priority classes, each relative priority is associated with a numeric value. The difference is that the relative priority is a signed value that, when added to a process's class priority, is used to determine the overall priority of a thread within the system. For this reason, relative priority is sometimes called *delta priority*. The overall priority of a thread can be any value from 1 to 31 (1 being the lowest). Constants are defined in the Windows unit that represents the signed value for each priority. Table 11.2 shows how each enumeration in TThreadPriority maps to an API constant.

TABLE 11.2 Relative Priorities for Threads

TThreadPriority	Constant	Value
tpIdle	THREAD_PRIORITY_IDLE	-15*
tpLowest	THREAD_PRIORITY_LOWEST	-2
tpBelow Normal	THREAD_PRIORITY_BELOW_NORMAL	-1
tpNormal	THREAD_PRIORITY_NORMAL	0
tpAbove Normal	THREAD_PRIORITY_ABOVE_NORMAL	1
tpHighest	THREAD_PRIORITY_HIGHEST	2
tpTimeCritical	THREAD_PRIORITY_TIME_CRITICAL	15*

The reason the values for the tpIdle and tpTimeCritical priorities are marked with asterisks is that, unlike the others, these relative priority values are not truly added to the class priority to determine overall thread priority. Any thread that has the tpIdle relative priority, regardless of its priority class, has an overall priority of 1. The exception to this rule is the Realtime priority class, which, when combined with the tpIdle relative priority, has an overall value of 16. Any thread that has a priority of tpTimeCritical, regardless of its priority class, has an overall priority of 15. The exception to this rule is the Realtime priority class, which, when combined with the tpTimeCritical relative priority, has an overall value of 31.

Suspending and Resuming Threads

Recall when you learned about `TThread`'s `Create()` constructor earlier in this chapter. At the time, you discovered that a thread could be created in a suspended state, and that you must call its `Resume()` method in order for the thread to begin execution. As you might guess, a thread can also be suspended and resumed dynamically. You accomplish this using the `Suspend()` method in conjunction with the `Resume()` method.

Timing a Thread

Back in the 16-bit days when we programmed under Windows 3.x, it was pretty common to wrap some portion of code with calls to `GetTickCount()` or `timeGetTime()` to determine how much time a particular calculation may take (something like the following, for example):

```
var
    StartTime, Total: Longint;
begin
    StartTime := GetTickCount;
    { Do some calculation here }
    Total := GetTickCount - StartTime;
```

In a multithreaded environment, this is much more difficult to do, because your application may be preempted by the operating system in the middle of the calculation in order to provide CPU cycles to other processes. Therefore, any timing you do that relies on the system time can't provide a true measure of how long it spends crunching the calculation in your thread.

To avoid such problems, Win32 under Windows NT/2000 provides a function called `GetThreadTimes()`, which provides quite detailed information on thread timing. This function is declared as follows:

```
function GetThreadTimes(hThread: THandle; var lpCreationTime, lpExitTime,
    lpKernelTime, lpUserTime: TFileTime): BOOL; stdcall;
```

The `hThread` parameter is the handle to the thread for which you want to obtain timing information. The other parameters for this function are passed by reference and are filled in by the function. Here's an explanation of each:

- `lpCreationTime`. The time when the thread was created.
- `lpExitTime`. The time when the thread was exited. If the thread is still running, this value is undefined.
- `lpKernelTime`. The amount of time the thread has spent executing operating system code.
- `lpUserTime`. The amount of time the thread has spent executing application code.

Each of the last four parameters is of type `TFileTime`, which is defined in the Windows unit as follows:

```
type
  TFileTime = record
    dwLowDateTime: DWORD;
    dwHighDateTime: DWORD;
  end;
```

The definition of this type is a bit unusual, but it's a part of the Win32 API, so here goes: `dwLowDateTime` and `dwHighDateTime` are combined into a quad word (64-bit) value that represents the number of 100-nanosecond intervals that have passed since January 1, 1601. This means, of course, that if you wanted to write a simulation of English fleet movements as they defeated the Spanish Armada in 1588, the `TFileTime` type would be a wholly inappropriate way to keep track of time...but we digress.

TIP

Because the `TFileTime` type is 64 bits in size, you can typecast a `TFileTime` to an `Int64` type in order to perform arithmetic on `TFileTime` values. The following code demonstrates how to quickly tell whether one `TFileTime` is greater than another:

```
if Int64(UserTime) > Int64(KernelTime) then Beep;
```

In order to help you work with `TFileTime` values in a manner more native to Delphi, the following functions allow you to convert back and forth between `TFileTime` and `TDateTime` types:

```
function FileTimeToDateTime(FileTime: TFileTime): TDateTime;
var
  SysTime: TSystemTime;
begin
  if not FileTimeToSystemTime(FileTime, SysTime) then
    raise EConvertError.CreateFmt('FileTimeToSystemTime failed. ' +
      'Error code %d', [GetLastError]);
  with SysTime do
    Result := EncodeDate(wYear, wMonth, wDay) +
      EncodeTime(wHour, wMinute, wSecond, wMilliseconds)
end;

function DateTimeToFileTime(DateTime: TDateTime): TFileTime;
var
  SysTime: TSystemTime;
```

```
begin
  with SysTime do
  begin
    DecodeDate(DateTime, wYear, wMonth, wDay);
    DecodeTime(DateTime, wHour, wMinute, wSecond, wMilliseconds);
    wDayOfWeek := DayOfWeek(DateTime);
  end;
  if not SystemTimeToFileTime(SysTime, Result) then
    raise EConvertError.CreateFmt('SystemTimeToFileTime failed. ' +
      + 'Error code %d', [GetLastError]);
  end;
```

CAUTION

Remember that the `GetThreadTimes()` function is implemented only under Windows NT/2000. The function always returns `False` when called under Windows 95 or 98. Unfortunately, Windows 95/98 doesn't provide any mechanism for retrieving thread-timing information.

Managing Multiple Threads

As indicated earlier, although threads can solve a variety of programming problems, they're also likely to introduce new types of problems that you must deal with in your applications. Most commonly, these problems revolve around multiple threads accessing global resources, such as global variables or handles. Additionally, problems can arise when you need to ensure that some event in one thread always occurs before or after some other event in another thread. In this section, you learn how to tackle these problems by using the facilities provided by Delphi for thread-local storage and those provided by the API for thread synchronization.

Thread-Local Storage

Because each thread represents a separate and distinct path of execution within a process, it logically follows that you will at some point want to have a means for storing data associated with each thread. There are three techniques for storing data unique to each thread: the first and most straightforward involves local (stack-based) variables. Because each thread gets its own stack, each thread executing within a single procedure or function will have its own copy of local variables. The second technique is to store local information in your `TThread` descendant object. Finally, you can also use Object Pascal's `threadvar` reserved word to take advantage of operating system-level thread-local storage.

TThread Storage

Storing pertinent data in the TThread descendant object should be your technique of choice for thread-local storage. It's both more straightforward and more efficient than using threadvar (described later). To declare thread-local data in this manner, simply add it to the definition of your TThread descendant, as shown here:

```
type
  TMyThread = class(TThread)
  private
    FLocalInt: Integer;
    FLocalStr: String;
    .
    .
    .
  end;
```

TIP

It's about 10 times faster to access a field of an object than to access a threadvar variable, so you should store your thread-specific data in your TThread descendant, if possible. Data that doesn't need to exist for more than the lifetime of a particular procedure or function should be stored in local variables, because those are faster still than the fields of a TThread object.

threadvar: API Thread-Local Storage

Earlier we mentioned that each thread is provided with its own stack for storing local variables, whereas global data has to be shared by all threads within an application. For example, say you have a procedure that sets or displays the value of a global variable. When you call the procedure passing a text string, the global variable is set, and when you call the procedure passing an empty string, the global variable is displayed. Such a procedure might look like this:

```
var
  GlobalStr: String;
procedure SetShowStr(const S: String);
begin
  if S = '' then
    MessageBox(0, PChar(GlobalStr), 'The string is...', MB_OK)
  else
    GlobalStr := S;
end;
```

If this procedure is called from within the context of one thread only, there wouldn't be any problems. You'd call the procedure once to set the value of GlobalStr and call it again to display the value. However, consider what can happen if two or more threads call this procedure

at any given time. In such a case, it's possible that one thread could call the procedure to set the string and then get preempted by another thread that might also call the function to set the string. By the time the operating system gives CPU time back to the first thread, the value of `GlobalStr` for that thread will be hopelessly lost.

For situations such as these, Win32 provides a facility known as *thread-local storage* that enables you to create separate copies of global variables for each running thread. Delphi nicely encapsulates this functionality with the `threadvar` clause. Just declare any global variables you want to exist separately for each thread within a `threadvar` (as opposed to `var`) clause, and the work is done. A redeclaration of the `GlobalStr` variable is as simple as this:

```
threadvar
  GlobalStr: String;
```

The unit shown in Listing 11.3 illustrates this very problem. It represents the main unit to a Delphi application that contains only a button on a form. When the button is clicked, the procedure is called to set and then to show `GlobalStr`. Next, another thread is created, and the value internal to the thread is set and shown again. After the thread creation, the primary thread again calls `SetShowStr` to display `GlobalStr`.

Try running this application with `GlobalStr` declared as a `var` and then as a `threadvar`. You'll see a difference in the output.

LISTING 11.3 The *MAIN.PAS* Unit for Thread-Local Storage Demo

```
Done. -sunit Main;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls;

type
  TMainForm = class(TForm)
    Button1: TButton;
    procedure Button1Click(Sender: TObject);
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  MainForm: TMainForm;
```

continues

LISTING 11.3 Continued

```
implementation

{$R *.DFM}

{ NOTE: Change GlobalStr from var to threadvar to see difference }
var
//threadvar
  GlobalStr: string;

type
  TTLSThread = class(TThread)
  private
    FNewStr: String;
  protected
    procedure Execute; override;
  public
    constructor Create(const ANewStr: String);
  end;

procedure SetShowStr(const S: String);
begin
  if S = '' then
    MessageBox(0, PChar(GlobalStr), 'The string is...', MB_OK)
  else
    GlobalStr := S;
end;

constructor TTLSThread.Create(const ANewStr: String);
begin
  FNewStr := ANewStr;
  inherited Create(False);
end;

procedure TTLSThread.Execute;
begin
  FreeOnTerminate := True;
  SetShowStr(FNewStr);
  SetShowStr('');
end;

procedure TMainForm.Button1Click(Sender: TObject);
begin
  SetShowStr('Hello world');
  SetShowStr('');
  TTLSThread.Create('Dilbert');
```

```
Sleep(100);  
SetShowStr('');  
end;  
  
end.
```

NOTE

The demo program calls the Win32 API `Sleep()` procedure after creating the thread. `Sleep()` is declared as follows:

```
procedure Sleep(dwMilliseconds: DWORD); stdcall;
```

The `Sleep()` procedure tells the operating system that the current thread doesn't need any more CPU cycles for another `dwMilliseconds` milliseconds. Inserting this call into the code has the effect of simulating system conditions where more multitasking is occurring and introducing a bit more "randomness" into the application as to which threads will be executing when.

It's often acceptable to pass zero in the `dwMilliseconds` parameter. Although that doesn't prevent the current thread from executing for any specific amount of time, it does cause the operating system to give CPU cycles to any waiting threads of equal or greater priority.

Be careful of using `Sleep()` to work around mysterious timing problems. `Sleep()` may work around a particular problem on your machine, but timing problems that are not solved conclusively will pop up again on somebody else's machine, especially when the machine is significantly faster or slower or has a different number of processors than your machine.

11**WRITING
MULTITHREADED
APPLICATIONS**

Thread Synchronization

When working with multiple threads, you'll often need to synchronize the access of threads to some particular piece of data or resource. For example, suppose you have an application that uses one thread to read a file into memory and another thread to count the number of characters in the file. It goes without saying that you can't count all the characters in the file until the entire file has been loaded into memory. However, because each operation occurs in its own thread, the operating system would like to treat them as two completely unrelated tasks. To fix this problem, you must synchronize the two threads so that the counting thread doesn't execute until the loading thread finishes.

These are the types of problems that thread synchronization addresses, and Win32 provides a variety of ways to synchronize threads. In this section, you'll see examples of thread synchronization techniques using critical sections, mutexes, semaphores, and events.

In order to examine these techniques, first take a look at a problem involving threads that need to be synchronized. For the purpose of illustration, suppose you have an array of integers that needs to be initialized with ascending values. You want to first go through the array and set the values from 1 to 128 and then reinitialize the array with values from 128 to 255. You'll then display the final thread in a list box. An approach to this might be to perform the initializations in two separate threads. Consider the code in Listing 11.4 for a unit that attempts to perform this task.

LISTING 11.4 A Unit That Attempts to Initialize an Array in Threads

```
unit Main;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls;

type
  TMainForm = class(TForm)
    Button1: TButton;
    ListBox1: TListBox;
    procedure Button1Click(Sender: TObject);
  private
    procedure ThreadsDone(Sender: TObject);
  end;

  TFooThread = class(TThread)
  protected
    procedure Execute; override;
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

const
  MaxSize = 128;

var
  NextNumber: Integer = 0;
```

```
DoneFlags: Integer = 0;
GlobalArray: array[1..MaxSize] of Integer;

function GetNextNumber: Integer;
begin
    Result := NextNumber; // return global var
    Inc(NextNumber);      // inc global var
end;

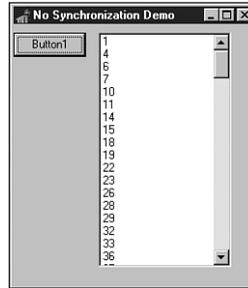
procedure TFooThread.Execute;
var
    i: Integer;
begin
    OnTerminate := MainForm.ThreadsDone;
    for i := 1 to MaxSize do
        begin
            GlobalArray[i] := GetNextNumber; // set array element
            Sleep(5);                        // let thread intertwine
        end;
    end;
end;

procedure TMainForm.ThreadsDone(Sender: TObject);
var
    i: Integer;
begin
    Inc(DoneFlags);
    if DoneFlags = 2 then // make sure both threads finished
        for i := 1 to MaxSize do
            { fill listbox with array contents }
            Listbox1.Items.Add(IntToStr(GlobalArray[i]));
        end;
end;

procedure TMainForm.Button1Click(Sender: TObject);
begin
    TFooThread.Create(False); // create threads
    TFooThread.Create(False);
end;

end.
```

Because both threads will execute simultaneously, what happens is that the contents of the array are corrupted as it's initialized. As proof, take a look at the output of this code, as shown in Figure 11.4.

**FIGURE 11.4**

Output from unsynchronized array initialization.

The solution to this problem is to synchronize the two threads as they access the global array so that they don't both dive in at the same time. You can take any of a number of valid approaches to this problem.

Critical Sections

Critical sections provide one of the most straightforward ways to synchronize threads. A *critical section* is some section of code that allows only one thread to execute through it at a time. If you wrap the code used to initialize the array in a critical section, other threads will be blocked from entering the code section until the first finishes.

Prior to using a critical section, you must initialize it using the `InitializeCriticalSection()` API procedure, which is declared as follows:

```
procedure InitializeCriticalSection(var lpCriticalSection:
    TRTLCriticalSection); stdcall;
```

`lpCriticalSection` is a `TRTLCriticalSection` record that's passed by reference. The exact definition of `TRTLCriticalSection` is unimportant, because you'll rarely (if ever) actually look at the contents of one. You'll pass an uninitialized record in the `lpCriticalSection` parameter, and the record will be filled by the procedure.

NOTE

Microsoft deliberately obscures the structure of the `TRTLCriticalSection` record because the contents vary from one hardware platform to another, and because tinkering with the contents of this structure can potentially wreak havoc on your process. On Intel-based systems, the critical section structure contains a counter, a field containing the current thread handle, and (potentially) a handle of a system event. On Alpha hardware, the counter is replaced with an Alpha-CPU data structure called a *spinlock*, which is more efficient than the Intel solution.

When the record is filled, you can create a critical section in your application by wrapping some block of code with calls to `EnterCriticalSection()` and `LeaveCriticalSection()`. These procedures are declared as follows:

```
procedure EnterCriticalSection(var lpCriticalSection:
    TRTLCriticalSection); stdcall;
procedure LeaveCriticalSection(var lpCriticalSection:
    TRTLCriticalSection); stdcall;
```

As you might guess, the `lpCriticalSection` parameter you pass these guys is the same one that's filled in by the `InitializeCriticalSection()` procedure.

When you're finished with the `TRTLCriticalSection` record, you should clean up by calling the `DeleteCriticalSection()` procedure, which is declared as follows:

```
procedure DeleteCriticalSection(var lpCriticalSection:
    TRTLCriticalSection); stdcall;
```

Listing 11.5 demonstrates the technique for synchronizing the array-initialization threads with critical sections.

LISTING 11.5 Using Critical Sections

```
unit Main;

interface

uses
    Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
    Dialogs, StdCtrls;

type
    TMainForm = class(TForm)
        Button1: TButton;
        ListBox1: TListBox;
        procedure Button1Click(Sender: TObject);
    private
        procedure ThreadsDone(Sender: TObject);
    end;

    TFooThread = class(TThread)
    protected
        procedure Execute; override;
    end;

var
    MainForm: TMainForm;
```

continues

LISTING 11.5 Continued

```
implementation

{$R *.DFM}

const
  MaxSize = 128;

var
  NextNumber: Integer = 0;
  DoneFlags: Integer = 0;
  GlobalArray: array[1..MaxSize] of Integer;
  CS: TRTLCriticalSection;

function GetNextNumber: Integer;
begin
  Result := NextNumber; // return global var
  inc(NextNumber);     // inc global var
end;

procedure TFooThread.Execute;
var
  i: Integer;
begin
  OnTerminate := MainForm.ThreadsDone;
  EnterCriticalSection(CS); // CS begins here
  for i := 1 to MaxSize do
  begin
    GlobalArray[i] := GetNextNumber; // set array element
    Sleep(5); // let thread intertwine
  end;
  LeaveCriticalSection(CS); // CS ends here
end;

procedure TMainForm.ThreadsDone(Sender: TObject);
var
  i: Integer;
begin
  inc(DoneFlags);
  if DoneFlags = 2 then
  begin // make sure both threads finished
    for i := 1 to MaxSize do
    { fill listbox with array contents }
    Listbox1.Items.Add(IntToStr(GlobalArray[i]));
    DeleteCriticalSection(CS);
  end;
end;
```

```
end;  
  
procedure TMainForm.Button1Click(Sender: TObject);  
begin  
    InitializeCriticalSection(CS);  
    TFooThread.Create(False); // create threads  
    TFooThread.Create(False);  
end;  
  
end.
```

After the first thread passes through the call to `EnterCriticalSection()`, all other threads are prevented from entering that block of code. The next thread that comes along to that line of code is put to sleep until the first thread calls `LeaveCriticalSection()`. At that point, the second thread is awakened and allowed to take control of the critical section. Figure 11.5 shows the output of this application when the threads are synchronized.

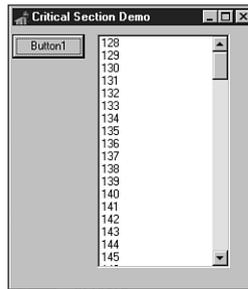


FIGURE 11.5

Output from synchronized array initialization.

Mutexes

Mutexes work very much like critical sections except for two key differences: First, mutexes can be used to synchronize threads across process boundaries. Second, mutexes can be given a string name, and additional handles to existing mutex objects can be created by referencing that name.

TIP

Semantics aside, the biggest difference between critical sections and event objects such as mutexes is performance: Critical sections are very lightweight—as few as

continues

10–15 clock cycles to enter or leave the critical section when there are no thread collisions. As soon as there is a thread collision for that critical section, the system creates an event object (a mutex, probably). The cost of using event objects such as mutexes is that it requires a roundtrip into the kernel, which requires a process context switch and a change of ring levels, which piles up to 400 to 600 clock cycles each way. All this overhead is incurred even if your app doesn't currently have multiple threads, or if no other threads are contending for the resource you're protecting.

The function used to create a mutex is appropriately called `CreateMutex()`. This function is declared as follows:

```
function CreateMutex(lpMutexAttributes: PSecurityAttributes;  
    bInitialOwner: BOOL; lpName: PChar): THandle; stdcall;
```

`lpMutexAttributes` is a pointer to a `TSecurityAttributes` record. It's common to pass `nil` in this parameter, in which case the default security attributes will be used.

`bInitialOwner` indicates whether the thread creating the mutex should be considered the owner of the mutex when it's created. If this parameter is `False`, the mutex is unowned.

`lpName` is the name of the mutex. This parameter can be `nil` if you don't want to name the mutex. If this parameter is non-`nil`, the function will search the system for an existing mutex with the same name. If an existing mutex is found, a handle to the existing mutex is returned. Otherwise, a handle to a new mutex is returned.

When you're finished using a mutex, you should close it using the `CloseHandle()` API function.

Listing 11.6 again demonstrates the technique for synchronizing the array-initialization threads, except this time it uses mutexes.

LISTING 11.6 Using Mutexes for Synchronization

```
Done. -sunit Main;  
  
interface  
  
uses  
    Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,  
    Dialogs, StdCtrls;  
  
type  
    TMainForm = class(TForm)  
        Button1: TButton;  
        ListBox1: TListBox;
```

```
    procedure Button1Click(Sender: TObject);
private
    procedure ThreadsDone(Sender: TObject);
end;

TFooThread = class(TThread)
protected
    procedure Execute; override;
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

const
    MaxSize = 128;

var
    NextNumber: Integer = 0;
    DoneFlags: Integer = 0;
    GlobalArray: array[1..MaxSize] of Integer;
    hMutex: THandle = 0;

function GetNextNumber: Integer;
begin
    Result := NextNumber; // return global var
    Inc(NextNumber);      // inc global var
end;

procedure TFooThread.Execute;
var
    i: Integer;
begin
    FreeOnTerminate := True;
    OnTerminate := MainForm.ThreadsDone;
    if WaitForSingleObject(hMutex, INFINITE) = WAIT_OBJECT_0 then
    begin
        for i := 1 to MaxSize do
        begin
            GlobalArray[i] := GetNextNumber; // set array element
            Sleep(5);                       // let thread intertwine
        end;
    end;
end;
```

continues

LISTING 11.6 Continued

```
    ReleaseMutex(hMutex);
end;

procedure TMainForm.ThreadsDone(Sender: TObject);
var
    i: Integer;
begin
    Inc(DoneFlags);
    if DoneFlags = 2 then    // make sure both threads finished
    begin
        for i := 1 to MaxSize do
            { fill listbox with array contents }
            Listbox1.Items.Add(IntToStr(GlobalArray[i]));
            CloseHandle(hMutex);
        end;
    end;
end;

procedure TMainForm.Button1Click(Sender: TObject);
begin
    hMutex := CreateMutex(nil, False, nil);
    TFooThread.Create(False); // create threads
    TFooThread.Create(False);
end;

end.
```

You'll notice that in this case the `WaitForSingleObject()` function is used to control thread entry into the synchronized block of code. This function is declared as follows:

```
function WaitForSingleObject(hHandle: THandle; dwMilliseconds: DWORD):
    DWORD; stdcall;
```

The purpose of this function is to sleep the current thread up to `dwMilliseconds` milliseconds until the API object specified in the `hHandle` parameter becomes signaled. *Signaled* means different things for different objects. A mutex becomes signaled when it's not owned by a thread, whereas a process, for example, becomes signaled when it terminates. Apart from an actual period of time, the `dwMilliseconds` parameter can also have the value `0`, which means to check the status of the object and return immediately, or `INFINITE`, which means to wait forever for the object to become signaled. The return value of this function can be any one of the values shown in Table 11.3.

TABLE 11.3 WAIT constants used by WaitForSingleObject() API function.

Value	Meaning
WAIT_ABANDONED	The specified object is a mutex object, and the thread owning the mutex was exited before it freed the mutex. This circumstance is referred to as an <i>abandoned mutex</i> ; in such a case, ownership of the mutex object is granted to the calling thread, and the mutex is set to nonsignaled.
WAIT_OBJECT_0	The state of the specified object is signaled.
WAIT_TIMEOUT	The timeout interval elapsed, and the object's state is nonsignaled.

Again, when a mutex isn't owned by a thread, it's in the signaled state. The first thread to call `WaitForSingleObject()` on this mutex is given ownership of the mutex, and the state of the mutex object is set to nonsignaled. The thread's ownership of the mutex is severed when the thread calls the `ReleaseMutex()` function, passing the mutex handle as the parameter. At that point, the state of the mutex again becomes signaled.

NOTE

In addition to `WaitForSingleObject()`, the Win32 API also has functions called `WaitForMultipleObjects()` and `MsgWaitForMultipleObjects()`, which enable you to wait for the state of one or more objects to become signaled. These functions are documented in the Win32 API online help.

Semaphores

Another technique for thread synchronization involves using semaphore API objects. *Semaphores* build on the functionality of mutexes while adding one important feature: They offer the capability of resource counting so that a predetermined number of threads can enter synchronized pieces of code at one time. The function used to create a semaphore is `CreateSemaphore()`, and it's declared as follows:

```
function CreateSemaphore(lpSemaphoreAttributes: PSecurityAttributes;
    InitialCount, lMaximumCount: Longint; lpName: PChar): THandle;stdcall;
```

Like `CreateMutex()`, the first parameter to `CreateSemaphore()` is a pointer to a `TSecurityAttributes` record to which you can pass `Nil` for the defaults.

`InitialCount` is the initial count of the semaphore object. This is a number between 0 and `lMaximumCount`. A semaphore is signaled as long as this parameter is greater than zero. The count of a semaphore is decremented whenever `WaitForSingleObject()` (or one of the other wait functions) releases a thread. A semaphore's count is increased by using the `ReleaseSemaphore()` function.

`lMaximumCount` specifies the maximum count value of the semaphore object. If the semaphore is used to count some resources, this number should represent the total number of resources available.

`lpName` is the name of the semaphore. This parameter behaves the same as the parameter of the same name in `CreateMutex()`.

Listing 11.7 demonstrates using semaphores to perform synchronization of the array-initialization problem.

LISTING 11.7 Using Semaphores for Synchronization

```
Done. -sunit Main;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls;

type
  TMainForm = class(TForm)
    Button1: TButton;
    ListBox1: TListBox;
    procedure Button1Click(Sender: TObject);
  private
    procedure ThreadsDone(Sender: TObject);
  end;

  TFooThread = class(TThread)
  protected
    procedure Execute; override;
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

const
  MaxSize = 128;

var
  NextNumber: Integer = 0;
```

```
    DoneFlags: Integer = 0;
    GlobalArray: array[1..MaxSize] of Integer;
    hSem: THandle = 0;

function GetNextNumber: Integer;
begin
    Result := NextNumber; // return global var
    Inc(NextNumber);      // inc global var
end;

procedure TFooThread.Execute;
var
    i: Integer;
    WaitReturn: DWORD;
begin
    OnTerminate := MainForm.ThreadsDone;
    WaitReturn := WaitForSingleObject(hSem, INFINITE);
    if WaitReturn = WAIT_OBJECT_0 then
    begin
        for i := 1 to MaxSize do
        begin
            GlobalArray[i] := GetNextNumber; // set array element
            Sleep(5);                        // let thread intertwine
        end;
    end;
    ReleaseSemaphore(hSem, 1, nil);
end;

procedure TMainForm.ThreadsDone(Sender: TObject);
var
    i: Integer;
begin
    Inc(DoneFlags);
    if DoneFlags = 2 then // make sure both threads finished
    begin
        for i := 1 to MaxSize do
        { fill listbox with array contents }
        Listbox1.Items.Add(IntToStr(GlobalArray[i]));
        CloseHandle(hSem);
    end;
end;

procedure TMainForm.Button1Click(Sender: TObject);
begin
    hSem := CreateSemaphore(nil, 1, 1, nil);
    TFooThread.Create(False); // create threads
```

LISTING 11.7 Continued

```
TFooThread.Create(False);  
end;  
  
end.
```

Because you allow only one thread to enter the synchronized portion of code, the maximum count for the semaphore is 1 in this case.

The `ReleaseSemaphore()` function is used to increase the count for the semaphore. Notice that this function is a bit more involved than its cousin, `ReleaseMutex()`. The declaration for `ReleaseSemaphore()` is as follows:

```
function ReleaseSemaphore(hSemaphore: THandle; lReleaseCount: Longint;  
    lpPreviousCount: Pointer): BOOL; stdcall;
```

The `lReleaseCount` parameter enables you to specify the number by which the count of the semaphore will be increased. The old count will be stored in the `longint` pointed to by the `lpPreviousCount` parameter if its value is not `Nil`. A subtle implication of this capability is that a semaphore is never really owned by any thread in particular. For example, suppose the maximum count of a semaphore is 10, and 10 threads call `WaitForSingleObject()` to set the count of the thread to 0 and put the thread in a nonsignaled state. All it takes is one of those threads to call `ReleaseSemaphore()` with 10 as the `lReleaseCount` parameter in order to not only make the thread signaled again, but to increase the count back to 10. This powerful capability can introduce some hard-to-track-down bugs into your applications, so you should use it with care.

Be sure to use the `CloseHandle()` function to free the semaphore handle allocated with `CreateSemaphore()`.

A Sample Multithreaded Application

To demonstrate the usage of `TThread` objects within the context of a real-world application, this section focuses on creating a file-search application that performs its searches in a specialized thread. The project is called `De1Srch`, which stands for *Delphi Search*, and the main form for this utility is shown in Figure 11.6.

The application works like this. The user chooses a path through which to search and provides a file specification to indicate the types of files to be searched. The user also enters a token to search for in the appropriate edit control. Some option check boxes on one side of the form enable the user to tailor the application to suit his or her needs for a particular search. When the user clicks the Search button, a search thread is created and the appropriate search information—such as token, path, and file specification—is passed to the `TThread` descendant object.

When the search thread finds the search token in certain files, information is appended to the list box. Finally, if the user double-clicks a file in the list box, the user can browse it with a text editor or view it from its desktop association.

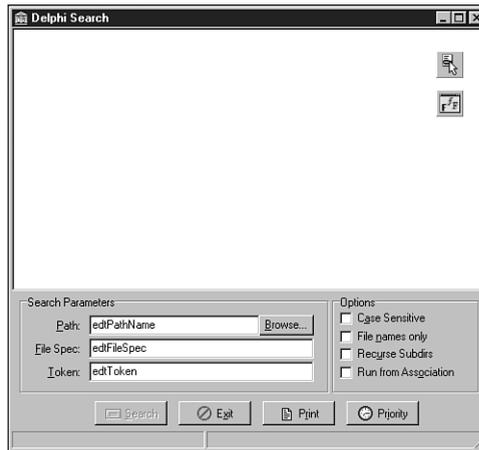


FIGURE 11.6

The Main form for the DeISrch project.

Although this is a fairly full-featured application, we'll focus mainly on explaining the application's key search features and how they relate to multithreading.

The User Interface

The main unit for the application is called `Main.pas`. Shown in Listing 11.8, this unit is responsible for managing the main form and the overall user interface. In particular, this unit contains the logic for owner-drawing the list box, invoking a viewer for files in the list box, invoking the search thread, printing the list box contents, and reading and writing UI settings to an INI file.

LISTING 11.8 The `Main.pas` Unit for the `DeISrch` Project

```
unit SrchU;  
  
interface  
  
uses Classes, StdCtrls;  
  
type  
  TSearchThread = class(TThread)  
  private
```

continues

LISTING 11.8 Continued

```
    LB: TListbox;
    CaseSens: Boolean;
    FileNames: Boolean;
    Recurse: Boolean;
    SearchStr: string;
    SearchPath: string;
    FileSpec: string;
    AddStr: string;
    FSearchFile: string;
    procedure AddToList;
    procedure DoSearch(const Path: string);
    procedure FindAllFiles(const Path: string);
    procedure FixControls;
    procedure ScanForStr(const FName: string; var FileStr: string);
    procedure SearchFile(const FName: string);
    procedure SetSearchFile;
protected
    procedure Execute; override;
public
    constructor Create(CaseS, FName, Rec: Boolean; const Str, SPath,
        FSpec: string);
    destructor Destroy; override;
end;

implementation

uses SysUtils, StrUtils, Windows, Forms, Main;

constructor TSearchThread.Create(CaseS, FName, Rec: Boolean; const Str,
    SPath, FSpec: string);
begin
    CaseSens := CaseS;
    FileNames := FName;
    Recurse := Rec;
    SearchStr := Str;
    SearchPath := AddBackSlash(SPath);
    FileSpec := FSpec;
    inherited Create(False);
end;

destructor TSearchThread.Destroy;
begin
    FSearchFile := '';
    Synchronize(SetSearchFile);
    Synchronize(FixControls);
```

```
    inherited Destroy;
end;

procedure TSearchThread.Execute;
begin
    FreeOnTerminate := True;    // set up all the fields
    LB := MainForm.lbFiles;
    Priority := TThreadPriority(MainForm.SearchPri);
    if not CaseSens then SearchStr := UpperCase(SearchStr);
    FindAllFiles(SearchPath);    // process current directory
    if Recurse then              // if subdirs, then...
        DoSearch(SearchPath);    // recurse, otherwise...
end;

procedure TSearchThread.FixControls;
{ Enables controls in main form. Must be called through Synchronize }
begin
    MainForm.EnableSearchControls(True);
end;

procedure TSearchThread.SetSearchFile;
{ Updates status bar with filename. Must be called through Synchronize }
begin
    MainForm.StatusBar.Panels[1].Text := FSearchFile;
end;

procedure TSearchThread.AddToList;
{ Adds string to main listbox. Must be called through Synchronize }
begin
    LB.Items.Add(AddStr);
end;

procedure TSearchThread.ScanForStr(const FName: string; var FileStr: string);
{ Scans a FileStr of file FName for SearchStr }
var
    Marker: string[1];
    FoundOnce: Boolean;
    FindPos: integer;
begin
    FindPos := Pos(SearchStr, FileStr);
    FoundOnce := False;
    while (FindPos <> 0) and not Terminated do
    begin
        if not FoundOnce then
        begin
            { use ":" only if user doesn't choose "filename only" }

```

continues

LISTING 11.8 Continued

```
        if FileNames then
            Marker := ''
        else
            Marker := ':';
        { add file to listbox }
        AddStr := Format('File %s%s', [FName, Marker]);
        Synchronize(AddToList);
        FoundOnce := True;
    end;
    { don't search for same string in same file if filenames only }
    if FileNames then Exit;

    { Add line if not filename only }
    AddStr := GetCurLine(FileStr, FindPos);
    Synchronize(AddToList);
    FileStr := Copy(FileStr, FindPos + Length(SearchStr), Length(FileStr));
    FindPos := Pos(SearchStr, FileStr);
end;
end;

procedure TSearchThread.SearchFile(const FName: string);
{ Searches file FName for SearchStr }
var
    DataFile: THandle;
    FileSize: Integer;
    SearchString: string;
begin
    FSearchFile := FName;
    Synchronize(SetSearchFile);
    try
        DataFile := FileOpen(FName, fmOpenRead or fmShareDenyWrite);
        if DataFile = 0 then raise Exception.Create('');
        try
            { set length of search string }
            FileSize := GetFileSize(DataFile, nil);
            SetLength(SearchString, FileSize);
            { Copy file data to string }
            FileRead(DataFile, Pointer(SearchString)^, FileSize);
        finally
            CloseHandle(DataFile);
        end;
        if not CaseSens then SearchString := UpperCase(SearchString);
        ScanForStr(FName, SearchString);
    except
        on Exception do
```

```

begin
  AddStr := Format('Error reading file: %s', [FName]);
  Synchronize(AddToList);
end;
end;
end;

procedure TSearchThread.FindAllFiles(const Path: string);
{ procedure searches Path subdir for files matching filespec }
var
  SR: TSearchRec;
begin
  { find first file matching spec }
  if FindFirst(Path + FileSpec, faArchive, SR) = 0 then
    try
      repeat
        SearchFile(Path + SR.Name);           // process file
      until (FindNext(SR) <> 0) or Terminated; // find next file
    finally
      SysUtils.FindClose(SR);                 // clean up
    end;
end;

procedure TSearchThread.DoSearch(const Path: string);
{ procedure recurses through a subdirectory tree starting at Path }
var
  SR: TSearchRec;
begin
  { look for directories }
  if FindFirst(Path + '*.*', faDirectory, SR) = 0 then
    try
      repeat
        { if it's a directory and not '.' or '..' then... }
        if ((SR.Attr and faDirectory) <> 0) and (SR.Name[1] <> '.') and
            not Terminated then
          begin
            FindAllFiles(Path + SR.Name + '\'); // process directory
            DoSearch(Path + SR.Name + '\');    // recurse
          end;
      until (FindNext(SR) <> 0) or Terminated; // find next directory
    finally
      SysUtils.FindClose(SR);                 // clean up
    end;
end;
end.

```

Several things worth mentioning happen in this unit. First, you'll notice the fairly small `PrintStrings()` procedure that's used to send the contents of `TStrings` to the printer. To accomplish this, the procedure takes advantage of Delphi's `AssignPrn()` standard procedure, which assigns a `TextFile` variable to the printer. That way, any text written to the `TextFile` is automatically written to the printer. When you're finished writing to the printer, be sure to use the `CloseFile()` procedure to close the connection to the printer.

Also of interest is the use of the `ShellExecute()` Win32 API procedure to launch a viewer for a file that will be shown in the list box. `ShellExecute()` not only enables you to invoke executable programs but also to invoke associations for registered file extensions. For example, if you try to invoke a file with a `.pas` extension using `ShellExecute()`, it will automatically load Delphi to view the file.

TIP

If `ShellExecute()` returns a value indicating an error, the application calls `RaiseLastWin32Error()`. This procedure, located in the `SysUtils` unit, calls the `GetLastError()` API function and Delphi's `SysErrorMessage()` in order to obtain more detailed information about the error and to format that information into a string. You can use `RaiseLastWin32Error()` in this manner in your own applications if you want your users to obtain detailed error messages on API failures.

The Search Thread

The searching engine is contained within a unit called `SrchU.pas`, which is shown in Listing 11.9. This unit does a number of interesting things, including copying an entire file into a string, recursing subdirectories, and communicating information back to the main form.

LISTING 11.9 The `SrchU.pas` Unit

```
unit SrchU;

interface

uses Classes, StdCtrls;

type
  TSearchThread = class(TThread)
  private
    LB: TListbox;
    CaseSens: Boolean;
    FileNames: Boolean;
```

```
    Recurse: Boolean;
    SearchStr: string;
    SearchPath: string;
    FileSpec: string;
    AddStr: string;
    FSearchFile: string;
    procedure AddToList;
    procedure DoSearch(const Path: string);
    procedure FindAllFiles(const Path: string);
    procedure FixControls;
    procedure ScanForStr(const FName: string; var FileStr: string);
    procedure SearchFile(const FName: string);
    procedure SetSearchFile;
protected
    procedure Execute; override;
public
    constructor Create(CaseS, FName, Rec: Boolean; const Str, SPath,
        FSpec: string);
    destructor Destroy; override;
end;

implementation

uses SysUtils, StrUtils, Windows, Forms, Main;

constructor TSearchThread.Create(CaseS, FName, Rec: Boolean; const Str,
    SPath, FSpec: string);
begin
    CaseSens := CaseS;
    FileNames := FName;
    Recurse := Rec;
    SearchStr := Str;
    SearchPath := AddBackSlash(SPath);
    FileSpec := FSpec;
    inherited Create(False);
end;

destructor TSearchThread.Destroy;
begin
    FSearchFile := '';
    Synchronize(SetSearchFile);
    Synchronize(FixControls);
    inherited Destroy;
end;

procedure TSearchThread.Execute;
```

continues

LISTING 11.9 Continued

```
begin
  FreeOnTerminate := True;      // set up all the fields
  LB := MainForm.lbFiles;
  Priority := TThreadPriority(MainForm.SearchPri);
  if not CaseSens then SearchStr := UpperCase(SearchStr);
  FindAllFiles(SearchPath);     // process current directory
  if Recurse then               // if subdirs, then...
    DoSearch(SearchPath);      // recurse, otherwise...
end;

procedure TSearchThread.FixControls;
{ Enables controls in main form. Must be called through Synchronize }
begin
  MainForm.EnableSearchControls(True);
end;

procedure TSearchThread.SetSearchFile;
{ Updates status bar with filename. Must be called through Synchronize }
begin
  MainForm.StatusBar.Panels[1].Text := FSearchFile;
end;

procedure TSearchThread.AddToList;
{ Adds string to main listbox. Must be called through Synchronize }
begin
  LB.Items.Add(AddStr);
end;

procedure TSearchThread.ScanForStr(const FName: string;
  var FileStr: string);
{ Scans a FileStr of file FName for SearchStr }
var
  Marker: string[1];
  FoundOnce: Boolean;
  FindPos: integer;
begin
  FindPos := Pos(SearchStr, FileStr);
  FoundOnce := False;
  while (FindPos <> 0) and not Terminated do
  begin
    if not FoundOnce then
    begin
      { use "." only if user doesn't choose "filename only" }
      if FileNames then
        Marker := '

```

```

else
    Marker := ':';
    { add file to listbox }
    AddStr := Format('File %s%s', [FName, Marker]);
    Synchronize(AddToList);
    FoundOnce := True;
end;
{ don't search for same string in same file if filenames only }
if FileNames then Exit;

{ Add line if not filename only }
AddStr := GetCurLine(FileStr, FindPos);
Synchronize(AddToList);
FileStr := Copy(FileStr, FindPos + Length(SearchStr),
    Length(FileStr));
FindPos := Pos(SearchStr, FileStr);
end;
end;

procedure TSearchThread.SearchFile(const FName: string);
{ Searches file FName for SearchStr }
var
    DataFile: THandle;
    FileSize: Integer;
    SearchString: string;
begin
    FSearchFile := FName;
    Synchronize(SetSearchFile);
    try
        DataFile := FileOpen(FName, fmOpenRead or fmShareDenyWrite);
        if DataFile = 0 then raise Exception.Create('');
        try
            { set length of search string }
            FileSize := GetFileSize(DataFile, nil);
            SetLength(SearchString, FileSize);
            { Copy file data to string }
            FileRead(DataFile, Pointer(SearchString)^, FileSize);
        finally
            CloseHandle(DataFile);
        end;
        if not CaseSens then SearchString := UpperCase(SearchString);
        ScanForStr(FName, SearchString);
    except
        on Exception do
            begin
                AddStr := Format('Error reading file: %s', [FName]);
            end;
    end;
end;

```

continues

LISTING 11.9 Continued

```
        Synchronize(AddToList);
    end;
end;
end;

procedure TSearchThread.FindAllFiles(const Path: string);
{ procedure searches Path subdir for files matching filespec }
var
    SR: TSearchRec;
begin
    { find first file matching spec }
    if FindFirst(Path + FileSpec, faArchive, SR) = 0 then
        try
            repeat
                SearchFile(Path + SR.Name);           // process file
            until (FindNext(SR) <> 0) or Terminated; // find next file
            finally
                SysUtils.FindClose(SR);               // clean up
            end;
        end;
    end;

procedure TSearchThread.DoSearch(const Path: string);
{ procedure recurses through a subdirectory tree starting at Path }
var
    SR: TSearchRec;
begin
    { look for directories }
    if FindFirst(Path + '.*', faDirectory, SR) = 0 then
        try
            repeat
                { if it's a directory and not '.' or '..' then... }
                if ((SR.Attr and faDirectory) <> 0) and (SR.Name[1] <> '.') and
                    not Terminated then
                    begin
                        FindAllFiles(Path + SR.Name + '\'); // process directory
                        DoSearch(Path + SR.Name + '\');     // recurse
                    end;
                until (FindNext(SR) <> 0) or Terminated; // find next directory
            finally
                SysUtils.FindClose(SR); // clean up
            end;
        end;
    end;

end.
```

When created, this thread first calls its `FindAllFiles()` method. This method uses `FindFirst()` and `FindNext()` to search for all files in the current directory matching the file specification indicated by the user. If the user has chosen to recurse subdirectories, the `DoSearch()` method is then called in order to traverse down a directory tree. This method again makes use of `FindFirst()` and `FindNext()` to find directories, but the twist is that it calls itself recursively in order to traverse the tree. As each directory is found, `FindAllFiles()` is called to process all matching files in the directory.

TIP

The recursion algorithm used by the `DoSearch()` method is a standard technique for traversing a directory tree. Because recursive algorithms are notoriously difficult to debug, the smart programmer will make use of ones that are already known to work. It's a good idea to save this method so that you can use it with other applications in the future.

To process each file, you'll notice that the algorithm for searching for a token within a file involves using the `TMemMapFile` object, which encapsulates a Win32 memory-mapped file. This object is discussed in detail in Chapter 12, "Working with Files," but for now you can just assume that this provides an easy way to map the contents of a file into memory. The entire algorithm works like this:

1. When a file matching the file spec is found by the `FindAllFiles()` method, the `SearchFile()` method is called and the file contents are copied into a string.
2. The `ScanForStr()` method is called for each file-string. `ScanForStr()` searches for occurrences of the search token within each string.
3. When an occurrence is found, the filename and/or the line of text is added to the list box. The line of text is added only when the user unchecks the File Names Only check box.

Note that all the methods in the `TSearchThread` object periodically check the status of the `StopIt` flag (which is tripped when the thread is told to stop) and the `Terminated` flag (which is tripped when the `TThread` object is to terminate).

CAUTION

Remember that any methods within a `TThread` object that modify the application's user interface in any way must be called through the `Synchronize()` method, or the user interface must be modified by sending messages.

Adjusting the Priority

Just to add yet another feature, DeISrch enables the user to adjust the priority of the search thread dynamically. The form used for this purpose is shown in Figure 11.7, and the unit for this form, PriU.PAS, is shown in Listing 11.10.

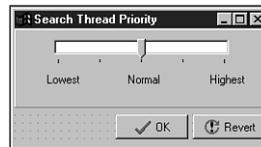


FIGURE 11.7

The thread priority form for the DeISrch project.

LISTING 11.10 The PriU.pas Unit

```
unit PriU;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls, ComCtrls, Buttons, ExtCtrls;

type
  TThreadPriWin = class(TForm)
    tbrPriTrackBar: TTrackBar;
    Label1: TLabel;
    Label2: TLabel;
    Label3: TLabel;
    btnOK: TBitBtn;
    btnRevert: TBitBtn;
    Panel1: TPanel;
    procedure tbrPriTrackBarChange(Sender: TObject);
    procedure btnRevertClick(Sender: TObject);
    procedure FormClose(Sender: TObject; var Action: TCloseAction);
    procedure FormShow(Sender: TObject);
    procedure btnOKClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
  private
    { Private declarations }
    OldPriVal: Integer;
  public
    { Public declarations }
  end;
end;
```

```
var
  ThreadPriWin: TThreadPriWin;

implementation

{$R *.DFM}

uses Main, SrchU;

procedure TThreadPriWin.tbrPriTrackBarChange(Sender: TObject);
begin
  with MainForm do
  begin
    SearchPri := tbrPriTrackBar.Position;
    if Running then
      SearchThread.Priority := TThreadPriority(tbrPriTrackBar.Position);
  end;
end;

procedure TThreadPriWin.btnRevertClick(Sender: TObject);
begin
  tbrPriTrackBar.Position := OldPriVal;
end;

procedure TThreadPriWin.FormClose(Sender: TObject;
  var Action: TCloseAction);
begin
  Action := caHide;
end;

procedure TThreadPriWin.FormShow(Sender: TObject);
begin
  OldPriVal := tbrPriTrackBar.Position;
end;

procedure TThreadPriWin.btnOKClick(Sender: TObject);
begin
  Close;
end;

procedure TThreadPriWin.FormCreate(Sender: TObject);
begin
  tbrPriTrackBarChange(Sender);      // initialize thread priority
end;

end.
```

The code for this unit is fairly straightforward. All it does is set the value of the `SearchPri` variable in the main form to match that of the track bar position. If the thread is running, it also sets the priority of the thread. Because `TThreadPriority` is an enumerated type, a straight typecast maps the values 1 to 5 in the track bar to enumerations in `TThreadPriority`.

Multithreading Database Access

Although database programming isn't really discussed until Chapter 28, "Writing Desktop Database Applications," this section is intended to give you some tips on how to use multiple threads in the context of database development. If you're unfamiliar with database programming under Delphi, you might want to look through Chapter 28 before reading on in this section.

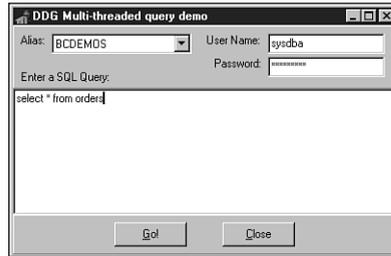
The most common request for database applications developers in Win32 is for the capability to perform complex queries or stored procedures in a background thread. Thankfully, this type of thing is supported by the 32-bit Borland Database Engine (BDE) and is fairly easy to do in Delphi.

There are really only two requirements for running a background query through, for example, a `TQuery` component:

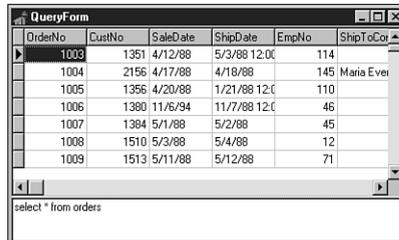
- Each threaded query must reside within its own session. You can provide a `TQuery` with its own session by placing a `TSession` component on your form and assigning its name to the `TQuery`'s `SessionName` property. This also implies that, if your `TQuery` uses a `TDatabase` component, a unique `TDatabase` must also be used for each session.
- The `TQuery` must not be attached to any `TDataSource` components at the time the query is opened from the secondary thread. When the query is attached to a `TDataSource`, it must be done through the context of the primary thread. `TDataSource` is only used to connect datasets to user interface controls, and user interface manipulation must be performed in the main thread.

To illustrate the techniques for background queries, Figure 11.8 shows the main form for a demo project called `BDEThrd`. This form enables you to specify a BDE alias, user name, and password for a particular database and to enter a query against the database. When the Go! button is clicked, a secondary thread is spawned to process the query and the results are displayed in a child form.

The child form, `TQueryForm`, is shown in Figure 11.9. Notice that this form contains a `TQuery`, `TDatabase`, `TSession`, `TDataSource`, and `TDBGrid` component. Therefore, each instance of `TQueryForm` has its own instances of these components.

**FIGURE 11.8**

The main form for the *BDEThrd* demo.

**FIGURE 11.9**

The child query form for the *BDEThrd* demo.

Listing 11.11 shows *Main.pas*, the application's main unit.

LISTING 11.11 The *Main.pas* Unit for the *BDEThrd* Demo

```

Fixed. -sunit Main;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, Grids, StdCtrls, ExtCtrls;

type
  TMainForm = class(TForm)
    pnlBottom: TPanel;
    pnlButtons: TPanel;
    GoButton: TButton;
    Button1: TButton;
    memQuery: TMemo;
  end;

```

continues

LISTING 11.11 Continued

```
    pnlTop: TPanel;
    Label1: TLabel;
    AliasCombo: TComboBox;
    Label3: TLabel;
    UserNameEd: TEdit;
    Label4: TLabel;
    PasswordEd: TEdit;
    Label2: TLabel;
    procedure Button1Click(Sender: TObject);
    procedure GoButtonClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
private
    { Private declarations }
public
    { Public declarations }
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

uses QryU, DB, DBTables;

var
    FQueryNum: Integer = 0;

procedure TMainForm.Button1Click(Sender: TObject);
begin
    Close;
end;

procedure TMainForm.GoButtonClick(Sender: TObject);
begin
    Inc(FQueryNum); // keep querynum unique
    { invoke new query }
    NewQuery(FQueryNum, memQuery.Lines, AliasCombo.Text, UserNameEd.Text,
        PasswordEd.Text);
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
    { fill drop-down list with BDE Aliases }
```

```

    Session.GetAliasNames(AliasCombo.Items);
end;

end.

```

As you can see, there's not much to this unit. The `AliasCombo` combobox is filled with BDE aliases in the `OnCreate` handler for the main form using `TSession`'s `GetAliasNames()` method. The handler for the `Go!` button `OnClick` event is in charge of invoking a new query by calling the `NewQuery()` procedure that lives in a second unit, `QryU.pas`. Notice that it passes a new unique number, `FQueryNum`, to the `NewQuery()` procedure with every button click. This number is used to create a unique session and database name for each query thread.

Listing 11.12 shows the code for the `QryU` unit.

LISTING 11.12 The `QryU.pas` Unit

```

unit QryU;

interface

uses
    Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Grids,
    DBGrids, DB, DBTables, StdCtrls;

type
    TQueryForm = class(TForm)
        Query: TQuery;
        DataSource: TDataSource;
        Session: TSession;
        Database: TDatabase;
        dbgQueryGrid: TDBGrid;
        memSQL: TMemo;
        procedure FormClose(Sender: TObject; var Action: TCloseAction);
    private
        { Private declarations }
    public
        { Public declarations }
    end;

procedure NewQuery(QryNum: integer; Qry: TStrings; const Alias, UserName,
    Password: string);

implementation

{$R *.DFM}

```

continues

LISTING 11.12 Continued

```
type
  TDBQueryThread = class(TThread)
  private
    FQuery: TQuery;
    FDataSource: TDataSource;
    FQueryException: Exception;
    procedure HookUpUI;
    procedure QueryError;
  protected
    procedure Execute; override;
  public
    constructor Create(Q: TQuery; D: TDataSource); virtual;
  end;

constructor TDBQueryThread.Create(Q: TQuery; D: TDataSource);
begin
  inherited Create(True);          // create suspended thread
  FQuery := Q;                    // set parameters
  FDataSource := D;
  FreeOnTerminate := True;
  Resume;                          // thread that puppy!
end;

procedure TDBQueryThread.Execute;
begin
  try
    FQuery.Open;                  // open the query
    Synchronize(HookUpUI);        // update UI from main thread
  except
    FQueryException := ExceptObject as Exception;
    Synchronize(QueryError);      // show exception from main thread
  end;
end;

procedure TDBQueryThread.HookUpUI;
begin
  FDataSource.DataSet := FQuery;
end;

procedure TDBQueryThread.QueryError;
begin
  Application.ShowException(FQueryException);
end;

procedure NewQuery(QryNum: integer; Qry: TStrings; const Alias, UserName,
  Password: string);
```

```

begin
  { Create a new Query form to show query results }
  with TQueryForm.Create(Application) do
  begin
    { Set a unique session name }
    Session.SessionName := Format('Sess%d', [QryNum]);
    with Database do
    begin
      { set a unique database name }
      DatabaseName := Format('DB%d', [QryNum]);
      { set alias parameter }
      AliasName := Alias;
      { hook database to session }
      SessionName := Session.SessionName;
      { user-defined username and password }
      Params.Values['USER NAME'] := UserName;
      Params.Values['PASSWORD'] := Password;
    end;
    with Query do
    begin
      { hook query to database and session }
      DatabaseName := Database.DatabaseName;
      SessionName := Session.SessionName;
      { set up the query strings }
      SQL.Assign(Qry);
    end;
    { display query strings in SQL Memo }
    memSQL.Lines.Assign(Qry);
    { show query form }
    Show;
    { open query in its own thread }
    TDBQueryThread.Create(Query, DataSource);
  end;
end;

procedure TQueryForm.FormClose(Sender: TObject; var Action: TCloseAction);
begin
  Action := caFree;
end;

end.

```

The `NewQuery()` procedure creates a new instance of the child form `TQueryForm`, sets up the properties for each of its data-access components, and creates unique names for its `TDatabase` and `TSession` components. The query's `SQL` property is filled from the `TStrings` passed in the `Qry` parameter, and the query thread is then spawned.

The code inside the `TDBQueryThread` itself is rather sparse. The constructor merely sets up some instance variables, and the `Execute()` method opens the query and calls the `HookupUI()` method through `Synchronize()` to attach the query to the data source. You should also take note of the `try...except` block inside the `Execute()` procedure, which uses `Synchronize()` to show exception messages from the context of the primary thread.

Multithreaded Graphics

We mentioned earlier that VCL isn't designed to be manipulated simultaneously by multiple threads, but this statement isn't entirely accurate. VCL has the capability to have multiple threads manipulate individual graphics objects. Thanks to new `Lock()` and `Unlock()` methods introduced in `TCanvas`, the entire Graphics unit has been made thread-safe. This includes the `TCanvas`, `TPen`, `TBrush`, `TFont`, `TBitmap`, `TMetafile`, `TPicture`, and `TIcon` classes.

The code for these `Lock()` methods is similar in that it uses a critical section and the `EnterCriticalSection()` API function (described earlier in this chapter) to guard access to the canvas or graphics object. After a particular thread calls a `Lock()` method, that thread is free to exclusively manipulate the canvas or graphics object. Other threads waiting to enter the portion of code following the call to `Lock()` will be put to sleep until the thread owning the critical section calls `Unlock()`, which calls `LeaveCriticalSection()` to release the critical section and let the next waiting thread (if any) into the protected portion of code. The following portion of code shows how these methods can be used to control access to a canvas object:

```
Form.Canvas.Lock;  
// code which manipulates canvas goes here  
Form.Canvas.Unlock;
```

To further illustrate this point, Listing 11.13 shows the unit `Main` of the `MTGraph` project—an application that demonstrates multiple threads accessing a form's canvas.

LISTING 11.13 The *Main.pas* Unit of the *MTGraph* Project

```
unit Main;  
  
interface  
  
uses  
    Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Menus;  
  
type  
    TMainForm = class(TForm)  
        MainMenu1: TMainMenu;  
        Options1: TMenuItem;  
        AddThread: TMenuItem;  
        RemoveThread: TMenuItem;
```

```
    ColorDialog1: TColorDialog;
    Add10: TMenuItem;
    RemoveAll: TMenuItem;
    procedure FormCreate(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
    procedure AddThreadClick(Sender: TObject);
    procedure RemoveThreadClick(Sender: TObject);
    procedure Add10Click(Sender: TObject);
    procedure RemoveAllClick(Sender: TObject);
private
    ThreadList: TList;
public
    { Public declarations }
end;

TDrawThread = class(TThread)
private
    FColor: TColor;
    FForm: TForm;
public
    constructor Create(AForm: TForm; AColor: TColor);
    procedure Execute; override;
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

{ TDrawThread }

constructor TDrawThread.Create(AForm: TForm; AColor: TColor);
begin
    FColor := AColor;
    FForm := AForm;
    inherited Create(False);
end;

procedure TDrawThread.Execute;
var
    P1, P2: TPoint;

    procedure GetRandCoords;
    var
        MaxX, MaxY: Integer;
```

continues

LISTING 11.13 Continued

```
begin
    // initialize P1 and P2 to random points within Form bounds
    MaxX := FForm.ClientWidth;
    MaxY := FForm.ClientHeight;
    P1.x := Random(MaxX);
    P2.x := Random(MaxX);
    P1.y := Random(MaxY);
    P2.y := Random(MaxY);
end;

begin
    FreeOnTerminate := True;
    // thread runs until it or the application is terminated
    while not (Terminated or Application.Terminated) do
    begin
        GetRandCoords;           // initialize P1 and P2
        with FForm.Canvas do
        begin
            Lock;                // lock canvas
            // only one thread at a time can execute the following code:
            Pen.Color := FColor; // set pen color
            MoveTo(P1.X, P1.Y);  // move to canvas position P1
            LineTo(P2.X, P2.Y);  // draw a line to position P2
            // after the next line executes, another thread will be allowed
            // to enter the above code block
            Unlock;              // unlock canvas
        end;
    end;
end;

{ TMainForm }

procedure TMainForm.FormCreate(Sender: TObject);
begin
    ThreadList := TList.Create;
end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
    RemoveAllClick(nil);
    ThreadList.Free;
end;

procedure TMainForm.AddThreadClick(Sender: TObject);
begin
    // add a new thread to the list... allow user to choose color
```

```
    if ColorDialog1.Execute then
        ThreadList.Add(TDrawThread.Create(Self, ColorDialog1.Color));
end;

procedure TMainForm.RemoveThreadClick(Sender: TObject);
begin
    // terminate the last thread in the list and remove it from list
    TDrawThread(ThreadList[ThreadList.Count - 1]).Terminate;
    ThreadList.Delete(ThreadList.Count - 1);
end;

procedure TMainForm.Add10Click(Sender: TObject);
var
    i: Integer;
begin
    // create 10 threads, each with a random color
    for i := 1 to 10 do
        ThreadList.Add(TDrawThread.Create(Self, Random(MaxInt)));
    end;
end;

procedure TMainForm.RemoveAllClick(Sender: TObject);
var
    i: Integer;
begin
    Cursor := crHourGlass;
    try
        for i := ThreadList.Count - 1 downto 0 do
            begin
                TDrawThread(ThreadList[i]).Terminate; // terminate thread
                TDrawThread(ThreadList[i]).WaitFor; // make sure thread terminates
            end;
        ThreadList.Clear;
    finally
        Cursor := crDefault;
    end;
end;

initialization
    Randomize; // seed random number generator
end.
```

This application has a main menu containing four items, as shown in Figure 11.10. The first item, Add thread, creates a new `TDrawThread` instance, which paints random lines on the main form. This option can be selected repeatedly in order to throw more and more threads into the mix of threads accessing the main form. The next item, Remove thread, removes the last thread

added. The third item, Add 10, creates 10 new TDrawThread instances. Finally, the fourth item, Remove all, terminates and destroys all TDrawThread instances. Figure 11.10 also shows the results of 10 threads simultaneously drawing to the form's canvas.

Canvas-locking rules dictate that as long as every user of a canvas locks it before drawing and unlocks it afterwards, multiple threads using that canvas will not interfere with each other. Note that all OnPaint events and Paint() method calls initiated by VCL automatically lock and unlock the canvas for you; therefore, existing, normal Delphi code can coexist with new background thread graphics operations.

Using this application as an example, examine the consequences or symptoms of thread collisions if you fail to properly perform canvas locking. If thread one sets a canvas's pen color to red and then draws a line, and thread two sets the pen color to blue and draws a circle, and these threads do not lock the canvas before starting these operations, the following thread collision scenario is possible: Thread one sets the pen color to red. The OS scheduler switches execution to thread two. Thread two sets the pen color to blue and draws a circle. Execution switches to thread one. Thread one draws a line. However, the line is not red, it is blue, because thread two had the opportunity to slip in between the operations of thread one.

Note also that it only takes one errant thread to cause problems. If thread one locks the canvas and thread two does not, the scenario just described is unchanged. Both threads must lock the canvas around their canvas operations to prevent that thread collision scenario.

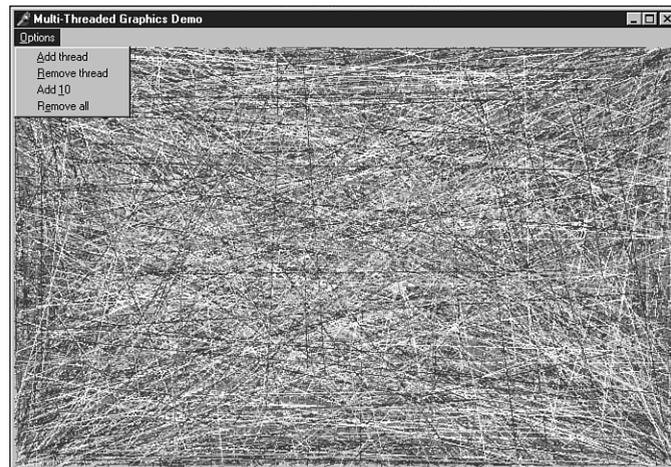


FIGURE 11.10

The MTGraph main form.

Summary

By now you've had a thorough introduction to threads and how to use them properly in the Delphi environment. You've learned several techniques for synchronizing multiple threads, and you've learned how to communicate between secondary threads and a Delphi application's primary thread. Additionally, you've seen examples of using threads within the context of a real-world file-search application, you've gotten the lowdown on how to leverage threads in database applications, and you've learned about drawing to a TCanvas with multiple threads. In the next chapter, "Working with Files," you'll learn a multitude of techniques for working with different types of files in Delphi.

11**WRITING
MULTITHREADED
APPLICATIONS**

IN THIS CHAPTER

- Dealing with File I/O 538
- The TTextRec and TFileRec Record Structures 560
- Working with Memory-Mapped Files 561
- Directories and Drives 580
- Using the SHFileOperation() Function 604
- Summary 606

Working with files, directories, and drives is a common programming task that you'll undoubtedly have to do at some time. This chapter illustrates how to work with the different file types: text files, typed files, and untyped files. The chapter covers how to use a `TFileStream` to encapsulate file I/O and how to take advantage of one of Win32's nicest features: memory-mapped files. You'll create a `TMemoryMappedFile` class that you can use, which encapsulates some of the memory-mapped functionality, and you'll learn how to use this class to perform text searches in text files. This chapter also demonstrates some useful routines to determine available drives, walk directory trees to search for files, and obtain version information on files. By the end of this chapter, you'll have a strong feel for working with files, directories, and drives.

Dealing with File I/O

You will probably need to deal with three types of files. These file types are text files, typed files, and binary files. The next few sections cover file I/O with these types of files. *Text files* are exactly what the name implies. They contain ASCII text that can be read by any text editor. *Typed files* are files that contain programmer-defined data types. *Binary files* cover just about anything else. This is a general name that covers any file that can contain data in any given format or no format at all.

Working with Text Files

This section shows you how to manipulate text files using the procedures and functions built into Object Pascal's Runtime Library. Before you can do anything with a text file, you must open it. First, you must declare a variable of type `TextFile`:

```
var
  MyTextFile: TextFile;
```

You can now use this variable to refer to a text file.

You need to know about two procedures in order to open the file. The first procedure is `AssignFile()`. `AssignFile()` associates a filename with the file variable:

```
AssignFile(MyTextFile, 'MyTextFile.txt');
```

After you've associated the file variable with a filename, you can open the file. You can open a text file in three ways. First, you can create and open a file using the `Rewrite()` procedure. If you use `Rewrite()` on an existing file, it will be overwritten and a new one will be created with the same name. You can also open a file for read-only access by using the `Reset()` procedure. You can append to an existing file by using the `Append()` procedure.

NOTE

`Reset()` opens typed and untyped files with read-write access.

To close a file after you've opened it, you use the `CloseFile()` procedure. Take a look at the following examples, which illustrate each procedure.

To open for read-only access, use this procedure:

```
var
  MyTextFile: TextFile;
begin
  AssignFile(MyTextFile, 'MyTextFile.txt');
  Reset(MyTextFile);
  try
    {manipulate the file }
  finally
    CloseFile(MyTextFile);
  end;
end;
```

To create a new file, do the following:

```
var
  MyTextFile: TextFile;
begin
  AssignFile(MyTextFile, 'MyTextFile.txt');
  Rewrite(MyTextFile);
  try
    {manipulate the file }
  finally
    CloseFile(MyTextFile);
  end;
end;
```

To append to an existing file, use this procedure:

```
var
  MyTextFile: TextFile;
begin
  AssignFile(MyTextFile, 'MyTextFile.txt');
  Append(MyTextFile);
  try
    {manipulate the file }
  finally
```

```
        CloseFile(MyTextFile);
    end;
end;
```

Listing 12.1 shows how you would use `Rewrite()` to create a file and add five lines of text to it.

LISTING 12.1 Creating a Text File

```
var
    MyTextFile: TextFile;
    S: String;
    i: integer;
begin
    AssignFile(MyTextFile, 'MyTextFile.txt');
    Rewrite(MyTextFile);
    try
        for i := 1 to 5 do
            begin
                S := 'This is line # ';
                Writeln(MyTextFile, S, i);
            end;
        finally
            CloseFile(MyTextFile);
        end;
    end;
end;
```

This file would now contain the following text:

```
This is line # 1
This is line # 2
This is line # 3
This is line # 4
This is line # 5
```

Listing 12.2 illustrates how you would add five more lines to that same file.

LISTING 12.2 Appending to a Text File

```
var
    MyTextFile: TextFile;
    S: String;
    i: integer;
begin
    AssignFile(MyTextFile, 'MyTextFile.txt');
    Append(MyTextFile);
    try
        for i := 6 to 10 do
```

```
begin
  S := 'This is line # ';
  Writeln(MyTextFile, S, i);
end;
finally
  CloseFile(MyTextFile);
end;
end;
```

This file's contents are shown here:

```
This is line # 1
This is line # 2
This is line # 3
This is line # 4
This is line # 5
This is line # 6
This is line # 7
This is line # 8
This is line # 9
This is line # 10
```

Notice that in both listings, you were able to write both a string and an integer to the file. The same is true for all numeric types in Object Pascal. To read from this same text file, you would do as shown in Listing 12.3.

LISTING 12.3 Reading from a Text File

```
var
  MyTextFile: TextFile;
  S: String[15];
  i: integer;
  j: integer;
begin
  AssignFile(MyTextFile, 'MyTextFile.txt');
  Reset(MyTextFile);
  try
    while not Eof(MyTextFile) do
      begin
        Readln(MyTextFile, S, j);
        Memo1.Lines.Add(S+IntToStr(j));
      end;
  finally
    CloseFile(MyTextFile);
  end;
end;
```

In Listing 12.3, you'll notice that the string variable `S` is declared as `String[15]`. This was required to prevent reading the entire line from the file into the variable, `S`. Not doing so would have caused an error when attempting to read a value into the integer variable `J`. This illustrates another important feature of text file I/O: You can write columns to text files. You can then read these columns into strings of a specific length. It's important that each column is set to a specific length even though the actual strings stored there might be of a different length. Also, notice the use of the `Eof()` function. This function performs a test to determine whether the file pointer is at the end of the file. If it is, you must break out of the loop because there's no more text to read.

To illustrate reading a columnar-formatted text file, we've created a text file named `USCaps.txt`, which contains a list of U.S. capitals in a columnar arrangement. A portion of this file is shown here:

Alabama	Montgomery
Alaska	Juneau
Arizona	Phoenix
Arkansas	Little Rock
California	Sacramento
Colorado	Denver
Connecticut	Hartford
Delaware	Dover

The state name column has exactly 20 characters. This way, the capitals line up vertically. We've created a project that reads this file and stores the states into a Paradox table. You'll find this project on the CD as `Capitals.dpr`. Its source is shown in Listing 12.4.

NOTE

Before you can run this demo, you will need to create the BDE alias, `DDGData`. Otherwise, the program will fail. If you installed the software from this book's CD, this alias has already been created for you.

LISTING 12.4 Source Code for the Capitals Project

```
unit MainFrm;  
  
interface  
  
uses  
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,  
  Dialogs, StdCtrls, Grids, DBGrids, DB, DBTables;
```

type

```
TMainForm = class(TForm)
  btnReadCapitals: TButton;
  tblCapitals: TTable;
  dsCapitals: TDataSource;
  dbgCapitals: TDBGrid;
  procedure btnReadCapitalsClick(Sender: TObject);
  procedure FormCreate(Sender: TObject);
end;
```

var

```
MainForm: TMainForm;
```

implementation

```
{ $R *.DFM }
```

```
procedure TMainForm.btnReadCapitalsClick(Sender: TObject);
```

var

```
F: TextFile;
StateName: String[20];
CapitalName: String[20];
```

begin

```
tblCapitals.Open;
// Assign the file to the columnar text file.
AssignFile(F, 'USCAPS.TXT');
// Open the file for read access.
Reset(F);
try
  while not Eof(F) do
  begin
    { Read a line of the file into the two strings each of whose length
      matches the number of characters that make up the column. }
    Readln(F, StateName, CapitalName);
    // Now store both strings into separate columns in a Paradox table
    tblCapitals.Insert;
    tblCapitals['State_Name'] := StateName;
    tblCapitals['State_Capital'] := CapitalName;
    tblCapitals.Post;
  end;
```

finally

```
CloseFile(F); // Close the file when finished.
```

end;

end;

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FILES**

continues

LISTING 12.4 Continued

```
procedure TMainForm.FormCreate(Sender: TObject);
begin
    // Empty the table when project starts.
    tblCapitals.EmptyTable;
end;

end.
```

Although this book hasn't covered Delphi database programming yet, the preceding code is straightforward. The point we're trying to make here is that often, text file processing might serve a very useful purpose. This text file just as well might have been a file containing bank account information downloaded from a bank's online banking service, for example.

Working with Typed Files (Files of Record)

You can store Object Pascal data structures in disk files. You can then read data from these files directly into your data structures. This enables you to use typed files for storing and retrieving information as though the data were records in a table. Files that store Pascal data structures are referred to as *files of record*. To illustrate the use of such files, look at the record structure defined here:

```
TPersonRec = packed record
    FirstName: String[20];
    LastName: String[20];
    MI: String[1];
    BirthDay: TDateTime;
    Age: Integer;
end;
```

NOTE

Records that contain ANSI strings, variants, class instances, interfaces, or dynamic arrays may not be written to a file.

Now suppose you wanted to store one or more such records in a file. You've already seen how you might do this using a text file in the previous section. However, you can also do this using a file of record defined like this:

```
DataFile: File of TPersonRec;
```

To read a single record of the type `TPersonRec`, you would do the following:

```
var
  PersonRec: TPersonRec;
  DataFile: File of TPersonRec;
begin
  AssignFile(DataFile, 'PersonFile.dat');
  Reset(DataFile);
  try
    if not Eof(DataFile) then
      read(DataFile, PersonRec);
  finally
    CloseFile(DataFile);
  end;
end;
```

The following code illustrates how you would append a single record to a file:

```
var
  PersonRec: TPersonRec;
  DataFile: File of TPersonRec;
begin
  AssignFile(DataFile, 'PersonFile.dat');
  Reset(DataFile);
  Seek(DataFile, FileSize(DataFile));
  try
    write(DataFile, PersonRec);
  finally
    CloseFile(DataFile);
  end;
end;
```

Note the use of the `Seek()` procedure to move the file position to the end of the file before writing the record to the file. This function usage is well documented in Delphi's online help, so we won't go into detail on it here.

To illustrate the use of typed files, we've created a small application that stores information on persons in an Object Pascal format. This application allows you to browse, add, and edit these records. We also illustrate the use of a `TFileStream` descendant, which we use to encapsulate the file I/O for such records.

Defining a `TFileStream` Descendant for Typed File I/O

`TFileStream` is a streaming class that can be used to store items that aren't objects. Record structures don't have methods with which they can store themselves to disk or memory. One solution would be to make the record an object instead. Then, you could attach the storage functionality to that object. Another solution is to use storage functionality of a `TFileStream` to store the records. Listing 12.5 shows a unit that defines a `TPersonRec` record and a `TRecordStream`, a descendant of `TFileStream`, which handles the file I/O for storing and retrieving records.

NOTE

Streaming is a topic that we cover in greater depth in Chapter 22, “Advanced Component Techniques.”

LISTING 12.5 The Source Code for PersRec.PAS: TRecordStream, a TFileStream Descendant

```
unit persrec;

interface
uses Classes, dialogs, sysutils;

type

    // Define the record that will hold the person's information.
    TPersonRec = packed record
        FirstName: String[20];
        LastName: String[20];
        MI: String[1];
        BirthDay: TDateTime;
        Age: Integer;
    end;

    // Create a descendant TFileStream which knows about the TPersonRec

    TRecordStream = class(TFileStream)
    private
        function GetNumRecs: Longint;
        function GetCurRec: Longint;
        procedure SetCurRec(RecNo: Longint);
    protected
        function GetRecSize: Longint; virtual;
    public
        function SeekRec(RecNo: Longint; Origin: Word): Longint;
        function WriteRec(const Rec): Longint;
        function AppendRec(const Rec): Longint;
        function ReadRec(var Rec): Longint;
        procedure First;
        procedure Last;
        procedure NextRec;
        procedure PreviousRec;
        // NumRecs shows the number of records in the stream
        property NumRecs: Longint read GetNumRecs;
```

```
// CurRec reflects the current record in the stream
property CurRec: Longint read GetCurRec write SetCurRec;
end;

implementation

function TRecordStream.GetRecSize: Longint;
begin
  { This function returns the size of the record that this stream
    knows about (TPersonRec) }
  Result := SizeOf(TPersonRec);
end;

function TRecordStream.GetNumRecs: Longint;
begin
  // This function returns the number of records in the stream
  Result := Size div GetRecSize;
end;

function TRecordStream.GetCurRec: Longint;
begin
  { This function returns the position of the current record. We must
    add one to this value because the file pointer is always at the
    beginning of the record which is not reflected in the equation:
    Position div GetRecSize }
  Result := (Position div GetRecSize) + 1;
end;

procedure TRecordStream.SetCurRec(RecNo: Longint);
begin
  { This procedure sets the position to the record in the stream
    specified by RecNo. }
  if RecNo > 0 then
    Position := (RecNo - 1) * GetRecSize
  else
    Raise Exception.Create('Cannot go beyond beginning of file.');
```

```
end;

function TRecordStream.SeekRec(RecNo: Longint; Origin: Word): Longint;
begin
  { This function positions the file pointer to a location
    specified by RecNo }

  { NOTE: This method does not contain error handling to determine if this
    operation will exceed beyond the beginning/ending of the streamed
    file }
```

LISTING 12.5 Continued

```
    Result := Seek(RecNo * GetRecSize, Origin);
end;

function TRecordStream.WriteRec(Const Rec): Longint;
begin
    // This function writes the record Rec to the stream
    Result := Write(Rec, GetRecSize);
end;

function TRecordStream.AppendRec(Const Rec): Longint;
begin
    // This function writes the record Rec to the stream
    Seek(0, 2);
    Result := Write(Rec, GetRecSize);
end;

function TRecordStream.ReadRec(var Rec): Longint;
begin
    { This function reads the record Rec from the stream and
      positions the pointer back to the beginning of the record }
    Result := Read(Rec, GetRecSize);
    Seek(-GetRecSize, 1);
end;

procedure TRecordStream.First;
begin
    { This function positions the file pointer to the beginning
      of the stream }
    Seek(0, 0);
end;

procedure TRecordStream.Last;
begin
    // This procedure positions the file pointer to the end of the stream
    Seek(0, 2);
    Seek(-GetRecSize, 1);
end;

procedure TRecordStream.NextRec;
begin
    { This procedure positions the file pointer at the next record
      location }

    { Go to the next record as long as it doesn't extend beyond the
```

```
    end of the file. }
    if ((Position + GetRecSize) div GetRecSize) = GetNumRecs then
        raise Exception.Create('Cannot read beyond end of file')
    else
        Seek(GetRecSize, 1);
end;

procedure TRecordStream.PreviousRec;
begin
{ This procedure positions the file pointer to the previous record
  in the stream }

    { Call this function as long as we don't extend beyond the
      beginning of the file }
    if (Position - GetRecSize >= 0) then
        Seek(-GetRecSize, 1)
    else
        Raise Exception.Create('Cannot read beyond beginning of the file. ');
end;

end.
```

In this unit, you first declare the record that you want to store, `TPersonRec`. `TRecordStream` is the `TFileStream` descendant you use to perform the file I/O for `TPersonRec`. `TRecordStream` has two properties: `NumRecs`, which indicates the number of records in the stream, and `CurRec`, which indicates the current record that the stream is viewing.

The `GetNumRecs()` method, which is the access method for the `NumRecs` property, determines how many records exist in the stream. It does this by dividing the total size of the stream in bytes, as determined from the `TStream.Size` property, by the size of the `TPersonRec` record. Therefore, given that the `TPersonRec` record is 56 bytes, if the `Size` property has the value of 162, there would be four records in the stream. Note, however, that the record is guaranteed to be 56 bytes only if it's packed. The reason behind this is that structured types, such as records and arrays, are aligned on word or double-word boundaries to allow for faster access. This can mean that the record consumes more space than it actually needs. By using the reserved word `packed` before the record declaration, you can ensure compressed and accurate data storage. Not using the `packed` keyword might cause inaccurate results from the `GetNumRecs()` method.

The `GetCurRec()` method determines which record is the current record. You do this by dividing the `TStream.Position` property by the size of the `TPersonRec` property and adding 1 to the value. The `SetCurRec()` method places the file pointer at the position in the stream at the beginning of the record specified by the `RecNo` property.

The `SeekRec()` method allows the caller to place the file pointer at a position determined by the `RecNo` and `Origin` parameters. This method moves the file pointer forward or backward in the stream from the beginning, ending, or current position of the file pointer, as specified by the value of the `Origin` property. This is done by using the `Seek()` method of the `TStream` object. The use of the `TStream.Seek()` method is explained in the online “Component Writers Guide” help file.

The `WriteRec()` method writes the contents of the `TPersonRec` parameter to the file at the current position, which will be the position of an existing record, so that it will overwrite that record.

The `AppendRec()` method adds a new record to the end of the file.

The `ReadRec()` method reads the data from the stream into the `TPersonRec` parameter. It then repositions the file pointer at the beginning of the record by using the `Seek()` method. The reason for this is that in order to use the `TRecordStream` object in a database manner, the file pointer must always be at the beginning of the current record (that is, the record being viewed).

The `First()` and `Last()` methods place the file pointer at the beginning and ending of the file, respectively.

The `NextRec()` method places the file pointer at the beginning of the next record provided that it’s not already sitting at the last record in the file.

The `PreviousRec()` method places the file pointer at the beginning of the previous record provided that the file pointer is not already at the first record in the file.

Using a `TFileStream` Descendant for File I/O

Listing 12.6 is the source code for the main form of an application that uses the `TRecordStream` object. This project is `FileOfRec.dpr` on the CD.

LISTING 21.6 The Source Code for the Main Form of the `FileOfRec.dpr` Project

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, Mask, Persrec, ComCtrls;

const
  // Declare the file name as a constant
  FName = 'PERSONS.DAT';

type
```

```
TMainForm = class(TForm)
  edtFirstName: TEdit;
  edtLastName: TEdit;
  edtMI: TEdit;
  meAge: TMaskEdit;
  lblFirstName: TLabel;
  lblLastName: TLabel;
  lblMI: TLabel;
  lblBirthDate: TLabel;
  lblAge: TLabel;
  btnFirst: TButton;
  btnNext: TButton;
  btnPrev: TButton;
  btnLast: TButton;
  btnAppend: TButton;
  btnUpdate: TButton;
  btnClear: TButton;
  lblRecNoCap: TLabel;
  lblRecNo: TLabel;
  lblNumRecsCap: TLabel;
  lblNoRecs: TLabel;
  dtpBirthDay: TDateTimePicker;
  procedure FormCreate(Sender: TObject);
  procedure FormDestroy(Sender: TObject);
  procedure FormShow(Sender: TObject);
  procedure btnAppendClick(Sender: TObject);
  procedure btnUpdateClick(Sender: TObject);
  procedure btnFirstClick(Sender: TObject);
  procedure btnNextClick(Sender: TObject);
  procedure btnLastClick(Sender: TObject);
  procedure btnPrevClick(Sender: TObject);
  procedure btnClearClick(Sender: TObject);
public
  PersonRec: TPersonRec;
  RecordStream: TRecordStream;
  procedure ShowCurrentRecord;
end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.FormCreate(Sender: TObject);
```

LISTING 21.6 Continued

```
begin
  { If the file does not exist, then create it, otherwise, open it for
    both read and write access. This is done by instantiating
    a TRecordStream }
  if FileExists(FName) then
    RecordStream := TRecordStream.Create(FName, fmOpenReadWrite)
  else
    RecordStream := TRecordStream.Create(FName, fmCreate);
end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
  RecordStream.Free; // Free the TRecordStream instance
end;

procedure TMainForm.ShowCurrentRecord;
begin
  // Read the current record.
  RecordStream.ReadRec(PersonRec);
  // Copy the data from the PersonRec to the form's controls
  with PersonRec do
  begin
    edtFirstName.Text := FirstName;
    edtLastName.Text  := LastName;
    edtMI.Text        := MI;
    dtpBirthDay.Date  := BirthDay;
    meAge.Text         := IntToStr(Age);
  end;
  // Show the record number and total records on the main form.
  lblRecNo.Caption   := IntToStr(RecordStream.CurRec);
  lblNoRecs.Caption  := IntToStr(RecordStream.NumRecs);
end;

procedure TMainForm.FormShow(Sender: TObject);
begin
  // Display the current record only if one exists.
  if RecordStream.NumRecs <> 0 then
    ShowCurrentRecord;
end;

procedure TMainForm.btnAppendClick(Sender: TObject);
begin
  // Copy the contents of the form controls to the PersonRec record
  with PersonRec do
```

```
begin
    FirstName := edtFirstName.Text;
    LastName  := edtLastName.Text;
    MI        := edtMI.Text;
    BirthDay  := dtpBirthDay.Date;
    Age       := StrToInt(meAge.Text);
end;
// Write the new record to the stream
RecordStream.AppendRec(PersonRec);
// Display the current record.
ShowCurrentRecord;
end;

procedure TMainForm.btnUpdateClick(Sender: TObject);
begin
    { Copy the contents of the form controls to the PersonRec and write
      it to the stream }
    with PersonRec do
    begin
        FirstName := edtFirstName.Text;
        LastName  := edtLastName.Text;
        MI        := edtMI.Text;
        BirthDay  := dtpBirthDay.Date;
        Age       := StrToInt(meAge.Text);
    end;
    RecordStream.WriteRec(PersonRec);
end;

procedure TMainForm.btnFirstClick(Sender: TObject);
begin
    { Go to the first record in the stream and display it as long as
      there are records that exist in the stream }
    if RecordStream.NumRecs <> 0 then
    begin
        RecordStream.First;
        ShowCurrentRecord;
    end;
end;

procedure TMainForm.btnNextClick(Sender: TObject);
begin
    // Go to the next record as long as records exist in the stream
    if RecordStream.NumRecs <> 0 then
    begin
        RecordStream.NextRec;
        ShowCurrentRecord;
    end;
end;
```

LISTING 21.6 Continued

```
    end;
end;

procedure TMainForm.btnLastClick(Sender: TObject);
begin
    { Go to the last record in the stream as long as there are records
      in the stream }
    if RecordStream.NumRecs <> 0 then
    begin
        RecordStream.Last;
        ShowCurrentRecord;
    end;
end;

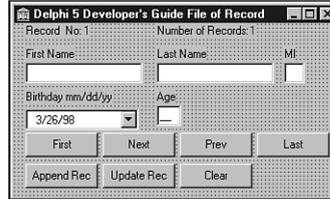
procedure TMainForm.btnPrevClick(Sender: TObject);
begin
    { Go to the previous record in the stream as long as there are records
      in the stream }
    if RecordStream.NumRecs <> 0 then
    begin
        RecordStream.PreviousRec;
        ShowCurrentRecord;
    end;
end;

procedure TMainForm.btnClearClick(Sender: TObject);
begin
    // Clear all controls on the form
    edtFirstName.Text := '';
    edtLastName.Text := '';
    edtMI.Text := '';
    meAge.Text := '';
end;

end.
```

Figure 12.1 shows the main form for this sample project.

The main form contains both a `TPersonRec` field and a `TRecordStream` class. The `TPersonRec` field holds the contents of the current record. The `TRecordStream` instance is created in the form's `OnCreate` event handler. If the file does not exist, it is created. Otherwise, it is opened.

**FIGURE 12.1**

The main form for the TRecordStream example.

The `ShowCurrentRecord()` method is used to extract the current record from the stream by calling the `RecordStream.ReadRec()` method. Recall that the `RecordStream.ReadRec()` method first reads the record, which positions the file pointer to the end of the record after it's read. It then repositions the file pointer at the beginning of the record.

Most of the functionality of this application is discussed in the source commentary. We'll briefly discuss the important points here.

The `btnAppendClick()` adds a new record to the file.

The `btnUpdateClick()` method writes the contents of the form's controls to the file at the position of the current record, thus modifying the contents at that position.

The remaining methods reposition the file pointer to the next, previous, first, and last records in the file, thus enabling you to browse the records in the file.

This example illustrates how you can use typed files to perform simple database operations using standard file I/O. It also illustrates how to make use of the `TFileStream` object to wrap the I/O functionality of the records in the file.

Working with Untyped Files

Up to this point, you've seen how to manipulate both text and typed files. Text files are used to store ASCII character sequences. Typed files store data where each element of that data follows the defined format of a Pascal record structure. In both cases, each file stores a number of bytes that can be interpreted accordingly by applications.

Many files don't follow an ordered format. For example, RTF files, although they do contain text, also contain information about the various attributes of the text within that file. You cannot load these files into any text editor to view them. You must use a view that's capable of interpreting rich text-formatted data.

The next few paragraphs illustrate how to manipulate untyped files.

The following line declares an untyped file:

```
var
  UntypedFile: File;
```

This declares a file consisting of a sequence of blocks, each having 128 bytes of data.

To read data from an untyped file, you would use the `BlockRead()` procedure. To write data to an untyped file, you use the `BlockWrite()` procedure. These procedures are declared as follows:

```
procedure BlockRead(var F: File; var Buf;
  Count: Integer []; var Result: Integer);
procedure BlockWrite(var f: File; var Buf;
  Count: Integer []; var Result: Integer);
```

Both `BlockRead()` and `BlockWrite()` take three parameters. The first parameter is an untyped file variable, `F`. The second parameter is a variable buffer, `Buf`, which holds the data read from or written to the file. The parameter `Count` contains the number of records to read from the file. The optional parameter `Result` contains the number of records read from the file in a read operation. In a write operation, `Result` contains the number of complete records written. If this value does not equal `Count`, it's possible that the disk has run out of space.

We'll explain what we're referring to when we say that these procedures read or write `Count` records. When you declare an untyped file as follows, by default, this defines a file whose records each consist of 128 bytes of data:

```
UntypedFile: File;
```

This has nothing to do with any particular record structure. It just specifies the size of the block of data that's read in for a single record. Listing 12.7 illustrates how to read one record of 128 bytes from a file:

LISTING 12.7 Reading from an Untyped File

```
var
  UnTypedFile: File;
  Buffer: array[0..128] of byte;
  NumRecsRead: Integer;
begin
  AssignFile(UnTypedFile, 'SOMEFILE.DAT');
  Reset(UnTypedFile);
  try
    BlockRead(UnTypedFile, Buffer, 1, NumRecsRead);
  finally
    CloseFile(UnTypedFile);
  end;
end;
```

Here, you open the file `SOMEFILE.DAT` and read 128 bytes of data (one record or block) into the buffer appropriately named `Buffer`. To write 128 bytes of data to a file, take a look at Listing 12.8.

LISTING 12.8 Writing Data to an Untyped File

```
var
  UnTypedFile: File;
  Buffer: array[0..128] of byte;
  NumRecsWritten: Integer;
begin
  AssignFile(UnTypedFile, 'SOMEFILE.DAT');
  // If file doesn't exist, create it. Otherwise,
  // just open it for read/write access
  if FileExists('SOMEFILE.DAT') then
    Reset(UnTypedFile)
  else
    Rewrite(UnTypedFile);
  try
    // Position the file pointer to the end of the file
    Seek(UnTypedFile, FileSize(UnTypedFile));
    FillChar(Buffer, SizeOf(Buffer), 'Y');
    BlockWrite(UnTypedFile, Buffer, 1, NumRecsWritten);
  finally
    CloseFile(UnTypedFile);
  end;
end;
```

A problem in using the default block size of 128 bytes when reading from a file is that its size must be a multiple of 128 to avoid reading beyond the end of the file. You can get around this by specifying a record size of one byte with the `Reset()` procedure. If you pass a record size of one byte, reading blocks of any size will always be a multiple of one byte. As an example, Listing 12.9 illustrates a simple file-copy routine using the `Blockread()` and `BlockWrite()` procedures.

LISTING 12.9 A File-Copy Demo

```
unit MainForm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, ComCtrls, Gauges;
```

continues

LISTING 12.9 Continued

```
type
  TMainForm = class(TForm)
    prbCopy: TProgressBar;
    btnCopy: TButton;
    procedure btnCopyClick(Sender: TObject);
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.btnCopyClick(Sender: TObject);
var
  SrcFile, DestFile: File;
  BytesRead, BytesWritten, TotalRead: Integer;
  Buffer: array[1..500] of byte;
  FSize: Integer;
begin
  { Assign both the source and destination files to their
    respective file variables }
  AssignFile(SrcFile, 'srcfile.tst');
  AssignFile(DestFile, 'destfile.tst');
  // Open the source file for read access.
  Reset(SrcFile, 1);
  try
    // Open destination file for write access.
    Rewrite(DestFile, 1);
  try
    { Encapsulate this into a try..except so that we can erase the file if
      an error occurs. }
  try
    // Initialize total bytes read to zero.
    TotalRead := 0;
    // Obtain the filesize of the source file
    FSize := FileSize(SrcFile);
    { Read SizeOf(Buffer) bytes from the source file
      and add these bytes to the destination file. Repeat this
      process until all bytes have been read from the source
      file. A progress bar is provided to show the progress of the
      copy operation. }
    repeat
      BlockRead(SrcFile, Buffer, SizeOf(Buffer), BytesRead);
```

```
    if BytesRead > 0 then
    begin
        BlockWrite(DestFile, Buffer, BytesRead, BytesWritten);
        if BytesRead <> BytesWritten then
            raise Exception.Create('Error copying file')
        else begin
            TotalRead := TotalRead + BytesRead;
            prbCopy.Position := Trunc(TotalRead / Fsize) * 100;
            prbCopy.Update;
        end;
    end
until BytesRead = 0;
except
    { On an exception, erase the destination file as it may be
      corrupt. Then re-raise the exception. }
    Erase(DestFile);
    raise;
end;
finally
    CloseFile(DestFile); // Close the destination file.
end;
finally
    CloseFile(SrcFile); // Close the source file.
end;
end;
```

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One of the demos that ships with Delphi 5 comes with several useful file-handling functions, including a function to copy a file. This demo is in the \DEMOS\DOC\FIL-MANEX\ directory. Here are the functions contained in the FmxUtils.PAS file:

```
procedure CopyFile(const FileName, DestName: string);
procedure MoveFile(const FileName, DestName: string);
function GetFileSize(const FileName: string): LongInt;
function FileDateTime(const FileName: string): TDateTime;
function HasAttr(const FileName: string; Attr: Word): Boolean;
function ExecuteFile(const FileName, Params,
    DefaultDir: string; ShowCmd: Integer): THandle;
```

Also, later in this chapter we show you how to copy files and entire directories using the ShFileOperation() function.

First, the demo opens a source file for input and creates a destination file to which the source file's data will be copied. The variables `TotalRead` and `FSize` are used in updating a `TProgressBar` component to indicate the status of the copy operation. Inside the repeat loop is where the copy operation is actually performed. First, `SizeOf(Buffer)` bytes are read from the source file. The variable `BytesRead` determines the actual number of bytes read. Then, an attempt is made to copy `BytesRead` to the destination file. The number of actual bytes written is stored in the variable `BytesWritten`. At this point, if no error has occurred, `BytesRead` and `BytesWritten` will have the same values. This process is continued until all bytes of the file have been copied. If an error occurs, an exception is raised and the destination file is erased from the disk.

A sample application illustrating the preceding code exists on the CD as `FileCopy.dpr`.

The TTextRec and TFileRec Record Structures

Most file-management functions are really operating system functions or interrupts that have been wrapped up in Object Pascal routines. The `Reset()` function, for example, is really a Pascal wrapper to `CreateFileA()`, a Win32 function of the `KERNEL32` dynamic link library. By wrapping up these Win32 functions into Object Pascal functions, you do not have to worry about the implementation details of these file operations. However, it also obscures how to access certain file details when needed (such as the file handle) because these are hidden for Object Pascal's usage.

When using nonnative Object Pascal functions that require a file handle, such as `LZCopy()`, you can get the file handle by typecasting your text file and binary file variables as `TTextRec` and `TFileRec`, respectively. These record types contain the file handle as well as other file details. Other than the file handle, you rarely will (and probably shouldn't) access the other data fields. The correct procedure for getting to the handle follows:

```
TFileRec(MyFileVar).Handle
```

The definition of the `TTextRec` record is shown here:

```
PTextBuf = ^TTextBuf;
TTextBuf = array[0..127] of Char; // Buffer definition for first 127
                                // characters in the file.
TTextRec = record
    Handle: Integer;           // File handle
    Mode: Integer;           // File mode
    BufSize: Cardinal;       // The following 4 parameters are
    BufPos: Cardinal;        // used for memory buffering.
    BufEnd: Cardinal;
    BufPtr: PChar;
    OpenFunc: Pointer;       // The XXXXFunc are points to file
```

```
InOutFunc: Pointer;           // access functions. They can be
FlushFunc: Pointer;          // modified when writing certain
CloseFunc: Pointer;          // file device drivers.
UserData: array[1..32] of Byte; // Not used.
Name: array[0..259] of Char;  // File's full path name
Buffer: TTextBuf;            // Buffer containing the
first 127 characters of the file
end;
```

Here's the definition of the TFileRec record structure:

```
TFileRec = record
  Handle: Integer;           // File Handle
  Mode: Integer;             // File mode
  RecSize: Cardinal;         // Size of each file record
  Private: array[1..28] of Byte; // Used internally by Object Pascal
  UserData: array[1..32] of Byte; // Not used.
  Name: array[0..259] of Char; // File's full path name
end;
```

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Working with Memory-Mapped Files

Probably one of the most convenient features of the Win32 environment is the ability to access files on disk as if you were accessing the file's contents in memory. This capability is provided through memory-mapped files.

Memory-mapped files enable you to avoid having to perform all the I/O operations on the file. Instead, you reserve a range of virtual address space and commit the physical storage of the file on disk to the address of this reserved memory space. You then reference the contents of the file through a pointer into this reserved region. Shortly, we'll show you how you can use this capability to create a useful text-searching utility for text files, made simple through the use of memory-mapped files.

Purposes for Memory-Mapped Files

Typically, there are three uses for memory-mapped files:

- The Win32 system loads and executes EXE and DLL files by using memory-mapped files. This conserves paging file space and therefore decreases the load time for such files.
- Memory-mapped files can be used to access data residing in the mapped file through a pointer to the mapped memory region. This not only simplifies data access, but also relieves you from having to code various file-buffering schemes.
- Memory-mapped files can be used to provide the ability to share data among different processes running on the same machine.

We won't discuss the first purpose for memory-mapped files because this really applies to the system behavior. In this chapter, we discuss the second purpose of memory-mapped files because this is a use that you, as a developer, will most likely need at some point. Chapter 9, "Dynamic Link Libraries," shows you how to share data with other processes by using memory-mapped files. You might want to look back at this example after reading this section so that you fully understand what we showed you.

Using Memory-Mapped Files

When you create a memory-mapped file, you're essentially associating the file to an area in the process's virtual memory address space. To create this association, you must create a *file-mapping object*. To view/edit the contents of a file, you must have a *file view* for the file-mapping object. This enables you to access the contents of the file through a pointer as though you were accessing an area of memory.

When you write to the file view, the system handles the caching, buffering, writing and loading of the file's data, as well as memory allocation and deallocation. As far as you're concerned, you're editing data residing in an area of memory. The file I/O is handled entirely by the system. This is the beauty of using memory-mapped files. Your task of file manipulation is greatly simplified over the standard file I/O techniques discussed previously and is usually faster as well.

The following sections cover the steps required to create/open a memory-mapped file.

Creating/Opening the File

The first step in creating/opening a memory-mapped file is to obtain the file handle for the file to be mapped. You can do this by using either the `FileCreate()` or `FileOpen()` functions.

`FileCreate()` is defined in the `SysUtils.pas` unit as follows:

```
function FileCreate(const FileName: string): Integer;
```

This function creates a new file with the filename specified by its `FileName` string parameter. If the function is successful, a valid file handle is returned. Otherwise, the value defined by the constant `INVALID_HANDLE_VALUE` is returned.

`FileOpen()` opens an existing file using a specified access mode. This function, when successful, will return a valid file handle. Otherwise, it will return the value defined by the constant `INVALID_HANDLE_VALUE`. `FileOpen()` is defined in the `SysUtils.pas` unit as follows:

```
function FileOpen(const FileName: string; Mode: Word): Integer;
```

The first parameter is the full path name of the file to which the mapping is to be applied. The second parameter is one of the file-access modes described in Table 12.1.

TABLE 12.1 fmOpenXXXX File Access Modes

<i>Access Mode</i>	<i>Meaning</i>
fmOpenRead	Enables you to read only from the file
fmOpenWrite	Enables you to write only to the file
fmOpenReadWrite	Enables you to read from and write to the file

If you specify a value of 0 as the *Mode* parameter, you won't be able to read from or write to the specified file. You might use this when all you want is to obtain various file attributes. You can specify how a file can be shared with different applications by applying the bitwise or operation using the access modes specified in Table 12.1 with one of the fmShareXXXX modes. The fmShareXXXX modes are listed in Table 12.2.

TABLE 12.2 fmShareXXXX File Share Modes

<i>Share Mode</i>	<i>Meaning</i>
fmShareCompat	The file-sharing mechanism is compatible with DOS 1.x and 2.x file control blocks. This is used in conjunction with other FmShareXXXX modes.
fmShareExclusive	No sharing allowed.
fmShareDenyWrite	Other attempts to open the file with fmOpenWrite access fail.
fmShareDenyRead	Other attempts to open the file with fmOpenRead access fail.
fmShareDenyNone	Other attempts to open the file with any mode succeed.

After a valid file handle is obtained, it's possible to obtain a file-mapping object.

Creating the File-Mapping Object

To create named or unnamed file-mapping objects, you use the `CreateFileMapping()` function. This function is defined as follows:

```
function CreateFileMapping(
hFile: THandle;
lpFileMappingAttributes: PSecurityAttributes;
flProtect,
dwMaximumSizeHigh,
dwMaximumSizeLow: DWORD;
lpName: PChar) : THandle;
```

The parameters passed to `CreateFileMapping()` give the system the necessary information required to create the file-mapping object. The first parameter, `hFile`, is the file handle

obtained from the previous call to `FileOpen()` or `FileCreate()`. It's important that the file be opened with the protection flags compatible with the `flProtect` parameter, which we'll discuss momentarily. Another method is to use `CreateFileMapping()` to create a file-mapping object backed by the system paging file. This technique is used to enable the sharing of data among separate processes that we illustrate in Chapter 9, "Dynamic Link Libraries."

The `lpFileMappingAttributes` parameter is a `PSecurityAttributes` pointer, which refers to the security attributes for the file-mapping object. This parameter will almost always be null.

The `flProtect` parameter specifies the type of protection applied to the file view. As we mentioned before, this value must be compatible with the attributes under which the file was opened to obtain a file handle. Table 12.3 lists the various attributes that can be assigned to the `flProtect` parameter.

TABLE 12.3 Protection Attributes

<i>Protection Attribute</i>	<i>Meaning</i>
PAGE_READONLY	You can read the file's contents. The file must have been created with the <code>FileCreate()</code> function or opened with <code>FileOpen()</code> and an access mode of <code>fmOpenRead</code> .
PAGE_READWRITE	You can read and write to the file. The file must have been opened with the <code>fmOpenReadWrite</code> access mode.
PAGE_WRITECOPY	You can read and write to the file. However, when you write to the file, a private copy of the modified page is created. The significance of this is that memory-mapped files that are shared between processes do not consume twice the resources in system memory or swap file usage. Only the memory required for the pages that are different is duplicated. The file must have been opened with the <code>fmOpenWrite</code> or <code>fmOpenReadWrite</code> access.

You can also apply section attributes to the `flProtect` parameter by using the bitwise or operator. Table 12.4 explains the meaning of these attributes.

TABLE 12.4 Section Attributes

<i>Section Attribute</i>	<i>Meaning</i>
SEC_COMMIT	Allocates physical storage in memory or in the paging file for all pages in a section. This is the default value.
SEC_IMAGE	File-mapping information and attributes are taken from the file image. This applies to executable image files only. (Note that this attribute is ignored under Windows 95/98.)

<i>Section Attribute</i>	<i>Meaning</i>
SEC_NOCACHE	No memory-mapped pages are cached. Therefore, the system applies all file writes directly to the file's data on disk. This mainly applies to device drivers and not to applications. (Note that this attribute is ignored under Windows 95/98.)
SEC_RESERVE	Reserves pages of a section without allocating physical storage.

The `dwMaximumSizeHigh` parameter specifies the high-order 32 bits of the file-mapping object's maximum size. Unless you're accessing files larger than 4GB, this value will always be zero.

The `dwMinimumSizeLow` parameter specifies the low-order 32 bits of the file-mapping object's maximum size. A value of zero for this parameter would indicate a maximum size for the file-mapping object equal to the size of the file being mapped.

The `lpName` parameter specifies the name of the file-mapping object. This value may contain any character except a backslash character (`\`). If this parameter matches the name of an existing file-mapping object, this function requests access to that same file-mapping object using the attributes specified by the `flProtect` parameter. It's valid to pass `nil` as this parameter, which creates a nameless file-mapping object.

If `CreateFileMapping()` is successful, it returns a valid handle to a file-mapping object. If this file-mapping object happens to refer to an already existing file-mapping object, the value `ERROR_ALREADY_EXISTS` will be returned from the `GetLastError()` function. If `CreateFileMapping()` fails, it returns a `nil` value. You must call the `GetLastError()` function to determine the reason for failure.

CAUTION

Under Windows 95/98, do not use file I/O functions on file handles that have been used to create file mappings. The data in such files may not be coherent. It is therefore recommended that you open the file with exclusive access. See the section "Memory-Mapped File Coherence."

After you've obtained a valid file-mapping object, you can map the file's data into the process's address space.

Mapping a View of the File into the Process's Address Space

The `MapViewOfFile()` function maps a view of the file into the process's address space. This function is defined as follows:

```
function MapViewOfFile(
    hFileMappingObject: THandle;
    dwDesiredAccess: DWORD;
    dwFileOffsetHigh,
    dwFileOffsetLow,
    dwNumberOfBytesToMap: DWORD): Pointer;
```

`hFileMappingObject` is the handle to an open file-mapping object that was opened with a call to either the `CreateFileMapping()` or `OpenFileMapping()` function.

The `dwDesiredAccess` parameter indicates how the file data is to be accessed and may be one of the values specified in Table 12.5.

TABLE 12.5 Desired Access to File View

<i>dwDesiredAccess Value</i>	<i>Meaning</i>
FILE_MAP_WRITE	Allows read-write access to the file data. The PAGE_READ_WRITE attribute must have been used with the <code>CreateFileMapping()</code> function.
FILE_MAP_READ	Allows read-only access to the file data. The PAGE_READ_WRITE or PAGE_READ attribute must have been used with the <code>CreateFileMapping()</code> function.
FILE_MAP_ALL_ACCESS	Same access provided by using FILE_MAP_WRITE.
FILE_MAP_COPY	Enables copy-on-write access. When you write to the file, a private copy of the page written to is created. <code>CreateFileMapping()</code> must have been used with the PAGE_READ_ONLY, PAGE_READ_WRITE, or PAGE_WRITE_COPY attributes.

The `dwFileOffsetHigh` parameter specifies the high-order 32 bits of the file offset where the file mapping begins.

The `dwFileOffsetLow` parameter specifies the lower-order 32 bits of the file offset where mapping begins.

The `dwNumberOfBytesToMap` parameter indicates how many bytes of the file to map. A zero value indicates the entire file.

`MapViewOfFile()` returns the starting address of the mapped view. If it's unsuccessful, `nil` is returned and you must call the `GetLastError()` function to determine the cause of the error.

Unmapping the View of the File

The `UnmapViewOfFile()` function unmaps the view of the file from the calling process's address space. This function is defined as follows:

```
function UnmapViewOfFile(lpBaseAddress: Pointer): BOOL;
```

This function's single parameter `lpBaseAddress` must point to the base address of the mapped region. This is the same value returned from the `MapViewOfFile()` function.

You need to call `UnmapViewOfFile()` when you've finished working with the file; otherwise, the mapped region of memory will not get released by the system until your process terminates.

Closing the File-Mapping and File Kernel Objects

The calls to `FileOpen()` and `CreateFileMapping()` are both open kernel objects that you're responsible for closing. This is done by using the `CloseHandle()` function. `CloseHandle()` is defined as follows:

```
function CloseHandle(hObject: THandle): BOOL;
```

If the call to `CloseHandle()` is successful, it will return `True`. Otherwise, it will return `False`, and you'll have to examine the result of `GetLastError()` to determine the cause of the error.

A Simple Memory-Mapped File Example

To illustrate the use of the memory-mapped file functions, examine Listing 12.10. You can find this project on the CD as `TextUpper.dpr`.

LISTING 12.10 A Simple Memory-Mapped File Example

```
unit MainForm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls;

const
  FName = 'test.txt';

type

  TMainForm = class(TForm)
    btnUpperCase: TButton;
    memTextContents: TMemo;
    lblContents: TLabel;
    btnLowerCase: TButton;
    procedure btnUpperCaseClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure btnLowerCaseClick(Sender: TObject);
```

continues

LISTING 12.10 Continued

```
public
    UCase: Boolean;
    procedure ChangeFileCase;
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.btnUpperCaseClick(Sender: TObject);
begin
    UCase := True;
    ChangeFileCase;
end;

procedure TMainForm.btnLowerCaseClick(Sender: TObject);
begin
    UCase := False;
    ChangeFileCase;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
    memTextContents.Lines.LoadFromFile(FName);
    // Change to upper case by default.
    UCase := True;
end;

procedure TMainForm.ChangeFileCase;
var
    FFileHandle: THandle; // Handle to the open file.
    FMapHandle: THandle; // Handle to a file-mapping object
    FFileSize: Integer; // Variable to hold the file size.
    FData: PByte; // Pointer to the file's data when mapped.
    PData: PChar; // Pointer used to reference the file data.
begin
    { First obtain a file handle to the file to be mapped. This code
      assumes the existence of the file. Otherwise, you can use the
      FileCreate() function to create a new file. }

    if not FileExists(FName) then
```

```
    raise Exception.Create('File does not exist.')
else
    FFileHandle := FileOpen(FName, fmOpenReadWrite);

// If CreateFile() was not successful, raise an exception
if FFileHandle = INVALID_HANDLE_VALUE then
    raise Exception.Create('Failed to open or create file');

try
    { Now obtain the file size which we will pass to the other file-
      mapping functions. We'll make this size one byte larger as we
      need to append a null-terminating character to the end of the
      mapped-file's data.}
    FFileSize := GetFileSize(FFileHandle, Nil);

    { Obtain a file-mapping object handle. If this function is not
      successful, then raise an exception. }
    FMapHandle := CreateFileMapping(FFileHandle, nil,
    PAGE_READWRITE, 0, FFileSize, nil);

    if FMapHandle = 0 then
        raise Exception.Create('Failed to create file mapping');
finally
    // Release the file handle
    CloseHandle(FFileHandle);
end;

try
    { Map the file-mapping object to a view. This will return a pointer
      to the file data. If this function is not successful, then raise
      an exception. }
    FData := MapViewOfFile(FMapHandle, FILE_MAP_ALL_ACCESS, 0, 0, FFileSize);

    if FData = Nil then
        raise Exception.Create('Failed to map view of file');

finally
    // Release the file-mapping object handle
    CloseHandle(FMapHandle);
end;

try
    { !!! Here is where you would place the functions to work with
      the mapped file's data. For example, the following line forces
      all characters in the file to uppercase }
    PData := PChar(FData);
```

LISTING 12.10 Continued

```
// Position the pointer to the end of the file's data
inc(PData, FFileSize);

// Append a null-terminating character to the end of the file's data
PData^ := #0;

// Now set all characters in the file to upper-case
if UCase then
    StrUpper(PChar(FData))
else
    StrLower(PChar(FData));

finally
    // Release the file mapping.
    UnmapViewOfFile(FData);
end;
memTextContents.Lines.Clear;
memTextContents.Lines.LoadFromFile(FName);
end;

end.
```

You'll see in Listing 12.10 that the first step is to obtain a handle to the file to be mapped to the process's region of memory. This is done by calling the `FileOpen()` function. You pass the `fmOpenReadWrite` file-access mode to this function to give you read/write access to the file's contents.

Next, you obtain the size of the file and change the last character to a null terminator. This should actually be the end-of-file marker, which is the same byte value as the null-terminator. You do it here for clarity. The point is that because you're manipulating the file's data as a null-terminating string, you need to ensure that a null-terminator is present.

The following step obtains the memory-mapping file object by calling `CreateFileMapping()`. If this function fails, you raise an exception. Otherwise, you go on to the next step to map the file-mapping object to a view. Again, you raise an exception if this function fails.

You then change the case of the data in the file. If you were to view the file in a text editor after executing this routine, you would see that the file's characters have all been converted to the selected case. Lastly, you unmap the view of the file by calling the `UnMapViewOfFile()` function.

You might have noticed that in this code, you release both the file handle and the file-mapping object's handle before you even manipulate the file's data after it has been mapped to a view.

This is possible because the system keeps a usage count on the file handle and file-mapping object when the call to `MapViewOfFile()` is made. Therefore, you can close the object up front by calling `CloseHandle()`, thus reducing the chances of causing a resource leak. Later, you'll see a more elaborate use of memory-mapped files as you build a `TMemoryMapFile` class and use it to perform text searches through text files.

Memory-Mapped File Coherence

The Win32 system ensures that multiple views of a file remain coherent as long as they're mapped using the same file-mapping object. This means that if one view modifies the contents of a file, a second view will realize those modifications. Keep in mind, however, that this is only true when using the same file-mapping objects. When you're using different file-mapping objects, multiple views are not guaranteed to be coherent. This particular problem exists only with files that are mapped for write access. Read-only files are always coherent. Also, files shared over a network are not kept coherent in write-file mappings in different machines.

The Text-File Search Utility

To illustrate a practical use of memory-mapped files, we've created a project that performs a text search on text files in the current directory. The filenames, along with the number of times a string is found in the file, are added to a list box on the main form. The main form for this project is shown in Figure 12.2. You can find this project on the CD as `FileSrch.dpr`.

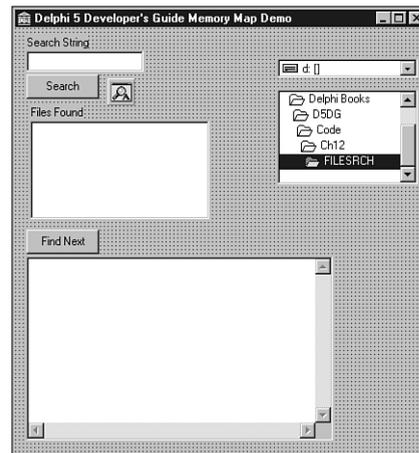


FIGURE 12.2

The main form for the text search project.

This project also illustrates how to encapsulate the functionality of memory-mapped files into an object. To show this, we've created the `TMemMapFile` class.

The TMemMapFile Class

The unit containing the TMemMapFile class is shown in Listing 12.11.

LISTING 12.11 The Source Code for MemMap.pas, the Unit Defining the TMemMapFile Class

```
unit MemMap;

interface

uses Windows, SysUtils, Classes;

type
  EMMFError = class(Exception);

  TMemMapFile = class
  private
    FFileName: String;    // File name of the mapped file.
    FSize: Longint;      // Size of the mapped view
    FFileSize: Longint;  // Actual File Size
    FFileMode: Integer;  // File access mode
    FFileHandle: Integer; // File handle
    FMapHandle: Integer; // Handle to the file mapping object.
    FData: PByte;        // Pointer to the file's data
    FMapNow: Boolean;    // Determines whether or
                        // not to map view of immediately.
    procedure AllocFileHandle;
    { Retrieves a handle to the disk file. }
    procedure AllocFileMapping;
    { Retrieves a file-mapping object handle }
    procedure AllocFileView;
    { Maps a view to the file }
    function GetSize: Longint;
    { Returns the size of the mapped view }
  public
    constructor Create(FileName: String; FileMode: integer;
                      Size: integer; MapNow: Boolean); virtual;
    destructor Destroy; override;
    procedure FreeMapping;
    property Data: PByte read FData;
    property Size: Longint read GetSize;
    property FileName: String read FFileName;
    property FileHandle: Integer read FFileHandle;
    property MapHandle: Integer read FMapHandle;
  end;

implementation
```

```

constructor TMemMapFile.Create(FileName: String; FileMode: integer;
                               Size: integer; MapNow: Boolean);
{ Creates Memory Mapped view of FileName file.
  FileName: Full pathname of file.
  FileMode: Use fmXXX constants.
  Size: size of memory map. Pass zero as the size to use the
        file's own size.
}
begin

  { Initialize private fields }
  FMapNow := MapNow;
  FFileName := FileName;
  FFFileMode := FileMode;

  AllocFileHandle; // Obtain a file handle of the disk file.
  { Assume file is < 2 gig }

  FFileSize := GetFileSize(FFFileHandle, Nil);
  FSize := Size;

  try
    AllocFileMapping; // Get the file mapping object handle.
  except
    on EMMFError do
      begin
        CloseHandle(FFFileHandle); // close file handle on error
        FFFileHandle := 0; // set handle back to 0 for clean up
        raise; // re-raise exception
      end;
    end;
    if FMapNow then
      AllocFileView; // Map the view of the file
  end;

destructor TMemMapFile.Destroy;
begin

  if FFFileHandle <> 0 then
    CloseHandle(FFFileHandle); // Release file handle.

  { Release file mapping object handle }
  if FMapHandle <> 0 then
    CloseHandle(FMapHandle);

  FreeMapping; { Unmap the file mapping view . }

```

LISTING 12.11 Continued

```
    inherited Destroy;
end;

procedure TMemMapFile.FreeMapping;
{ This method unmaps the view of the file from this process's address
  space. }
begin
    if FData <> Nil then
        begin
            UnmapViewOfFile(FData);
            FData := Nil;
        end;
end;

function TMemMapFile.GetSize: Longint;
begin
    if FSize <> 0 then
        Result := FSize
    else
        Result := FFileSize;
end;

procedure TMemMapFile.AllocFileHandle;
{ creates or opens disk file before creating memory mapped file }
begin
    if FFileMode = fmCreate then
        FFileHandle := FileCreate(FFileName)
    else
        FFileHandle := FileOpen(FFileName, FFileMode);

    if FFileHandle < 0 then
        raise EMMFError.Create('Failed to open or create file');
end;

procedure TMemMapFile.AllocFileMapping;
var
    ProtAttr: DWORD;
begin
    if FFileMode = fmOpenRead then // obtain correct protection attribute
        ProtAttr := Page_ReadOnly
    else
        ProtAttr := Page_ReadWrite;
    { attempt to create file mapping of disk file.
      Raise exception on error. }
    FMapHandle := CreateFileMapping(FFileHandle, Nil, ProtAttr,
```

```
    0, FSize, Nil);
  if FMapHandle = 0 then
    raise EMMFError.Create('Failed to create file mapping');
end;

procedure TMemMapFile.AllocFileView;
var
  Access: Longint;
begin
  if FFileMode = fmOpenRead then // obtain correct file mode
    Access := File_Map_Read
  else
    Access := File_Map_All_Access;
  FData := MapViewOfFile(FMapHandle, Access, 0, 0, FSize);
  if FData = Nil then
    raise EMMFError.Create('Failed to map view of file');
end;

end.
```

12

WORKING WITH
FILES

The commentary lists the purpose of the various fields and methods for the `TMemMapFile` class.

The class contains the methods `AllocFileHandle()`, `AllocFileMapping()`, and `AllocFileView()` to retrieve the file handle, file-mapping object handle, and a view to the specified file, respectively.

The `Create()` constructor is where the fields get initialized and the methods to allocate the various handles get called. Failure of any of those methods results in an exception being raised. The `Destroy()` destructor ensures that the view gets unmapped by calling the `UnMapViewOfFile()` method.

Using the `TMemMapFile` Class

The main form for the file-search project is shown in Listing 12.12.

LISTING 12.12 The Source Code for the Main Form for the File-Search Project

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls, Buttons, FileCtrl;

type
```

continues

LISTING 12.12 Continued

```
TMainForm = class(TForm)
  btnSearch: TButton;
  lbFilesFound: TListBox;
  edtSearchString: TEdit;
  lblSearchString: TLabel;
  lblFilesFound: TLabel;
  memFileText: TMemo;
  btnFindNext: TButton;
  FindDialog: TFindDialog;
  dcbDrives: TDriveComboBox;
  dlbDirectories: TDirectoryListBox;
  procedure btnSearchClick(Sender: TObject);
  procedure lbFilesFoundClick(Sender: TObject);
  procedure btnFindNextClick(Sender: TObject);
  procedure FindDialogFind(Sender: TObject);
  procedure edtSearchStringChange(Sender: TObject);
  procedure memFileTextChange(Sender: TObject);
public
end;

var
  MainForm: TMainForm;

implementation
uses MemMap, Search;

{$R *.DFM}

procedure TMainForm.btnSearchClick(Sender: TObject);
var
  MemMapFile: TMemMapFile;
  SearchRec: TSearchRec;
 RetVal: Integer;
  FoundStr: PChar;
  FName: String;
  FindString: String;
  WordCount: Integer;
begin
  memFileText.Lines.Clear;
  btnFindNext.Enabled := False;
  lbFilesFound.Items.Clear;

  { Retrieve each text file on which the text search is to be
    performed. Use the FindFirst/FindNext sequence on this search. }
  RetVal := FindFirst(dlbDirectories.Directory+'*.txt', faAnyFile, SearchRec);
```

```
try
  while RetVal = 0 do
  begin
    FName := SearchRec.Name;

    // Open the memory mapped file for read-only access.
    MemMapFile := TMemMapFile.Create(FName, fmOpenRead, 0, True);
  try

    { Use a temporary storage for the search string }
    FindString := edtSearchString.Text;

    WordCount := 0; // Initialize the WordCount to zero
    { Get the first occurrence of the search string }
    FoundStr := StrPos(PChar(MemMapFile.Data), PChar(FindString));

    if FoundStr <> nil then
    begin
      { Continue to search through the remaining text of the file
        for occurrences of the search string. On each find,
        increment the WordCount variable }
      repeat
        inc(WordCount);
        inc(FoundStr, Length(FoundStr));

        { Retrieve the next occurrence of the search string. }
        FoundStr := StrPos(PChar(FoundStr), PChar(FindString));
      until FoundStr = nil;
      { Add the file's name to the list box }
      lbFilesFound.Items.Add(SearchRec.Name +
        ' - '+IntToStr(WordCount));
    end;
    { Retrieve the next file on which to perform the search }
    RetVal := FindNext(SearchRec);
  finally
    MemMapFile.Free; { Free the memory mapped file instance }
  end;
end;
finally
  FindClose(SearchRec);
end;
end;

procedure TMainForm.lbFilesFoundClick(Sender: TObject);
var
  FName: String;
```

LISTING 12.12 Continued

```
    B: Byte;
begin
  with lbFilesFound do
    if ItemIndex <> -1 then
      begin
        B := Pos(' ', Items[ItemIndex]);
        FName := Copy(Items[ItemIndex], 1, B);
        memFileText.Clear;
        memFileText.Lines.LoadFromFile(FName);
      end;
    end;

  procedure TMainForm.btnFindNextClick(Sender: TObject);
  begin
    FindDialog.FindText := edtSearchString.Text;
    FindDialog.Execute;
    FindDialog.Top := Top+Height;
    FindDialogFind(FindDialog);
  end;

  procedure TMainForm.FindDialogFind(Sender: TObject);
  begin
    with Sender as TFindDialog do
      if not SearchMemo(memFileText, FindText, Options) then
        ShowMessage('Cannot find "' + FindText + '".');
    end;
  end;

  procedure TMainForm.edtSearchStringChange(Sender: TObject);
  begin
    btnSearch.Enabled := edtSearchString.Text <> EmptyStr;
  end;

  procedure TMainForm.memFileTextChange(Sender: TObject);
  begin
    btnFindNext.Enabled := memFileText.Lines.Count > 0;
  end;

end.
```

This project performs a case-sensitive search on text files in the current directory.

`btnSearchClick()` contains the code that performs the actual search, determines the number of times the specified string is found in each file, and adds the files containing the search string to `lbFilesFound`.

It first uses a `FindFirst()/FindNext()` sequence of calls to find each file with a `.txt` extension in the current directory. Both these functions are discussed later in this chapter. The method then uses a `TMemMapFile` class on the temporary file to get access to the file's data. This file is opened with read-only access because you won't be modifying it. The following lines of code perform the logic required to obtain a count of the number of times the search string occurs in the file:

```
if FoundStr <> nil then
begin
  repeat
    inc(WordCount);
    inc(FoundStr, length(FoundStr));
    FoundStr := StrPos(PChar(FoundStr), PChar(FindString))
  until FoundStr = nil;
```

Both the filename and number of occurrences of the search string in the file are added to `lbFilesFound`.

When the user double-clicks a `TListBox` item, the file is loaded into the `TMemo` control, where the user can locate each occurrence of the search string by clicking the Find Next button.

The `btnFindNext()` event handler initializes the `FindDialog.FindText` property to the string in `edtSearchString`. It then invokes `FindDialog`.

When the user clicks the Find Next button on `FindDialog`, its `OnFind` event handler gets invoked. This event handler is `FindDialogFind()`. `FindDialogFind()` uses the function `SearchMemo()`, which is defined in the unit `Search.pas`.

`SearchMemo()` scans the text of any `TCustomEdit` descendant and selects that text, which brings it into view.

NOTE

The `Search.pas` unit is a file that ships with Borland Delphi 1.0 as one of its demos. We obtained permission to include this file on the CD-ROM accompanying this book from Borland. This unit does not make use of various string-handling features because it was designed for Delphi 1.0. We did, however, make a minor change to allow a `TMemo` control to bring the caret into view, which was done automatically in Windows 3.1. In Win32, you must pass an `EM_SCROLLCARET` message to the `TMemo` control after setting its `SelStart` property. Read the comments in `Search.pas` for further information.

Directories and Drives

You can perform several tasks that you might find useful in your applications with the drives installed on a system and the directories on those drives. The next several sections cover some of these tasks.

Obtaining a List of Available Drives and Drive Types

To obtain a list of available drives on your system, you use the `GetDriveType()` Win32 API function. This function takes a `PChar` parameter and returns an integer value representing one of the drive types specified in Table 12.6.

TABLE 12.6 `GetDriveType()` Return Values

<i>Return Value</i>	<i>Meaning</i>
0	Cannot determine the drive type.
1	Root directory does not exist.
DRIVE_REMOVABLE	Drive is removable.
DRIVE_FIXED	Drive is not removable.
DRIVE_REMOTE	Drive is a remote (network) drive.
DRIVE_CDROM	Drive is a CD-ROM drive.
DRIVE_RAMDISK	Drive is a RAM disk.

Listing 12.13 illustrates how you would use the `GetDriveType()` function.

LISTING 12.13 Use of the `GetDriveType()` Function

```
procedure TMainForm.btnGetDriveTypesClick(Sender: TObject);
var
  i: Integer;
  C: String;
  DType: Integer;
  DriveString: String;
begin
  { Loop from A..Z to determine available drives }
  for i := 65 to 90 do
  begin
    C := chr(i)+':\'; // Format a string to represent the root directory.
    { Call the GetDriveType() function which returns an integer
      value representing one of the types shown in the case statement
      below }
    DType := GetDriveType(PChar(C));
```

```
{ Based on the drive type returned, format a string to add to
the listbox displaying the various drive types. }
case DType of
  0: DriveString := C+' The drive type cannot be determined.';
  1: DriveString := C+' The root directory does not exist.';
  DRIVE_REMOVABLE: DriveString :=
    C+' The drive can be removed from the drive.';
  DRIVE_FIXED: DriveString :=
    C+' The disk cannot be removed from the drive.';
  DRIVE_REMOTE: DriveString :=
    C+' The drive is a remote (network) drive.';
  DRIVE_CDROM: DriveString := C+' The drive is a CD-ROM drive.';
  DRIVE_RAMDISK: DriveString := C+' The drive is a RAM disk.';
end;
{ Only add drive types that can be determined. }
if not ((DType = 0) or (DType = 1)) then
  lbDrives.Items.AddObject(DriveString, Pointer(i));
end;
end;
```

Listing 12.13 is a simple routine that loops through all characters in the alphabet and passes them to the `GetDriveType()` function as root directories to determine whether they are valid drive types. If so, `GetDriveType()` will return which type of drive they are, which is determined by the case statement. A descriptive string is created and added to a list box along with the number representing the drive letter in the list box's `Objects` array. Only those drives that are valid are added to the list box. By the way, Delphi 5 does come with a `TDriveComboBox` component that enables you to select a drive. You'll find this on the Win 3.1 page of the Component Palette.

Obtaining Drive Information

In addition to determining the available drives and their types, you can obtain useful information on a particular drive. This information includes the following:

- Sectors per cluster
- Bytes per sector
- Number of free clusters
- Total number of clusters
- Total bytes of free disk space
- Total bytes of disk size

The first four items can be obtained by calling the `GetDiskFreeSpace()` Win32 API function. The last two items can be calculated from the information provided by `GetDiskFreeSpace()`. Listing 12.14 illustrates how you would use `GetDiskFreeSpace()`.

LISTING 12.14 Use of the `GetDiskFreeSpace()` Function

```

procedure TMainForm.lbDrivesClick(Sender: TObject);
var
  RootPath: String;           // Holds the drive root path
  SectorsPerCluster: DWord;  // Sectors per cluster
  BytesPerSector: DWord;     // Bytes per sector
  NumFreeClusters: DWord;    // Number of free clusters
  TotalClusters: DWord;      // Total clusters
  DriveByte: Byte;           // Drive byte value
  FreeSpace: Int64;          // Free space on drive
  TotalSpace: Int64;         // Total drive space.
  DriveNum: Integer;         // Drive number 1 = A, 2 = B, etc.

begin
  with lbDrives do
  begin
    { Convert the ascii value for the drive letter to a valid drive number:
      1 = A, 2 = B, etc. by subtracting 64 from the ascii value. }
    DriveByte := Integer(Items.Objects[ItemIndex])-64;
    { First create the root path string }
    RootPath := chr(Integer(Items.Objects[ItemIndex]))+'\';
    { Call GetDiskFreeSpace to obtain the drive information }
    if GetDiskFreeSpace(PChar(RootPath), SectorsPerCluster,
      BytesPerSector, NumFreeClusters, TotalClusters) then
    begin
      { If this function is successful, then update the labels to
        display the disk information. }
      lblSectPerCluster.Caption := Format('%0n', [SectorsPerCluster*1.0]);
      lblBytesPerSector.Caption := Format('%0n', [BytesPerSector*1.0]);
      lblNumFreeClust.Caption := Format('%0n', [NumFreeClusters*1.0]);
      lblTotalClusters.Caption := Format('%0n', [TotalClusters*1.0]);
      // Obtain the available disk space
      FreeSpace := DiskFree(DriveByte);
      TotalSpace := DiskSize(DriveByte);
      lblFreeSpace.Caption := Format('%0n', [FreeSpace*1.0]);
      { Calculate the total disk space }
      lblTotalDiskSpace.Caption := Format('%0n', [TotalSpace*1.0]);
    end
  else begin
    { Set labels to display nothing }
  end
end

```

```
    lblSectPerCluster.Caption := 'X';
    lblBytesPerSector.Caption := 'X';
    lblNumFreeClust.Caption := 'X';
    lblTotalClusters.Caption := 'X';
    lblFreeSpace.Caption := 'X';
    lblTotalDiskSpace.Caption := 'X';
    ShowMessage('Cannot get disk info');
end;
end;
end;
```

Listing 12.14 is the `OnClick` event handler for a list box. In fact, a sample project illustrating both the `GetDriveType()` and `GetDiskFreeSpace()` functions exists on the CD as `DrvInfo.dpr`.

In Listing 12.14, when the user clicks one of the available items in `lbDrives`, a string representing the root directory for that drive is created and passed to the `GetDiskFreeSpace()` function. If the function is successful in determining the drive information, various labels on the form are updated to reflect that information. An example of the form for the sample project just mentioned is shown in Figure 12.3.

Note that you don't use the values returned from `GetDiskFreeSpace()` to determine the drive's size or its free space. Instead, you use the `DiskFree()` and `DiskSize()` functions that are defined in `SysUtils.pas`. The reason for this is that `GetDiskFreeSpace()` is flawed in Windows 95 in that it does not report drive sizes larger than 2GB, and it reports altered sector sizes for drives larger than 1GB. The `DiskSize()` and `DiskFree()` functions use a new Win32 API to obtain the information if it's available from the operating system.

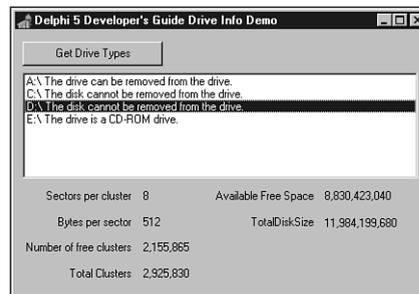


FIGURE 12.3

The main form showing drive information for available drives.

Obtaining the Location of the Windows Directory

To obtain the location of the Windows directory, you must use the `GetWindowsDirectory()` Win32 API function. This function is defined as follows:

```
function GetWindowsDirectory(lpBuffer: PChar; uSize: UINT): UINT;
```

The first parameter is a null-terminated string buffer that will hold the Windows directory location. The second parameter indicates the size of the buffer. The following code fragment illustrates how you would use this function:

```
var
  WDir: String;
begin
  SetLength(WDir, 144);
  if GetWindowsDirectory(PChar(WDir), 144) <> 0 then
  begin
    SetLength(WDir, StrLen(PChar(WDir)));
    ShowMessage(WDir);
  end
  else
    RaiseLastWin32Error;
end;
```

Notice that because we used a long-string variable, we were able to typecast it as a `PChar` type. The `GetWindowsDirectory()` function returns an integer value representing the length of the directory path. Otherwise, it returns zero, indicating that an error occurred, in which case you must call `RaiseLastWin32Error` to determine the cause.

NOTE

You'll notice in the preceding code that we added the following line after the call to `GetWindowsDirectory()`:

```
SetLength(WDir, StrLen(PChar(WDir)));
```

Whenever you pass a long string to a function by first typecasting it as a `PChar`, Delphi doesn't know that the string has been manipulated and therefore cannot update its length information. You must explicitly do this by using the technique shown, which uses `StrLen()` to search for the null-terminator to determine the string's length. It then resizes the string through `SetLength()`.

Obtaining the Location of the System Directory

You can also obtain the location of the system directory by calling the `GetSystemDirectory()` Win32 API function. `GetSystemDirectory()` works just like `GetWindowsDirectory()` except

that it returns the full path to the Windows system directory as opposed to the Windows directory. The following code fragment illustrates how you would use this function:

```
var
  SDir: String;
begin
  SetLength(SDir, 144);
  if GetSystemDirectory(PChar(SDir), 144) <> 0 then
    begin
      SetLength(SDir, StrLen(PChar(SDir)));
      ShowMessage(SDir);
    end
  else
    RaiseLastWin32Error;
end;
```

The return value of this function represents the same values from the `GetWindowsDirectory()` function.

Obtaining the Name of the Current Directory

Often, you need to obtain the current directory (that is, the directory from which your application was executed). To do this, you call the `GetCurrentDirectory()` Win32 API function. If you guess that the `GetCurrentDirectory()` operates just like the last two functions mentioned, you're absolutely right (well, sort of). There's one slight catch—the parameters are reversed. The following code fragment illustrates the use of this function:

```
var
  CDir: String;
begin
  SetLength(CDir, 144);
  if GetCurrentDirectory(144, PChar(CDir)) <> 0 then
    begin
      SetLength(CDir, StrLen(PChar(CDir)));
      ShowMessage(CDir);
    end
  else
    RaiseLastWin32Error;
end;
```

NOTE

Delphi provides the functions `CurDir()` and `ChDir()` in the `System` unit as well as the `GetCurrentDir()` and `SetCurrentDir()` functions in `SysUtils.pas`.

NOTE

Delphi comes with its own set of routines to obtain directory information on a given file. For example, the `TApplication.ExeName` property holds the full path and file-name for the running process. Assuming that this parameter holds the value "C:\Delphi\Bin\Project.exe", Table 12.7 shows the values returned from the various Delphi functions when passing the `TApplication.ExeName` property.

TABLE 12.7 Delphi File/Directory Information Function

<i>Function</i>	<i>Result of Passing "C:\Delphi\Bin\Project.exe"</i>
<code>ExtractFileDir()</code>	C:\Delphi\Bin
<code>ExtractFileDrive()</code>	C:
<code>ExtractFileExt()</code>	.exe
<code>ExtractFileName()</code>	Project1.exe
<code>ExtractFilePath()</code>	C:\Delphi\Bin\

Searching for a File Across Directories

You might at some time need to search for or perform some process on files, given a file mask across a directory and its subdirectories. Listing 12.15 illustrates how you can do this using a procedure that gets called recursively so that the subdirectories can be searched as well as the current directory. This demo exists on the CD as `DirSrch.dpr`.

NOTE

You can use the Win32 API function `SearchPath()` to search across a specified directory, the system directories, directories in the environment variable `PATH`, or a semi-colon-delimited list of directories. This function doesn't search across subdirectories of a given directory, however.

LISTING 12.15 Example of Searching Across Directories to Perform a File Search

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
```

```
Forms, Dialogs, StdCtrls, FileCtrl, Grids, Outline, DirOutln;

type
  TMainForm = class(TForm)
    dcbDrives: TDriveComboBox;
    edtFileMask: TEdit;
    lblFileMask: TLabel;
    btnSearchForFiles: TButton;
    lbFiles: TListBox;
    dolDirectories: TDirectoryOutline;
    procedure btnSearchForFilesClick(Sender: TObject);
    procedure dcbDrivesChange(Sender: TObject);
  private
    FFileName: String;
    function GetDirectoryName(Dir: String): String;
    procedure FindFiles(APath: String);
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

function TMainForm.GetDirectoryName(Dir: String): String;
{ This function formats the directory name so that it is a valid
  directory containing the back-slash (\) as the last character. }
begin
  if Dir[Length(Dir)] <> '\' then
    Result := Dir + '\'
  else
    Result := Dir;
end;

procedure TMainForm.FindFiles(APath: String);
{ This is a procedure which is called recursively so that it finds the
  file with a specified mask through the current directory and its
  sub-directories. }
var
  FSearchRec,
  DSearchRec: TSearchRec;
  FindResult: integer;

  function IsDirNotation(ADirName: String): Boolean;
  begin
```

LISTING 12.15 Continued

```

    Result := (ADirName = '.') or (ADirName = '..');
end;

begin
    APath := GetDirectoryName(APath); // Obtain a valid directory name
    { Find the first occurrence of the specified file name }
    FindResult := FindFirst(APath+FFileName,faAnyFile+faHidden+
        faSysFile+faReadOnly,FSearchRec);

    try
        { Continue to search for the files according to the specified
          mask. If found, add the files and their paths to the listbox.}
        while FindResult = 0 do
            begin
                lbFiles.Items.Add(LowerCase(APath+FSearchRec.Name));
                FindResult := FindNext(FSearchRec);
            end;

            { Now search the sub-directories of this current directory. Do this
              by using FindFirst to loop through each subdirectory, then call
              FindFiles (this function) again. This recursive process will
              continue until all sub-directories have been searched. }
            FindResult := FindFirst(APath+'*.*', faDirectory, DSearchRec);

            while FindResult = 0 do
                begin
                    if ((DSearchRec.Attr and faDirectory) = faDirectory) and not
                        IsDirNotation(DSearchRec.Name) then
                        FindFiles(APath+DSearchRec.Name); // Recursion here
                        FindResult := FindNext(DSearchRec);
                    end;
                finally
                    FindClose(FSearchRec);
                end;
            end;
        end;

    procedure TMainForm.btnSearchForFilesClick(Sender: TObject);
    { This method starts the searching process. It first changes the cursor
      to an hourglass since the process may take awhile. It then clears the
      listbox and calls the FindFiles() function which will be called
      recursively to search through sub-directories }
    begin
        Screen.Cursor := crHourGlass;
        try
            lbFiles.Items.Clear;
            FFileName := edtFileMask.Text;
            FindFiles(dolDirectories.Directory);
        end;
    end;
end;

```

```

finally
    Screen.Cursor := crDefault;
end;
end;

procedure TMainForm.dcbDrivesChange(Sender: TObject);
begin
    dcbDirectories.Drive := dcbDrives.Drive;
end;

end.

```

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In the `FindFiles()` method, the first `while..do` construct searches for files in the current directory specified by the `APath` parameter and then adds the files and their paths to `lbFiles`. The second `while..do` construct finds the subdirectories in the current directory and appends them to the `APath` variable. The `FindFiles()` method then passes `APath`, now with a subdirectory name, to itself, resulting in a recursive call. This process continues until all subdirectories have been searched through.

Figure 12.4 shows the results of a file search for all PAS files in the Delphi 5 Code directory.

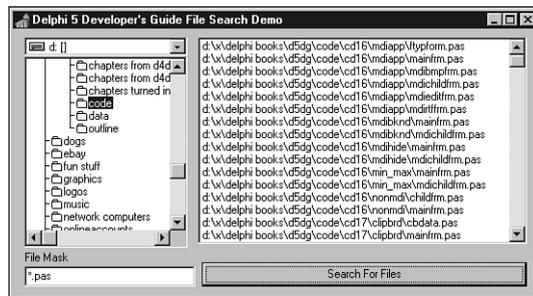


FIGURE 12.4

The result of a file search across directories.

Two Object Pascal structures and two functions merit mention here. First, we'll talk about the `TSearchRec` structure and the `FindFirst()` and `FindNext()` functions. Then, we'll discuss the `TWin32FindData` structure.

Copying and Deleting a Directory Tree

Before Win32, you were required to parse a directory tree and use the `FindFirst()/FindNext()` pairs to copy a directory to another location. Now you can use the

ShFileOperation() Win32 function, which greatly simplifies the process. The following code illustrates a function that uses the ShFileOperation() API to perform a directory copy operation. This function is well documented in the Win32 online help, so we won't repeat that information here. Instead, we suggest that you give it a readthrough. Note the inclusion of the ShellAPI unit in the uses clause. Here's the code:

```
uses
  ShellAPI;

procedure CopyDirectoryTree(AHandle: THandle; AFromDir, AToDir: String);
var
  SHFileOpStruct: TSHFileOpStruct;
begin
  with SHFileOpStruct do
  begin
    Wnd      := AHandle;
    wFunc    := FO_COPY;
    pFrom    := PChar(AFromDir);
    pTo      := PChar(AToDir);
    fFlags   := FOF_NOCONFIRMATION or FOF_RENAMEONCOLLISION;
    fAnyOperationsAborted := False;
    hNameMappings := nil;
    lpszProgressTitle := nil;
  end;
  ShFileOperation(SHFileOpStruct);
end;
```

The ShFileOperation() function can also be used to move a directory to the Recycle Bin, as illustrated here:

```
uses ShellAPI;

procedure ToRecycle(AHandle: THandle; AFileName: SString);
var
  SHFileOpStruct: TSHFileOpStruct;
begin
  with SHFileOpStruct do
  begin
    Wnd      := AHandle;
    wFunc    := FO_DELETE;
    pFrom    := PChar(AFileName);
    fFlags   := FOF_ALLOWUNDO;
  end;
  ShFileOperation(SHFileOpStruct);
end;
```

We will discuss the SHFileOperation() in greater detail later in this chapter.

The TSearchRec Record

The TSearchRec record defines data returned by the FindFirst() and FindNext() functions. Object Pascal defines this record as the following:

```
TSearchRec = record
    Time: Integer;
    Size: Integer;
    Attr: Integer;
    Name: TFileName;
    ExcludeAttr: Integer;
    FindHandle: THandle;
    FindData: TWin32FindData;
end;
```

TSearchRec's fields are modified by the aforementioned functions when the file is found.

The Time field contains the file time of creation or modification. The Size field contains the size of the file in bytes. The Name field holds the name of the file. The Attr field contains one or more of the file attributes shown in Table 12.8.

TABLE 12.8 File Attributes

<i>Attribute</i>	<i>Value</i>	<i>Description</i>
faReadOnly	\$01	Read-only file
faHidden	\$02	Hidden file
faSysFile	\$04	System file
faVolumeID	\$08	Volume ID file
faDirectory	\$10	Directory
faArchive	\$20	Archive file
faAnyFile	\$3F	Any file

The FindHandle and ExcludeAttr fields are used internally by FindFirst() and FindNext(). You need not concern yourself with these fields.

Both FindFirst() and FindNext() take a path as a parameter that can contain wildcard characters—for example, C:\DELPHI 5\BIN*.EXE means all files with an .EXE extension in the C:\DELPHI 5\BIN\ directory. The Attr parameter specifies the file attributes on which to search. Suppose that you want to search on system files only; you would invoke FindFirst() and/or FindNext(), as in this code:

```
FindFirst(Path, faSysFile, SearchRec);
```

The TWin32FindData Record

The TWin32FindData record contains information about the found file or subdirectory. This record is defined as follows:

```
TWin32FindData = record
    dwFileAttributes: DWORD;
    ftCreationTime: TFileTime;
    ftLastAccessTime: TFileTime;
    ftLastWriteTime: TFileTime;
    nFileSizeHigh: DWORD;
    nFileSizeLow: DWORD;
    dwReserved0: DWORD;
    dwReserved1: DWORD;
    cFileName: array[0..MAX_PATH - 1] of AnsiChar;
    cAlternateFileName: array[0..13] of AnsiChar;
end;
```

Table 12.9 shows the meaning of TWin32FindData's fields.

TABLE 12.9 TWin32FindData Field Meanings

<i>Field</i>	<i>Meaning</i>
dwFileAttributes	The file attributes for the found file. See the online help under WIN32_FIND_DATA for more information.
FtCreationTime	The time the file was created.
FtLastAccessTime	The time the file was last accessed.
FtLastWriteTime	The time the file was last modified.
NFileSizeHigh	The high-order DWORD of the file size in bytes. This value is zero unless the file is larger than MAXDWORD.
NFileSizeLow	The low-order DWORD of the file size in bytes.
DwReserved0	Not currently used (reserved).
DwReserved1	Not currently used (reserved).
CFileName	Null-terminated filename.
CAlternateFileName	An 8.3 formatted name, a truncation of the long filename.

Getting File Version Information

It's possible to extract version information from EXE and DLL files that contain the version information resource. In the following sections, you create a class that encapsulates the functionality to extract the version information resource, and you use that class in a sample project.

Defining the TVerInfoRes Class

The TVerInfoRes class encapsulates three Win32 API functions for extracting version information from files that contain version information. These functions are GetFileVersionInfoSize(), GetFileVersionInfo() and VerQueryValue(). Version information on a file may include data such as company name, file description, version, and comments, just to name a few. The data that TVerInfoRes retrieves is as follows:

- *Company name.* The name of the company that created the file
- *Comments.* Any additional comments that may be attached to the file
- *File description.* A description of the file
- *File version.* A version number
- *Internal name.* An internal name as defined by the company generating the file
- *Legal copyright.* All copyright notices that apply to the file
- *Legal trademarks.* Legal trademarks that apply to the file
- *Original filename.* The original filename (if any)

The unit that defines the TVerInfoRes class, VERINFO.PAS, is shown in Listing 12.16.

LISTING 12.16 The Source Code for VERINFO.PAS, the TVerInfoRes Class Definition

```
unit VerInfo;

interface

uses SysUtils, WinTypes, Dialogs, Classes;

type
  { define a generic exception class for version info, and an exception
    to indicate that no version info is available. }
  EVerInfoError = class(Exception);
  ENoVerInfoError = class(Exception);
  eNoFixeVerInfo = class(Exception);

  // define enum type representing different types of version info
  TVerInfoType =
    (viCompanyName,
     viFileDescription,
     viFileVersion,
     viInternalName,
     viLegalCopyright,
     viLegalTrademarks,
     viOriginalFilename,
```

LISTING 12.16 Continued

```
        viProductName,
        viProductVersion,
        viComments);

const

    // define an array constant of strings representing the pre-defined
    // version information keys.
VerNameArray: array[viCompanyName..viComments] of String[20] =
('CompanyName',
 'FileDescription',
 'FileVersion',
 'InternalName',
 'LegalCopyright',
 'LegalTrademarks',
 'OriginalFilename',
 'ProductName',
 'ProductVersion',
 'Comments');

type

    // Define the version info class
TVerInfoRes = class
private
    Handle          : DWord;
    Size            : Integer;
    RezBuffer       : String;
    TransTable      : PLongint;
    FixedFileInfoBuf : PVSFixedFileInfo;
    FFileFlags      : TStringList;
    FFileName       : String;
    procedure FillFixedFileInfoBuf;
    procedure FillFileVersionInfo;
    procedure FillFileMaskInfo;
protected
    function GetFileVersion   : String;
    function GetProductVersion: String;
    function GetFileOS        : String;
public
    constructor Create(AFileName: String);
    destructor Destroy; override;
    function GetPreDefKeyString(AVerKind: TVerInfoType): String;
    function GetUserDefKeyString(AKey: String): String;
    property FileVersion      : String read GetFileVersion;
```

```
    property ProductVersion : String read GetProductVersion;
    property FileFlags      : TStringList read FFileFlags;
    property FileOS        : String read GetFileOS;
end;

implementation

uses Windows;

const
    // strings that must be fed to VerQueryValue() function
    SFInfo          = '\StringFileInfo\';
    VerTranslation: PChar = '\VarFileInfo\Translation';
    FormatStr       = '%s%.4x%.4x\%s%s';

constructor TVerInfoRes.Create(AFileName: String);
begin
    FFileName := aFileName;
    FFileFlags := TStringList.Create;
    // Get the file version information
    FillFileVersionInfo;
    //Get the fixed file info
    FillFixedFileInfoBuf;
    // Get the file mask values
    FillFileMaskInfo;
end;

destructor TVerInfoRes.Destroy;
begin
    FFileFlags.Free;
end;

procedure TVerInfoRes.FillFileVersionInfo;
var
    SBSize: UInt;
begin
    // Determine size of version information
    Size := GetFileVersionInfoSize(PChar(FFileName), Handle);
    if Size <= 0 then { raise exception if size <= 0 }
        raise ENoVerInfoError.Create('No Version Info Available. ');

    // Set the length accordingly
    SetLength(RezBuffer, Size);
    // Fill the buffer with version information, raise exception on error
```

LISTING 12.16 Continued

```
    if not GetFileVersionInfo(PChar(FFFileName), Handle, Size,
    ↪PChar(RezBuffer)) then
        raise EVerInfoError.Create('Cannot obtain version info.');
```

```
    // Get translation info, raise exception on error
    if not VerQueryValue(PChar(RezBuffer), VerTranslation, pointer(TransTable),
    SBSize) then
        raise EVerInfoError.Create('No language info.');
```

```
end;
```

```
procedure TVerInfoRes.FillFixedFileInfoBuf;
var
    Size: Longint;
begin
    if VerQueryValue(PChar(RezBuffer), '\', pointer(FixedFileInfoBuf),
    ↪Size) then begin
        if Size < SizeOf(TVSFixedFileInfo) then
            raise eNoFixeVerInfo.Create('No fixed file info');
```

```
        end
    else
        raise eNoFixeVerInfo.Create('No fixed file info')
    end;
```

```
procedure TVerInfoRes.FillFileMaskInfo;
begin
    with FixedFileInfoBuf^ do begin
        if (dwFileFlagsMask and dwFileFlags and VS_FF_PRERELEASE) <> 0 then
            FFileFlags.Add('Pre-release');
```

```
        if (dwFileFlagsMask and dwFileFlags and VS_FF_PRIVATEBUILD) <> 0 then
            FFileFlags.Add('Private build');
```

```
        if (dwFileFlagsMask and dwFileFlags and VS_FF_SPECIALBUILD) <> 0 then
            FFileFlags.Add('Special build');
```

```
        if (dwFileFlagsMask and dwFileFlags and VS_FF_DEBUG) <> 0 then
            FFileFlags.Add('Debug');
```

```
    end;
```

```
end;
```

```
function TVerInfoRes.GetPreDefKeyString(AVerKind: TVerInfoType): String;
var
    P: PChar;
    S: UInt;
begin
    Result := Format(FormatStr, [SfInfo, LoWord(TransTable^), HiWord(TransTable^),
    VerNameArray[aVerKind], #0]);
    // get and return version query info, return empty string on error
```

```

    if VerQueryValue(PChar(RezBuffer), @Result[1], Pointer(P), S) then
        Result := StrPas(P)
    else
        Result := '';
end;

function TVerInfoRes.GetUserDefKeyString(AKey: String): String;
var
    P: Pchar;
    S: UInt;
begin
    Result := Format(FormatStr, [SfInfo, LoWord(TransTable^), HiWord(TransTable^),
        aKey, #0]);
    // get and return version query info, return empty string on error
    if VerQueryValue(PChar(RezBuffer), @Result[1], Pointer(P), S) then
        Result := StrPas(P)
    else
        Result := '';
end;

function VersionString(Ms, Ls: Longint): String;
begin
    Result := Format('%d.%d.%d.%d', [HIWORD(Ms), LOWORD(Ms),
        HIWORD(Ls), LOWORD(Ls)]);
end;

function TVerInfoRes.GetFileVersion: String;
begin
    with FixedFileInfoBuf^ do
        Result := VersionString(dwFileVersionMS, dwFileVersionLS);
end;

function TVerInfoRes.GetProductVersion: String;
begin
    with FixedFileInfoBuf^ do
        Result := VersionString(dwProductVersionMS, dwProductVersionLS);
end;

function TVerInfoRes.GetFileOS: String;
begin
    with FixedFileInfoBuf^ do
        case dwFileOS of
            VOS_UNKNOWN: // Same as VOS__BASE
                Result := 'Unknown';
            VOS_DOS:

```

*continues***12****WORKING WITH
FILES**

LISTING 12.16 Continued

```
        Result := 'Designed for MS-DOS';
VOS_OS216:
        Result := 'Designed for 16-bit OS/2';
VOS_OS232:
        Result := 'Designed for 32-bit OS/2';
VOS_NT:
        Result := 'Designed for Windows NT';

VOS__WINDOWS16:
        Result := 'Designed for 16-bit Windows';
VOS__PM16:
        Result := 'Designed for 16-bit PM';
VOS__PM32:
        Result := 'Designed for 32-bit PM';
VOS__WINDOWS32:
        Result := 'Designed for 32-bit Windows';

VOS_DOS_WINDOWS16:
        Result := 'Designed for 16-bit Windows, running on MS-DOS';
VOS_DOS_WINDOWS32:
        Result := 'Designed for Win32 API, running on MS-DOS';
VOS_OS216_PM16:
        Result := 'Designed for 16-bit PM, running on 16-bit OS/2';
VOS_OS232_PM32:
        Result := 'Designed for 32-bit PM, running on 32-bit OS/2';
VOS_NT_WINDOWS32:
        Result := 'Designed for Win32 API, running on Windows/NT';
else
        Result := 'Unknown';
end;
end;

end.
```

TVerInfoRes contains the required fields and encapsulates the appropriate Win32 API routines to obtain version information from any file. The file from which the version information is to be obtained is specified by passing the filename as AFileName to the TVerInfoRes.Create() constructor. This filename is assigned to the field FFileName, which is used in another routine to actually extract the version information. The constructor then calls three methods, FillFileVersionInfo(), FillFixedFileInfoBuf(), and FillFileMaskInfo().

The FillFileVersionInfo() Method

The `FillFileVersionInfo()` method performs the initial work of loading the version information before you can start to examine the version information specifics. This method first determines whether the file even has version information and, if so, its size. The size is necessary to determine how much memory to allocate to hold this information when it's retrieved. The Win32 API function `GetFileVersionInfoSize()` determines the size of the version information contained in a file. This function is declared as follows:

```
function GetFileVersionInfoSize(lpstrFilename: PChar;  
var lpdwHandle: DWORD): DWORD; stdcall;
```

The `lpstrFileName` parameter refers to the file from which the version information is to be obtained. The `lpdwHandle` parameter is a `DWORD` variable that's set to zero when the function is called. As far as we can determine, this variable serves no other purpose.

`FillFileVersionInfo()` passes `FFilename` to `GetFileVersionInfoSize()`; if the return value, stored in the `Size` variable, is greater than zero, a buffer, `RezBuffer`, is allocated to store `Size` bytes.

After memory for `RezBuffer` has been allocated, it's passed to the function `GetFileVersionInfo()`, which actually fills `RezBuffer` with the version information. `GetFileVersionInfo()` is declared as follows:

```
function GetFileVersionInfo(lpstrFilename: PChar; dwHandle,  
dwLen: DWORD; lpData: Pointer): BOOL; stdcall;
```

The `lpstrFileName` parameter takes the filename of the file, `FFilename`. `DwHandle` is ignored. `DwLen` is the return value from `GetFileVersionInfoSize()`, which was stored in the variable `Size`. `lpData` is a pointer to the buffer that holds the version information. If `GetFileVersionInfo()` does not succeed in retrieving the version information, it returns `False`; otherwise, `True` is returned.

Finally, the `FillFileVersionInfo()` method calls the API function `VerQueryValue()`, which is used to return selected version information from the version information resource. In this instance, `VerQueryValue()` is called to retrieve a pointer to the language and character set identifier array. This array is used in subsequent calls to `VerQueryValue()` to access version information in the language-specific `StringTable` in the version information resource.

`VerQueryValue()` is declared as follows:

```
function VerQueryValue(pBlock: Pointer; lpSubBlock: PChar;  
var lpIpBuffer: Pointer; var puLen: UINT): BOOL; stdcall;
```

The parameter `pBlock` refers to the `lpData` parameter, which was passed to `GetFileVersionInfo()`. `lpSubBlock` is a null-terminated string that specifies which version

information value to retrieve. You might take a look at the online help for `VerQueryValue()`, which describes the various strings that can be passed to `VerQueryValue()`. In the case of the preceding example, the string `"\VarFileInfo\Translation"` is passed as the `lpSubBlock` parameter to retrieve the language and character set translation information. The `lpBuffer` parameter points to the buffer that holds the version information value. The `puLen` parameter contains the length of the data retrieved.

The `FillFixedFileInfoBuf()` Method

The `FillFixedFileInfoBuf()` method illustrates how to use `VerQueryValue()` to obtain a pointer to the `VS_FIXEDFILEINFO` structure, which contains the version information about the file. This is done by passing the string `"\"` as the `lpSubBlock` parameter to the `VerQueryValue()` function. This pointer is stored in the `TVerInfoRes.FixedFileInfoBuf` field.

The `FillFileMaskInfo()` Method

The `FillFileMaskInfo()` method illustrates how to obtain module attributes. This is handled by performing the appropriate bitmask operation on the `dwFileFlagsMask` and `dwFileFlags` fields of `FixedFileInfoBuf` as well as on the specific flag being evaluated. We won't get into the specifics as to the meaning of these flags. If you're interested, the online help for the Version Info page of the Project Options dialog box explains this in detail.

The `GetPreDefKeyString()` and `GetUserDefKeyString()` Methods

The `GetPreDefKeyString()` and `GetUserDefKeyString()` methods illustrate how to use the `VerQueryValue()` function to retrieve the version information strings that are entered into the key table on the Version Info page of the Project Options dialog box. By default, the Win32 API provides 10 predefined strings that we've placed into the `VerNameArray` constant. To retrieve a specific string, you must pass as the `lpSubBlock` parameter of `VerQueryValue()` the string `"\StringFileInfo\lang-charset\string-name"`. The `lang-charset` string refers to the language and character set identifier previously retrieved in the `FillFileVersionInfo()` method and referred to by the `TransTable` field. The `string-name` string refers to one of the predefined string constants in `VerNameArray`. `GetPreDefKeyString()` handles retrieving the predefined version information strings.

`GetUserDefKeyString()` is similar in functionality to `GetPreDefKeyString()` except that the key string must be passed in as a parameter. The value of the `lpSubBlock` string is constructed in this method, using the `AKey` parameter as the key.

Getting the Version Numbers

The `GetFileVersion()` and `GetProductVersion()` methods illustrate how to obtain the file and product version numbers for a file.

The `FixedFileInfoBuf` structure contains fields that refer to the version number of the file itself as well as the version number of the product with which the file may be distributed. These version numbers are stored in a 64-bit number. The most significant and least significant 32 bits are retrieved separately by using different fields.

The file's binary version number is stored in the fields `dwFileVersionMS` and `dwFileVersionLS`. The version number for the product with which a file is distributed is stored in the `dwProductVersionMS` and `dwProductVersionLS` fields.

The `GetFileVersion()` and `GetProductVersion()` methods return a string representing the version number for a given file. They both use a helper function, `VersionString()`, to properly format the string.

Getting the Operating System Information

The `GetFileOS()` method illustrates how to determine for which operating system the file was designed. This is accomplished by examining the `dwFileOS` field of the `FixedFileInfoBuf` structure. For more information on the meaning of the various values that can be assigned to `dwFileOS`, examine the online API help for `VS_FIXEDFILEINFO`.

Using the `TVerInfoRes` Class

We created the project `VerInfo.dpr` to illustrate the use of the `TVerInfoRes` class. Listing 12.17 shows the source for this project's main form.

LISTING 12.17 The Source Code for the Version Information Demo Main Form

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, FileCtrl, StdCtrls, verinfo, Grids, Outline, DirOutln,
  ComCtrls;

type
  TMainForm = class(TForm)
    lvVersionInfo: TListView;
    btnClose: TButton;
    procedure FormDestroy(Sender: TObject);
    procedure FormShow(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure btnCloseClick(Sender: TObject);
```

continues

LISTING 12.17 Continued

```
private
  VerInfoRes: TVerInfoRes;
end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure AddListViewItem(const aCaption, aValue: String; aData: Pointer;
  aLV: TListView);
// This method is used to add a TListItem to the TListView, aLV
var
  NewItem: TListItem;
begin
  NewItem := aLV.Items.Add;
  NewItem.Caption := aCaption;
  NewItem.Data := aData;
  NewItem.SubItems.Add(aValue);
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
  VerInfoRes := TVerInfoRes.Create(Application.ExeName);
end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
  VerInfoRes.Free;
end;

procedure TMainForm.FormShow(Sender: TObject);
var
  VerString: String;
  i: integer;
  sFFlags: String;

begin
  for i := ord(viCompanyName) to ord(viComments) do begin
    VerString := VerInfoRes.GetPreDefKeyString(TVerInfoType(i));
    if VerString <> '' then
      AddListViewItem(VerNameArray[TVerInfoType(i)], VerString, nil,
        lvVersionInfo);
  end;
end;
```


Using the SHFileOperation() Function

A very useful Windows API function is `SHFileOperation()`. This function uses a `SHFILEOPSTRUCT` structure to perform copy, move, rename, or delete operations on any file system object, such as files and directories. The Win32 API help file documents this structure well, so we won't repeat that information here. We will, however, show a few useful and frequently requested techniques on using this function to copy an entire directory to another location and to delete a file so that it's placed into the Windows Recycle Bin.

Copying a Directory

Listing 12.18 is a procedure we wrote to copy a directory tree from one location to another.

LISTING 12.18 The `CopyDirectoryTree()` Procedure

```
procedure CopyDirectoryTree(AHandle: THandle;
  const AFromDirectory, AToDirectory: String);
var
  SHFileOpStruct: TSHFileOpStruct;
  FromDir: PChar;
  ToDir: PChar;
begin
  GetMem(FromDir, Length(AFromDirectory)+2);
  try
    GetMem(ToDir, Length(AToDirectory)+2);
    try

      FillChar(FromDir^, Length(AFromDirectory)+2, 0);
      FillChar(ToDir^, Length(AToDirectory)+2, 0);

      StrCopy(FromDir, PChar(AFromDirectory));
      StrCopy(ToDir, PChar(AToDirectory));

      with SHFileOpStruct do
      begin
        Wnd := AHandle; // Assign the window handle
        wFunc := FO_COPY; // Specify a file copy
        pFrom := FromDir;
        pTo := ToDir;
        fFlags := FOF_NOCONFIRMATION or FOF_RENAMEONCOLLISION;
        fAnyOperationsAborted := False;
        hNameMappings := nil;
        lpszProgressTitle := nil;
        if SHFileOperation(SHFileOpStruct) <> 0 then
          RaiseLastWin32Error;
```

```
    end;
  finally
    FreeMem(ToDir, Length(AToDirectory)+2);
  end;
  finally
    FreeMem(FromDir, Length(AFromDirectory)+2);
  end;
end;
```

The `CopyDirectoryTree()` procedure takes three parameters. The first, `AHandle`, is the handle of a dialog box owner that would display any status information about the file operation. The remaining two parameters are the source and destination directory locations. Since Windows API functions work with `PChars`, we simply copy these two locations into `PChar` variables after we allocate memory for the `PChars`. Then, we assign these values to the `pFrom` and `pTo` members of the `SHFileOpStruct` structure. Note the assignment to the `wFunc` member as `FO_COPY`. This is what instructs `SHFileOperation` of the type of operation to perform. The remaining members are explained in the online help. On the call to `SHFileOperation()`, the source directory would be moved to the destination specified by the `AToDirectory` parameter.

Moving Files and Directories to the Recycle Bin.

Listing 12.19 shows a similar technique to that preceding listing, except that this shows how you might move a file to the Windows Recycle Bin.

LISTING 12.19 The `ToRecycle()` Procedure

```
procedure ToRecycle(AHandle: THandle; const ADirName: String);
var
  SHFileOpStruct: TSHFileOpStruct;
  DirName: PChar;
  BufferSize: Cardinal;
begin
  BufferSize := Length(ADirName) + 1 + 1;
  GetMem(DirName, BufferSize);
  try
    FillChar(DirName^, BufferSize, 0);
    StrCopy(DirName, PChar(ADirName));

    with SHFileOpStruct do
      begin
        Wnd := AHandle;
        wFunc := FO_DELETE;
        pFrom := DirName;
        pTo := nil;
      end;
    end;
  end;
end;
```

continues

LISTING 12.19 Continued

```
fFlags := FOF_ALLOWUNDO;

fAnyOperationsAborted := False;
hNameMappings := nil;
lpszProgressTitle := nil;
end;

if SHFileOperation(SHFileOpStruct) <> 0 then
  RaiseLastWin32Error;
finally
  FreeMem(DirName, BufferSize);
end;
end;
```

You'll notice that there's not much of a difference between this procedure and the previous except that the `wFunc` member is assigned `FO_DELETE` and the `pTo` member is set to `nil`. The `pTo` member is ignored by the `SHFileOperation()` function on a delete operation. Also, because the `FOF_ALLOWUNDO` flag is added to the `fFlags` member, the function will move the file to the Recycle Bin to allow for undoing the operation.

Examples of both of these operations are included on the CD in the `SHFileOp.dpr` project.

Summary

This chapter gave you a substantial amount of information on working with files, directories, and drives. You learned how to manipulate different file types. The chapter illustrated the technique of descending from Delphi's `TFileStream` class to encapsulate record-file I/O. It even showed you how to use Win32's memory-mapped files. You created a `TMemMapFile` class to encapsulate the memory-mapped functionality. Finally, the chapter demonstrated how to retrieve version information from a file containing such information.

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There comes a time when you must step off the beaten path to accomplish a particular goal. This chapter teaches you some advanced techniques you can use in your Delphi applications. You get much closer to the Win32 API in this chapter than you do in most of the other chapters, and you explore some things that aren't obvious or aren't provided under the Visual Component Library (VCL). You learn about concepts such as window procedures, multiple program instances, Windows hooks, and sharing Delphi and C++ code.

Advanced Application Message Handling

As discussed in Chapter 5, “Understanding Windows Messaging,” a *window procedure* is a function that Windows calls whenever a particular window receives a message. Because the `TApplication` object contains a window, it has a window procedure that's called to receive all the messages sent to your application. The `TApplication` class even comes equipped with an `OnMessage` event that notifies you whenever one of these messages comes down the pike.

Well...not exactly.

`TApplication.OnMessage` fires only when a message is retrieved from the application's message queue (again, refer to Chapter 5, for a discussion of all this message terminology). Messages found in the application queue are typically those dealing with window management (`WM_PAINT` and `WM_SIZE`, for example) and those posted to the window by using an API function such as `PostMessage()`, `PostAppMessage()`, or `BroadcastSystemMessage()`. The problem arises when other types of messages are sent directly to the window procedure by Windows or by the `SendMessage()` function. When this occurs, the `TApplication.OnMessage` event never happens, and there's no way to know whether the message occurred based on this event.

Subclassing

To know when a message is sent to your application, you must replace the `Application` window's procedure with your own. In your window procedure, you should do whatever processing or message handling you need to do before passing the message to the original window procedure. This process is known as *subclassing* a window.

You can use the `SetWindowLong()` Win32 API function with the `GWL_WNDPROC` constant to set a new window procedure function for a window. The window procedure function itself can have one of two formats: It can follow the API definition of a window procedure, or you can take advantage of some Delphi helper functions and make the window procedure a special method referred to as a *window method*.

CAUTION

A problem that can arise when you subclass the window procedure of a VCL window is that the handle of the window can be re-created beneath you, thus causing your application to fail. Beware of using this technique if there's a chance the window handle of the window you're subclassing will be re-created. A safer technique is to use `Application.HookMainWindow()`, which is shown later in this chapter.

A Win32 API Window Procedure

An API window procedure must have the following declaration:

```
function AWndProc(Handle: hWnd; Msg, wParam, lParam: Longint):  
    Longint; stdcall;
```

The `Handle` parameter identifies the destination window, the `Msg` parameter is the window message, and the `wParam` and `lParam` parameters contain additional message-specific information. This function returns a value that depends on the message received. Note carefully that this function must use the `stdcall` calling convention.

You can use the `SetWindowLong()` function to set the window procedure of `Application`'s window, as shown here:

```
var  
    WProc: Pointer;  
begin  
    WProc := Pointer(SetWindowLong(Application.Handle, GWL_WNDPROC,  
        Integer(@NewWndProc)));
```

After this call, `WProc` will hold a pointer to the old window procedure. It's necessary to save this value because you must pass on any messages you don't handle yourself to the old window procedure using the `CallWindowProc()` API function. The following code gives you an idea of the implementation of the window procedure:

```
function NewWndProc(Handle: hWnd; Msg, wParam, lParam: Longint):  
    Longint; stdcall;  
begin  
    { Check value of Msg, and perform whatever type of action you'd }  
    { like depending on the value of the message. For messages you }  
    { don't explicitly handle, you must pass the message information }  
    { on to the original window procedure as shown below: }  
    Result := CallWindowProc(WProc, Application.Handle, Msg, wParam,  
        lParam);  
end;
```

Listing 13.1 shows the `ScWndProc.pas` unit, which subclasses `Application`'s window procedure to handle a user-defined message called `DDGM_FOMSG`.

LISTING 13.1 `ScWndProc.pas`

```
unit ScWndProc;

interface

uses Forms, Messages;

const
  DDGM_FOMSG = WM_USER;

implementation

uses Windows, SysUtils, Dialogs;

var
  WProc: Pointer;

function NewWndProc(Handle: hWnd; Msg, wParam, lParam: Longint): Longint;
  stdcall;
{ This is a Win32 API-level window procedure. It handles the messages }
{ received by the Application window. }
begin
  if Msg = DDGM_FOMSG then
    { If it's our user-defined message, then alert the user. }
    ShowMessage(Format('Message seen by WndProc! Value is: %x', [Msg]));
    { Pass message on to old window procedure }
    Result := CallWindowProc(WProc, Handle, Msg, wParam, lParam);
  end;

initialization
  { Set window procedure of Application window. }
  WProc := Pointer(SetWindowLong(Application.Handle, gw1_WndProc,
    Integer(@NewWndProc)));
end.
```

CAUTION

Be sure to save the old window procedure returned by `GetWindowLong()`. If you don't call the old window procedure inside your subclassed window procedure for messages that you don't want to handle, you're likely to crash your application, and you might even crash the operating system.

A Delphi Window Method

Delphi provides a function called `MakeObjectInstance()` that bridges the gap between an API window procedure and a Delphi method. `MakeObjectInstance()` enables you to create a method of type `TWndMethod` to serve as the window procedure. `MakeObjectInstance()` is declared in the `Forms` unit as follows:

```
function MakeObjectInstance(Method: TWndMethod): Pointer;
```

`TWndMethod` is defined in the `Forms` unit as follows:

```
type  
  TWndMethod = procedure(var Message: TMessage) of object;
```

The return value of `MakeObjectInstance()` is a `Pointer` to the address of the newly created window procedure. This is the value you pass as the last parameter to `SetWindowLong()`. You should free any window methods created with `MakeObjectInstance()` by using the `FreeObjectInstance()` function.

As an illustration, the project called `WinProc.dpr` demonstrates both techniques for subclassing the `Application` window procedure and its advantages over `Application.OnMessage`. The main form for this project is shown in Figure 13.1.



FIGURE 13.1

WinProc's main form.

Listing 13.2 shows the source code for `Main.pas`, the main unit for the `WinProc` project.

LISTING 13.2 The Source Code for `Main.pas`

```
unit Main;  
  
interface  
  
uses  
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,  
  Forms, Dialogs, StdCtrls;  
  
type  
  TMainForm = class(TForm)  
    SendBtn: TButton;  
    PostBtn: TButton;
```

continues

LISTING 13.2 Continued

```
    procedure SendBtnClick(Sender: TObject);
    procedure PostBtnClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
private
    OldWndProc: Pointer;
    WndProcPtr: Pointer;
    procedure WndMethod(var Msg: TMessage);
    procedure HandleAppMessage(var Msg: TMsg; var Handled: Boolean);
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

uses ScWndProc;

procedure TMainForm.HandleAppMessage(var Msg: TMsg;
    var Handled: Boolean);
{ OnMessage handler for Application object. }
begin
    if Msg.Message = DDGM_FOOSMSG then
        { if it's the user-defined message, then alert the user. }
        ShowMessage(Format('Message seen by OnMessage! Value is: %x',
            [Msg.Message]));
end;

procedure TMainForm.WndMethod(var Msg: TMessage);
begin
    if Msg.Msg = DDGM_FOOSMSG then
        { if it's the user-defined message, then alert the user. }
        ShowMessage(Format('Message seen by WndMethod! Value is: %x',
            [Msg.Msg]));
    with Msg do
        { Pass message on to old window procedure. }
        Result := CallWindowProc(OldWndProc, Application.Handle, Msg, wParam,
            lParam);
end;

procedure TMainForm.SendBtnClick(Sender: TObject);
begin
    SendMessage(Application.Handle, DDGM_FOOSMSG, 0, 0);
```

```
end;

procedure TMainForm.PostBtnClick(Sender: TObject);
begin
    PostMessage(Application.Handle, DDGM_FOOSMSG, 0, 0);
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
    Application.OnMessage := HandleAppMessage;    // set OnMessage handler
    WndProcPtr := MakeObjectInstance(WndMethod);  // make window proc
    { Set window procedure of application window. }
    OldWndProc := Pointer(SetWindowLong(Application.Handle, GWL_WNDPROC,
        Integer(WndProcPtr)));
end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
    { Restore old window procedure for Application window }
    SetWindowLong(Application.Handle, GWL_WNDPROC, Longint(OldWndProc));
    { Free our user-created window procedure }
    FreeObjectInstance(WndProcPtr);
end;

end.
```

When `SendBtn` is clicked, the `SendMessage()` API function is used to send the message `DDGM_FOOSMSG` to `Application`'s window handle. When `PostBtn` is clicked, the same message is posted to `Application` using the `PostMessage()` API function.

The `HandleAppMessage()` is assigned to handle the `Application.OnMessage` event. This procedure simply uses `ShowMessage()` to invoke a dialog box indicating that it sees a message. The `OnMessage` event is assigned in the `OnCreate` event handler for the main form.

Notice that the `OnDestroy` handler for the main form resets `Application`'s window procedure to the original value (`OldWndProc`) before calling `FreeObjectInstance()` to free the procedure created with `MakeProcInstance()`. If the old window procedure isn't first reinstated, the effect would be that of "unplugging" the window procedure from an active window—effectively removing the window's capability to handle messages. That's bad news because doing so could potentially crash the application or the OS.

Just for kicks, the `ScWndProc` unit, shown earlier in this chapter, is included in `Main`. This means that the `Application` window will be subclassed twice: once by `ScWndProc` using the API technique and once by `Main` using the window method technique. There's absolutely no danger in doing this as long as you remember to use `CallWindowProc()` in the window procedure and method to pass messages down to the old window procedures.

When you run this application, you'll be able to see that the `ShowMessage()` dialog box is shown from both the window procedure and method no matter which button is pushed. What's more, you'll see that `Application.OnMessage` sees only the messages posted to the window.

HookMainWindow()

Another perhaps more VCL-friendly technique for intercepting messages meant for the `TApplication` window is `TApplication`'s `HookMainWindow()` method. This method allows you to insert your own message handler at the top of `TApplication`'s `WndProc()` method to perform special message processing or prevent `TApplication` from processing certain messages. `HookMainWindow()` is defined as follows:

```
procedure HookMainWindow(Hook: TWindowHook);
```

The parameter for this method is of type `TWindowHook`, which is defined as this:

type

```
TWindowHook = function (var Message: TMessage): Boolean of object;
```

There isn't much to using this method; just call `HookMainWindow()`, passing your own method in the `Hook` parameter. This adds your method to a list of window hook methods that will be called prior to the normal message processing that occurs in `TApplication.WndProc()`. If a window hook method returns `True`, the message is considered handled, and the `WndProc()` method will immediately exit.

When you're through processing messages, call the `UnhookMainWindow()` method to remove your method from the window hook method list. This method is similarly defined as follows:

```
procedure UnhookMainWindow(Hook: TWindowHook);
```

Listing 13.3 shows the main form for a simple one-form VCL project that employs this technique, and Figure 13.2 shows this application in action.

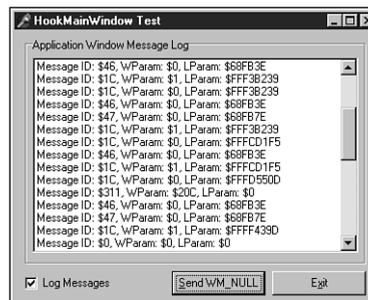


FIGURE 13.2

Spying on the Application with the HookWnd project.

LISTING 13.3 Main.pas for the HookWnd Project

```
unit HookMain;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls, ExtCtrls;

type
  THookForm = class(TForm)
    SendBtn: TButton;
    GroupBox1: TGroupBox;
    LogList: TListBox;
    DoLog: TCheckBox;
    ExitBtn: TButton;
    procedure SendBtnClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
    procedure ExitBtnClick(Sender: TObject);
  private
    function AppWindowHook(var Message: TMessage): Boolean;
  end;

var
  HookForm: THookForm;

implementation

{$R *.DFM}

procedure THookForm.FormCreate(Sender: TObject);
begin
  Application.HookMainWindow(AppWindowHook);
end;

procedure THookForm.FormDestroy(Sender: TObject);
begin
  Application.UnhookMainWindow(AppWindowHook);
end;

function THookForm.AppWindowHook(var Message: TMessage): Boolean;
const
  LogStr = 'Message ID: $%x, WParam: $%x, LParam: $%x';
begin
```

LISTING 13.3 Continued

```
Result := True;
if DoLog.Checked then
  with Message do
    LogList.Items.Add(Format(LogStr, [Msg, WParam, LParam]));
end;

procedure THookForm.SendBtnClick(Sender: TObject);
begin
  SendMessage(Application.Handle, WM_NULL, 0, 0);
end;

procedure THookForm.ExitBtnClick(Sender: TObject);
begin
  Close;
end;

end.
```

Preventing Multiple Application Instances

Multiple instances means running more than one copy of your program simultaneously. The capability to run multiple instances of an application independently from one another is a feature provided by the Win32 operating system. While this feature is great, there are cases that arise when we only wish for the end user to be able to run one copy of a given application at a time. An example of this type of application might be one that controls a unique resource on the machine, such as a modem or the parallel port. In such cases, it becomes necessary to write some code into your application to solve this problem by allowing only one copy of an application to run at any given time.

This was a fairly simple task in the 16-bit Windows world: The `hPrevInst` system variable can be used to determine whether multiple copies of an application are running simultaneously. If the value of `hPrevInst` is nonzero, another instance of the application is active. However, as explained in Chapter 3, “The Win32 API,” Win32 provides a thick layer of R32 insulation between each process, which isolates each from the other. Because of this, the value for `hPrevInst` is always zero for Win32 applications.

Another technique that works for both 16-bit and 32-bit Windows is to use the `FindWindow()` API function to search for an already-active Application window. This solution has two disadvantages, however. First, `FindWindow()` allows you to search for a window based only on its class name or caption. Depending on the class name isn’t a particularly robust solution because there’s no guarantee that the class name of your form is unique throughout the system.

Searching based on the form caption has obvious drawbacks in that the solution breaks down if you attempt to change the caption of the form while it runs (as do applications such as Delphi and Microsoft Word). The second drawback to `FindWindow()` is that it tends to be slow because it must iterate over all top-level windows.

The optimal solution for Win32, then, is to use some type of API object that's persistent across processes. As explained in Chapter 11, "Writing Multithreaded Applications," several of the thread-synchronization objects are persistent across multiple processes. Because of their simplicity of use, mutexes provide an ideal solution to this problem.

The first time an application is run, a mutex is created using the `CreateMutex()` API function. The `lpName` parameter of this function holds a unique string identifier. Subsequent instances of this application should try to open the mutex by name using the `OpenMutex()` function. `OpenMutex()` will succeed only when a mutex has already been created using the `CreateMutex()` function.

Additionally, when you attempt to run a second instance of these applications, the first instance of the application should come into focus. The most elegant approach to focusing the main form of the previous instance is to use a registered window message obtained by the `RegisterWindowMessage()` function to create a message identifier unique to your application. You then can have the initial instance of your application respond to this message by returning its main window handle, which can then be focused by the second instance. This approach is illustrated in Listing 13.4, which shows the source for the `MultInst.pas` unit, and Listing 13.5, `OIMain.pas`, which is the main unit of the `OneInst` project. The application is shown in all its glory in Figure 13.3.

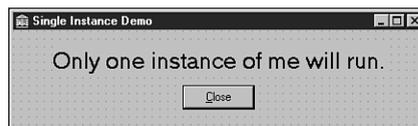


FIGURE 13.3

The main form for the `OneInst` project.

LISTING 13.4 The `MultInst.pas` Unit, Which Permits Only One Application Instance

```
unit MultInst;  
  
interface  
  
const  
    MI_QUERYWINDOWHANDLE = 1;
```

continues

LISTING 13.4 Continued

```
MI_RESPONDWINDOWHANDLE = 2;

MI_ERROR_NONE           = 0;
MI_ERROR_FAILSUBCLASS  = 1;
MI_ERROR_CREATINGMUTEX = 2;

// Call this function to determine if error occurred in startup.
// Value will be one or more of the MI_ERROR_* error flags.
function GetMIError: Integer;

implementation

uses Forms, Windows, SysUtils;

const
  UniqueAppStr = 'DDG.I_am_the_Eggman!';

var
  MessageId: Integer;
  WProc: TFNWndProc;
  MutHandle: THandle;
  MIError: Integer;

function GetMIError: Integer;
begin
  Result := MIError;
end;

function NewWndProc(Handle: HWND; Msg: Integer; wParam, lParam: Longint):
  Longint; stdcall;
begin
  Result := 0;
  // If this is the registered message...
  if Msg = MessageID then
  begin
    case wParam of
      MI_QUERYWINDOWHANDLE:
        // A new instance is asking for main window handle in order
        // to focus the main window, so normalize app and send back
        // message with main window handle.
        begin
          if IsIconic(Application.Handle) then
          begin
            Application.MainForm.WindowState := wsNormal;
            Application.Restore;
          end;
        end;
    end;
  end;
end;
```

```

        end;
        PostMessage(HWND(lParam), MessageID, MI_RESPONDWINDOWHANDLE,
            Application.MainForm.Handle);
    end;
MI_RESPONDWINDOWHANDLE:
    // The running instance has returned its main window handle,
    // so we need to focus it and go away.
    begin
        SetForegroundWindow(HWND(lParam));
        Application.Terminate;
    end;
end;
end;
// Otherwise, pass message on to old window proc
else
    Result := CallWindowProc(WProc, Handle, Msg, wParam, lParam);
end;

procedure SubClassApplication;
begin
    // We subclass Application window procedure so that
    // Application.OnMessage remains available for user.
    WProc := TFNWndProc(SetWindowLong(Application.Handle, GWL_WNDPROC,
        Longint(@NewWndProc)));
    // Set appropriate error flag if error condition occurred
    if WProc = nil then
        MIError := MIError or MI_ERROR_FAILSUBCLASS;
end;

procedure DoFirstInstance;
// This is called only for the first instance of the application
begin
    // Create the mutex with the (hopefully) unique string
    MutHandle := CreateMutex(nil, False, UniqueAppStr);
    if MutHandle = 0 then
        MIError := MIError or MI_ERROR_CREATINGMUTEX;
end;

procedure BroadcastFocusMessage;
// This is called when there is already an instance running.
var
    BSMRecipients: DWORD;
begin
    // Prevent main form from flashing
    Application.ShowMainForm := False;
    // Post message to try to establish a dialogue with previous instance

```

continues

LISTING 13.4 Continued

```
    BSMRecipients := BSM_APPLICATIONS;
    BroadCastSystemMessage(BSF_IGNORECURRENTTASK or BSF_POSTMESSAGE,
        @BSMRecipients, MessageID, MI_QUERYWINDOWHANDLE,
        Application.Handle);
end;

procedure InitInstance;
begin
    SubClassApplication; // hook application message loop
    MutHandle := OpenMutex(MUTEX_ALL_ACCESS, False, UniqueAppStr);
    if MutHandle = 0 then
        // Mutex object has not yet been created, meaning that no previous
        // instance has been created.
        DoFirstInstance
    else
        BroadcastFocusMessage;
end;

initialization
    MessageID := RegisterWindowMessage(UniqueAppStr);
    InitInstance;
finalization
    // Restore old application window procedure
    if WProc <> Nil then
        SetWindowLong(Application.Handle, GWL_WNDPROC, LongInt(WProc));
    if MutHandle <> 0 then CloseHandle(MutHandle); // Free mutex
end.
```

LISTING 13.5 OIMain.pas

```
unit OIMain;

interface

uses
    Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
    Dialogs, StdCtrls;

type
    TMainForm = class(TForm)
        Label1: TLabel;
        CloseBtn: TButton;
        procedure CloseBtnClick(Sender: TObject);
    end;
```

```
private
  { Private declarations }
public
  { Public declarations }
end;

var
  MainForm: TMainForm;

implementation

uses MultInst;

{$R *.DFM}

procedure TMainForm.CloseBtnClick(Sender: TObject);
begin
  Close;
end;

end.
```

Using BASM with Delphi

Because Delphi is based on a true compiler, one benefit you receive is the capacity to write assembly code right in the middle of your Object Pascal procedures and functions. This capability is facilitated through Delphi's built-in assembler (BASM). Before you learn about BASM, you should learn when to use assembly language in your Delphi programs. It's great to have such a powerful tool at your disposal, but, like any good thing, BASM can be overdone. If you follow these simple BASM rules, you can help yourself write better, cleaner, and more portable code:

- Never use assembly language for something that can be done in Object Pascal. For example, you wouldn't write assembly language routines to communicate through the serial ports because the Win32 API provides built-in functions for serial communications.
- Don't over-optimize your programs with assembly language. Hand-optimized assembly might run faster than Object Pascal code—but at the price of readability and maintainability. Object Pascal is a language that communicates algorithms so naturally that it's a shame to have that communication muddled by a bunch of low-level register operations. In addition, after all your assembler toils, you might be surprised to find out that Delphi's optimizing compiler often compiles code that executes faster than handwritten assembly code.

- Always comment your assembly code thoroughly. Your code will probably be read in the future by another programmer—or even by you—and lack of comments can make it difficult to understand.
- Don't use BASM to access machine hardware. Although Windows 95/98 will let you get away with this in most cases, Windows NT/2000 won't.
- Where possible, wrap your assembly language code in procedures or functions callable from Object Pascal. This will make your code not only easier to maintain but also easier to port to other platforms when the time comes.

NOTE

This section doesn't teach you assembler programming, but it shows you the Delphi spin on assembler if you're already familiar with the language.

Also, if you programmed in BASM with Delphi 1, bear in mind that in 32-bit Delphi, BASM is a whole new ballgame. Because you must now write 32-bit assembly language, almost all your 16-bit BASM code will have to be rewritten for the new platform. The fact that BASM code can require so much care to maintain is yet another reason to minimize your use of BASM in applications.

How Does BASM Work?

Using assembly code in your Delphi applications is easier than you might think. In fact, it's so simple that it's scary. Just use the `asm` keyword followed by your assembly code and then an end. The following code fragment demonstrates how to use assembly code inline:

```
var
  i: integer;
begin
  i := 0;
  asm
    mov eax, i
    inc eax
    mov i, eax
  end;
  { i has incremented by one }
```

This snippet declares a variable `i` and initializes it to `0`. It then moves the value of `i` into the `eax` register, increments the register by one, and moves the value of the `eax` register back into `i`. This illustrates not only how easy it is to use BASM, but, as the usage of the variable `i` shows, how easily you can access your Pascal variables from BASM.

Easy Parameter Access

Not only is it easy to access variables declared globally or locally to a procedure, it's just as easy to access variables passed into procedures, as the following code illustrates:

```
procedure Foo(I: integer);
begin
  { some code }
  asm
    mov eax, I
    inc eax
    mov I, eax
  end;
  { I has incremented by one }
  { some more code }
end;
```

The capability to access parameters by name is important because you don't have to reference variables passed into a procedure through the stack base pointer (ebp) register as you would in a normal assembly program. In a regular assembly language procedure, you would have to refer to the variable I as [ebp+4] (its offset from the stack's base pointer).

NOTE

When you use BASM to reference parameters passed into a procedure, remember that you can access those parameters by name, and you don't have to access them by their offset from the ebp register. Accessing by offset from ebp makes your code more difficult to maintain.

var Parameters

Remember that when a parameter is declared as `var` in a function or procedure's parameter list, a pointer to that variable is passed instead of the value. This means that when you reference `var` parameters within a BASM block, you must take into account that the parameter is a 32-bit pointer to a variable and not a variable instance. To expand on the earlier sample snippet, the following example shows how you would increment the variable I if it were passed in as a `var` parameter:

```
procedure Foo(var I: integer);
begin
  { some code }
  asm
    mov eax, I
    inc dword ptr [eax]
  end;
end;
```

```
end;  
{ I has now been incremented by one }  
{ some more code }  
end;
```

Register Calling Convention

Remember that the default calling convention for Object Pascal functions and procedures is register. Taking advantage of this method of parameter passing can help you to optimize your code. The register calling convention dictates that the first three 32-bit parameters are passed in the `eax`, `edx`, and `ecx` registers. This means that for the function declaration

```
function BlahBlah(I1, I2, I3: Integer): Integer;
```

you can count on the fact that the value of `I1` is stored in `eax`, `I2` in `edx`, and `I3` in `ecx`.

Consider the following method as another example:

```
procedure TSomeObject.SomeProc(S1, S2: PChar);
```

Here, the value of `S1` will be passed in `ecx`, `S2` in `edx`, and the implicit `Self` parameter will be passed in `eax`.

All-Assembly Procedures

Object Pascal enables you to write procedures and functions entirely in assembly language simply by beginning the function or procedure with the word `asm`, rather than `begin`, as shown here:

```
function IncAnInt(I: Integer): Integer;  
asm  
    mov eax, I  
    inc eax  
end;
```

NOTE

If you're poring over 16-bit code, you should know that it's no longer necessary to use the `assembler` directive from Delphi 1 days. That directive is simply ignored by the 32-bit Delphi compiler.

The preceding procedure accepts an integer variable `I` and increments it. Because the variable value is placed in the `eax` register, that's the value returned by the function. Table 13.1 shows how different types of data are returned from a function in Delphi.

TABLE 13.1 How Values Are Returned from Delphi Functions

<i>Return Type</i>	<i>Return Method</i>
Char, Byte	al register.
SmallInt, Word	ax register.
Integer, LongWord, AnsiString, Pointer, class	eax register.
Real48	eax contains a pointer to data on the stack.
Int64	edx:eax register pair.
Single, Double, Extended, Comp	ST(0) on 8087's register stack.

NOTE

A ShortString type is returned as a pointer to a temporary instance of a string on the stack.

Records

BASM provides a slick shortcut for accessing the fields of a record. You can access the fields of any record in a BASM block using the syntax *Register.Type.Field*. For example, consider a record defined as follows:

```
type
  TDumbRec = record
    i: integer;
    c: char;
  end;
```

Also, consider a function that accepts a TDumbRec as a reference parameter, as shown here:

```
procedure ManipulateRec(var DR: TDumbRec);
asm
  mov [eax].TDumbRec.i, 24
  mov [eax].TDumbRec.c, 's'
end;
```

Notice the shortcut syntax for accessing the fields of a record. The alternative would be to manually calculate the proper offset into the record to get or set the appropriate value. Use this technique wherever you use records in BASM to make your BASM more resilient to potential changes to data types.

Using Windows Hooks

Windows *hooks* give programmers the means to control the occurrence and handling of system events. A hook offers perhaps the ultimate degree of power for an applications programmer because it enables the programmer to preview and modify system events and messages as well as to prevent system events and messages from occurring systemwide.

Setting the Hook

A Windows hook is set using the `SetWindowsHookEx()` API function:

```
function SetWindowsHookEx(idHook: Integer; lpfn: TFNHookProc; hmod: HINST;
    dwThreadId: DWORD): HHOOK; stdcall;
```

CAUTION

Use only the `SetWindowsHookEx()` function—not the `SetWindowsHook()` function—in your applications. `SetWindowsHook()`, which existed in Windows 3.x, is not implemented in the Win32 API.

The `idHook` parameter describes the type of hook to be installed. This can be any one of the predefined hook constants shown in Table 13.2.

TABLE 13.2 Windows Hook Constants

<i>Hook Constant</i>	<i>Description</i>
WH_CALLWNDPROC	A window procedure filter. The hook procedure is called whenever a message is sent to a window procedure.
WH_CALLWNDPROCRET*	Installs a hook procedure that monitors messages after they've been processed by the destination window procedure.
WH_CBT	A computer-based training filter. The hook procedure is called before processing most window-management, mouse, and keyboard messages.
WH_DEBUG	A debugging filter. The hook function is called before any other Windows hook.
WH_GETMESSAGE	A message filter. The hook function is called whenever a message is retrieved from the application queue.
WH_HARDWARE	A hardware message filter. The hook function is called whenever a hardware message is retrieved from the application queue.

<i>Hook Constant</i>	<i>Description</i>
WH_JOURNALPLAYBACK	The hook function is called whenever a message is retrieved from the system queue. Typically used to insert system events into the queue.
WH_JOURNALRECORD	The hook function is called whenever an event is requested from the system queue. Typically used to “record” system events.
WH_KEYBOARD	A keyboard filter. The hook function is called whenever a WM_KEYDOWN or WM_KEYUP message is retrieved from the application queue.
WH_KEYBOARD_LL*	A low-level keyboard filter.
WH_MOUSE	A mouse message filter. The hook function is called whenever a mouse message is retrieved from the application queue.
WH_MOUSE_LL*	A low-level mouse message filter.
WH_MSGFILTER	A special message filter. The hook function is called whenever an application’s dialog box, menu, or message box is about to process a message.
WH_SHELL	A shell application filter. The hook function is called when top-level windows are created and destroyed as well as when the shell application needs to become active.

* = available only on Windows NT 4.0 and Windows 2000

The `lpfn` parameter is the address of the callback function to act as the Windows hook function. This function is of type `TFNHookProc`, which is defined as follows:

```
TFNHookProc = function (code: Integer; wparam: WPARAM; lparam: LPARAM):
    LRESULT stdcall;
```

The contents of each of the hook function’s parameters vary according to the type of hook installed; the parameters are documented in the Win32 API help.

The `hMod` parameter should be the value of `hInstance` in the EXE or DLL containing the hook callback.

The `dwThreadId` parameter identifies the thread with which the hook is to be associated. If this parameter is zero, the hook will be associated with all threads.

The return value is a hook handle that you must save in a global variable for later use.

Windows can have multiple hooks installed at one time, and it can even have the same type of hook installed multiple times.

Note also that some hooks operate with the restriction that they must be implemented from a DLL. Check the Win32 API documentation for details on each specific hook.

CAUTION

One serious limitation for system hooks is that new instances of the hook DLL are loaded into each process address space separately. Because of this, the hook DLL cannot communicate directly with the host application that set the hook. You have to go through messages or shared memory areas (such as the memory mapped files described in Chapter 12, “Working with Files”) to communicate with the host application.

Using the Hook Function

The values of the hook function’s `Code`, `wParam`, and `lParam` parameters vary depending on the type of hook installed, and they’re documented in the Windows API help. These parameters all have one thing in common: Depending on the value of `Code`, you’re responsible for calling the next hook in the chain.

To call the next hook, use the `CallNextHookEx()` API function:

```
Result := CallNextHookEx(HookHandle, Code, wParam, lParam);
```

CAUTION

When calling the next hook in the chain, don’t call `DefHookProc()`. This is another unimplemented Windows 3.x function.

Using the Unhook Function

When you want to release the Windows hook, you just need to call the `UnhookWindowsHookEx()` API function, passing it the hook handle as a parameter. Again, be careful not to call `UnhookWindowsHook()` here because it’s another old-style function:

```
UnhookWindowsHookEx(HookHandle);
```

Using SendKeys: A JournalPlayback Hook

If you come to Delphi from an environment such as Visual Basic or Paradox for Windows, you might be familiar with a function called `SendKeys()`. `SendKeys()` enables you to pass it a string of characters that it then plays back as if they were typed from the keyboard, and all the keystrokes are sent to the active window. Because Delphi doesn’t have a function like this built in, creating one proves a great opportunity to add a powerful feature to Delphi as well as to demonstrate how to implement a `wh_JournalPlayback` hook from within Delphi.

Deciding Whether to Use a JournalPlayback Hook

There are a number of reasons why a hook is the best way to send keystrokes to your application or another application. You might wonder, “Why not just post `wm_KeyDown` and `wm_KeyUp` messages?” The primary reason is that you might not know the handle of the window to which you want to post messages, or that the handle for that window might periodically change. And, of course, if you don’t know the window handle, you can’t send a message. Also, some applications call API functions to check the state of the keyboard in addition to looking at messages to obtain information on keystrokes.

Understanding How SendKeys Works

The declaration of the `SendKeys()` function looks like this:

```
function SendKeys(S: String): TSendKeyError; export;
```

The `TSendKeyError` return type is an enumerated type that indicates the error condition. It can be any one of the values shown in Table 13.3.

TABLE 13.3 Sendkey Error Codes

<i>Value</i>	<i>Meaning</i>
<code>sk_None</code>	The function was successful.
<code>sk_FailSetHook</code>	The Windows hook couldn’t be set.
<code>sk_InvalidToken</code>	An invalid token was detected in the string.
<code>sk_UnknownError</code>	Some other unknown but fatal error occurred.
<code>sk_AlreadyPlaying</code>	The hook is currently active, and keystrokes are already being played back.

S can include any alphanumeric character or `@` for the Alt key, `^` for the Ctrl key, or `~` for the Shift key. `SendKeys()` also enables you to specify special keyboard keys in curly braces, as depicted in the `KeyDefs.pas` unit in Listing 13.6.

LISTING 13.6 `KeyDefs.pas`: Special Key Definitions for `SendKeys()`

```
unit KeyDefs;

interface

uses Windows;

const
  MaxKeys = 24;
```

continues

LISTING 13.6 Continued

```
ControlKey = '^';
AltKey = '@';
ShiftKey = '~';
KeyGroupOpen = '{';
KeyGroupClose = '}';

type
  TKeyString = String[7];

  TKeyDef = record
    Key: TKeyString;
    vkCode: Byte;
  end;

const
  KeyDefArray : array[1..MaxKeys] of TKeyDef = (
    (Key: 'F1';    vkCode: vk_F1),
    (Key: 'F2';    vkCode: vk_F2),
    (Key: 'F3';    vkCode: vk_F3),
    (Key: 'F4';    vkCode: vk_F4),
    (Key: 'F5';    vkCode: vk_F5),
    (Key: 'F6';    vkCode: vk_F6),
    (Key: 'F7';    vkCode: vk_F7),
    (Key: 'F8';    vkCode: vk_F8),
    (Key: 'F9';    vkCode: vk_F9),
    (Key: 'F10';   vkCode: vk_F10),
    (Key: 'F11';   vkCode: vk_F11),
    (Key: 'F12';   vkCode: vk_F12),
    (Key: 'INSERT'; vkCode: vk_Insert),
    (Key: 'DELETE'; vkCode: vk_Delete),
    (Key: 'HOME';  vkCode: vk_Home),
    (Key: 'END';   vkCode: vk_End),
    (Key: 'PGUP';  vkCode: vk_Prior),
    (Key: 'PGDN';  vkCode: vk_Next),
    (Key: 'TAB';   vkCode: vk_Tab),
    (Key: 'ENTER'; vkCode: vk_Return),
    (Key: 'BKSP';  vkCode: vk_Back),
    (Key: 'PRTSC'; vkCode: vk_SnapShot),
    (Key: 'SHIFT'; vkCode: vk_Shift),
    (Key: 'ESCAPE'; vkCode: vk_Escape));

function FindKeyInArray(Key: TKeyString; var Code: Byte): Boolean;

implementation
```

```
uses SysUtils;

function FindKeyInArray(Key: TKeyString; var Code: Byte): Boolean;
{ function searches array for token passed in Key, and returns the }
{ virtual key code in Code. }
var
  i: word;
begin
  Result := False;
  for i := Low(KeyDefArray) to High(KeyDefArray) do
    if UpperCase(Key) = KeyDefArray[i].Key then begin
      Code := KeyDefArray[i].vkCode;
      Result := True;
      Break;
    end;
  end;
end;

end.
```

After receiving the string, `SendKeys()` parses the individual key presses out of the string and adds each of the key presses to a list in the form of message records containing `wm_KeyUp` and `wm_KeyDown` messages. These messages then are played back to Windows through a `wh_JournalPlayback` hook.

Creating Key Presses

After each key press is parsed out of the string, the virtual key code and message (the message can be `wm_KeyUp`, `wm_KeyDown`, `wm_SysKeyUp`, or `wm_SysKeyDown`) are passed to a procedure called `MakeMessage()`. `MakeMessage()` creates a new message record for the key press and adds it to a list of messages called `MessageList`. The message record used here isn't the standard `TMessage` that you're familiar with, or even the `TMsg` record discussed in Chapter 5. This record is called a `TEvent` message, and it represents a system queue message. The definition is as follows:

```
type
  { Message Structure used in Journaling }
  PEventMsg = ^TEventMsg;
  TEventMsg = packed record
    message: UINT;
    paramL: UINT;
    paramH: UINT;
    time: DWORD;
    hwnd: HWND;
  end;
```

Table 13.4 shows the values for TEventMsg's fields.

TABLE 13.4 Values for TEventMsg Fields

<i>Field</i>	<i>Value</i>
message	The message constant. Can be <code>wm_(Sys)KeyUp</code> or <code>wm_SysKeyDown</code> for a keyboard message. Can be <code>wm_XButtonUp</code> , <code>wm_XButtonDown</code> , or <code>wm_MouseMove</code> for a mouse message.
paramL	If <code>message</code> is a keyboard message, this field holds the virtual key code. If <code>message</code> is a mouse message, <code>wParam</code> contains the x coordinate of the mouse cursor (in screen units).
paramH	If <code>message</code> is a keyboard message, this field holds the scan code of the key. If it's a mouse message, <code>lParam</code> contains the y coordinate of the mouse cursor.
time	The time, in system ticks, that the message occurred.
hwnd	Identifies the window to which the message is posted. This parameter isn't used for <code>wh_JournalPlayback</code> hooks.

Because the table in the `KeyDefs` unit maps only to the virtual key code, you must find a way to determine the scan code of the key given the virtual key code. Luckily, the Windows API provides a function called `MapVirtualKey()` that does just that. The following code shows the source for the `MakeMessage()` procedure:

```

procedure MakeMessage(vKey: byte; M: Cardinal);
{ procedure builds a TEventMsg record that emulates a keystroke and }
{ adds it to message list }
var
  E: PEventMsg;
begin
  New(E); // allocate a message record
  with E^ do begin
    message := M; // set message field
    paramL := vKey; // vk code in ParamL
    paramH := MapVirtualKey(vKey, 0); // scan code in ParamH
    time := GetTickCount; // set time
    hwnd := 0; // ignored
  end;
  MessageList.Add(E);
end;

```

After the entire message list is created, the hook can be set to play back the key sequence. You do this through a procedure called `StartPlayback()`. `StartPlayback` primes the pump by placing the first message from the list into a global buffer. It also initializes a global buffer that keeps track of how many messages have been played and the flags that indicate the state of the

Ctrl, Alt, and Shift keys. This procedure then sets the hook. `StartPlayBack()` is shown in the following code:

```

procedure StartPlayback;
{ Initializes globals and sets the hook }
begin
  { grab first message from list and place in buffer in case we }
  { get an hc_GetNext before an hc_Skip }
MessageBuffer := TEventMsg(MessageList.Items[0]^);
  { initialize message count and play indicator }
  MsgCount := 0;
  { initialize Alt, Control, and Shift key flags }
  AltPressed := False;
  ControlPressed := False;
  ShiftPressed := False;
  { set the hook! }
  HookHandle := SetWindowsHookEx(wh_JournalPlayback, Play, hInstance, 0);
  if HookHandle = 0 then
    raise ESKSetHookError.Create('Couldn't set hook')
  else
    Playing := True;
end;

```

As you might notice from the `SetWindowsHookEx()` call, `Play` is the name of the hook function. The declaration for `Play` is as follows:

```
function Play(Code: integer; wParam, lParam: Longint): Longint; stdcall;
```

Table 13.5 shows its parameters.

TABLE 13.5 Parameters for `Play()`, the Windows Hook Function

<i>Value</i>	<i>Meaning</i>
Code	A value of <code>hc_GetNext</code> indicates that you should prepare the next message in the list for processing. You do this by copying the next message from the list into your global buffer. A value of <code>hc_Skip</code> means that a pointer to the next message should be placed into the <code>lParam</code> parameter for processing. Any other value means that you should call <code>CallNextHookEx()</code> and pass on the parameters to the next hook in the chain.
wParam	Unused.
lParam	If Code is <code>hc_Skip</code> , you should place a pointer to the next <code>TEventMsg</code> record in the <code>lParam</code> parameter.
Return value	Returns zero if Code is <code>hc_GetNext</code> . If Code is <code>hc_Skip</code> , returns the amount of time (in ticks) before this message should be processed. If zero is returned, the message is processed. Otherwise, the return value should be the return value of <code>CallNextHookEx()</code> .

Listing 13.7 shows the complete source code to the `SendKey.pas` unit.

LISTING 13.7 The `SendKey.pas` Unit

```
unit SendKey;

interface

uses
  SysUtils, Windows, Messages, Classes, KeyDefs;

type
  { Error codes }
  TSendKeyError = (sk_None, sk_FailSetHook, sk_InvalidToken,
    sk_UnknownError, sk_AlreadyPlaying);
  { first vk code to last vk code }
  TvkKeySet = set of vk_LButton..vk_Scroll;

  { exceptions }
  ESendKeyError = class(Exception);
  ESKSetHookError = class(ESendKeyError);
  ESKInvalidToken = class(ESendKeyError);
  ESKAlreadyPlaying = class(ESendKeyError);

function SendKeys(S: String): TSendKeyError;
procedure WaitForHook;
procedure StopPlayback;

var
  Playing: Boolean;

implementation

uses Forms;

type
  { a TList descendant that know how to dispose of its contents }
  TMessageList = class(TList)
  public
    destructor Destroy; override;
  end;

const
  { valid "sys" keys }
  vkKeySet: TvkKeySet = [Ord('A')..Ord('Z'), vk_Menu, vk_F1..vk_F12];

destructor TMessageList.Destroy;
```

```

var
  i: longint;
begin
  { deallocate all the message records before discarding the list }
  for i := 0 to Count - 1 do
    Dispose(PEventMsg(Items[i]));
  inherited Destroy;
end;

var
  { variables global to the DLL }
  MsgCount: word = 0;
  MessageBuffer: TEventMsg;
  HookHandle: hHook = 0;
  MessageList: TMessageList = Nil;
  AltPressed, ControlPressed, ShiftPressed: Boolean;

procedure StopPlayback;
{ Unhook the hook, and clean up }
begin
  { if Hook is currently active, then unplug it }
  if Playing then
    UnhookWindowsHookEx(HookHandle);
  MessageList.Free;
  Playing := False;
end;

function Play(Code: integer; wParam, lParam: Longint): Longint; stdcall;
{ This is the JournalPlayback callback function. It is called by }
{ Windows when Windows polls for hardware events. The code parameter }
{ indicates what to do. }
begin
  case Code of
    HC_SKIP:
      { HC_SKIP means to pull the next message out of our list. If we }
      { are at the end of the list, it's okay to unhook the }
      { JournalPlayback hook from here. }
      begin
        { increment message counter }
        inc(MsgCount);
        { check to see if all messages have been played }
        if MsgCount >= MessageList.Count then StopPlayback
        { otherwise copy next message from list into buffer }
        else MessageBuffer := TEventMsg(MessageList.Items[MsgCount]^);
        Result := 0;
      end;
  end;
end;

```

LISTING 13.7 Continued

```

HC_GETNEXT:
  { HC_GETNEXT means to fill the wParam and lParam with the proper }
  { values so that the message can be played back. DO NOT unhook }
  { hook from within here. Return value indicates how much time }
  { until Windows should playback message. We'll return 0 so that }
  { it is processed right away. }
  begin
    { move message in buffer to message queue }
    PEventMsg(lParam)^ := MessageBuffer;
    Result := 0 { process immediately }
  end
else
  { if Code isn't HC_SKIP or HC_GETNEXT, call next hook in chain }
  Result := CallNextHookEx(HookHandle, Code, wParam, lParam);
end;
end;

procedure StartPlayback;
{ Initializes globals and sets the hook }
begin
  { grab first message from list and place in buffer in case we }
  { get a hc_GetNext before and hc_Skip }
  MessageBuffer := TEventMsg(MessageList.Items[0]^);
  { initialize message count and play indicator }
  MsgCount := 0;
  { initialize Alt, Control, and Shift key flags }
  AltPressed := False;
  ControlPressed := False;
  ShiftPressed := False;
  { set the hook! }
  HookHandle := SetWindowsHookEx(wh_JournalPlayback, Play, hInstance, 0);
  if HookHandle = 0 then
    raise ESKSetHookError.Create('Failed to set hook');
  Playing := True;
end;

procedure MakeMessage(vKey: byte; M: Cardinal);
{ procedure builds a TEventMsg record that emulates a keystroke and }
{ adds it to message list }
var
  E: PEventMsg;
begin
  New(E); // allocate a message record
  with E^ do

```

```

begin
    message := M;           // set message field
    paramL := vKey;         // vk code in ParamL
    paramH := MapVirtualKey(vKey, 0); // scan code in ParamH
    time := GetTickCount;  // set time
    hwnd := 0;             // ignored
end;
MessageList.Add(E);
end;

procedure KeyDown(vKey: byte);
{ Generates KeyDownMessage }
begin
    { don't generate a "sys" key if the control key is pressed }
    { (This is a Windows quirk) }
    if AltPressed and (not ControlPressed) and (vKey in vkKeySet) then
        MakeMessage(vKey, wm_SysKeyDown)
    else
        MakeMessage(vKey, wm_KeyDown);
end;

procedure KeyUp(vKey: byte);
{ Generates KeyUp message }
begin
    { don't generate a "sys" key if the control key is pressed }
    { (This is a Windows quirk) }
    if AltPressed and (not ControlPressed) and (vKey in vkKeySet) then
        MakeMessage(vKey, wm_SysKeyUp)
    else
        MakeMessage(vKey, wm_KeyUp);
end;

procedure SimKeyPresses(VKeyCode: Word);
{ This function simulates keypresses for the given key, taking into }
{ account the current state of Alt, Control, and Shift keys }
begin
    { press Alt key if flag has been set }
    if AltPressed then
        KeyDown(vk_Menu);
    { press Control key if flag has been set }
    if ControlPressed then
        KeyDown(vk_Control);
    { if shift is pressed, or shifted key and control is not pressed... }
    if ((Hi(VKeyCode) and 1) <> 0) and (not ControlPressed)) or
        ShiftPressed then
        KeyDown(vk_Shift);    { ...press shift }
end;

```

LISTING 13.7 Continued

```

KeyDown(Lo(VKeyCode)); { press key down }
KeyUp(Lo(VKeyCode));   { release key }
{ if shift is pressed, or shifted key and control is not pressed... }
if ((Hi(VKeyCode) and 1) <> 0) and (not ControlPressed) or
  ShiftPressed then
  KeyUp(vk_Shift);      { ...release shift }
{ if shift flag is set, reset flag }
if ShiftPressed then begin
  ShiftPressed := False;
end;
{ Release Control key if flag has been set, reset flag }
if ControlPressed then begin
  KeyUp(vk_Control);
  ControlPressed := False;
end;
{ Release Alt key if flag has been set, reset flag }
if AltPressed then begin
  KeyUp(vk_Menu);
  AltPressed := False;
end;
end;

procedure ProcessKey(S: String);
{ This function parses each character in the string to create the }
{ message list }
var
  KeyCode: word;
  Key: byte;
  index: integer;
  Token: TKeyString;
begin
  index := 1;
  repeat
    case S[index] of
      KeyGroupOpen:
        { It's the beginning of a special token! }
        begin
          Token := '';
          inc(index);
          while S[index] <> KeyGroupClose do begin
            { add to Token until the end token symbol is encountered }
            Token := Token + S[index];
            inc(index);
          { check to make sure the token's not too long }

```

```

        if (Length(Token) = 7) and (S[index] <> KeyGroupClose) then
            raise ESKInvalidToken.Create('No closing brace');
        end;
        { look for token in array, Key parameter will }
        { contain vk code if successful }
        if not FindKeyInArray(Token, Key) then
            raise ESKInvalidToken.Create('Invalid token');
        { simulate keypress sequence }
        SimKeyPresses(MakeWord(Key, 0));
    end;
    AltKey: AltPressed := True;           // set Alt flag
    ControlKey: ControlPressed := True;   // set Control flag
    ShiftKey: ShiftPressed := True;       // set Shift flag
    else begin
        { A normal character was pressed }
        { convert character into a word where the high byte contains }
        { the shift state and the low byte contains the vk code }
        KeyCode := vkKeyScan(S[index]);
        { simulate keypress sequence }
        SimKeyPresses(KeyCode);
    end;
end;
Inc(index);
until index > Length(S);
end;

procedure WaitForHook;
begin
    repeat Application.ProcessMessages until not Playing;
end;

function SendKeys(S: String): TSendKeyError;
{ This is the one entry point. Based on the string passed in the S }
{ parameter, this function creates a list of keyup/keydown messages, }
{ sets a JournalPlayback hook, and replays the keystroke messages. }
begin
    Result := sk_None;                       // assume success
    try
        if Playing then raise ESKAlreadyPlaying.Create('');
        MessageList := TMessageList.Create; // create list of messages
        ProcessKey(S);                       // create messages from string
        StartPlayback;                       // set hook and play back messages
    except
        { if an exception occurs, return an error code, and clean up }
        on E:ESendKeyError do
            begin

```

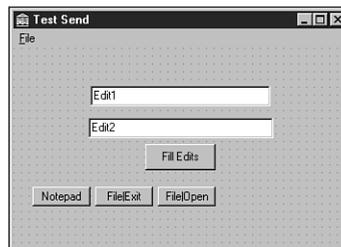
LISTING 13.7 Continued

```
MessageList.Free;
if E is ESKSetHookError then
    Result := sk_FailSetHook
else if E is ESKInvalidToken then
    Result := sk_InvalidToken
else if E is ESKAlreadyPlaying then
    Result := sk_AlreadyPlaying;
end
else
    Result := sk_UnknownError; // Catch-all exception handler
end;
end;

end.
```

Using SendKeys()

In this section, you'll create a small project that demonstrates the `SendKeys()` function. Start with a form that contains two `TEdit` components and several `TButton` components, as shown in Figure 13.4. This project is called `TestSend.dpr`.

**FIGURE 13.4**

The TestSend main form.

Listing 13.8 shows the source code for `TestSend`'s main unit, `Main.pas`. This unit includes event handlers for the button-click events.

LISTING 13.8 The Source Code for `Main.pas`

```
unit Main;

interface

uses
```

SysUtils, Windows, Messages, Classes, Graphics, Controls,
Forms, Dialogs, StdCtrls, Menus;

```

type
  TForm1 = class(TForm)
    Edit1: TEdit;
    Edit2: TEdit;
    Button1: TButton;
    Button2: TButton;
    MainMenu1: TMainMenu;
    File1: TMenuItem;
    Open1: TMenuItem;
    Exit1: TMenuItem;
    Button4: TButton;
    Button3: TButton;
    procedure Button1Click(Sender: TObject);
    procedure Button2Click(Sender: TObject);
    procedure Open1Click(Sender: TObject);
    procedure Exit1Click(Sender: TObject);
    procedure Button4Click(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
    procedure Button3Click(Sender: TObject);
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  Form1: TForm1;

implementation

{$R *.DFM}

uses SendKey, KeyDefs;

procedure TForm1.Button1Click(Sender: TObject);
begin
  Edit1.SetFocus; // focus Edit1
  SendKeys('^{\DELETE}I love...'); // send keys to Edit1
  WaitForHook; // let keys playback
  Perform(WM_NEXTDLGCTL, 0, 0); // move to Edit2
  SendKeys('~delphi ~developer's ~guide!'); // send keys to Edit2
end;

```

LISTING 13.8 Continued

```
procedure TForm1.Button2Click(Sender: TObject);
var
  H: hWnd;
  PI: TProcessInformation;
  SI: TStartupInfo;
begin
  FillChar(SI, SizeOf(SI), 0);
  SI.cb := SizeOf(SI);
  { Invoke notepad }
  if CreateProcess(nil, 'notepad', nil, nil, False, 0, nil, nil, SI,
    PI) then
  begin
    { wait until notepad is ready to receive keystrokes }
    WaitForInputIdle(PI.hProcess, INFINITE);
    { find new notepad window }
    H := FindWindow('Notepad', 'Untitled - Notepad');
    if SetForegroundWindow(H) then           // bring it to front
      SendKeys('Hello from the Delphi Developer''s Guide SendKeys ' +
        'example!{ENTER}'); // send keys!
  end
  else
    MessageDlg(Format('Failed to invoke Notepad. Error code %d',
      [GetLastError]), mtError, [mbOk], 0);
end;

procedure TForm1.Open1Click(Sender: TObject);
begin
  ShowMessage('Open');
end;

procedure TForm1.Exit1Click(Sender: TObject);
begin
  Close;
end;

procedure TForm1.Button4Click(Sender: TObject);
begin
  WaitForInputIdle(GetCurrentProcess, INFINITE);
  SendKeys('@fx');
end;

procedure TForm1.FormDestroy(Sender: TObject);
begin
  WaitForHook;
end;
```

```
procedure TForm1.Button3Click(Sender: TObject);
begin
    WaitForInputIdle(GetCurrentProcess, INFINITE);
    SendKeys('@fo');
end;

end.
```

After you click `Button1`, `SendKeys()` is called, and the following key presses are sent: `Shift+Del` deletes the contents of `Edit1`; “I love...” then is typed into `Edit1`; a tab character is sent, which moves the focus to `Edit2`, where `Shift+D`, “e1phi “, `Shift+D`, “evelopers “, `Shift+G`, “uide!” is sent.

The `OnClick` handler for `Button2` is also interesting. This method uses the `CreateProcess()` API function to invoke an instance of Notepad. It then uses the `WaitForInputIdle()` API function to pause until Notepad’s process is ready for input. Finally, it types a message in the Notepad window.

Using C/C++ OBJ Files

Delphi provides you with the capability for linking object (OBJ) files created using another compiler directly into your Delphi programs. You can link an object file into your Object Pascal code by using the `$L` or `$LINK` directives. The syntax for this is as follows:

```
{$L filename.obj}
```

After the object file is linked, you must define each function you want to call out of the object file in your Object Pascal code. Use the `external` directive to indicate that the Pascal compiler should wait until link time to attempt to resolve the function name. For example, the following line of code defines an external function called `Foo` that neither takes nor returns any parameters:

```
procedure Foo; external;
```

Although this capability might seem powerful on the surface, it comes with a number of limitations that make this feature difficult to implement in many cases:

- Object Pascal can directly access only code, not data, contained in object files (although there is a trick to getting at data in an OBJ, which you’ll see later). However, Pascal data can be accessed from object files.
- Object Pascal can’t link with LIB (static library) files.
- Object files containing C++ classes will not link due to the implicit references to C++ RTL. Although it might be possible to resolve these references by pulling apart the C++ RTL into OBJs, it’s generally more trouble than it’s worth.

- Object files must be in the Intel OMF format. This is the output format of the Borland C++ compilers, but not the Microsoft C++ compilers, which produce COFF-format OBJ files.

NOTE

One previously stifling limitation that has recently been addressed by the Delphi compiler is the capability to resolve OBJ-to-OBJ references. In earlier versions of Delphi, object files couldn't contain references to code or data stored in other object files.

Calling a Function

Suppose you had a C++ object file called `ccode.obj` that includes a function with the following prototype:

```
int __fastcall SAYHELLO(char * hellostr)
```

To call this function from a Delphi application, you must first link the object file into the EXE using either the `$L` or `$LINK` directive:

```
{ $L ccode.obj }
```

After that, you must create an Object Pascal definition for the function, as shown here:

```
function SayHello(Text: PChar): integer; external;
```

CAUTION

Notice the use of the `__fastcall` directive in C++, which serves to ensure that the calling conventions used in the C++ and Object Pascal code are the same. Heinous crash errors can occur if you don't correctly match calling conventions between the C++ prototype and the Object Pascal declaration, and calling convention problems are the most common obstacle for developers trying to share code between the two languages. To help clear things up, the following table shows the correspondence between Object Pascal and C++ calling convention directives.

Object Pascal	C++
<code>register*</code>	<code>__fastcall</code>
<code>pascal</code>	<code>__pascal</code>
<code>cdecl</code>	<code>__cdecl*</code>
<code>stdcall</code>	<code>__stdcall</code>

**Indicates the default calling convention for the language.*

Name Mangling

By default, the C++ compiler will mangle the names of functions not explicitly declared using the `extern "C"` modifier. The Object Pascal compiler, of course, doesn't mangle the names of functions. For example, Delphi's TDUMP utility reveals the exported symbol name of the SAYHELLO function shown earlier in `ccode.obj` as `@SAYHELLO$qqrpc`, whereas the name of the imported function according to Object Pascal is SAYHELLO (Object Pascal forces symbols to uppercase).

On the surface, this would seem to be a problem: How can the Delphi linker resolve the external if the function name isn't even the same? The answer is that the Delphi linker simply ignores the mangled portion (the `@` and everything after the `$`) of the symbol, but this can have some pretty nasty side effects.

The whole reason C++ mangles names is to allow function overloading (functions having the same names and different parameter lists). If you have a function that has several overloaded definitions and Delphi ignores the mangling portion of the symbol, you'll never know for sure whether Delphi is calling the overloaded function you want to call. Because of these complexities, we recommend that you don't attempt to call overloaded functions through object files.

NOTE

Functions in a C++ source file (.CPP) will always be mangled unless the prototypes are combined with the `extern "C"` modifier or the proper command-line switch is used on the C++ compiler to suppress name mangling.

13

Sharing Data

As mentioned earlier, it's possible to access Delphi data from the object file. The first step is to declare a global variable in your Object Pascal source similar to the variable shown here (note the underscore):

```
var
  _GLOBALVAR: PChar = 'This is a Delphi String';
```

Note that although the variable is initialized, this isn't a requirement.

In the C++ module, declare a variable of the same name using the external modifier, as shown here:

```
extern char * GLOBALVAR;
```

CAUTION

The default behavior of the Borland C++ compiler is to prepend external variables with an underscore when generating the external symbol (that is, GLOBALVAR becomes `_GLOBALVAR`). You can get around this in one of two ways:

- Use the command-line switch to disable the addition of the underscore (`-u-` with Borland C++ compilers).
- Place an underscore in front of the variable name in the Object Pascal code.

Although it's not possible to directly share data declared in an OBJ file with Object Pascal code, it is possible to trick Object Pascal into accessing OBJ-based data. The first step is to declare the data you want to export in your C++ code using the `__export` directive. For example, you would make a char array available for export like this:

```
char __export C_VAR[128];
```

Next (here comes part one of the trick), you declare this data as an external procedure in your Object Pascal code as follows (note, again, the underscore):

```
procedure _C_VAR; external; // trick to import OBJ data
```

This will allow the linker to resolve references to `_C_VAR` in your Pascal code. Finally (here's the second part of the trick), you can use `_C_VAR` in your Pascal code as a pointer to the data. For example, the following code can be used to get the value of the array:

```
type
  PCharArray = ^TCharArray;
  TCharArray = array[0..127] of char;

function GetCArray: string;
var
  A: PCharArray;
begin
  A := PCharArray(@_C_VAR);
  Result := A^;
end;
```

And the following code can be used to set the value of the array:

```
procedure SetCArray(const S: string);
var
  A: PCharArray;
begin
```

```
A := PCharArray(@_C_VAR);
StrLCopy(A^, PChar(S), SizeOf(TCharArray));
end;
```

Using the Delphi RTL

It can be difficult to link an object file to your Delphi application if the object file contains references to the C++ RTL. This is because the C++ RTL generally lives in LIB files, and Delphi doesn't have the capability to link with LIB files.

How do you get around this problem? One way is to cut the definitions of the external functions you use out of the C++ RTL source code and place it in your object file. However, unless you're calling only one or two external functions, this type of solution will get mighty complex—not to mention the fact that your object file will become huge.

A more elegant solution to this problem is to create one or more header files that redeclare all the RTL functions you call using the `external` modifier and actually implement these functions inside your Object Pascal code. For example, let's say you want to call the `MessageBox()` API function from your C++ code. Normally, this would require you to use the `#include` preprocessor directive to include `windows.h` and link with the necessary Win32 libraries. However, redefining `MessageBox()` in your C++ code like this

```
extern int __stdcall MessageBox(long, char *, char *, long);
```

will cause the Object Pascal linker to search for a function of its own called `MessageBox` when it builds the executable. Of course, there's a function of that name defined in the Windows unit. Now your application will happily compile and link without a hitch.

Listing 13.9 shows a complete example of everything we've talked about so far. It's a fairly simple C module called `ccode.c`.

LISTING 13.9 A Simple C++ Module: `ccode.c`

```
#include "PasStng.h"

// globals
extern char * GLOBALVAR;

// exported data
char __export C_VAR[128];

#ifdef __cplusplus
extern "C" {
#endif
```

continues

LISTING 13.9 Continued

```
//externals
extern int __stdcall MessageBox(long, char *, char *, long);

//functions
int __export __cdecl SAYHELLO(char * hellostr)
{
    char a[64];
    memset(a, 64, 0);
    strcat(a, hellostr);
    strcat(a, " from Borland C++Builder");
    MessageBox(0, a, GLOBALVAR, 0);
    return 0;
}

#ifdef __cplusplus
} // end of extern "C"
#endif
```

In addition to `MessageBox()`, notice the calls that this module makes to the `memset()` and `strcat()` C++ RTL functions. These functions are handled similarly in the `PasStng.h` header file, which contains some of the more common functions from the `string.h` header. This file is shown in Listing 13.10.

LISTING 13.10 `PasStng.h`, C++ `string.h` Emulation for Pascal

```
// PasStng.h
// This module externalizes a portion of the string.h C++ RTL header so
// that the Object Pascal RTL can instead handle the calls.

#ifndef PASSTNG_H
#define PASSTNG_H

#ifndef _SIZE_T
#define _SIZE_T
typedef unsigned size_t;
#endif

#ifdef __cplusplus
extern "C" {
#endif

extern char * __cdecl strcat(char *dest, const char *src);
extern int __cdecl strcmp(const char *s1, const char *s2);
extern size_t __cdecl strlen(const char *s);
```

```

extern char * __cdecl strlwr(char *s);
extern char * __cdecl strncat(char *dest, const char *src,
    size_t maxlen);
extern void * __cdecl memcpy(void *dest, const void *src, size_t n);
extern int __cdecl strcmp(const char *s1, const char *s2,
    size_t maxlen);
extern int __cdecl strncmp(const char *s1, const char *s2, size_t n);
extern void * __cdecl memmove(void *dest, const void *src, size_t n);
extern char * __cdecl strncpy(char *dest, const char *src,
    size_t maxlen);
extern void * __cdecl memset(void *s, int c, size_t n);
extern int __cdecl strnicmp(const char *s1, const char *s2,
    size_t maxlen);
extern void __cdecl movmem(const void *src, void *dest, unsigned length);
extern void __cdecl setmem(void *dest, unsigned length, char value);
extern char * __cdecl stpcpy(char *dest, const char *src);
extern int __cdecl strcmp(const char *s1, const char *s2);
extern char * __cdecl strstr(char *s1, const char *s2);
extern int __cdecl strcmpi(const char *s1, const char *s2);
extern char * __cdeclstrupr(char *s);
extern char * __cdeclstrcpy(char *dest, const char *src);

#ifdef __cplusplus
} // end of extern "C"
#endif

#endif // PASSTNG_H

```

Because these functions don't exist in the Object Pascal RTL, we can work around the problem by creating an Object Pascal unit to include in our project that maps these functions to their Object Pascal counterparts. This unit, `PasStrng.pas`, is shown in Listing 13.11.

LISTING 13.11 `PasStrng.pas`, an Implementation of `string.h` Emulation Functions

```

unit PasStrng;

interface

uses Windows;

function _strcat(Dest, Source: PChar): PChar; cdecl;
procedure _memset(P: Pointer; Count: Integer; value: DWORD); cdecl;
function _stricmp(P1, P2: PChar): Integer; cdecl;
function _strlen(P1: PChar): Integer; cdecl;
function _strlwr(P1: PChar): PChar; cdecl;

```

continues

LISTING 13.11 Continued

```
function _strncat(Dest, Source: PChar; MaxLen: Integer): PChar; cdecl;
function _memcpy(Dest, Source: Pointer; Len: Integer): Pointer;
function _strncmp(P1, P2: PChar; MaxLen: Integer): Integer; cdecl;
function _strncmpi(P1, P2: PChar; MaxLen: Integer): Integer; cdecl;
function _memmove(Dest, Source: Pointer; Len: Integer): Pointer;
function _strncpy(Dest, Source: PChar; MaxLen: Integer): PChar; cdecl;
function _strnicmp(P1, P2: PChar; MaxLen: Integer): Integer; cdecl;
procedure _movmem(Source, Dest: Pointer; MaxLen: Integer); cdecl;
procedure _setmem(Dest: Pointer; Len: Integer; Value: Char); cdecl;
function _strcpy(Dest, Source: PChar): PChar; cdecl;
function _strcmp(P1, P2: PChar): Integer; cdecl;
function _strstr(P1, P2: PChar): PChar; cdecl;
function _strcmpi(P1, P2: PChar): Integer; cdecl;
function _strupr(P: PChar): PChar; cdecl;
function _strcpy(Dest, Source: PChar): PChar; cdecl;

implementation

uses SysUtils;

function _strcat(Dest, Source: PChar): PChar;
begin
    Result := SysUtils.StrCat(Dest, Source);
end;

function _stricmp(P1, P2: PChar): Integer;
begin
    Result := StrIComp(P1, P2);
end;

function _strlen(P1: PChar): Integer;
begin
    Result := SysUtils.StrLen(P1);
end;

function _strlwr(P1: PChar): PChar;
begin
    Result := StrLower(P1);
end;

function _strncat(Dest, Source: PChar; MaxLen: Integer): PChar;
begin
    Result := StrLCat(Dest, Source, MaxLen);
end;
```

```
function _memcpy(Dest, Source: Pointer; Len: Integer): Pointer;
begin
  Move(Source^, Dest^, Len);
  Result := Dest;
end;

function _strncpy(P1, P2: PChar; MaxLen: Integer): Integer;
begin
  Result := StrLComp(P1, P2, MaxLen);
end;

function _strncmpi(P1, P2: PChar; MaxLen: Integer): Integer;
begin
  Result := StrLIComp(P1, P2, MaxLen);
end;

function _memmove(Dest, Source: Pointer; Len: Integer): Pointer;
begin
  Move(Source^, Dest^, Len);
  Result := Dest;
end;

function _strcpy(Dest, Source: PChar; MaxLen: Integer): PChar;
begin
  Result := StrLCopy(Dest, Source, MaxLen);
end;

procedure _memset(P: Pointer; Count: Integer; Value: DWORD);
begin
  FillChar(P^, Count, Value);
end;

function _strnicmp(P1, P2: PChar; MaxLen: Integer): Integer;
begin
  Result := StrLIComp(P1, P2, MaxLen);
end;

procedure _movmem(Source, Dest: Pointer; MaxLen: Integer);
begin
  Move(Source^, Dest^, MaxLen);
end;

procedure _setmem(Dest: Pointer; Len: Integer; Value: Char);
begin
  FillChar(Dest^, Len, Value);
end;
```

LISTING 13.11 Continued

```
function _stpcpy(Dest, Source: PChar): PChar;
begin
    Result := StrCopy(Dest, Source);
end;

function _strcmp(P1, P2: PChar): Integer;
begin
    Result := StrComp(P1, P2);
end;

function _strstr(P1, P2: PChar): PChar;
begin
    Result := StrPos(P1, P2);
end;

function _strncmpi(P1, P2: PChar): Integer;
begin
    Result := StrIComp(P1, P2);
end;

function _strupr(P: PChar): PChar;
begin
    Result := StrUpper(P);
end;

function _strncpy(Dest, Source: PChar): PChar;
begin
    Result := StrCopy(Dest, Source);
end;

end.
```

TIP

Using the technique shown here, you could externalize more of the C++ RTL and Win32 API into header files that map to Object Pascal units.

Using C++ Classes

Although it's impossible to use C++ classes contained in an object file, it's possible to get some limited use from C++ classes contained in DLLs. By "limited use," we mean that you'll be able to call the virtual functions exposed by the C++ class only from the Delphi side. This

is possible because both Object Pascal and C++ follow the COM standard for virtual interfaces (see Chapter 23, “COM and ActiveX”).

Listing 13.12 shows the source code for `cd11.cpp`, a C++ module that contains a class definition. Notice in particular the standalone functions—one of which creates and returns a reference to a new object, and another of which frees a given reference. These functions are the conduits through which we’ll share the object between the languages.

LISTING 13.12 `cd11.cpp`: A C++ Module That Contains a Class Definition

```
#include <windows.h>

// objects
class TFoo
{
    virtual int function1(char *);
    virtual int function2(int);
};

//member functions
int TFoo::function1(char * str1)
{
    MessageBox(NULL, str1, "Hello from C++ DLL", MB_OK);
    return 0;
}

int TFoo::function2(int i)
{
    return i * i;
}

#ifdef __cplusplus
extern "C" {
#endif

//prototypes
TFoo * __declspec(dllexport) ClassFactory(void);
void __cdeclspec(dllexport) ClassKill(TFoo *);

TFoo * __declspec(dllexport) CLASSFACTORY(void)
{
    TFoo * Foo;
    Foo = new TFoo;
    return Foo;
}
```

continues

LISTING 13.12 Continued

```
void __declspec(dllexport) CLASSKILL(TFoo * Foo)
{
    delete Foo;
}

int WINAPI DllEntryPoint(HINSTANCE hinst, unsigned long reason, void*)
{
    return 1;
}

#ifdef __cplusplus
}
#endif
```

To use this object from a Delphi application, you must do two things. First, you must import the functions that create and destroy class instances. Second, you must define a virtual abstract Object Pascal class definition that wraps the C++ class. Here's how to do that:

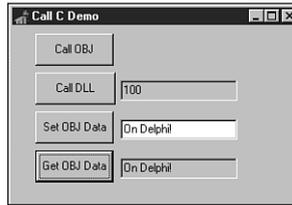
```
type
    TFoo = class
        function Function1(Str1: PChar): integer; virtual; cdecl; abstract;
        function Function2(i: integer): integer; virtual; cdecl; abstract;
    end;

function ClassFactory: TFoo; cdecl; external 'cdll.dll'
    name '_CLASSFACTORY';
procedure ClassKill(Foo: TFoo); cdecl; external 'cdll.dll' name
    '_CLASSKILL';
```

NOTE

When defining the Object Pascal wrapper for a C++ class, you don't need to worry about the names of the functions because they're unimportant in determining how the function is called internally. Because all calls will be dispatched through the Virtual Method Table, the order in which the functions are declared is key. Make sure that the order of the functions is the same in both the C++ and Object Pascal definitions.

Listing 13.13 shows `Main.pas`, the main unit for the `CallC.dpr` project, which demonstrates all the C++ techniques shown so far in this chapter. The main form for this project is shown in Figure 13.5.

**FIGURE 13.5**

The main form for the CallC project.

LISTING 13.13 Main.pas, the Main Unit for the CallC Project

```
unit Main;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls, ExtCtrls;

type
  TMainForm = class(TForm)
    Button1: TButton;
    Button2: TButton;
    FooData: TEdit;
    Button3: TButton;
    Button4: TButton;
    SetCVarData: TEdit;
    GetCVarData: TEdit;
    procedure Button1Click(Sender: TObject);
    procedure Button2Click(Sender: TObject);
    procedure Button3Click(Sender: TObject);
    procedure Button4Click(Sender: TObject);
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  MainForm: TMainForm;
  _GlobalVar: PChar = 'This is a Delphi String';

implementation
```

LISTING 13.13 Continued

```
uses PasStrng;

{$R *.DFM}

{$L ccode.obj}

type
  TFoo = class
    function Function1(Str1: PChar): integer; virtual; cdecl; abstract;
    function Function2(i: integer): integer; virtual; cdecl; abstract;
  end;

  PCharArray = ^TCharArray;
  TCharArray = array[0..127] of char;

// import from OBJ file:
function _SAYHELLO(Text: PChar): Integer; cdecl; external;
procedure _C_VAR; external; // trick to import OBJ data

// imports from DLL file:
function ClassFactory: TFoo; cdecl; external 'cdll.dll'
  name '_CLASSFACTORY';
procedure ClassKill(Foo: TFoo); cdecl; external 'cdll.dll'
  name '_CLASSKILL';

procedure TMainForm.Button1Click(Sender: TObject);
begin
  _SayHello('hello world');
end;

procedure TMainForm.Button2Click(Sender: TObject);
var
  Foo: TFoo;
begin
  Foo := ClassFactory;
  Foo.Function1('huh huh, cool. ');
  FooData.Text := IntToStr(Foo.Function2(10));
  ClassKill(Foo);
end;

function GetCArray: string;
var
  A: PCharArray;
begin
```

```
    A := PCharArray(@_C_VAR);
    Result := A^;
end;

procedure SetCArray(const S: string);
var
    A: PCharArray;
begin
    A := PCharArray(@_C_VAR);
    StrLCopy(A^, PChar(S), SizeOf(TCharArray));
end;

procedure TMainForm.Button3Click(Sender: TObject);
begin
    SetCArray(SetCVarData.Text);
end;

procedure TMainForm.Button4Click(Sender: TObject);
begin
    GetCVarData.Text := GetCArray;
end;

end.
```

TIP

Although the technique demonstrated here does allow a limited means for communicating with C++ classes from Object Pascal, if you want to do this type of thing on a large scale, we recommend you use COM objects to communicate between languages, as described in Chapter 23.

Thinking

At some point in your development of Windows and Win32 applications, you'll need to call 16-bit code from a 32-bit application or even 32-bit code from a 16-bit application. This process is known as *thinking*. Although the different varieties of Win32 provide various facilities to make this possible, it remains one of the more difficult tasks to accomplish when developing Windows applications.

TIP

Aside from thinking, you should know that Automation (described in Chapter 23) provides a reasonable alternative for crossing 16/32-bit boundaries. This capability is built into Automation's IDispatch interface.

Win32 provides three different types of thinking: universal, generic, and flat. Each of these techniques has its advantages and drawbacks:

- *Universal thinking* is available only under the Win32s platform (Win32s is the Win32 API subset available under 16-bit Windows). It allows 16-bit applications to load and call Win32 DLLs. Because this variety of thinking is supported only for Win32s, a platform not officially supported by Delphi, we won't devote any more discussion to this topic.
- *Generic thinking* enables 16-bit Windows applications to call Win32 DLLs under Windows 95, 98, NT, and 2000. This is the most flexible type of thinking because it's available on all major Win32 platforms and is API-based. We'll discuss this option in detail shortly.
- *Flat thinking* allows Win32 applications to call 16-bit DLLs and 16-bit applications to call Win32 DLLs. Unfortunately, this type of thinking is available only under Windows 95/98; it also requires the use of a thunk compiler to create object files, which must be linked to both the 32-bit and 16-bit sides. Because of the lack of portability and requirement for additional tools, we won't cover flat thinking here.

In addition, there's a way to share data between 32-bit and 16-bit processes by using the `WM_COPYDATA` Windows message. In particular, `WM_COPYDATA` provides a straightforward means for accessing 16-bit code from Windows NT/2000 (where thinking can be a headache), so we'll also cover that in this section.

Generic Thinking

Generic thinking is facilitated through a set of APIs that sit on both the 16-bit and 32-bit sides. These APIs are known as `WOW16` and `WOW32`, respectively. From 16-bit land, `WOW16` provides functions that allow you to load the Win32 DLL, get the address of functions in the DLL, and call those functions. The source code for the `WOW16.pas` unit is shown in Listing 13.14.

LISTING 13.14 `WOW16.pas`, Functions to Load a 32-bit DLL from a 16-bit Application

```
unit WOW16;  
// Unit which provides an interface to the 16-bit Windows on Win32 (WOW)  
// API from a 16-bit application running under Win32.
```

```

// These functions allow 16-bit applications to call 32-bit DLLs.
// Copyright (c) 1996, 1999 Steve Teixeira and Xavier Pacheco

interface

uses WinTypes;

type
  THandle32 = Longint;
  DWORD = Longint;

{ Win32 module management.}

{ The following routines accept parameters that correspond directly }
{ to the respective Win32 API function calls that they invoke. Refer }
{ to the Win32 reference documentation for more detail. }
function LoadLibraryEx32W(LibFileName: PChar; hFile, dwFlags: DWORD):
  THandle32;
function FreeLibrary32W(LibModule: THandle32): BOOL;
function GetProcAddress32W(Module: THandle32; ProcName: PChar): TFarProc;

{ GetVDMPointer32W converts a 16-bit (16:16) pointer into a }
{ 32-bit flat (0:32) pointer. The value of FMode should be 1 if }
{ the 16-bit pointer is a protected mode address (the normal }
{ situation in Windows 3.x) or 0 if the 16-bit pointer is real }
{ mode. }
{ NOTE: Limit checking is not performed in the retail build }
{ of Windows NT. It is performed in the checked (debug) build }
{ of WOW32.DLL, which will cause 0 to be returned when the }
{ limit is exceeded by the supplied offset. }
function GetVDMPointer32W(Address: Pointer; fProtectedMode: WordBool):
  DWORD;

{ CallProc32W calls a proc whose address was retrieved by }
{ GetProcAddress32W. The true definition of this function }
{ actually allows for multiple DWORD parameters to be passed }
{ prior to the ProcAddress parameter, and the nParams parameter }
{ should reveal the number of params passed prior to ProcAddress. }
{ The AddressConvert parameter is a bitmask which indicates which }
{ of the params are 16-bit pointers in need of conversion before }
{ the 32-bit function is called. Since this function doesn't lend }
{ itself to being defined in Object Pascal, you may want to use }
{ the simplified Call132BitProc function instead. }
function CallProc32W(Params: DWORD; ProcAddress, AddressConvert,
  nParams: DWORD): DWORD;

```



```

var
  NumParams: word;
begin
  FixParams(Params, AddressConvert);
  NumParams := High(Params) + 1;
  asm
    les di, Params          { es:di -> Params }
    mov cx, NumParams      { loop counter = num params }
  @@1:
    push es:word ptr [di + 2] { push hiword of param x }
    push es:word ptr [di]   { push loword of param x }
    add di, 4               { skip to next param }
    loop @@1               { iterate over all params }
    mov cx, ProcAddress.Word[2] { cx = hiword of ProcAddress }
    mov dx, ProcAddress.Word[0] { dx = loword of ProcAddress }
    push cx                 { push hi ProcAddress }
    push dx                 { push lo ProcAddress }
    mov ax, 0
    push ax                 { push dummy hi AddressConvert }
    push ax                 { push dummy lo AddressConvert }
    push ax                 { push hi NumParams }
    mov cx, NumParams
    push cx                 { push lo Number of Params }
    call CallProc32W       { call function }
    mov Result.Word[0], ax
    mov Result.Word[2], dx { store return value }
  end
end;

{ 16-bit WOW functions }
function LoadLibraryEx32W;          external 'KERNEL' index 513;
function FreeLibrary32W;           external 'KERNEL' index 514;
function GetProcAddress32W;        external 'KERNEL' index 515;
function GetVDMPointer32W;         external 'KERNEL' index 516;
function CallProc32W;              external 'KERNEL' index 517;

end.

```

All the functions in this unit are simply exports from the 16-bit kernel except for the `Call132BitProc()` function, which employs some assembly code to allow the user to pass a variable number of parameters in an array of `Longint`.

The `WOW32` functions make up the `WOW32.pas` unit, which is shown in Listing 13.15.

LISTING 13.15 WOW32.pas, Interface for WOW32.dll, Which Provides Access to 16-bit code from Win32 Applications

```
unit WOW32;
// Import of WOW32.DLL, which provides utilities for accessing
// 16-bit code from Win32.
// Copyright (c) 1996, 1999 Steve Teixeira and Xavier Pacheco

interface

uses Windows;

//
// 16:16 -> 0:32 Pointer translation.
//
// WOWGetVDMPointer will convert the passed in 16-bit address
// to the equivalent 32-bit flat pointer.  If fProtectedMode
// is TRUE, the function treats the upper 16 bits as a selector
// in the local descriptor table.  If fProtectedMode is FALSE,
// the upper 16 bits are treated as a real-mode segment value.
// In either case the lower 16 bits are treated as the offset.
//
// The return value is 0 if the selector is invalid.
//
// NOTE: Limit checking is not performed in the retail build
// of Windows NT.  It is performed in the checked (debug) build
// of WOW32.DLL, which will cause 0 to be returned when the
// limit is exceeded by the supplied offset.
//
function WOWGetVDMPointer(vp, dwBytes: DWORD; fProtectedMode: BOOL):
    Pointer; stdcall;

//
// The following two functions are here for compatibility with
// Windows 95.  On Win95, the global heap can be rearranged,
// invalidating flat pointers returned by WOWGetVDMPointer, while
// a thunk is executing.  On Windows NT, the 16-bit VDM is completely
// halted while a thunk executes, so the only way the heap will
// be rearranged is if a callback is made to Win16 code.
//
// The Win95 versions of these functions call GlobalFix to
// lock down a segment's flat address, and GlobalUnfix to
// release the segment.
//
// The Windows NT implementations of these functions do *not*
// call GlobalFix/GlobalUnfix on the segment, because there
// will not be any heap motion unless a callback occurs.
```

```
// If your thunk does callback to the 16-bit side, be sure
// to discard flat pointers and call WOWGetVDMPointer again
// to be sure the flat address is correct.
//
function WOWGetVDMPointerFix(vp, dwBytes: DWORD; fProtectedMode: BOOL):
    Pointer; stdcall;
procedure WOWGetVDMPointerUnfix(vp: DWORD); stdcall;

//
// Win16 memory management.
//
// These functions can be used to manage memory in the Win16
// heap. The following four functions are identical to their
// Win16 counterparts, except that they are called from Win32
// code.
//
function WOWGlobalAlloc16(wFlags: word; cb: DWORD): word; stdcall;
function WOWGlobalFree16(hMem: word): word; stdcall;
function WOWGlobalLock16(hMem: word): DWORD; stdcall;
function WOWGlobalUnlock16(hMem: word): BOOL; stdcall;

//
// The following three functions combine two common operations in
// one switch to 16-bit mode.
//
function WOWGlobalAllocLock16(wFlags: word; cb: DWORD; phMem: PWord):
    DWORD; stdcall;
function WOWGlobalLockSize16(hMem: word; pcb: PDWORD): DWORD; stdcall;
function WOWGlobalUnlockFree16(vpMem: DWORD): word; stdcall;

//
// Yielding the Win16 nonpreemptive scheduler
//
// The following two functions are provided for Win32 code called
// via Generic Thunks which needs to yield the Win16 scheduler so
// that tasks in that VDM can execute while the thunk waits for
// something to complete. These two functions are functionally
// identical to calling back to 16-bit code which calls Yield or
// DirectedYield.
//
procedure WOWYield16;
procedure WOWDirectedYield16(htask16: word);

//
// Generic Callbacks.
//
```

LISTING 13.15 Continued

```
// WOWCallback16 can be used in Win32 code called
// from 16-bit (such as by using Generic Thunks) to call back to
// the 16-bit side. The function called must be declared similarly
// to the following:
//
// function CallbackRoutine(dwParam: Longint): Longint; export;
//
// If you are passing a pointer, declare the parameter as such:
//
// function CallbackRoutine(vp: Pointer): Longint; export;
//
// NOTE: If you are passing a pointer, you'll need to get the
// pointer using WOWGlobalAlloc16 or WOWGlobalAllocLock16
//
// If the function called returns a word instead of a Longint, the
// upper 16 bits of the return value is undefined. Similarly, if
// the function called has no return value, the entire return value
// is undefined.
//
// WOWCallback16Ex allows any combination of arguments up to
// WCB16_MAX_CBARGS bytes total to be passed to the 16-bit routine.
// cbArgs is used to properly clean up the 16-bit stack after calling
// the routine. Regardless of the value of cbArgs, WCB16_MAX_CBARGS
// bytes will always be copied from pArgs to the 16-bit stack. If
// pArgs is less than WCB16_MAX_CBARGS bytes from the end of a page,
// and the next page is inaccessible, WOWCallback16Ex will incur an
// access violation.
//
// If cbArgs is larger than the WCB16_MAX_ARGS which the running
// system supports, the function returns FALSE and GetLastError
// returns ERROR_INVALID_PARAMETER. Otherwise the function
// returns TRUE and the DWORD pointed to by pdwRetCode contains
// the return code from the callback routine. If the callback
// routine returns a WORD, the HIWORD of the return code is
// undefined and should be ignored using LOWORD(dwRetCode).
//
// WOWCallback16Ex can call routines using the PASCAL and CDECL
// calling conventions. The default is to use the PASCAL
// calling convention. To use CDECL, pass WCB16_CDECL in the
// dwFlags parameter.
//
// The arguments pointed to by pArgs must be in the correct
// order for the callback routine's calling convention.
// To call the routine SetWindowText,
//
```

```

// SetWindowText(Handle: hWnd; lpsz: PChar): Longint;
//
// pArgs would point to an array of words:
//
// SetWindowTextArgs: array[0..2] of word =
//     (LoWord(Longint(lpsz)), HiWord(Longint(lpsz)), Handle);
//
// In other words, the arguments are placed in the array in reverse
// order with the least significant word first for DWORDs and offset
// first for FAR pointers. Further, the arguments are placed in the
// array in the order listed in the function prototype with the least
// significant word first for DWORDs and offset first for FAR pointers.
//
function WOWCallback16(vpfn16, dwParam: DWORD): DWORD; stdcall;

const
    WCB16_MAX_CBARGS = 16;
    WCB16_PASCAL      = $0;
    WCB16_CDECL       = $1;

function WOWCallback16Ex(vpfn16, dwFlags, cbArgs: DWORD; pArgs: Pointer;
    pdwRetCode: PDWORD): BOOL; stdcall;

//
// 16 <--> 32 Handle mapping functions.
//
type
    TWOWHandleType = (
        WOW_TYPE_HWND,
        WOW_TYPE_HMENU,
        WOW_TYPE_HDWP,
        WOW_TYPE_HDROP,
        WOW_TYPE_HDC,
        WOW_TYPE_HFONT,
        WOW_TYPE_HMETAFILE,
        WOW_TYPE_HRGN,
        WOW_TYPE_HBITMAP,
        WOW_TYPE_HBRUSH,
        WOW_TYPE_HPALETTE,
        WOW_TYPE_HPEN,
        WOW_TYPE_HACCEL,
        WOW_TYPE_HTASK,
        WOW_TYPE_FULLHWND);

function WOWHandle16(Handle32: THandle; HandType: TWOWHandleType): Word;
    stdcall;

```

LISTING 13.15 Continued

```
function WOWHandle32(Handle16: word; HandleType: TWOWHandleType):
    THandle; stdcall;

implementation

const
    WOW32DLL = 'WOW32.DLL';

function WOWCallback16;
    external WOW32DLL name 'WOWCallback16';
function WOWCallback16Ex;
    external WOW32DLL name 'WOWCallback16Ex';
function WOWGetVDMPointer;
    external WOW32DLL name 'WOWGetVDMPointer';
function WOWGetVDMPointerFix;
    external WOW32DLL name 'WOWGetVDMPointerFix';
procedure WOWGetVDMPointerUnfix;
    external WOW32DLL name 'WOWGetVDMPointerUnfix';
function WOWGlobalAlloc16;
    external WOW32DLL name 'WOWGlobalAlloc16';
function WOWGlobalAllocLock16;
    external WOW32DLL name 'WOWGlobalAllocLock16';
function WOWGlobalFree16;
    external WOW32DLL name 'WOWGlobalFree16';
function WOWGlobalLock16;
    external WOW32DLL name 'WOWGlobalLock16';
function WOWGlobalLockSize16;
    external WOW32DLL name 'WOWGlobalLockSize16';
function WOWGlobalUnlock16;
    external WOW32DLL name 'WOWGlobalUnlock16';
function WOWGlobalUnlockFree16;
    external WOW32DLL name 'WOWGlobalUnlockFree16';
function WOWHandle16;
    external WOW32DLL name 'WOWHandle16';
function WOWHandle32;
    external WOW32DLL name 'WOWHandle32';
procedure WOWYield16;
    external WOW32DLL name 'WOWYield16';
procedure WOWDirectedYield16;
    external WOW32DLL name 'WOWDirectedYield16';

end.
```

To illustrate generic thinking, we'll create a small 32-bit DLL that will be called from a 16-bit executable. The 32-bit DLL project, `TestDLL.dpr`, is shown in Listing 13.16.

LISTING 13.16 TestDLL.dpr, DLL Project for Testing Generic Thunking. -s

```
library TestDLL;

uses
  SysUtils, Dialogs, Windows, WOW32;

const
  DLLStr = 'I am in the 32-bit DLL. The string you sent is: "%s"';

function DLLFunc32(P: PChar; CallbackFunc: DWORD): Integer; stdcall;
const
  MemSize = 256;
var
  Mem16: DWORD;
  Mem32: PChar;
  Hand16: word;
begin
  { Show string P }
  ShowMessage(Format(DLLStr, [P]));
  { Allocate some 16-bit memory }
  Hand16 := WOWGlobalAlloc16(GMem_Share or GMem_Fixed or GMem_ZeroInit,
                             MemSize);

  { Lock the 16-bit memory }
  Mem16 := WOWGlobalLock16(Hand16);
  { Convert 16-bit pointer to 32-bit pointer. Now they point to the }
  { same place. }
  Mem32 := PChar(WOWGetVDMPointer(Mem16, MemSize, True));
  { Copy string into 32-bit pointer }
  StrPCopy(Mem32, 'I REALLY love DDG!!');
  { Call back into the 16-bit app, passing 16-bit pointer }
  Result := WOWCallback16(CallbackFunc, Mem16);
  { clean up allocated 16-bit memory }
  WOWGlobalUnlockFree16(Mem16);
end;

exports
  DLLFunc32 name 'DLLFunc32' resident;

begin
end.
```

This DLL exports one function that takes a PChar and a callback function as parameters. The PChar is immediately displayed in a ShowMessage(). The callback function allows the function to call back into the 16-bit process, passing some specially allocated 16-bit memory.

The code for the 16-bit application, `Call32.dpr`, is shown in Listing 13.17. The main form is shown in Figure 13.6.

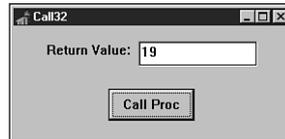


FIGURE 13.6

The Call32 main form.

LISTING 13.17 `Main.pas`, the Main Unit for the 16-bit Portion of the Generic Thinking Test Application

```
unit Main;
{$C FIXED DEMANDLOAD PERMANENT}

interface

uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls;

type
  TMainForm = class(TForm)
    CallBtn: TButton;
    Edit1: TEdit;
    Label1: TLabel;
    procedure CallBtnClick(Sender: TObject);
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}
```

```

uses WOW16;

const
  ExeStr = 'The 32-bit DLL has called back into the 16-bit EXE. ' +
    'The string to the EXE is: "%s"';

function CallBackFunc(P: PChar): Longint; export;
begin
  ShowMessage(Format(ExeStr, [StrPas(P)]));
  Result := StrLen(P);
end;

procedure TMainForm.CallBtnClick(Sender: TObject);
var
  H: THandle32;
  R, P: Longint;
  AStr: PChar;
begin
  { load 32-bit DLL }
  H := LoadLibraryEx32W('TestDLL.dll', 0, 0);
  AStr := StrNew('I love DDG.');
```

```

  try
    if H > 0 then
      begin
        { Retrieve address of proc from 32-bit DLL }
        TFarProc(P) := GetProcAddress32W(H, 'DLLFunc32');
        if P > 0 then
          begin
            { Call proc in 32-bit DLL }
            R := Call32BitProc(P, [Longint(AStr), Longint(@CallBackFunc)],
              1);
            Edit1.Text := IntToStr(R);
          end;
        end;
      end;
    finally
      StrDispose(AStr);
      if H > 0 then FreeLibrary32W(H);
    end;
  end;
end.

```

This application passes a 16-bit PChar and function address to the 32-bit DLL. CallBackFunc() is eventually called by the 32-bit DLL. In fact, if you look closely, the return value of DLLFunc32() is the value returned by CallBackFunc().

WM_COPYDATA

Windows 95/98 supports flat thunks to call 16-bit DLLs from Win32 applications. Windows NT/2000 doesn't provide a means to directly call 16-bit code from a Win32 application. Given this limitation, the question that follows is, what's the best way to communicate data between 32-bit and 16-bit processes on NT? What's more, that leads us to another question: Is there an easy way to share data in such a way that it runs under all the major Win32 platforms, Windows 95, 98, NT, and 2000?

The answer to both questions is `WM_COPYDATA`. The `WM_COPYDATA` Windows message provides a means for transferring binary data between processes—whether 32-bit or 16-bit processes. When a `WM_COPYDATA` message is sent to a window, the `wParam` of this message identifies the window passing the data, and the `lParam` holds a pointer to a `TCopyDataStruct` record. This record is defined as follows:

```
type
    PCopyDataStruct = ^TCopyDataStruct;
    TCopyDataStruct = packed record
        dwData: DWORD;
        cbData: DWORD;
        lpData: Pointer;
    end;
```

The `dwData` field holds 32 bits of user-defined information. `cbData` contains the size of the buffer pointed to by `lpData`. `lpData` is a pointer to a buffer of information you want to pass between applications. If you send this message between a 32-bit and a 16-bit application, Windows will automatically convert the `lpData` pointer from a 0:32 pointer to a 16:16 pointer, or vice versa. Additionally, Windows will ensure that the data pointed to by `lpData` is mapped into the receiving process's address space.

NOTE

`WM_COPYDATA` works great for relatively small amounts of information, but if you have a lot of information that you must communicate across the 16/32-bit boundary, you may wish to do so using Automation, which has the built-in ability to marshal across process boundaries. Automation is described in Chapter 23.

TIP

It should be clear that, although NT doesn't support direct usage of 16-bit DLLs from Win32 applications, you can create a 16-bit executable that encapsulates the DLL and can communicate with that executable by using `WM_COPYDATA`.

To show how `WM_COPYDATA` works, we'll create two projects, the first being a 32-bit application. This application will have a memo control into which you can type some text. Additionally, this application will provide a means for communicating with the second project, a 16-bit application, to transfer memo text. To provide a means whereby the two applications can begin communication, take the following steps:

1. Register a window message to obtain a unique message ID for interapplication communication.
2. Broadcast the message system-wide from the Win32 application. In the `wParam` of this message, store the handle to the main window of the Win32 application.
3. When the 16-bit application receives the broadcast message, it will answer by sending the registered message back to the sending application and pass its own main form's window handle as the `wParam`.
4. After receiving the response, the 32-bit application now has the handle to the main form of the 16-bit application. The 32-bit application can now send a `WM_COPYDATA` message to the 16-bit application so that the sharing can begin.

The code for the `RegMsg.pas` unit, which is shared by the two projects, is shown in Listing 13.18.

LISTING 13.18 `RegMsg.pas`, the Unit Which Registers the Handshaking Message

```
unit RegMsg;

interface

var
  DDGM_HandshakeMessage: Cardinal;

implementation

uses WinProcs;

const
  HandshakeMessageStr: PChar = 'DDG.CopyData.Handshake';

initialization
  DDGM_HandshakeMessage := RegisterWindowMessage(HandshakeMessageStr);
end.
```

The source code for `CopyMain.pas`, the main unit of the 32-bit `CopyData.dpr` project, is shown in Listing 13.19. This is the unit that establishes the conversation and sends the data.

LISTING 13.19 CopyMain.pas, the Main Unit for the 32-bit Portion of the WM_COPYDATA Demonstration

```
unit CopyMain;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls, ExtCtrls, Menus;

type
  TMainForm = class(TForm)
    DataMemo: TMemo;
    BottomPnl: TPanel;
    BtnPnl: TPanel;
    CloseBtn: TButton;
    CopyBtn: TButton;
    MainMenu1: TMainMenu;
    File1: TMenuItem;
    CopyData1: TMenuItem;
    N1: TMenuItem;
    Exit1: TMenuItem;
    Help1: TMenuItem;
    About1: TMenuItem;
    procedure CloseBtnClick(Sender: TObject);
    procedure FormResize(Sender: TObject);
    procedure About1Click(Sender: TObject);
    procedure CopyBtnClick(Sender: TObject);
  private
    { Private declarations }
  protected
    procedure WndProc(var Message: TMessage); override;
  public
    { Public declarations }
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

uses AboutU, RegMsg;

// The following declaration is necessary because of an error in
// the declaration of BroadcastSystemMessage() in the Windows unit
```

```
function BroadcastSystemMessage(Flags: DWORD; Recipients: PDWORD;
    uiMessage: UINT; wParam: WPARAM; lParam: LPARAM): Longint; stdcall;
external 'user32.dll';

var
    Recipients: DWORD = BSM_APPLICATIONS;

procedure TMainForm.WndProc(var Message: TMessage);
var
    DataBuffer: TCopyDataStruct;
    Buf: PChar;
    BufSize: Integer;
begin
    if Message.Msg = DDGM_HandshakeMessage then begin
        { Allocate buffer }
        BufSize := DataMemo.GetTextLen + (1 * SizeOf(Char));
        Buf := AllocMem(BufSize);
        { Copy memo to buffer }
        DataMemo.GetTextBuf(Buf, BufSize);
        try
            with DataBuffer do begin
                { Fill dwData with registered message as safety check }
                dwData := DDGM_HandshakeMessage;
                cbData := BufSize;
                lpData := Buf;
            end;
            { NOTE: WM_COPYDATA message must be *sent* }
            SendMessage(Message.wParam, WM_COPYDATA, Handle,
                Longint(@DataBuffer));
        finally
            FreeMem(Buf, BufSize);
        end;
    end
    else
        inherited WndProc(Message);
end;

procedure TMainForm.CloseBtnClick(Sender: TObject);
begin
    Close;
end;

procedure TMainForm.FormResize(Sender: TObject);
begin
    BtnPnl.Left := BottomPnl.Width div 2 - BtnPnl.Width div 2;
end;
```

LISTING 13.19 Continued

```
procedure TMainForm.About1Click(Sender: TObject);
begin
    AboutBox;
end;

procedure TMainForm.CopyBtnClick(Sender: TObject);
begin
    { Call for any listening apps }
    BroadcastSystemMessage(BSF_IGNORECURRENTTASK or BSF_POSTMESSAGE,
        @Recipients, DDGM_HandshakeMessage, Handle, 0);
end;

end.
```

The source for `ReadMain.pas`, the main unit for the 16-bit `ReadData.dpr` project, is shown in Listing 13.20. This is the unit that communicates with the `CopyData` project and receives the data buffer.

LISTING 13.20 `ReadMain.pas`, the Main Unit for the 16-bit Portion of the `WM_COPYDATA` Demonstration

```
unit Readmain;

interface

uses
    SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
    Forms, Dialogs, Menus, StdCtrls;

{ The WM_COPYDATA Windows message is not defined in the 16-bit Messages }
{ unit, although it is available to 16-bit applications running under   }
{ Windows 95 or NT. This message is discussed in the Win32 API online   }
{ help. }
const
    WM_COPYDATA = $004A;

type
    TMainForm = class(TForm)
        ReadMemo: TMemo;
        MainMenu1: TMainMenu;
        File1: TMenuItem;
        Exit1: TMenuItem;
        Help1: TMenuItem;
        About1: TMenuItem;
    end;
```

```

    procedure Exit1Click(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure About1Click(Sender: TObject);
private
    procedure OnAppMessage(var M: TMsg; var Handled: Boolean);
    procedure WMCopyData(var M: TMessage); message WM_COPYDATA;
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

uses RegMsg, AboutU;

type
    { The TCopyDataStruct record type is not defined in WinTypes unit, }
    { although it is available in the 16-bit Windows API when running }
    { under Windows 95 and NT. The lParam of the WM_COPYDATA message }
    { points to one of these. }
    PCopyDataStruct = ^TCopyDataStruct;
    TCopyDataStruct = record
        dwData: DWORD;
        cbData: DWORD;
        lpData: Pointer;
    end;

procedure TMainForm.OnAppMessage(var M: TMsg; var Handled: Boolean);
{ OnMessage handler for Application object. }
begin
    { The DDGM_HandshakeMessage message is received as a broadcast to }
    { all applications. The wParam of this message contains the handle }
    { of the window which broadcasted the message. We respond by posting }
    { the same message back to the sender, with our handle in the wParam. }
    if M.Message = DDGM_HandshakeMessage then begin
        PostMessage(M.wParam, DDGM_HandshakeMessage, Handle, 0);
        Handled := True;
    end;
end;

procedure TMainForm.WMCopyData(var M: TMessage);
{ Handler for WM_COPYDATA message }
begin
    { Check wParam to ensure we know WHO sent us the WM_COPYDATA message }

```

continues

LISTING 13.20 Continued

```
if PCopyDataStruct(M.lParam)^.dwData = DDGM_HandshakeMessage then
  { When WM_COPYDATA message is received, the lParam points to}
  ReadMemo.SetTextBuf(PChar(PCopyDataStruct(M.lParam)^.lpData));
end;

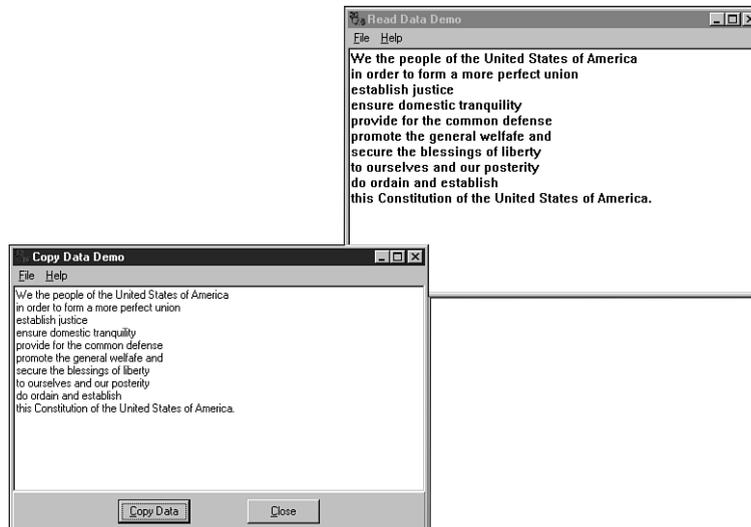
procedure TMainForm.Exit1Click(Sender: TObject);
begin
  Close;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
  Application.OnMessage := OnAppMessage;
end;

procedure TMainForm.About1Click(Sender: TObject);
begin
  AboutBox;
end;

end.
```

Figure 13.7 shows the two applications working in harmony.

**FIGURE 13.7**

Communicating with WM_COPYDATA.

Obtaining Package Information

Packages are great. They provide a convenient means to logically and physically divide your application into separate modules. Packages are compiled binary modules consisting of one or more units, and they can reference units contained in other compiled packages. Of course, if you have the source code for a particular package, it's very easy to figure out what units are contained in that package and what other packages it requires. But what happens when you need to obtain that information for a package for which you have no source code? Fortunately, this is not terribly difficult if you don't mind writing a few lines of code. In fact, you can obtain this information with a call to only one procedure: `GetPackageInfo()`, which is contained in the `SysUtils` unit. `GetPackageInfo()` is declared as follows:

```
procedure GetPackageInfo(Module: HMODULE; Param: Pointer; var Flags: Integer;
  InfoProc: TPackageInfoProc);
```

`Module` is the Win32 API module handle of the package file, such as the handle returned by the `LoadLibrary()` API function.

`Param` is user-defined data that will be passed to the procedure specified by the `InfoProc` parameter.

Upon return, the `Flags` parameter will hold information about the package. This will become a combination of the flags shown in Table 13.6.

TABLE 13.6 `GetPackageInfo()` Flags

<i>Flag</i>	<i>Value</i>	<i>Meaning</i>
<code>pfNeverBuild</code>	<code>\$00000001</code>	This is a "never build" package.
<code>pfDesignOnly</code>	<code>\$00000002</code>	This is a design package.
<code>pfRunOnly</code>	<code>\$00000004</code>	This is a run package.
<code>pfIgnoreDupUnits</code>	<code>\$00000008</code>	Ignores multiple instances of the same unit in this package.
<code>pfModuleTypeMask</code>	<code>\$C0000000</code>	The mask used to identify the module type.
<code>pfExeModule</code>	<code>\$00000000</code>	The package module is an EXE (not used).
<code>pfPackageModule</code>	<code>\$40000000</code>	The package module is a package file.
<code>pfProducerMask</code>	<code>\$0C000000</code>	The mask used to identify the product that created this package.
<code>pfV3Produced</code>	<code>\$00000000</code>	The package produced by Delphi 3 or BCB 3.
<code>pfProducerUndefined</code>	<code>\$04000000</code>	The producer of this package is not defined.
<code>pfBCB4Produced</code>	<code>\$08000000</code>	The packages were produced by BCB 4.
<code>pfDelphi4Produced</code>	<code>\$0C000000</code>	The package was produced by Delphi 4.
<code>pfLibraryModule</code>	<code>\$80000000</code>	The package module is a DLL.

The `InfoProc` parameter identifies a callback method that will be called once for each package this package requires and for each unit contained in this package. This parameter is of type `TPackageInfoProc`, which is defined as follows:

```
type
  TNameType = (ntContainsUnit, ntRequiresPackage);
  TPackageInfoProc = procedure (const Name: string; NameType: TNameType;
    Flags: Byte; Param: Pointer);
```

In this method type, `Name` identifies the name of the package or unit, `NameType` indicates whether this file is a package or a unit, `Flags` provides some additional information for the file, and `Param` contains the user-defined data originally passed to `GetPackageInfo()`.

To demonstrate the `GetPackageInfo()` procedure, what follows is a sample application used to obtain information for any package. This project is called `PackInfo`, and the project file is shown in Listing 13.21.

LISTING 13.21 `PackInfo.dpr`, the Project File for the Application

```
program PkgInfo;

uses
  Forms,
  Dialogs,
  SysUtils,
  PkgMain in 'PkgMain.pas' {PackInfoForm};

{$R *.RES}

var
  OpenDialog: TOpenDialog;
begin
  if (ParamCount > 0) and FileExists(ParamStr(1)) then
    PkgName := ParamStr(1)
  else begin
    OpenDialog := TOpenDialog.Create(Application);
    OpenDialog.DefaultExt := '*.bpl';
    OpenDialog.Filter := 'Packages (*.bpl)|*.bpl|Delphi 3 Packages ' +
      ' (*.dpl)|*.dpl';
    if OpenDialog.Execute then PkgName := OpenDialog.FileName;
  end;
  if PkgName <> '' then
    begin
      Application.Initialize;
      Application.CreateForm(TPackInfoForm, PackInfoForm);
      Application.Run;
    end;
end.
```

If no command-line parameters are passed to this application, it immediately presents the user with a File Open dialog box in which the user can select a package file. If a package file is passed on the command line or if a file is selected in the dialog box, that filename is assigned to `PkgName`, and the application then runs normally.

The main unit for this application is shown in Listing 13.22. This is the unit that performs the call to `GetPackageInfo()`.

LISTING 13.22 `PkgMain.pas`, Obtaining Package Information

```
unit PkgMain;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls, ExtCtrls;

type
  TPackInfoForm = class(TForm)
    GroupBox1: TGroupBox;
    DsgnPkg: TCheckBox;
    RunPkg: TCheckBox;
    BuildCtl: TRadioGroup;
    GroupBox2: TGroupBox;
    GroupBox3: TGroupBox;
    Button1: TButton;
    Label1: TLabel;
    DescEd: TEdit;
    memContains: TMemo;
    memRequires: TMemo;
    procedure FormCreate(Sender: TObject);
    procedure Button1Click(Sender: TObject);
  end;

var
  PackInfoForm: TPackInfoForm;
  PkgName: string; // This is assigned in project file

implementation

{$R *.DFM}

procedure PackageInfoCallback(const Name: string; NameType: TNameType;
  Flags: Byte; Param: Pointer);
var
```

continues

LISTING 13.22 Continued

```
    AddName: string;
    Memo: TMemo;
begin
    Assert(Param <> nil);
    AddName := Name;
    case NameType of
        ntContainsUnit: Memo := TPackInfoForm(Param).memContains;
        ntRequiresPackage: Memo := TPackInfoForm(Param).memRequires;
    else
        Memo := nil;
    end;
    if Memo <> nil then
        begin
            if Memo.Text <> '' then AddName := ', ' + AddName;
            Memo.Text := Memo.Text + AddName;
        end;
    end;

procedure TPackInfoForm.FormCreate(Sender: TObject);
var
    PackMod: HMODULE;
    Flags: Integer;
begin
    // Since we only need to get into the package's resources,
    // LoadLibraryEx with LOAD_LIBRARY_AS_DATAFILE provides a speed-
    // efficient means for loading the package.
    PackMod := LoadLibraryEx(PChar(PkgName), 0, LOAD_LIBRARY_AS_DATAFILE);
    if PackMod = 0 then Exit;
    try
        GetPackageInfo(PackMod, Pointer(Self), Flags, PackageInfoCallback);
    finally
        FreeLibrary(PackMod);
    end;
    Caption := 'Package Info: ' + ExtractFileName(PkgName);
    DsgnPkg.Checked := Flags and pfDesignOnly <> 0;
    RunPkg.Checked := Flags and pfRunOnly <> 0;
    if Flags and pfNeverBuild <> 0 then
        BuildCtl.ItemIndex := 1;
    DescEd.Text := GetPackageDescription(PChar(PkgName));
end;

procedure TPackInfoForm.Button1Click(Sender: TObject);
```

```
begin
  Close;
end;

end.
```

It seems as though there's a disproportionately small amount of code for this unit, considering the low-level information it obtains. When the form is created, the package is loaded, `GetPackageInfo()` is called, and some UI is updated. The `PackageInfoCallback()` method is passed in the `InfoProc` parameter of `GetPackageInfo()`. `PackageInfoCallback()` adds the package or unit name to the appropriate `TMemo` control. Figure 13.8 shows the `PackInfo` application displaying information for one of the Delphi packages.

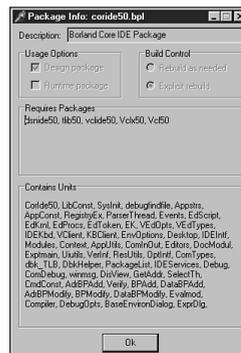


FIGURE 13.8

Viewing package information with `PackInfo`.

Summary

Whew, this was an in-depth chapter! Step back for a moment and take a look at all you learned: subclassing window procedures, preventing multiple instances, windows hooks, BASM programming, using C++ object files, using C++ classes, thinking, `WM_COPYDATA`, and getting information for compiled packages. I don't know about you, but we've covered so much hacker stuff in this chapter that I'm hungry for Cheetos and Jolt Cola! Since we're on a roll with low-level programming, the next chapter, "Snooping System Information," details how to get inside the OS to obtain information about processes, threads, and modules.

Snooping System Information

CHAPTER

14

IN THIS CHAPTER

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- **Windows 95/98: Using ToolHelp32 701**
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In this chapter, you'll learn how to create a full-featured utility, called SysInfo, that's designed to browse the vital parameters of your system. Through the course of developing this application, you'll learn how to employ lesser-known APIs to gain access to low-level, systemwide information on processes, threads, modules, heaps, drivers, and pages. This chapter also covers how Windows 95/98 and Windows NT obtain this information differently. Additionally, SysInfo provides you with techniques for obtaining information on free memory resources, Windows version information, environment variable settings, and a list of loaded modules. Not only do you learn to use these nuts-and-bolts API functions, but you also learn how to integrate this information into a functional and aesthetically pleasing user interface. Additionally, you learn which of the Windows 3.x API functions the Win32 functions in this chapter are designed to replace.

You'd want to get such information from Windows for several reasons. Of course, the hacker in each of us would argue that being able to snoop around the operating system's backyard like some kind of cyber-voyeur is its own reward. Perhaps you're writing a program that needs to access environment variables in order to find certain files. Maybe you need to determine which modules are loaded in order to remove modules from memory manually. Possibly you need to come up with a killer chapter for a book you're writing. See, lots of valid reasons exist!

InfoForm: Obtaining General Information

To warm up, this section shows you how to obtain system information in an API that's consistent across Win32 versions. The code for this application will make a bit more sense if you learn about its user interface first. You'll learn about the user interface of this application a little bit backward, though, because we're going to explain one of the application's child forms first. This form, shown in Figure 14.1, is called InfoForm, and it's used to display various system and process settings, such as memory and hardware information, operating system (OS) version and directory information, and environment variables.

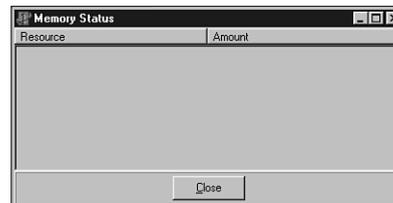


FIGURE 14.1

The InfoForm child form.

The contents of the form are quite simple. The form contains a `THeaderListBox` (a custom component covered in Chapter 21, "Writing Delphi Custom Components") and a `TButton`. To refresh your memory, the `THeaderListBox` control is a combination of a `THeader` control and a `TListBox` control. When the sections of the header are sized, the list box contents will also size

appropriately. The `TheaderListBox` control, called `InfoLB`, displays the information mentioned earlier. The button dismisses the form.

Formatting the Strings

This application makes extensive use of the `Format()` function to format predefined strings with data retrieved from the OS at runtime. The strings that will be used are defined in a `const` section in the main unit:

```
const
{
  Memory status strings }
SMemUse   = 'Memory in useq%d%';
STotMem   = 'Total physical memoryq$.8x bytes';
SFreeMem  = 'Free physical memoryq$.8x bytes';
STotPage  = 'Total page file memoryq$.8x bytes';
SFreePage = 'Free page file memoryq$.8x bytes';
STotVirt  = 'Total virtual memoryq$.8x bytes';
SFreeVirt = 'Free virtual memoryq$.8x bytes';
{ OS version info strings }
SOSVer    = 'OS Versionq%d.%d';
SBuildNo  = 'Build Numberq%d';
SOSPlat   = 'Platformq%s';
SOSWin32s = 'Windows 3.1x running Win32s';
SOSWin95  = 'Windows 95/98';
SOSWinNT  = 'Windows NT/2000';
{ System info strings }
SProc     = 'Processor Arhitectureq%s';
SPIntel   = 'Intel';
SPageSize = 'Page Sizeq$.8x bytes';
SMinAddr  = 'Minimum Application Addressq%p';
SMaxAddr  = 'Maximum Application Addressq%p';
SNumProcs = 'Number of Processorsq%d';
SAllocGra = 'Allocation Granularityq$.8x bytes';
SProcLevl = 'Processor Levelq%s';
SIntel3   = '80386';
SIntel4   = '80486';
SIntel5   = 'Pentium';
SIntel6   = 'Pentium Pro';
SProcRev  = 'Processor Revisionq%.4x';
{ Directory strings }
SWinDir   = 'Windows directoryq%s';
SSysDir   = 'Windows system directoryq%s';
SCurDir   = 'Current directoryq%s';
```

You're probably wondering about the conspicuous "q" in the middle of each of the strings. When displaying these strings, the `DelimChar` property of `InfoLB` is set to `q`, which means that the `InfoLB` component assumes that the character `q` defines the delimiter between each column in the list box.

There are three primary reasons for using `Format()` with predefined strings rather than individually formatting string literals:

- Because `Format()` accepts various types as parameters, you don't have to cloud your code with a bunch of varied calls to functions (such as `IntToStr()` and `IntToHex()`), which format different parameter types for display.
- `Format()` easily handles multiple data types. In this case, we use the `%s` and `%d` format strings to format string and numeric data so that it's more flexible.
- Keeping the strings in a separate location makes it easier to find, add, and change strings, if necessary. It's also more maintainable.

NOTE

Use a double percent sign (`%%`) to display a single percent symbol in a formatted string.

Obtaining Memory Status

The first bit of system information you can obtain to place in `InfoLB` is the memory status obtained by the `GlobalMemoryStatus()` API call. `GlobalMemoryStatus()` is a procedure that accepts one `var` parameter of type `TMemoryStatus`, which is defined as follows:

```
type
  TMemoryStatus = record
    dwLength: DWORD;
    dwMemoryLoad: DWORD;
    dwTotalPhys: DWORD;
    dwAvailPhys: DWORD;
    dwTotalPageFile: DWORD;
    dwAvailPageFile: DWORD;
    dwTotalVirtual: DWORD;
    dwAvailVirtual: DWORD;
  end;
```

- The first field in this record, `dwLength`, describes the length of the `TMemoryStatus` record. You should initialize this value to `SizeOf(TMemoryStatus)` prior to calling

`GlobalMemoryStatus()`. Doing this allows Windows to change the size of this record in future versions because it will be able to differentiate versions based on the value of the first field.

- `dwMemoryLoad` provides a number from 0 to 100 that's intended to give a general idea of memory usage. 0 means that no memory is being used, and 100 means that all memory is in use.
- `dwTotalPhys` indicates the total number of bytes of physical memory (the amount of RAM installed on the computer), and `dwAvailPhys` indicates how much of that total is currently unused.
- `dwTotalPageFile` indicates the total number of bytes that can be stored to hard disk page file(s). This number is not the same as the size of a page file on disk. `dwAvailPageFile` indicates how much of that total is available.
- `dwTotalVirtual` indicates the total number of bytes of usable virtual memory in the calling process. `dwAvailVirtual` indicates how much of this memory is available to the calling process.

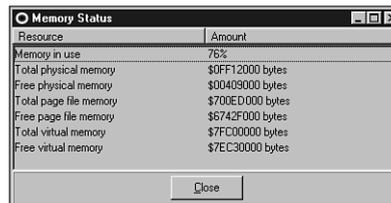
The following code obtains the memory status and fills the list box with the status information:

```
procedure TInfoForm.ShowMemStatus;
var
  MS: TMemoryStatus;
begin
  InfoLB.DelimChar := 'q';
  MS.dwLength := SizeOf(MS);
  GlobalMemoryStatus(MS);
  with InfoLB.Items, MS do
  begin
    Clear;
    Add(Format(SMemUse, [dwMemoryLoad]));
    Add(Format(STotMem, [dwTotalPhys]));
    Add(Format(SFreeMem, [dwAvailPhys]));
    Add(Format(STotPage, [dwTotalPageFile]));
    Add(Format(SFreePage, [dwAvailPageFile]));
    Add(Format(STotVirt, [dwTotalVirtual]));
    Add(Format(SFreeVirt, [dwAvailVirtual]));
  end;
  InfoLB.Sections[0].Text := 'Resource';
  InfoLB.Sections[1].Text := 'Amount';
  Caption:= 'Memory Status';
end;
```

CAUTION

Don't forget to initialize the `dwLength` field of the `TMemoryStatus` structure before calling `GlobalMemoryStatus()`.

Figure 14.2 shows `InfoForm` displaying memory status information at runtime.



Resource	Amount
Memory in use	76%
Total physical memory	\$0FF12000 bytes
Free physical memory	\$00409000 bytes
Total page file memory	\$700E0000 bytes
Free page file memory	\$6742F000 bytes
Total virtual memory	\$7FC00000 bytes
Free virtual memory	\$7EC30000 bytes

FIGURE 14.2

Viewing memory status information.

Getting the OS Version

You can find out what version of Windows and the Win32 OS you're running by making a call to the `GetVersionEx()` API function. `GetVersionEx()` accepts as its only parameter a `TOSVersionInfo` record, by reference. This record is defined as follows:

type

```
TOSVersionInfo = record
    dwOSVersionInfoSize: DWORD;
    dwMajorVersion: DWORD;
    dwMinorVersion: DWORD;
    dwBuildNumber: DWORD;
    dwPlatformId: DWORD;
    szCSDVersion: array[0..126] of AnsiChar; {Maintenance string for PSS usage}
end;
```

- The `dwOSVersionInfoSize` field should be initialized to `SizeOf(TOSVersionInfo)` prior to calling `GetVersionEx()`.
- `dwMajorVersion` indicates the major release number of the OS. In other words, if the OS version number is 4.0, the value of this field will be 4.
- `dwMinorVersion` indicates the minor release number of the OS. In other words, if the OS version number is 4.0, the value of this field will be 0.
- `dwBuildNumber` holds the build number of the OS in its low-order word.

- `dwPlatformId` describes the current Win32 platform. This parameter can have any one of the values in the following table:

<i>Value</i>	<i>Platform</i>
<code>VER_PLATFORM_WIN32s</code>	Win32s on Windows 3.1
<code>VER_PLATFORM_WIN32_WINDOWS</code>	Win32 on Windows 95 or Windows 98
<code>VER_PLATFORM_WIN32_NT</code>	Windows NT or Windows 2000

- `szCSDVersion` contains additional arbitrary OS information. This value is often an empty string.

The following procedure populates `InfoLB` with OS version information:

```
procedure TInfoForm.GetOSVerInfo;
var
  VI: TOSVersionInfo;
begin
  VI.dwOSVersionInfoSize := SizeOf(VI);
  GetVersionEx(VI);
  with InfoLB.Items, VI do
  begin
    Clear;
    Add(Format(SOSVer, [dwMajorVersion, dwMinorVersion]));
    Add(Format(SBuildNo, [LoWord(dwBuildNumber)]));
    case dwPlatformID of
      VER_PLATFORM_WIN32S: Add(Format(SOSPlat, [SOSWin32s]));
      VER_PLATFORM_WIN32_WINDOWS: Add(Format(SOSPlat, [SOSWin95]));
      VER_PLATFORM_WIN32_NT: Add(Format(SOSPlat, [SOSWinNT]));
    end;
  end;
end;
```

NOTE

In Windows 3.x, the `GetVersion()` function obtained similar version information. Because you're now in Win32 land, you should use the `GetVersionEx()` function; it provides more detailed information than `GetVersion()`.

Obtaining Directory Information

The OS uses the `Windows` and `System` directories extensively to store shared DLLs, drivers, applications, and INI files. Additionally, Win32 also maintains a current directory for each process. Throughout the course of writing Win32 applications, it's likely that you'll encounter

a situation where you need to obtain the location of one of these directories. When this happens, you'll be in luck because three functions in the Win32 API enable you to obtain that directory information.

The functions—`GetWindowsDirectory()`, `GetSystemDirectory()`, and `GetCurrentDirectory()`—are pretty straightforward. Each takes a pointer to a buffer where the directory string is copied as the first parameter and the buffer size is copied as the second parameter. The function copies into the buffer a null-terminated string containing the path. Hopefully, you can tell which directory each function returns by the name of the function. If not, well, let's just say we hope you don't rely on programming to eat.

This method uses a temporary array of `char` into which the directory information is stored. From there, the string is added to `InfoLB`, as you can see for yourself in the following code:

```
procedure TInfoForm.GetDirInfo;
var
  S: array[0..MAX_PATH] of char;
begin
  { Get Windows directory }
  GetWindowsDirectory(S, SizeOf(S));
  InfoLB.Items.Add(Format(SWinDir, [S]));
  { Get Windows system directory }
  GetSystemDirectory(S, SizeOf(S));
  InfoLB.Items.Add(Format(SSysDir, [S]));
  { Get Current directory for current process }
  GetCurrentDirectory(SizeOf(S), S);
  InfoLB.Items.Add(Format(SCurDir, [S]));
end;
```

NOTE

The `GetWindowsDir()` and `GetSystemDir()` functions from the Windows 3.x API are unavailable under Win32.

Getting System Information

The Win32 API provides a procedure called `GetSystemInfo()` that, in turn, provides some very low-level details on the operating system. This procedure accepts one parameter of type `TSystemInfo` by reference, and it fills the record with the proper values. The `TSystemInfo` record is defined as follows:

```
type
  PSystemInfo = ^TSystemInfo;
```

```
TSystemInfo = record
  case Integer of
    0: (
      dwOemId: DWORD);
    1: (
      wProcessorArchitecture: Word;
      wReserved: Word;
      dwPageSize: DWORD;
      lpMinimumApplicationAddress: Pointer;
      lpMaximumApplicationAddress: Pointer;
      dwActiveProcessorMask: DWORD;
      dwNumberOfProcessors: DWORD;
      dwProcessorType: DWORD;
      dwAllocationGranularity: DWORD;
      wProcessorLevel: Word;
      wProcessorRevision: Word);
  end;
```

- The `dwOemId` field is used for Windows 95. This value is always set to 0 or `PROCESSOR_ARCHITECTURE_INTEL`.
- Under NT, the `wProcessorArchitecture` portion of the variant record is used. This field describes the type of processor architecture under which you're currently running. Because Delphi is designed for Intel only, however, it's the only type that matters at this point. For the sake of completeness, this field can have any one of the following values:
`PROCESSOR_ARCHITECTURE_INTEL`
`PROCESSOR_ARCHITECTURE_MIPS`
`PROCESSOR_ARCHITECTURE_ALPHA`
`PROCESSOR_ARCHITECTURE_PPC`
- The `wReserved` field is unused at this time.
- The `dwPageSize` field holds the page size in kilobytes (KB) and specifies the granularity of page protection and commitment. On Intel x86 machines, this value is 4KB.
- `lpMinimumApplicationAddress` returns the lowest memory address accessible to applications and DLLs. Attempts to access a memory address below this value is likely to result in an access violation. `lpMaximumApplicationAddress` returns the highest memory address accessible to applications and DLLs. Attempts to access a memory address above this value are likely to result in an access violation.
- `dwActiveProcessorMask` returns a mask representing the set of processors configured into the system. Bit 0 represents the first processor, and bit 31 represents the 32nd processor. Wouldn't having 32 processors be cool? Because Windows 95/98 supports only one processor, only bit 0 will be set under that implementation of Win32.

- `dwNumberOfProcessors` also returns the number of processors in the system. We're not sure why Microsoft bothered to put both this and the preceding field in the `TSystemInfo` record, but here they are.
- The `dwProcessorType` field is no longer relevant. It was retained for backward compatibility. This field can have any one of the following values:

```
PROCESSOR_INTEL_386
PROCESSOR_INTEL_486
PROCESSOR_INTEL_PENTIUM
PROCESSOR_MIPS_R4000
PROCESSOR_ALPHA_21064
```

Of course, under Windows 95/98, only the `PROCESSOR_INTEL_x` values are possible, whereas all are valid under Windows NT.

- `dwAllocationGranularity` returns the allocation granularity upon which memory will be allocated. In previous implementations of Win32, this value was hard-coded as 64KB. It's possible, however, that other hardware architectures may require different values.
- The `wProcessorLevel` field specifies the system's architecture-dependent processor level. This field can hold a variety of values for different processors. For Intel processors, this parameter can have any of the values in the following table:

<i>Value</i>	<i>Meaning</i>
3	Processor is an 80386
4	Processor is an 80486
5	Processor is a Pentium
6	Processor is a Pentium Pro or higher

- `wProcessorRevision` specifies an architecture-dependent processor revision. Like `wProcessorLevel`, this field can hold a variety of values for different processors. For Intel architectures, this field holds a number in the format `xyyy`. For Intel 386 and 486 chips, `xx + $0A` is the stepping level and `yy` is the stepping (for example, `0300` is a D0 chip). For Intel Pentium or Cyrex/NextGen 486 chips, `xx` is the model number, and `yy` is the stepping (for example, `0201` is Model 2, Stepping 1).

The procedure used to obtain and add the formatted system information strings to `InfoLB` is as follows (note that this code is purposely slanted to display only Intel architecture information):

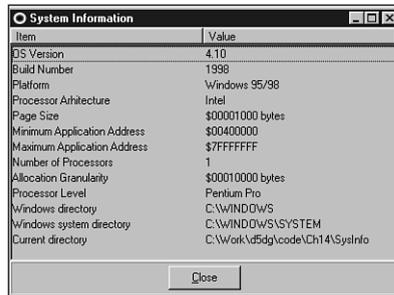
```
procedure TInfoForm.GetSysInfo;
var
  SI: TSystemInfo;
begin
  GetSystemInfo(SI);
```

```
with InfoLB.Items, SI do
begin
  Add(Format(SProc, [SPIntel]));
  Add(Format(SPageSize, [dwPageSize]));
  Add(Format(SMinAddr, [lpMinimumApplicationAddress]));
  Add(Format(SMaxAddr, [lpMaximumApplicationAddress]));
  Add(Format(SNumProcs, [dwNumberOfProcessors]));
  Add(Format(SAllocGra, [dwAllocationGranularity]));
  case wProcessorLevel of
    3: Add(Format(SProcLevl, [SIntel3]));
    4: Add(Format(SProcLevl, [SIntel4]));
    5: Add(Format(SProcLevl, [SIntel5]));
    6: Add(Format(SProcLevl, [SIntel6]));
  else Add(Format(SProcLevl, [IntToStr(wProcessorLevel)]));
  end;
end;
end;
```

NOTE

The `GetSystemInfo()` function effectively replaces the `GetWinFlags()` function from the Windows 3.x API.

Figure 14.3 shows `InfoForm` displaying system information, including OS version and directory information, at runtime.

**FIGURE 14.3**

Viewing system information.

Checking Out the Environment

Obtaining the list of environment variables—things such as sets, path, and prompt—for the current process is an easy task, thanks to the `GetEnvironmentStrings()` API function. This function takes no parameters and returns a null-separated list of environment strings. The format of this list is a string, followed by a null, followed by a string, followed by a null, and so on until the entire string is terminated with a double null (`#0#0`). The following function is used in the `SysInfo` application to retrieve the output from the `GetEnvironmentStrings()` function and place it into `InfoLB`:

```
procedure TInfoForm.ShowEnvironment;
var
  EnvPtr, SavePtr: PChar;
begin
  InfoLB.DelimChar := '=';
  EnvPtr := GetEnvironmentStrings;
  SavePtr := EnvPtr;
  InfoLB.Items.Clear;
  repeat
    InfoLB.Items.Add(StrPas(EnvPtr));
    inc(EnvPtr, StrLen(EnvPtr) + 1);
  until EnvPtr^ = #0;
  FreeEnvironmentStrings(SavePtr);
  InfoLB.Sections[0].Text := 'Environment Variable';
  InfoLB.Sections[1].Text := 'Value';
  Caption:= 'Current Environment';
end;
```

NOTE

The `ShowEnvironment()` method takes advantage of Object Pascal's capability to perform pointer arithmetic on `PChar`-type strings. Notice how few lines of code are required to traverse the list of environment strings.

A couple of comments on this method are in order. First, notice that the `DelimChar` property of `InfoLB` is initially set to '='. Because each of the environment variable and value pairs are already separated by that character, it's very easy to display them properly in `InfoLB`. Also, when you're finished using the environment strings, you should call the `FreeEnvironmentStrings()` function to free the allocated block.

TIP

You can't obtain or set individual environment variables with the `GetEnvironmentStrings()` function. For getting and setting individual environment variables, see the `GetEnvironmentVariable()` and `SetEnvironmentVariable()` functions in the Win32 API help.

Figure 14.4 shows the InfoForm environment strings at runtime.

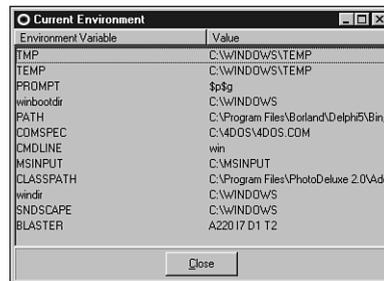


FIGURE 14.4

Viewing environment strings.

Listing 14.1 shows the entire source code for the InfoU.pas unit.

LISTING 14.1 The Source Code for the InfoU.pas Unit

```
unit InfoU;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  HeadList, StdCtrls, ExtCtrls, SysMain;

type
  TInfoVariety = (ivMemory, ivSystem, ivEnvironment);

  TInfoForm = class(TForm)
    InfoLB: THeaderListbox;
    Panel1: TPanel;
  end;
end;
```

continues

LISTING 14.1 Continued

```
    OkBtn: TButton;
private
    procedure GetOSVerInfo;
    procedure GetSysInfo;
    procedure GetDirInfo;
public
    procedure ShowMemStatus;
    procedure ShowSysInfo;
    procedure ShowEnvironment;
end;

procedure ShowInformation(Variety: TInfoVariety);

implementation

{$R *.DFM}

procedure ShowInformation(Variety: TInfoVariety);
begin
    with TInfoForm.Create(Application) do
        try
            Font := MainForm.Font;
            case Variety of
                ivMemory: ShowMemStatus;
                ivSystem: ShowSysInfo;
                ivEnvironment: ShowEnvironment;
            end;
            ShowModal;
        finally
            Free;
        end;
    end;
end;

const
    { Memory status strings }
    SMemUse   = 'Memory in useq%d%';
    STotMem  = 'Total physical memoryq$%.8x bytes';
    SFreeMem = 'Free physical memoryq$%.8x bytes';
    STotPage = 'Total page file memoryq$%.8x bytes';
    SFreePage = 'Free page file memoryq$%.8x bytes';
    STotVirt = 'Total virtual memoryq$%.8x bytes';
```

```

SFreeVirt = 'Free virtual memoryq$%.8x bytes';

{ OS version info strings }
SOSVer    = 'OS Versionqd.%d';
SBuildNo  = 'Build Numberqd';
SOSPlat   = 'Platformqs';
SOSWin32s = 'Windows 3.1x running Win32s';
SOSWin95  = 'Windows 95/98';
SOSWinNT  = 'Windows NT/2000';

{ System info strings }
SProc     = 'Processor Arhitectureqs';
SPIntel   = 'Intel';
SPageSize = 'Page Sizeq$%.8x bytes';
SMinAddr  = 'Minimum Application Addressq$p';
SMaxAddr  = 'Maximum Application Addressq$p';
SNumProcs = 'Number of Processorsqd';
SAllocGra = 'Allocation Granularityq$%.8x bytes';
SProcLevl = 'Processor Levelqs';
SIntel3   = '80386';
SIntel4   = '80486';
SIntel5   = 'Pentium';
SIntel6   = 'Pentium Pro';
SProcRev  = 'Processor Revisionq%.4x';

{ Directory strings }
SWinDir   = 'Windows directoryqs';
SSysDir   = 'Windows system directoryqs';
SCurDir   = 'Current directoryqs';

procedure TInfoForm.ShowMemStatus;
var
  MS: TMemoryStatus;
begin
  InfoLB.DelimChar := 'q';
  MS.dwLength := SizeOf(MS);
  GlobalMemoryStatus(MS);
  with InfoLB.Items, MS do
  begin
    Clear;
    Add(Format(SMemUse, [dwMemoryLoad]));
    Add(Format(STotMem, [dwTotalPhys]));
  end;
end;

```

continues

LISTING 14.1 Continued

```
Add(Format(SFreeMem, [dwAvailPhys]));
Add(Format(STotPage, [dwTotalPageFile]));
Add(Format(SFreePage, [dwAvailPageFile]));
Add(Format(STotVirt, [dwTotalVirtual]));
Add(Format(SFreeVirt, [dwAvailVirtual]));
end;
InfoLB.Sections[0].Text := 'Resource';
InfoLB.Sections[1].Text := 'Amount';
Caption:= 'Memory Status';
end;

procedure TInfoForm.GetOSVerInfo;
var
    VI: TOSVersionInfo;
begin
    VI.dwOSVersionInfoSize := SizeOf(VI);
    GetVersionEx(VI);
    with InfoLB.Items, VI do
    begin
        Clear;
        Add(Format(SOSVer, [dwMajorVersion, dwMinorVersion]));
        Add(Format(SBuildNo, [LoWord(dwBuildNumber)]));
        case dwPlatformID of
            VER_PLATFORM_WIN32S: Add(Format(SOSPlat, [SOSWin32s]));
            VER_PLATFORM_WIN32_WINDOWS: Add(Format(SOSPlat, [SOSWin95]));
            VER_PLATFORM_WIN32_NT: Add(Format(SOSPlat, [SOSWinNT]));
        end;
    end;
end;

procedure TInfoForm.GetSysInfo;
var
    SI: TSystemInfo;
begin
    GetSystemInfo(SI);
    with InfoLB.Items, SI do
    begin
        Add(Format(SProc, [SPIntel]));
        Add(Format(SPageSize, [dwPageSize]));
        Add(Format(SMinAddr, [lpMinimumApplicationAddress]));
```

```
Add(Format(SMaxAddr, [lpMaximumApplicationAddress]));
Add(Format(SNumProcs, [dwNumberOfProcessors]));
Add(Format(SAllocGra, [dwAllocationGranularity]));
case wProcessorLevel of
  3: Add(Format(SProcLevl, [SIntel3]));
  4: Add(Format(SProcLevl, [SIntel4]));
  5: Add(Format(SProcLevl, [SIntel5]));
  6: Add(Format(SProcLevl, [SIntel6]));
  else Add(Format(SProcLevl, [IntToStr(wProcessorLevel)]));
end;
end;
end;

procedure TInfoForm.GetDirInfo;
var
  S: array[0..MAX_PATH] of char;
begin
  { Get Windows directory }
  GetWindowsDirectory(S, SizeOf(S));
  InfoLB.Items.Add(Format(SWinDir, [S]));
  { Get Windows system directory }
  GetSystemDirectory(S, SizeOf(S));
  InfoLB.Items.Add(Format(SSysDir, [S]));
  { Get Current directory for current process }
  GetCurrentDirectory(SizeOf(S), S);
  InfoLB.Items.Add(Format(SCurDir, [S]));
end;

procedure TInfoForm.ShowSysInfo;
begin
  InfoLB.DelimChar := 'q';
  GetOSVerInfo;
  GetSysInfo;
  GetDirInfo;
  InfoLB.Sections[0].Text := 'Item';
  InfoLB.Sections[1].Text := 'Value';
  Caption:= 'System Information';
end;

procedure TInfoForm.ShowEnvironment;
var
  EnvPtr, SavePtr: PChar;
```

continues

LISTING 14.1 Continued

```
begin
  InfoLB.DelimChar := '=';
  EnvPtr := GetEnvironmentStrings;
  SavePtr := EnvPtr;
  InfoLB.Items.Clear;
  repeat
    InfoLB.Items.Add(StrPas(EnvPtr));
    inc(EnvPtr, StrLen(EnvPtr) + 1);
  until EnvPtr^ = #0;
  FreeEnvironmentStrings(SavePtr);
  InfoLB.Sections[0].Text := 'Environment Variable';
  InfoLB.Sections[1].Text := 'Value';
  Caption:= 'Current Environment';
end;

end.
```

Platform-Neutral Design

SysInfo is designed to function under both Windows 95/98 and Windows NT, even though the different versions of Win32 have very different ways of accessing low-level information such as processes and memory. The approach we took to enable platform-neutrality is to define an interface that contains methods that can obtain system information. This interface is then implemented for the two different operating systems. The interface is called `IWin32Info`; it's pretty simple and is shown here:

```
type
  IWin32Info = interface
    procedure FillProcessInfoList(ListView: TListView; ImageList: TImageList);
    procedure ShowProcessProperties(Cookie: Pointer);
  end;
```

- `FillProcessInfoList()` is responsible for filling a `TListView` and `TImageList` component with a list of running processes and their associated icons, if any.
- `ShowProcessProperties()` is called to obtain more information for a particular process selected in `TListView`.

In the SysInfo project, you'll find a unit called `W95Info` that contains a `TWin95Info` class that implements `IWin32Info` for Windows 95/98 using the `ToolHelp32` API. Likewise, the project contains a `WNTInfo` unit with a `TWinNTInfo` class that takes advantage of `PSAPI` to implement `IWin32Info`. The following code segment, `SysMain` (which was taken from the project's main unit), shows how the proper class is created depending on the operating system:

```
if Win32Platform = VER_PLATFORM_WIN32_WINDOWS then
  FWinInfo := TWin95Info.Create
else if Win32Platform = VER_PLATFORM_WIN32_NT then
  FWinInfo := TWinNTInfo.Create
else
  raise Exception.Create('This application must be run on Win32');
```

Windows 95/98: Using ToolHelp32

ToolHelp32 is a collection of functions and procedures, part of the Win32 API, which enables you to see the status of some of the operating system's low-level operations. In particular, functions enable you to obtain information on all processes currently executing in the system and the threads, modules, and heaps that go with each of the processes. As you might guess, most of the information obtainable from ToolHelp32 is primarily used by applications that must look "inside" the OS, such as debuggers, although going through these functions gives even the average developer a better idea of how Win32 is put together.

NOTE

The ToolHelp32 API is available only under the Windows 95/98 implementation of Win32. This type of functionality would violate NT's robust process-protection and security features. Therefore, applications that use ToolHelp32 functions will function only under Windows 95/98 and not under Windows NT.

We say *ToolHelp32* to differentiate it from the 16-bit version of ToolHelp that was included in Windows 3.1x. Most of the functions in the previous version of ToolHelp no longer apply to Win32 and are therefore no longer supported. Also, under Windows 3.1x, the ToolHelp functions were physically located in a DLL called TOOLHELP.DLL, whereas ToolHelp32 functions reside in the kernel under Win32.

ToolHelp32 types and function definitions are located in the T1He1p32 unit, so be sure to have that in your uses clause when working with these functions. To ensure that you receive a solid overview, the application you build in this chapter uses every function defined in the T1He1p32 unit.

Figure 14.5 shows the main form for SysInfo. The user interface consists primarily of TheaderListbox, a custom control explained in detail in Chapter 11, "Writing Multithreaded Applications." The list contains important information for a given process. By double-clicking a process in the list, you can obtain more detailed information about it. This detail is shown in a child form similar to the main form.

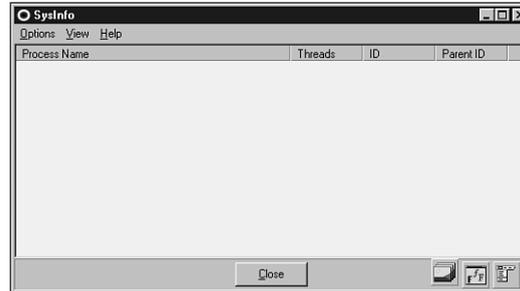


FIGURE 14.5

SysInfo's main form, TMainForm.

Snapshots

Due to the multitasking nature of the Win32 environment, objects such as processes, threads, modules, and heaps are constantly being created, destroyed, and modified. Because the status of the machine is constantly in a state of flux, system information that might be meaningful now may have no meaning a second from now. For example, suppose you want to write a program to enumerate through all the modules loaded systemwide. Because the operating system might preempt the thread executing your program at any time in order to provide time slices to other threads in the system, modules theoretically can be created and destroyed even as you enumerate through them.

In this dynamic environment, it would make more sense if you could freeze the system in time for a moment in order to obtain such system information. Although ToolHelp32 doesn't provide a means for freezing the system in time, it does provide a function that enables you to take a snapshot of the system at a particular moment. `CreateToolhelp32Snapshot()` is that function and is declared as follows:

```
function CreateToolhelp32Snapshot(dwFlags, th32ProcessID: DWORD): THandle;
stdcall;
```

- The `dwFlags` parameter indicates what type of information should be included in the snapshot. This parameter can have any one of the values shown in the following table:

<i>Value</i>	<i>Meaning</i>
TH32CS_INHERIT	Indicates that the snapshot handle will be inheritable
TH32CS_SNAPALL	Equivalent to specifying the TH32CS_SNAPHEAPLIST, TH32CS_SNAPMODULE, TH32CS_SNAPPROCESS, and TH32CS_SNAPTHREAD values
TH32CS_SNAPHEAPLIST	Includes the heap list of the specified Win32 process in the snapshot

TH32CS_SNAPMODULE	Includes the module list of the specified Win32 process in the snapshot
TH32CS_SNAPPROCESS	Includes the Win32 process list in the snapshot
TH32CS_SNAPTHREAD	Includes the Win32 thread list in the snapshot

- The `th32ProcessID` parameter identifies the process for which you want to obtain information. Pass `0` in this parameter to indicate the current process. This parameter affects only module and heap lists because they are process-specific. The process and thread lists provided by `ToolHelp32` are systemwide.
- The `CreateToolhelp32Snapshot()` function returns the handle to a snapshot or `-1` in case of an error. The handle returned works just as other Win32 handles do regarding the processes and threads for which they're valid.

The following code creates a snapshot handle that contains information on all processes currently loaded systemwide (`EToolhelpError` is a programmer-defined exception):

```
var
  Snap: THandle;
begin
  Snap := CreateToolhelp32Snapshot(TH32CS_SNAPPROCESS, 0);
  if Snap = -1 then
    raise EToolhelpError.Create('CreateToolHelp32Snapshot failed');
end;
```

NOTE

When you're done using the handle, use the Win32 API `CloseHandle()` function to free resources associated with a handle created by `CreateToolhelp32Snapshot()`.

Process Walking

Given a snapshot handle that includes process information, `ToolHelp32` defines two functions that provide you with the capability of enumerating over (*walking*) processes. The functions, `Process32First()` and `Process32Next()`, are declared as follows:

```
function Process32First(hSnapshot: THandle;
  var lpe: TProcessEntry32): BOOL; stdcall;
function Process32Next(hSnapshot: THandle;
  var lpe: TProcessEntry32): BOOL; stdcall;
```

The first parameter to these functions, `hSnapshot`, is the snapshot handle returned by `CreateToolhelp32Snapshot()`.

The second parameter, `lppe`, is a `TProcessEntry32` record that's passed by reference. As you go through the enumeration, the functions will fill this record with information on the next process. The `TProcessEntry32` record is defined as follows:

```
type
  TProcessEntry32 = record
    dwSize: DWORD;
    cntUsage: DWORD;
    th32ProcessID: DWORD;
    th32DefaultHeapID: DWORD;
    th32ModuleID: DWORD;
    cntThreads: DWORD;
    th32ParentProcessID: DWORD;
    pcPriClassBase: Longint;
    dwFlags: DWORD;
    szExeFile: array[0..MAX_PATH - 1] of Char;
  end;
```

- The `dwSize` field holds the size of the `TProcessEntry32` record. This should be initialized to `SizeOf(TProcessEntry32)` prior to using the record.
- The `cntUsage` field indicates the reference count of the process. When the reference count is zero, the operating system will unload the process.
- The `th32ProcessID` field contains the identification number of the process.
- The `th32DefaultHeapID` field contains an identifier for the process's default heap. The ID has meaning only within `ToolHelp32`, and it can't be used with other Win32 functions.
- The `thModuleID` field identifies the module associated with the process. This field has meaning only within `ToolHelp32` functions.
- The `cntThreads` field indicates how many threads of execution the process has started.
- The `th32ParentProcessID` identifies the parent process to this process.
- The `pcPriClassBase` field holds the base priority of the process. The operating system uses this value to manage thread scheduling.
- The `dwFlags` field is reserved; don't use it.
- The `szExeFile` field is a null-terminated string that contains the pathname and filename of the EXE or driver associated with the process.

Once a snapshot containing process information has been taken, iterating over all processes is a matter of calling `Process32First()` and then calling `Process32Next()` until it returns `False`.

The process-walking code is encapsulated in the `TWin95Info` class, which implements the `IWin32Info` interface. The following code shows the private `Refresh()` method of the `TWin95Info` class, which iterates over the system processes and adds each to a list:

```

procedure TWin95Info.Refresh;
var
  PE: TProcessEntry32;
  PPE: PProcessEntry32;
begin
  FProcList.Clear;
  if FSnap > 0 then CloseHandle(FSnap);
  FSnap := CreateToolHelp32Snapshot(TH32CS_SNAPPROCESS, 0);
  if FSnap = -1 then
    raise Exception.Create('CreateToolHelp32Snapshot failed');
  PE.dwSize := SizeOf(PE);
  if Process32First(FSnap, PE) then           // get process
    repeat
      New(PPE);                               // create new PPE
      PPE^ := PE;                             // fill it
      FProcList.Add(PPE);                     // add it to list
    until not Process32Next(FSnap, PE);      // get next process
end;

```

The Refresh() method is called by the FillProcessInfoList() method. As explained earlier, this method fills a TListView and TImageList component with information on all the running processes. It's shown here:

```

procedure TWin95Info.FillProcessInfoList(ListView: TListView;
  ImageList: TImageList);
var
  I: Integer;
  ExeFile: string;
  PE: TProcessEntry32;
  HAppIcon: HIcon;
begin
  Refresh;
  ListView.Columns.Clear;
  ListView.Items.Clear;
  for I := Low(ProcessInfoCaptions) to High(ProcessInfoCaptions) do
    with ListView.Columns.Add do
      begin
        if I = 0 then Width := 285
        else Width := 75;
        Caption := ProcessInfoCaptions[I];
      end;
  for I := 0 to FProcList.Count - 1 do
  begin

```

```

PE := PProcessEntry32(FProcList.Items[I])^;
HAppIcon := ExtractIcon(HInstance, PE.szExeFile, 0);
try
  if HAppIcon = 0 then HAppIcon := FWinIcon;
  ExeFile := PE.szExeFile;
  if ListView.ViewStyle = vsList then
    ExeFile := ExtractFileName(ExeFile);
  // insert new item, set its caption, add subitems
  with ListView.Items.Add, SubItems do
  begin
    Caption := ExeFile;
    Data := FProcList.Items[I];
    Add(IntToStr(PE.cntThreads));
    Add(IntToHex(PE.th32ProcessID, 8));
    Add(IntToHex(PE.th32ParentProcessID, 8));
    if ImageList <> nil then
      ImageIndex := ImageList_AddIcon(ImageList.Handle, HAppIcon);
    end;
  finally
    if HAppIcon <> FWinIcon then DestroyIcon(HAppIcon);
  end;
end;
end;
end;

```

Figure 14.6 shows this code in action, displaying process information on a Windows 98 machine.

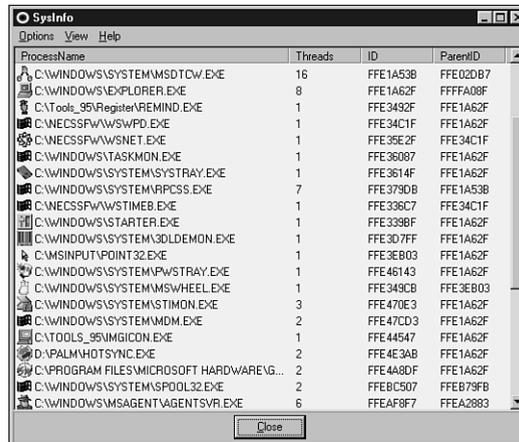


FIGURE 14.6

Viewing processes under Windows 98.

Not to be ignored is the code that obtains an icon for each process. Displaying the icon along with the application name gives the application a more professional appearance and a more native Windows feel. The `ExtractIcon()` API function from the `ShellAPI` unit attempts to extract the icon from the application file. If `ExtractIcon()` fails, `HWinIcon` is used instead. `HWinIcon` is the standard Windows icon, and it has been preloaded in the `OnCreate` event handler for this form using the `LoadImage()` API function:

```
HWinIcon := LoadImage(0, IDI_WINLOGO, IMAGE_ICON, LR_DEFAULTSIZE,
  LR_DEFAULTSIZE, LR_DEFAULTSIZE or LR_DEFAULTCOLOR or LR_SHARED);
```

When the user double-clicks one of the processes in the main form (refer to Figure 14.6), the `ShowProcessProperties()` method of `IWin32Info` is called, and the implementation of this method passes the parameter on to a method in the `Detail9x` unit called `ShowProcessDetails()`:

```
procedure TWin95Info.ShowProcessProperties(Cookie: Pointer);
begin
  ShowProcessDetails(PProcessEntry32(Cookie));
end;
```

`ShowProcessDetails()` must take another snapshot with `CreateToolHelp32Snapshot()` in order to obtain a snapshot of information for the selected process. This is done by passing the `Cookie` parameter, which holds the process (ID in this case) to the chosen process as the `th32ProcessID` field for `CreateToolHelp32Snapshot()`. The `TH32CS_SNAPALL` flag is passed as the `dwFlags` parameter to put all the information into the snapshot, as shown in the following snippet:

```
{ Create a snapshot for the current process }
FCurSnap := CreateToolhelp32Snapshot(TH32CS_SNAPALL, P^.th32ProcessID);
if FCurSnap = -1 then
  raise EToolHelpError.Create('CreateToolHelp32Snapshot failed');
```

The `TDetailForm` object displays only one list at a time. An enumerated type keeps track of which list is which:

```
type
  TListType = (ltThread, ltModule, ltHeap);
```

`TDetailForm` also maintains three separate `TStringList` components for each of the threads, modules, and heaps. These lists are defined as part of an array called `DetailLists`:

```
DetailLists: array[TListType] of TStringList;
```

Thread Walking

To walk a process's thread list, `ToolHelp32` provides two functions similar to those for process walking: `Thread32First()` and `Thread32Next()`. These functions are declared as follows:

```
function Thread32First(hSnapshot: THandle;
  var lpte: TThreadEntry32): BOOL; stdcall;
```

```
function Thread32Next(hSnapshot: THandle;
  var lpte: TThreadEntry32): BOOL; stdcall;
```

In addition to the usual `hSnapshot` parameter, these functions also accept a parameter by reference of type `TThreadEntry32`. As for the process functions, the calling function fills in this record. The `TThreadEntry32` record is defined as follows:

```
type
  TThreadEntry32 = record
    dwSize: DWORD;
    cntUsage: DWORD;
    th32ThreadID: DWORD;
    th32OwnerProcessID: DWORD;
    tpBasePri: Longint;
    tpDeltaPri: Longint;
    dwFlags: DWORD;
  end;
```

- `dwSize` is the size of the record, and it should be initialized to `SizeOf(TThreadEntry32)` prior to using the record.
- `cntUsage` is the reference count of the thread. When this value reaches zero, the thread is unloaded by the operating system.
- `th32ThreadID` is the identification number of the thread. This value has meaning only within the `ToolHelp32` functions.
- `th32OwnerProcessID` is the identifier of the process that owns this thread. This ID can be used with other `Win32` functions.
- `tpBasePri` is the base priority class of the thread. This value is the same for all threads of a given process. The possible values for this field are usually in the range of 4 through 24. The following table lists the meaning of each value:

<i>Value</i>	<i>Meaning</i>
4	Idle
8	Normal
13	High
24	Real time

- `tpDeltaPri` is the *delta* (change in) *priority* from `tpBasePri`. It's a signed number that, when combined with the base priority class, reveals the overall priority of the thread. The following table shows the constants defined for each possible value:

<i>Constant</i>	<i>Value</i>
THREAD_PRIORITY_IDLE	-15
THREAD_PRIORITY_LOWEST	-2
THREAD_PRIORITY_BELOW_NORMAL	-1
THREAD_PRIORITY_NORMAL	0
THREAD_PRIORITY_ABOVE_NORMAL	1
THREAD_PRIORITY_HIGHEST	2
THREAD_PRIORITY_TIME_CRITICAL	15

- dwFlags is currently reserved and shouldn't be used.

The WalkThreads() method of TDetailForm is used to walk the thread list. As the thread list is traversed, important information about the thread is added to the thread element of the DetailLists array. Here's the code for this method:

```

procedure TWin95DetailForm.WalkThreads;
{ Uses ToolHelp32 functions to walk list of threads }
var
  T: TThreadEntry32;
begin
  DetailLists[lThread].Clear;
  T.dwSize := SizeOf(T);
  if Thread32First(FCurSnap, T) then
    repeat
      { Make sure thread is for current process }
      if T.th32OwnerProcessID = FCurProc.th32ProcessID then
        DetailLists[lThread].Add(Format(SThreadStr, [T.th32ThreadID,
          GetClassPriorityString(T.tpBasePri),
          GetThreadPriorityString(T.tpDeltaPri), T.cntUsage]));
    until not Thread32Next(FCurSnap, T);
end;

```

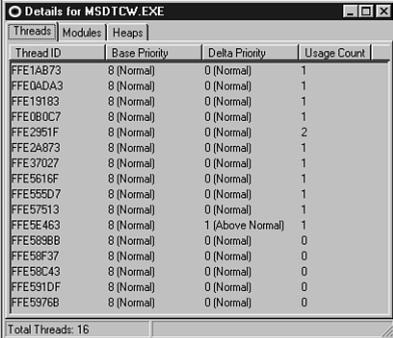
NOTE

The following line of code in the WalkThreads() method is important because ToolHelp32 thread lists are not process-specific:

```
if T.th32OwnerProcessID = FCurProc.th32ProcessID then
```

You must therefore do a manual comparison as you iterate through the threads to determine which threads are associated with the process in question.

Figure 14.7 shows the detail form with the thread list visible.



Thread ID	Base Priority	Delta Priority	Usage Count
FFE1AB73	8 (Normal)	0 (Normal)	1
FFE0ADA3	8 (Normal)	0 (Normal)	1
FFE19183	8 (Normal)	0 (Normal)	1
FFE0B0C7	8 (Normal)	0 (Normal)	1
FFE2951F	8 (Normal)	0 (Normal)	2
FFE2A873	8 (Normal)	0 (Normal)	1
FFE37027	8 (Normal)	0 (Normal)	1
FFE5616F	8 (Normal)	0 (Normal)	1
FFE55D7	8 (Normal)	0 (Normal)	1
FFE57513	8 (Normal)	0 (Normal)	1
FFE4463	8 (Normal)	1 (Above Normal)	1
FFE589BB	8 (Normal)	0 (Normal)	0
FFE58F37	8 (Normal)	0 (Normal)	0
FFE59C43	8 (Normal)	0 (Normal)	0
FFE591DF	8 (Normal)	0 (Normal)	0
FFE5976B	8 (Normal)	0 (Normal)	0

Total Threads: 16

FIGURE 14.7

Viewing threads in the detail form under Windows 98.

Module Walking

Module walking works much the same as process and thread walking. ToolHelp32 provides two functions that do the work: `Module32First()` and `Module32Next()`. These functions are declared as follows:

```
function Module32First(hSnapshot: THandle;
    var lpme: TModuleEntry32): BOOL; stdcall;
```

```
function Module32Next(hSnapshot: THandle;
    var lpme: TModuleEntry32): BOOL; stdcall;
```

Again, the snapshot handle is the first parameter to the functions. The second var parameter, `lpme`, is a `TModuleEntry32` record. This record is defined as follows:

```
type
    TModuleEntry32 = record
        dwSize: DWORD;
        th32ModuleID: DWORD;
        th32ProcessID: DWORD;
        GblCntUsage: DWORD;
        ProcCntUsage: DWORD;
        modBaseAddr: PBYTE;
        modBaseSize: DWORD;
        hModule: HMODULE;
```

```

    szModule: array[0..MAX_MODULE_NAME32 + 1] of Char;
    szExePath: array[0..MAX_PATH - 1] of Char;
end;

```

- `dwSize` is the size of the record, and it should be initialized to `SizeOf(TModuleEntry32)` prior to using the record.
- `th32ModuleID` is the identifier of the module. This value has meaning only with `ToolHelp32` functions.
- `th32ProcessID` is the identifier of the process being examined. This value can be used with other Win32 functions.
- `GblCntUsage` is the global reference count of the module.
- `ProcCntUsage` is the reference count of the module within the context of the owning process.
- `modBaseAddr` is the base address of the module in memory. This value is valid only within the context of `th32ProcessID`'s context.
- `modBaseSize` is the size in bytes of the module in memory.
- `hModule` is the module handle. This value is valid only within `th32ProcessID`'s context.
- `szModule` is a null-terminated string containing the module name.
- `szExepath` is a null-terminated string containing the full path of the module.

The `WalkModules()` method of `TDetailForm` is very similar to its `WalkThreads()` method. As shown in the following code, this method traverses the module list and adds it to the module list portion of the `DetailLists` array:

```

procedure TWin95DetailForm.WalkModules;
{ Uses ToolHelp32 functions to walk list of modules }
var
    M: TModuleEntry32;
begin
    DetailLists[lModule].Clear;
    M.dwSize := SizeOf(M);
    if Module32First(FCurSnap, M) then
        repeat
            DetailLists[lModule].Add(Format(SModuleStr, [M.szModule, M.ModBaseAddr,
                M.ModBaseSize, M.ProcCntUsage]));
        until not Module32Next(FCurSnap, M);
end;

```

Figure 14.8 shows the detail form with the module list visible.

Module	Base Addr	Size	Usage Count
MSH_ZWF.DLL	\$0D2D0000	61440 bytes	1
RPCLTS5.DLL	\$00E00000	28672 bytes	1
RPCLTCM.DLL	\$00E00000	45056 bytes	1
RPCLTS5.DLL	\$00E60000	32768 bytes	1
RSVPSP.DLL	\$7A440000	40960 bytes	1
RAPILB.DLL	\$7A6C0000	28672 bytes	1
MSWSOSP.DLL	\$7B110000	45056 bytes	1
RASAPI32.DLL	\$7F8D0000	196608 bytes	1
SECUR32.DLL	\$10000000	40960 bytes	1
MSVCRT20.DLL	\$7FC60000	282624 bytes	2
SVRAPI.DLL	\$7F990000	32768 bytes	1
MSNET32.DLL	\$7FB40000	77824 bytes	1
MSPWL32.DLL	\$7FB90000	40960 bytes	1
TAPI32.DLL	\$7F9A0000	122880 bytes	1
NETAPI32.DLL	\$7F9D0000	20480 bytes	3
NETBIOS.DLL	\$7F890000	32768 bytes	1

Total Modules: 54

FIGURE 14.8

Viewing modules in the detail form under Windows 98.

Heap Walking

Heap walking is slightly more complicated than the other types of enumeration you've learned about in this chapter. ToolHelp32 provides four functions that enable heap walking. The first two functions, `Heap32ListFirst()` and `Heap32ListNext()`, enable you to iterate over each of a process's heaps. The other two functions, `Heap32First()` and `Heap32Next()`, enable you to obtain more detailed information on all the blocks within an individual heap.

`Heap32ListFirst()` and `Heap32ListNext()` are defined as follows:

```
function Heap32ListFirst(hSnapshot: THandle;
    var lph1: THeapList32): BOOL; stdcall;
```

```
function Heap32ListNext(hSnapshot: THandle;
    var lph1: THeapList32): BOOL; stdcall;
```

Again, the first parameter is the customary snapshot handle. The second parameter, `lph1`, is a `THeapList32` record that's passed by reference. This record is defined as follows:

```
type
    THeapList32 = record
        dwSize: DWORD;
        th32ProcessID: DWORD;
        th32HeapID: DWORD;
        dwFlags: DWORD;
    end;
```

- `dwSize` is the size of the record, and it should be initialized to `SizeOf(THeapList32)` prior to using the record.

- `th32ProcessID` is the identifier of the owning process.
- `th32HeapID` is the identifier of the heap. This value has meaning only for the specified process and within `ToolHelp32`.
- `dwFlags` holds a flag that determines the heap type. The value of this field can be either `HF32_DEFAULT`, which means that the current heap is the process's default heap, or `HF32_SHARED`, which means that the current heap is a normal shared heap.

The `Heap32First()` and `Heap32Next()` functions are defined as follows:

```
function Heap32First(var lphe: THeapEntry32; th32ProcessID,
    th32HeapID: DWORD): BOOL; stdcall;
```

```
function Heap32Next(var lphe: THeapEntry32): BOOL; stdcall;
```

Notice that the parameter lists of these functions are a bit of a departure from the process, thread, module, and heap list enumeration functions that you've learned about in this chapter. These functions are designed to enumerate the blocks of a given heap in a given process rather than enumerating over some properties of just a process. When calling `Heap32First()`, the `th32ProcessID` and `th32HeapID` parameters should be set to the values of the field of the same name of the `THeapList32` record filled by `Heap32ListFirst()` or `Heap32ListNext()`. The `lphe` var parameter of `Heap32First()` and `Heap32Next()` is of type `THeapEntry32`. This record contains descriptive information pertaining to the heap block and is defined as follows:

type

```
THeapEntry32 = record
    dwSize: DWORD;
    hHandle: THandle;    // Handle of this heap block
    dwAddress: DWORD;    // Linear address of start of block
    dwBlockSize: DWORD; // Size of block in bytes
    dwFlags: DWORD;
    dwLockCount: DWORD;
    dwResvd: DWORD;
    th32ProcessID: DWORD; // owning process
    th32HeapID: DWORD;    // heap block is in
```

end;

- `dwSize` is the size of the record, and it should be initialized to `SizeOf(THeapEntry32)` prior to using the record.
- `hHandle` is the handle of the heap block.
- `dwAddress` is the linear address of the start of the heap block.
- `dwBlockSize` is the size, in bytes, of this heap block.
- `dwFlags` describes the type of heap block. This field can have any of the values shown in the following table:

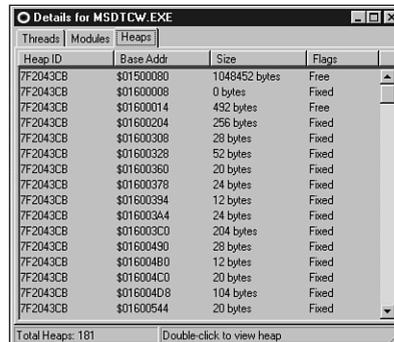
<i>Value</i>	<i>Meaning</i>
LF32_FIXED	The memory block has a fixed (unmovable) location.
LF32_FREE	The memory block is not used.
LF32_MOVEABLE	The memory block location can be moved.

- `dwLockCount` is the lock count of the memory block. This value is increased by one every time the process calls `GlobalLock()` or `LocalLock()` on this block.
- `dwResvd` is reserved at this time and shouldn't be used.
- `th32ProcessID` is the identifier of the owning process.
- `th32HeapID` is the identifier of the heap to which the block belongs.

Because you must first walk the list of heap lists before you can walk the heap block list, the code for heap block walking is a bit—but not much—more complex than what you've seen so far. As you see in the `TDetailForm.WalkHeaps()` method that follows, the trick is to nest the `Heap32First()/Heap32Next()` loop within the `Heap32ListFirst()/Heap32ListNext()` loop. The method adds an additional level of complexity by adding a `PHeapEntry32` record pointer to the objects in the heap list portion of the `DetailLists` array. This is done so that information on the heap is available later when viewing heap contents:

```
procedure TWin95DetailForm.WalkHeaps;
{ Uses ToolHelp32 functions to walk list of heaps }
var
  HL: THeapList32;
  HE: THeapEntry32;
  PHE: PHeapEntry32;
begin
  DetailLists[lHeap].Clear;
  HL.dwSize := SizeOf(HL);
  HE.dwSize := SizeOf(HE);
  if Heap32ListFirst(FCurSnap, HL) then
    repeat
      if Heap32First(HE, HL.th32ProcessID, HL.th32HeapID) then
        repeat
          New(PHE);      // need to make copy of THeapList32 record so we
          PHE^ := HE;    // have enough info to view heap later
          DetailLists[lHeap].AddObject(Format(SHeapStr, [HL.th32HeapID,
            Pointer(HE.dwAddress), HE.dwBlockSize,
            GetHeapFlagString(HE.dwFlags)]), TObject(PHE));
        until not Heap32Next(HE);
      until not Heap32ListNext(FCurSnap, HL);
    HeapListAlloc := True;
end;
```

Figure 14.9 shows the detail form with the heap block list visible.



Heap ID	Base Addr	Size	Flags
7F2043CB	\$01500080	1048452 bytes	Free
7F2043CB	\$01600008	0 bytes	Fixed
7F2043CB	\$01600014	492 bytes	Free
7F2043CB	\$01600204	256 bytes	Fixed
7F2043CB	\$01600308	28 bytes	Fixed
7F2043CB	\$01600328	52 bytes	Fixed
7F2043CB	\$01600360	20 bytes	Fixed
7F2043CB	\$01600378	24 bytes	Fixed
7F2043CB	\$01600394	12 bytes	Fixed
7F2043CB	\$016003A4	24 bytes	Fixed
7F2043CB	\$016003C0	204 bytes	Fixed
7F2043CB	\$01600490	28 bytes	Fixed
7F2043CB	\$016004B0	12 bytes	Fixed
7F2043CB	\$016004C0	20 bytes	Fixed
7F2043CB	\$016004D8	104 bytes	Fixed
7F2043CB	\$01600544	20 bytes	Fixed

Total Heaps: 181 Double-click to view heap

FIGURE 14.9

Viewing Windows heap blocks in the detail form under Windows 98.

Heap Viewing

Up to this point, you've learned about every function in the ToolHelp32 API except for one: `ToolHelp32ReadProcessMemory()`. To make sure you finish this chapter with a warm, fuzzy feeling, you'll also learn about this function.

`ToolHelp32ReadProcessMemory()` is declared this way:

```
function Toolhelp32ReadProcessMemory(th32ProcessID: DWORD;
  lpBaseAddress: Pointer; var lpBuffer; cbRead: DWORD;
  var lpNumberOfBytesRead: DWORD): BOOL; stdcall;
```

This function is arguably the most powerful and definitely the most fun in ToolHelp32 because it actually allows you to peek into the memory space of another process. The parameters for this function are as follows:

- `th32ProcessID` is the identifier of the process whose memory you want to read. You can obtain this value by any of the ToolHelp32 enumeration functions. You can pass zero in this parameter to indicate the current process.
- `lpBaseAddress` is the linear address of the first byte of memory you want to read in process `th32ProcessID`. You need to use the right process with the right address because any given linear address is meaningful only to a particular process.
- `lpBuffer` is the buffer to which you want to copy process `th32ProcessID`'s memory. You must ensure that memory is allocated for this buffer.
- `cbRead` is the number of bytes to read from process `th32ProcessID`, starting at `lpBaseAddress`.
- `lpNumberOfBytesRead` is filled in by the function before it returns. This is the number of bytes actually read from process `th32ProcessID`.

Once the memory of a particular process is copied to a local buffer using this function, SysInfo shows another modal form, HeapViewForm, which formats the memory dump for viewing. To handle the formatting, HeapViewForm makes use of a custom component called TMemView for viewing a memory dump. Because discussing the internals of the TMemView control is beyond the focus of this chapter (and because the control isn't terribly complex), you can browse the source code for the control on this book's CD-ROM. The following method of TDetailForm, DetailLBDb1Click(), is called when the user double-clicks in the THeaderListbox component's DetailLB:

```

procedure TWin95DetailForm.DetailLBDb1Click(Sender: TObject);
{ This procedure is called when the user double clicks on an item }
{ in DetailLB. If the current tab page is heaps, a heap view      }
{ form is presented to the user. }
var
  NumRead: DWORD;
  HE: THeapEntry32;
  MemSize: integer;
begin
  inherited;
  if DetailTabs.TabIndex = 2 then
  begin
    HE := PHeapEntry32(DetailLB.Items.Objects[DetailLB.ItemIndex])^;
    MemSize := HE.dwBlockSize;          // get heap size
    { if heap is too big, use ProcMemMaxSize }
    if MemSize > ProcMemMaxSize then MemSize := ProcMemMaxSize;
    ProcMem := AllocMem(MemSize);      // allocate a temp buffer
    Screen.Cursor := crHourGlass;
    try
      { Copy heap into temp buffer }
      if Toolhelp32ReadProcessMemory(FCurProc.th32ProcessID,
        Pointer(HE.dwAddress), ProcMem^, MemSize, NumRead) then
        { point HeapView control at temp buffer }
        ShowHeapView(ProcMem, MemSize)
      else
        MessageDlg(SHeapReadErr, mtInformation, [mbOk], 0);
    finally
      Screen.Cursor := crDefault;
      FreeMem(ProcMem, MemSize);
    end;
  end;
end;

```

This method first checks to see whether the current tab page is the heap list page. If so, it allocates a temporary buffer and passes it to the ToolHelp32ReadProcessMemory() function to be

filled. Once the buffer is filled, it's displayed in the TMemView control HeapView, and HeapViewForm is shown modally. When the form returns from the ShowModal() call, the buffer is freed. Figure 14.10 shows a heap view in action.

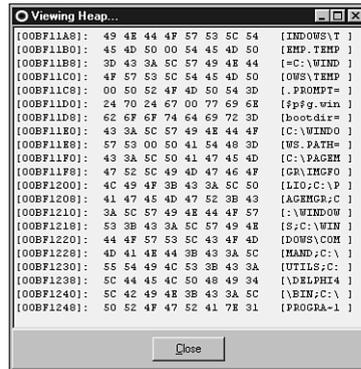


FIGURE 14.10

Viewing the heap of another Windows 98 process.

The Source

Listings 14.2 and 14.3 show the complete source for the W9xInfo.pas and Detail9x.pas units, respectively.

LISTING 14.2 W9xInfo.pas, Obtaining Process Information Under Windows 95/98

```
unit W9xInfo;

interface

uses Windows, InfoInt, Classes, TlHelp32, Controls, ComCtrls;

type
  TWin9xInfo = class(TInterfacedObject, IWin32Info)
  private
    FProcList: TList;
    FWinIcon: HICON;
    FSnap: THandle;
    procedure Refresh;
  public
    constructor Create;
    destructor Destroy; override;
    procedure FillProcessInfoList(ListView: TListView; ImageList: TImageList);
```

continues

LISTING 14.2 Continued

```
    procedure ShowProcessProperties(Cookie: Pointer);
    end;

implementation

uses ShellAPI, CommCtrl, SysUtils, Detail9x;

const
    ProcessInfoCaptions: array[0..3] of string = (
        'ProcessName', 'Threads', 'ID', 'ParentID');

{ TProcList }

type
    TProcList = class(TList)
        procedure Clear; override;
    end;

procedure TProcList.Clear;
var
    I: Integer;
begin
    for I := 0 to Count - 1 do Dispose(PProcessEntry32(Items[I]));
    inherited Clear;
end;

{ TWin95Info }

constructor TWin9xInfo.Create;
begin
    FProcList := TProcList.Create;
    FWinIcon := LoadImage(0, IDI_WINLOGO, IMAGE_ICON, LR_DEFAULTSIZE,
        LR_DEFAULTSIZE, LR_DEFAULTSIZE or LR_DEFAULTCOLOR or LR_SHARED);
end;

destructor TWin9xInfo.Destroy;
begin
    DestroyIcon(FWinIcon);
    if FSnap > 0 then CloseHandle(FSnap);
    FProcList.Free;
    inherited Destroy;
end;

procedure TWin9xInfo.FillProcessInfoList(ListView: TListView;
    ImageList: TImageList);
```

```

var
  I: Integer;
  ExeFile: string;
  PE: TProcessEntry32;
  HAppIcon: HIcon;
begin
  Refresh;
  ListView.Columns.Clear;
  ListView.Items.Clear;
  for I := Low(ProcessInfoCaptions) to High(ProcessInfoCaptions) do
    with ListView.Columns.Add do
      begin
        if I = 0 then Width := 285
        else Width := 75;
        Caption := ProcessInfoCaptions[I];
      end;
  for I := 0 to FProcList.Count - 1 do
  begin
    PE := PProcessEntry32(FProcList.Items[I])^;
    HAppIcon := ExtractIcon(HInstance, PE.szExeFile, 0);
    try
      if HAppIcon = 0 then HAppIcon := FWinIcon;
      ExeFile := PE.szExeFile;
      if ListView.ViewStyle = vsList then
        ExeFile := ExtractFileName(ExeFile);
      // insert new item, set its caption, add subitems
      with ListView.Items.Add, SubItems do
        begin
          Caption := ExeFile;
          Data := FProcList.Items[I];
          Add(IntToStr(PE.cntThreads));
          Add(IntToHex(PE.th32ProcessID, 8));
          Add(IntToHex(PE.th32ParentProcessID, 8));
          if ImageList <> nil then
            ImageIndex := ImageList_AddIcon(ImageList.Handle, HAppIcon);
          end;
        finally
          if HAppIcon <> FWinIcon then DestroyIcon(HAppIcon);
        end;
      end;
    end;
  end;
end;

procedure TWin9xInfo.Refresh;
var
  PE: TProcessEntry32;
  PPE: PProcessEntry32;

```

LISTING 14.2 Continued

```
begin
  FProcList.Clear;
  if FSnap > 0 then CloseHandle(FSnap);
  FSnap := CreateToolHelp32Snapshot(TH32CS_SNAPPROCESS, 0);
  if FSnap = INVALID_HANDLE_VALUE then
    raise Exception.Create('CreateToolHelp32Snapshot failed');
  PE.dwSize := SizeOf(PE);
  if Process32First(FSnap, PE) then           // get process
    repeat
      New(PPE);                             // create new PPE
      PPE^ := PE;                           // fill it
      FProcList.Add(PPE);                   // add it to list
    until not Process32Next(FSnap, PE);     // get next process
end;

procedure TWin9xInfo.ShowProcessProperties(Cookie: Pointer);
begin
  ShowProcessDetails(PProcessEntry32(Cookie));
end;

end.
```

LISTING 14.3 Detail9x.pas, Obtaining Process Details Under Windows 95/98

```
unit Detail9x;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ComCtrls, HeadList, TlHelp32, Menus, SysMain, DetBase;

type
  TListType = (ltThread, ltModule, ltHeap);

  TWin9xDetailForm = class(TBaseDetailForm)
  procedure DetailTabsChange(Sender: TObject);
  procedure FormCreate(Sender: TObject);
  procedure FormDestroy(Sender: TObject);
  procedure DetailLDBblClick(Sender: TObject);
  private
    FCurSnap: THandle;
    FCurProc: TProcessEntry32;
    DetailLists: array[TListType] of TStringList;
  end;
```

```

    ProcMem: PByte;
    HeapListAlloc: Boolean;
    procedure FreeHeapList;
    procedure ShowList(ListType: TListType);
    procedure WalkThreads;
    procedure WalkHeaps;
    procedure WalkModules;
public
    procedure NewProcess(P: PProcessEntry32);
end;

procedure ShowProcessDetails(P: PProcessEntry32);

implementation

{$R *.DFM}

uses ProcMem;

const
    { Array of strings which goes into the header of each respective list. }
    HeaderStrs: array[TListType] of TDetailStrings = (
        ('Thread ID', 'Base Priority', 'Delta Priority', 'Usage Count'),
        ('Module', 'Base Addr', 'Size', 'Usage Count'),
        ('Heap ID', 'Base Addr', 'Size', 'Flags'));

    { Array of strings which goes into the footer of each list. }
    ACountStrs: array[TListType] of string[31] = (
        'Total Threads: %d', 'Total Modules: %d', 'Total Heaps: %d');

    TabStrs: array[TListType] of string[7] = ('Threads', 'Modules', 'Heaps');

    SCaptionStr = 'Details for %s';           // form caption
    SThreadStr  = '%x#1'%s#1'%s#1'%d'; // id, base pri, delta pri, usage
    SModuleStr  = '%s#1'$p#1'%d bytes#1'%d'; // name, addr, size, usage
    SHeapStr    = '%x#1'$p#1'%d bytes#1'%s'; // ID, addr, size, flags
    SHeapReadErr = 'This heap is not accessible for read access.';

    ProcMemMaxSize = $7FFE;                 // max size of heap view

procedure ShowProcessDetails(P: PProcessEntry32);
var
    I: TListType;
begin
    with TWin9xDetailForm.Create(Application) do
        try

```

LISTING 14.3 Continued

```
    for I := Low(TabStrs) to High(TabStrs) do
        DetailTabs.Tabs.Add(TabStrs[I]);
    NewProcess(P);
    Font := MainForm.Font;
    ShowModal;
finally
    Free;
end;
end;

function GetThreadPriorityString(Priority: Integer): string;
{ Returns string describing thread priority }
begin
    case Priority of
        THREAD_PRIORITY_IDLE:      Result := '%d (Idle)';
        THREAD_PRIORITY_LOWEST:    Result := '%d (Lowest)';
        THREAD_PRIORITY_BELOW_NORMAL: Result := '%d (Below Normal)';
        THREAD_PRIORITY_NORMAL:    Result := '%d (Normal)';
        THREAD_PRIORITY_ABOVE_NORMAL: Result := '%d (Above Normal)';
        THREAD_PRIORITY_HIGHEST:   Result := '%d (Highest)';
        THREAD_PRIORITY_TIME_CRITICAL: Result := '%d (Time critical)';
    else
        Result := '%d (unknown)';
    end;
    Result := Format(Result, [Priority]);
end;

function GetClassPriorityString(Priority: DWORD): String;
{ returns string describing process priority class }
begin
    case Priority of
        4: Result := '%d (Idle)';
        8: Result := '%d (Normal)';
        13: Result := '%d (High)';
        24: Result := '%d (Real time)';
    else
        Result := '%d (non-standard)';
    end;
    Result := Format(Result, [Priority]);
end;

function GetHeapFlagString(Flag: DWORD): String;
{ Returns a string describing a heap flag }
begin
    case Flag of
```

```

    LF32_FIXED:    Result := 'Fixed';
    LF32_FREE:    Result := 'Free';
    LF32_MOVEABLE: Result := 'Moveable';
end;
end;

procedure TWin9xDetailForm.ShowList(ListType: TListType);
{ Shows appropriate thread, heap, or module list in DetailLB }
var
    i: Integer;
begin
    Screen.Cursor := crHourGlass;
    try
        with DetailLB do
            begin
                for i := 0 to 3 do
                    Sections[i].Text := HeaderStrs[ListType, i];
                    Items.Clear;
                    Items.Assign(DetailLists[ListType]);
                end;
                DetailsB.Panels[0].Text := Format(ACountStrs[ListType],
                    [DetailLists[ListType].Count]);
                if ListType = ltHeap then
                    DetailsB.Panels[1].Text := 'Double-click to view heap'
                else
                    DetailsB.Panels[1].Text := '';
            end;
        finally
            Screen.Cursor := crDefault;
        end;
    end;
end;

procedure TWin9xDetailForm.WalkThreads;
{ Uses ToolHelp32 functions to walk list of threads }
var
    T: TThreadEntry32;
begin
    DetailLists[ltThread].Clear;
    T.dwSize := SizeOf(T);
    if Thread32First(FCurSnap, T) then
        repeat
            { Make sure thread is for current process }
            if T.th32OwnerProcessID = FCurProc.th32ProcessID then
                DetailLists[ltThread].Add(Format(SThreadStr, [T.th32ThreadID,
                    GetClassPriorityString(T.tpBasePri),
                    GetThreadPriorityString(T.tpDeltaPri), T.cntUsage]));
        until not Thread32Next(FCurSnap, T);
end;

```

LISTING 14.3 Continued

```
end;

procedure TWin9xDetailForm.WalkModules;
{ Uses ToolHelp32 functions to walk list of modules }
var
  M: TModuleEntry32;
begin
  DetailLists[ltModule].Clear;
  M.dwSize := SizeOf(M);
  if Module32First(FCurSnap, M) then
    repeat
      DetailLists[ltModule].Add(Format(SModuleStr, [M.szModule, M.ModBaseAddr,
        M.ModBaseSize, M.ProcCntUsage]));
    until not Module32Next(FCurSnap, M);
end;

procedure TWin9xDetailForm.WalkHeaps;
{ Uses ToolHelp32 functions to walk list of heaps }
var
  HL: THeapList32;
  HE: THeapEntry32;
  PHE: PHeapEntry32;
begin
  DetailLists[ltHeap].Clear;
  HL.dwSize := SizeOf(HL);
  HE.dwSize := SizeOf(HE);
  if Heap32ListFirst(FCurSnap, HL) then
    repeat
      if Heap32First(HE, HL.th32ProcessID, HL.th32HeapID) then
        repeat
          New(PHE);      // need to make copy of THeapList32 record so we
          PHE^ := HE;    // have enough info to view heap later
          DetailLists[ltHeap].AddObject(Format(SHeapStr, [HL.th32HeapID,
            Pointer(HE.dwAddress), HE.dwBlockSize,
            GetHeapFlagString(HE.dwFlags)]), TObject(PHE));
        until not Heap32Next(HE);
      until not Heap32ListNext(FCurSnap, HL);
    HeapListAlloc := True;
end;

procedure TWin9xDetailForm.FreeHeapList;
{ Since special allocation of PHeapList32 objects are added to the list, }
{ these must be freed. }
var
  i: integer;
```

```

begin
  for i := 0 to DetailLists[lhHeap].Count - 1 do
    Dispose(PHeapEntry32(DetailLists[lhHeap].Objects[i]));
  end;

procedure TWin9xDetailForm.NewProcess(P: PProcessEntry32);
{ This procedure is called from the main form to show the detail }
{ form for a particular process. }
begin
  { Create a snapshot for the current process }
  FCurSnap := CreateToolhelp32Snapshot(TH32CS_SNAPALL, P^.th32ProcessID);
  if FCurSnap = INVALID_HANDLE_VALUE then
    raise Exception.Create('CreateToolHelp32Snapshot failed');
  HeapListAlloc := False;
  Screen.Cursor := crHourGlass;
  try
    FCurProc := P^;
    { Include module name in detail form caption }
    Caption := Format(SCaptionStr, [ExtractFileName(FCurProc.szExeFile)]);
    WalkThreads;           // walk ToolHelp32 lists
    WalkModules;
    WalkHeaps;
    DetailTabs.TabIndex := 0;           // 0 = thread tab
    ShowList(lhThread);           // show thread page first
  finally
    Screen.Cursor := crDefault;
    if HeapListAlloc then FreeHeapList;
    CloseHandle(FCurSnap);           // close snapshot handle
  end;
end;

procedure TWin9xDetailForm.DetailTabsChange(Sender: TObject);
{ OnChange event handler for tab set. Sets visible list to jive with tabs. }
begin
  inherited;
  ShowList(TListType(DetailTabs.TabIndex));
end;

procedure TWin9xDetailForm.FormCreate(Sender: TObject);
var
  LT: TListType;
begin
  inherited;
  { Dispose of lists }
  for LT := Low(TListType) to High(TListType) do
    DetailLists[LT] := TStringList.Create;

```

LISTING 14.3 Continued

```
end;

procedure TWin9xDetailForm.FormDestroy(Sender: TObject);
var
  LT: TListType;
begin
  inherited;
  { Dispose of lists }
  for LT := Low(TListType) to High(TListType) do
    DetailLists[LT].Free;
end;

procedure TWin9xDetailForm.DetailLBDb1Click(Sender: TObject);
{ This procedure is called when the user double clicks on an item }
{ in DetailLB. If the current tab page is heaps, a heap view }
{ form is presented to the user. }
var
  NumRead: DWORD;
  HE: THeapEntry32;
  MemSize: integer;
begin
  inherited;
  if DetailTabs.TabIndex = 2 then
  begin
    HE := PHeapEntry32(DetailLB.Items.Objects[DetailLB.ItemIndex])^;
    MemSize := HE.dwBlockSize; // get heap size
    { if heap is too big, use ProcMemMaxSize }
    if MemSize > ProcMemMaxSize then MemSize := ProcMemMaxSize;
    ProcMem := AllocMem(MemSize); // allocate a temp buffer
    Screen.Cursor := crHourGlass;
    try
      { Copy heap into temp buffer }
      if Toolhelp32ReadProcessMemory(FCurProc.th32ProcessID,
        Pointer(HE.dwAddress), ProcMem^, MemSize, NumRead) then
        { point HeapView control at temp buffer }
        ShowHeapView(ProcMem, MemSize)
      else
        MessageDlg(SHeapReadErr, mtInformation, [mbOk], 0);
    finally
      Screen.Cursor := crDefault;
      FreeMem(ProcMem, MemSize);
    end;
  end;
end;

end.
```

Windows NT/2000: PSAPI

As we mentioned earlier, the ToolHelp32 API does not exist under Windows NT/2000. The Windows Platform SDK, however, provides a DLL called `PSAPI.DLL` from which you can obtain the same types of information as with ToolHelp32 under Windows NT/2000, including

- Running processes
- Modules loaded per process
- Loaded device drivers
- Process memory information
- Files memory mapped per process

Later versions of Windows NT and all versions of Windows 2000 include `PSAPI.DLL`, although you can redistribute this file if you wish to deploy it to the users of your applications. Delphi provides an interface unit for this DLL called `PSAPI.pas`, which loads all its functions dynamically. Therefore, applications that use this unit will run on machines with or without `PSAPI.DLL` (of course, the functions won't work without `PSAPI.DLL` installed, but the application will run).

The first step in obtaining process information using PSAPI is to call `EnumProcesses()`, which is defined as follows:

```
function EnumProcesses(lpIdProcess: LPDWORD; cb: DWORD;  
    var cbNeeded: DWORD): BOOL;
```

- `lpIdProcess` is a pointer to an array of `DWORD`s that will be filled in with process IDs by the function.
- `cb` contains the number of `DWORD`s in the array passed in `lpIdProcess`.
- Upon return, `cbNeeded` will hold the number of bytes copied into `lpIdProcess`. The expression `cbNeeded div SizeOf(DWORD)` will provide the number of elements copied into the array and therefore the number of running processes.

After calling this function, the array passed in `lpIdProcess` will contain a bunch of process IDs. Process IDs aren't particularly useful on their own, but you can pass a process ID to the `OpenProcess()` API function in order to obtain a process handle. Once you have a process handle, you can call other PSAPI functions or even other Win32 API functions that call for process handles.

PSAPI provides a similar function for obtaining information on loaded device drivers called—we'll give you one guess—`EnumDeviceDrivers()`. This method is defined as follows:

```
function EnumDeviceDrivers(lpImageBase: PPointer; cb: DWORD;  
    var lpcbNeeded: DWORD): BOOL;
```

- `lpImageBase` is a pointer to an array of `Pointer`s that will be filled with the base address of each device driver.

- `cb` contains the number of Pointers in the array passed in `lpImageBase`.
- Upon return, `lpcbNeeded` will hold the number of bytes copied to `lpImageBase`.

In the SysInfo project ID is a unit called `WNTInfo.pas`, which contains a class called `TWinNTInfo` that implements `IWin32Info`. This class contains a private method called `Refresh()`, which obtains process and device driver information:

```
procedure TWinNTInfo.Refresh;
var
  Count: DWORD;
  BigArray: array[0..$3FFF - 1] of DWORD;
begin
  // Get array of process IDs
  if not EnumProcesses(@BigArray, SizeOf(BigArray), Count) then
    raise Exception.Create(SFailMessage);
  SetLength(FProcList, Count div SizeOf(DWORD));
  Move(BigArray, FProcList[0], Count);
  // Get array of Driver addresses
  if not EnumDeviceDrivers(@BigArray, SizeOf(BigArray), Count) then
    raise Exception.Create(SFailMessage);
  SetLength(FDrvList, Count div SizeOf(DWORD));
  Move(BigArray, FDrvList[0], Count);
end;
```

This method initially passes a local called `BigArray` to `EnumProcesses()` and `EnumDeviceDrivers()` and then moves the data from `BigArray` into dynamic arrays called `FProcList` and `FDrvList`. The reason for this ungainly implementation of these functions is that neither `EnumProcesses()` nor `EnumDeviceDrivers()` provide a means for determining how many elements will be returned before allocating an array. We are therefore stuck passing a large array (that we hope is large enough) to the methods and copying the result to an appropriately sized dynamic array.

The `FillProcessInfoList()` method for `TWinNTInfo` calls two helper methods—`FillProcesses()` and `FillDrivers()`—to fill the contents of the `TListView` on the main form. `FillProcesses()` is shown here:

```
procedure TWinNTInfo.FillProcesses(ListView: TListView;
  ImageList: TImageList);
var
  I: Integer;
  Count: DWORD;
  ProcHand: THandle;
  ModHand: HMODULE;
```

```

    HAppIcon: HICON;
    ModName: array[0..MAX_PATH] of char;
begin
    for I := Low(FProcList) to High(FProcList) do
    begin
        ProcHand := OpenProcess(PROCESS_QUERY_INFORMATION or PROCESS_VM_READ,
            False, FProcList[I]);
        if ProcHand > 0 then
            try
                EnumProcessModules(Prochand, @ModHand, 1, Count);
                if GetModuleFileNameEx(Prochand, ModHand, ModName,
                    SizeOf(ModName)) > 0 then
                    begin
                        HAppIcon := ExtractIcon(HInstance, ModName, 0);
                        try
                            if HAppIcon = 0 then HAppIcon := FWinIcon;
                            with ListView.Items.Add, SubItems do
                                begin
                                    Caption := ModName;           // file name
                                    Data := Pointer(FProcList[I]);   // save ID
                                    Add(SProcName);                 // "process"
                                    Add(IntToStr(FProcList[I]));     // process ID
                                    Add('$' + IntToHex(ProcHand, 8)); // process handle
                                    // priority class
                                    Add(GetPriorityClassString(GetPriorityClass(ProcHand)));
                                    // icon
                                    if ImageList <> nil then
                                        ImageIndex := ImageList_AddIcon(ImageList.Handle,
                                            HAppIcon);
                                end;
                            finally
                                if HAppIcon <> FWinIcon then DestroyIcon(HAppIcon);
                            end;
                        end;
                    end;
                finally
                    CloseHandle(ProcHand);
                end;
            end;
        end;
    end;
end;

```

This method uses `OpenProcess()` to convert each process ID into a process handle. Several flags can be passed to this method in the first parameter, but for purposes of querying information with PSAPI, `PROCESS_QUERY_INFORMATION` and `PROCESS_VM_READ` together work best.

Given a process handle, the code then calls `EnumProcessModules()` to obtain the filename for the process. This method is defined as follows:

```
function EnumProcessModules(hProcess: THandle; lphModule: LPDWORD;
    cb: DWORD; var lpcbNeeded: DWORD): BOOL;
```

This method works in a manner similar to the other PSAPI functions: `hProcess` is a process handle, `lphModule` is a pointer to an array of module handles, `cb` indicates the number of elements in the array, and the final parameter returns the number of bytes copied to `lphModule`.

Because we're only interested in the primary module for this process right now, we only pass an array of one element. The first module returned by `EnumProcessModules()` is the primary module for the process. All the process information is then added to the `TListView` component in a manner similar to that shown in `TWin9xInfo`.

`FillDrivers()` functions in a like manner, except that it uses the `GetDeviceDriverFileName()` method shown here:

```
function GetDeviceDriverFileName(ImageBase: Pointer; lpFileName: PChar;
    nSize: DWORD): DWORD;
```

This method takes the image base of the device driver as the first parameter, a pointer to a string buffer as the second parameter, and the size of the buffer in the last parameter. Upon successful return, `lpFileName` will contain the filename of the device driver. Our use of this method is shown in the following code:

```
procedure TWinNTInfo.FillDrivers(ListView: TListView;
    ImageList: TImageList);
var
    I: Integer;
    DrvName: array[0..MAX_PATH] of char;
begin
    for I := Low(FDrvList) to High(FDrvList) do
        if GetDeviceDriverFileName(FDrvList[I], DrvName, SizeOf(DrvName)) > 0 then
            with ListView.Items.Add do
                begin
                    Caption := DrvName;
                    SubItems.Add(SDrvName);
                    SubItems.Add('$' + IntToHex(Integer(FDrvList[I]), 8));
                end;
            end;
end;
```

Figure 14.11 shows the `SysInfo` application running on a Windows NT 4.0 machine.

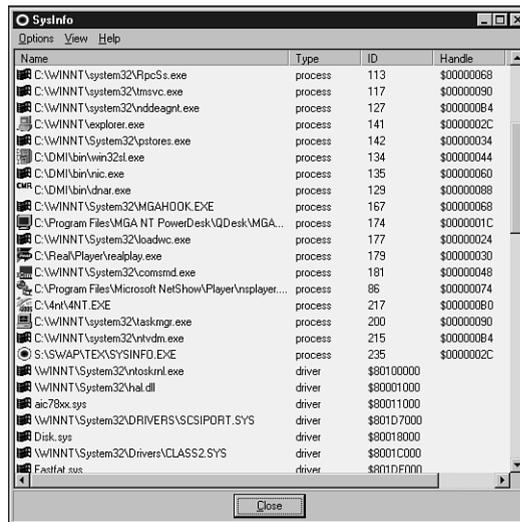


FIGURE 14.11

Browsing Windows NT processes and drivers.

Like TWIn95Info's implementation of ShowProcessProperties(), TWInNTInfo calls out to another unit to display a form containing more process information. In particular, the additional information pertains to process modules and memory usage. The method that does the work of obtaining this information resides in the TWInNTDetailForm class in the DetailNT unit, and it's shown in the following code:

```

procedure TWInNTDetailForm.NewProcess(ProcessID: DWORD);
const
  AddrMask = DWORD($FFFFFF00);
var
  I, Count: Integer;
  ProcHand: THandle;
  WSPtr: Pointer;
  ModHandles: array[0..$3FFF - 1] of DWORD;
  WorkingSet: array[0..$3FFF - 1] of DWORD;
  ModInfo: TModuleInfo;
  ModName, MapFileName: array[0..MAX_PATH] of char;
begin
  ProcHand := OpenProcess(PROCESS_QUERY_INFORMATION or PROCESS_VM_READ, False,
    ProcessID);

```

```
if ProcHand = 0 then
    raise Exception.Create('No information available for this process/driver');
try
    EnumProcessModules(ProcHand, @ModHandles, SizeOf(ModHandles), Count);
    for I := 0 to (Count div SizeOf(DWORD)) - 1 do
        if (GetModuleFileNameEx(ProcHand, ModHandles[I], ModName,
            SizeOf(ModName)) > 0) and GetModuleInformation(ProcHand,
            ModHandles[I], @ModInfo, SizeOf(ModInfo)) then
            with ModInfo do
                DetailLists[ltModules].Add(Format(SModuleStr, [ModName, lpBaseOfDll,
                    SizeOfImage, EntryPoint]));
    if QueryWorkingSet(ProcHand, @WorkingSet, SizeOf(WorkingSet)) then
        for I := 1 to WorkingSet[0] do
            begin
                WSPtr := Pointer(WorkingSet[I] and AddrMask);
                GetMappedFileName(ProcHand, WSPtr, MapFileName, SizeOf(MapFileName));
                DetailLists[ltMemory].Add(Format(SMemoryStr, [WSPtr,
                    MemoryTypeToString(WorkingSet[I]), MapFileName]));
            end;
        finally
            CloseHandle(ProcHand);
        end;
    end;
end;
```

As you can see, this method makes calls to `OpenProcess()` and `EnumProcessModules()`, about which you've already learned. This method also calls a PSAPI function called `QueryWorkingSet()`, however, to obtain memory information for a process. This function is defined as follows:

```
function QueryWorkingSet(hProcess: THandle; pv: Pointer; cb: DWORD): BOOL;
```

`hProcess` is the process handle. `pv` is a pointer to an array of `DWORD`s, and `cb` holds the number of elements in the array. Upon return, `pv` will point to an array of `DWORD`s. The upper 20 bits of this `DWORD` hold the base address of a memory page, and the lower 12 bits of each `DWORD` hold flags that indicate whether the page is readable, writable, executable, and so on.

Figures 14.12 and 14.13 show module and memory details under Windows NT. Listings 14.4 and 14.5 show the `WNTInfo.pas` and `DetailNT.pas` units, respectively.

The screenshot shows the 'WinNT DetailForm' window with the 'Modules' tab selected. It displays a list of loaded modules for the process 'C:\Program Files\Microsoft NetShow\Player\vnplayer.exe'. The columns are 'Module', 'Base Addr', 'Size', and 'Entry Point'. The total number of modules is 38.

Module	Base Addr	Size	Entry Point
C:\Program Files\Microsoft NetShow\Player\vnplayer.exe	\$01000000	69632 bytes	\$010036F0
C:\WINNT\System32\ntldr.dll	\$77F60000	376832 bytes	\$00000000
C:\WINNT\System32\ADVAPI32.dll	\$77DC0000	253952 bytes	\$77DC1000
C:\WINNT\System32\USER32.dll	\$77F00000	389024 bytes	\$77F01000
C:\WINNT\System32\GDI32.dll	\$77E70000	344064 bytes	\$77E78037
C:\WINNT\System32\RPCRT4.dll	\$77E10000	336872 bytes	\$77E186D5
C:\WINNT\System32\comdlg32.dll	\$77D90000	204800 bytes	\$77D91000
C:\WINNT\System32\SHELL32.dll	\$77C40000	1294336 bytes	\$77C41094
C:\WINNT\System32\CDMCTL32.dll	\$70FF0000	471040 bytes	\$70FF18F1
C:\WINNT\System32\ole32.dll	\$77B20000	729088 bytes	\$77B2284F
C:\WINNT\System32\OLEAUT32.dll	\$65340000	507904 bytes	\$6534C633
C:\PROGRAM~1\MICROS~2\Player\vnplay.ocx	\$37700000	765952 bytes	\$37746F20
C:\WINNT\System32\VERSION.dll	\$77A90000	45056 bytes	\$77A92FD0
C:\WINNT\System32\UZ32.dll	\$779C0000	32768 bytes	\$779C1881
C:\WINNT\System32\MSACM32.dll	\$75D50000	106496 bytes	\$75D5E440
C:\WINNT\System32\WMM.dll	\$77FD0000	172032 bytes	\$77FD5640

Total Modules: 38

FIGURE 14.12

Viewing Windows NT process modules.

The screenshot shows the 'WinNT DetailForm' window with the 'Memory' tab selected. It displays a list of memory pages with columns for 'Page Addr', 'Type', and 'Mem Map File'. The total number of pages is 517.

Page Addr	Type	Mem Map File
\$77667000	Unknown, Shareable	.
\$77E7B000	Unknown, Shareable	.
\$00490000	Unknown, Shareable	.
\$77F0C000	Unknown, Shareable	.
\$3772E000	Unknown, Shareable	.
\$01849000	Read/write	.
\$01E5E000	Read/write	.
\$002A0000	Read-only, Shareable	.\Device\Harddisk0\Partition1\WINNT\System32\sortkey.nls
\$00166000	Read/write	.\Device\Harddisk0\Partition1\WINNT\System32\sortkey.nls
\$10088000	Read/write	.\Device\Harddisk0\Partition1\WINNT\System32\sortkey.nls
\$777F0000	Unknown, Shareable	.\Device\Harddisk0\Partition1\WINNT\System32\sortkey.nls
\$01842000	Read/write	.\Device\Harddisk0\Partition1\WINNT\System32\sortkey.nls
\$001C4000	Read/write	.\Device\Harddisk0\Partition1\WINNT\System32\sortkey.nls
\$01840000	Read/write	.\Device\Harddisk0\Partition1\WINNT\System32\sortkey.nls
\$77E53000	Read-only	.\Device\Harddisk0\Partition1\WINNT\System32\sortkey.nls
\$37766000	Unknown, Shareable	.\Device\Harddisk0\Partition1\WINNT\System32\sortkey.nls
\$00149000	Read/write	.\Device\Harddisk0\Partition1\WINNT\System32\sortkey.nls

Total Pages: 517

FIGURE 14.13

Viewing Windows NT process memory details.

LISTING 14.4 WNTInfo.pas, Obtaining Process Information Under Windows NT/2000

```

unit WNTInfo;

interface

uses InfoInt, Windows, Classes, ComCtrls, Controls;

type
  TWinNTInfo = class(TInterfacedObject, IWin32Info)
  private

```

continues

LISTING 14.4 Continued

```
FProcList: array of DWORD;
FDrvList: array of Pointer;
FWinIcon: HICON;
procedure FillProcesses(ListView: TListView; ImageList: TImageList);
procedure FillDrivers(ListView: TListView; ImageList: TImageList);
procedure Refresh;
public
  constructor Create;
  destructor Destroy; override;
  procedure FillProcessInfoList(ListView: TListView;
    ImageList: TImageList);
  procedure ShowProcessProperties(Cookie: Pointer);
end;

implementation

uses SysUtils, PSAPI, ShellAPI, CommCtrl, DetailNT;

const
  SFailMessage = 'Failed to enumerate processes or drivers. Make sure '+
    'PSAPI.DLL is installed on your system.';
  SDrvName = 'driver';
  SProcname = 'process';
  ProcessInfoCaptions: array[0..4] of string = (
    'Name', 'Type', 'ID', 'Handle', 'Priority');

function GetPriorityClassString(PriorityClass: Integer): string;
begin
  case PriorityClass of
    HIGH_PRIORITY_CLASS: Result := 'High';
    IDLE_PRIORITY_CLASS: Result := 'Idle';
    NORMAL_PRIORITY_CLASS: Result := 'Normal';
    REALTIME_PRIORITY_CLASS: Result := 'Realtime';
  else
    Result := Format('Unknown (%x)', [PriorityClass]);
  end;
end;

{ TWinNTInfo }

constructor TWinNTInfo.Create;
```

```
begin
  FWinIcon := LoadImage(0, IDI_WINLOGO, IMAGE_ICON, LR_DEFAULTSIZE,
    LR_DEFAULTSIZE, LR_DEFAULTSIZE or LR_DEFAULTCOLOR or LR_SHARED);
end;

destructor TWinNTInfo.Destroy;
begin
  DestroyIcon(FWinIcon);
  inherited Destroy;
end;

procedure TWinNTInfo.FillDrivers(ListView: TListView;
  ImageList: TImageList);
var
  I: Integer;
  DrvName: array[0..MAX_PATH] of char;
begin
  for I := Low(FDrvList) to High(FDrvList) do
    if GetDeviceDriverFileName(FDrvList[I], DrvName,
      SizeOf(DrvName)) > 0 then
      with ListView.Items.Add do
        begin
          Caption := DrvName;
          SubItems.Add(SDrvName);
          SubItems.Add('$' + IntToHex(Integer(FDrvList[I]), 8));
        end;
      end;
  end;

end;

procedure TWinNTInfo.FillProcesses(ListView: TListView;
  ImageList: TImageList);
var
  I: Integer;
  Count: DWORD;
  ProcHand: THandle;
  ModHand: HMODULE;
  HAppIcon: HICON;
  ModName: array[0..MAX_PATH] of char;
begin
  for I := Low(FProcList) to High(FProcList) do
    begin
      ProcHand := OpenProcess(PROCESS_QUERY_INFORMATION or PROCESS_VM_READ,
        False, FProcList[I]);
```

LISTING 14.4 Continued

```
if ProcHand > 0 then
  try
    EnumProcessModules(Prochand, @ModHand, 1, Count);
    if GetModuleFileNameEx(Prochand, ModHand, ModName,
      SizeOf(ModName)) > 0 then
      begin
        HAppIcon := ExtractIcon(HInstance, ModName, 0);
        try
          if HAppIcon = 0 then HAppIcon := FWinIcon;
          with ListView.Items.Add, SubItems do
            begin
              Caption := ModName;           // file name
              Data := Pointer(FProcList[I]); // save ID
              Add(SProcName);               // "process"
              Add(IntToStr(FProcList[I]));  // process ID
              Add('$' + IntToHex(ProcHand, 8)); // process handle
              // priority class
              Add(GetPriorityClassString(GetPriorityClass(ProcHand)));
              // icon
              if ImageList <> nil then
                ImageIndex := ImageList_AddIcon(ImageList.Handle,
                  HAppIcon);
            end;
          finally
            if HAppIcon <> FWinIcon then DestroyIcon(HAppIcon);
          end;
        end;
      finally
        CloseHandle(ProcHand);
      end;
    end;
end;

procedure TWinNTInfo.FillProcessInfoList(ListView: TListView;
  ImageList: TImageList);
var
  I: Integer;
begin
  Refresh;
  ListView.Columns.Clear;
  ListView.Items.Clear;
  for I := Low(ProcessInfoCaptions) to High(ProcessInfoCaptions) do
```

```
with ListView.Columns.Add do
begin
  if I = 0 then Width := 285
  else Width := 75;
  Caption := ProcessInfoCaptions[I];
end;
FillProcesses(ListView, ImageList); // Add processes to listview
FillDrivers(ListView, ImageList); // Add device drivers to listview
end;

procedure TWinNTInfo.Refresh;
var
  Count: DWORD;
  BigArray: array[0..$3FFF - 1] of DWORD;
begin
  // Get array of process IDs
  if not EnumProcesses(@BigArray, SizeOf(BigArray), Count) then
    raise Exception.Create(SFailMessage);
  SetLength(FProcList, Count div SizeOf(DWORD));
  Move(BigArray, FProcList[0], Count);
  // Get array of Driver addresses
  if not EnumDeviceDrivers(@BigArray, SizeOf(BigArray), Count) then
    raise Exception.Create(SFailMessage);
  SetLength(FDrvList, Count div SizeOf(DWORD));
  Move(BigArray, FDrvList[0], Count);
end;

procedure TWinNTInfo.ShowProcessProperties(Cookie: Pointer);
begin
  ShowProcessDetails(DWORD(Cookie));
end;

end.
```

LISTING 14.5 DetailNT.pas, Obtaining Process Details Under Windows NT/2000

```
unit DetailNT;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
```

continues

LISTING 14.5 Continued

```

    DetBase, ComCtrls, HeadList;

type
    TListType = (ltModules, ltMemory);

    TWinNTDetailForm = class(TBaseDetailForm)
    procedure FormCreate(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
    procedure DetailTabsChange(Sender: TObject);
    private
        FProcHand: THandle;
        DetailLists: array[TListType] of TStringList;
    procedure ShowList(ListType: TListType);
    public
        procedure NewProcess(ProcessID: DWORD);
    end;

procedure ShowProcessDetails(ProcessID: DWORD);

implementation

uses PSAPI;

{$R *.DFM}

const
    TabStrs: array[0..1] of string[7] = ('Modules', 'Memory');

    { Array of strings that goes into the footer of each list. }
    ACountStrs: array[TListType] of string[31] = (
        'Total Modules: %d', 'Total Pages: %d');

    { Array of strings that goes into the header of each respective list. }
    HeaderStrs: array[TListType] of TDetailStrings = (
        ('Module', 'Base Addr', 'Size', 'Entry Point'),
        ('Page Addr', 'Type', 'Mem Map File', ''));

    SCaptionStr = 'Details for %s'; // form caption
    SModuleStr = '%s#1'$%p'#1'%d bytes'#1'$%p'; // name, addr, size, entry pt
    SMemoryStr = '$%p'#1'%s'#1'%s'; // addr, type, mem map file

procedure ShowProcessDetails(ProcessID: DWORD);

```

```
var
  I: Integer;
begin
  with TWinNTDetailForm.Create(Application) do
    try
      for I := Low(TabStrs) to High(TabStrs) do
        DetailTabs.Tabs.Add(TabStrs[I]);
        NewProcess(ProcessID);
        ShowList(ltModules);
        ShowModal;
      finally
        Free;
      end;
    end;
  end;

function MemoryTypeToString(Value: DWORD): string;
const
  TypeMask = DWORD($0000000F);
begin
  Result := '';
  case Value and TypeMask of
    1: Result := 'Read-only';
    2: Result := 'Executable';
    4: Result := 'Read/write';
    5: Result := 'Copy on write';
  else
    Result := 'Unknown';
  end;
  if Value and $100 <> 0 then
    Result := Result + ', Shareable';
end;

procedure TWinNTDetailForm.FormCreate(Sender: TObject);
var
  LT: TListType;
begin
  inherited;
  { Dispose of lists }
  for LT := Low(TListType) to High(TListType) do
    DetailLists[LT] := TStringList.Create;
  end;

procedure TWinNTDetailForm.FormDestroy(Sender: TObject);
```

LISTING 14.5 Continued

```
var
  LT: TListType;
begin
  inherited;
  { Dispose of lists }
  for LT := Low(TListType) to High(TListType) do
    DetailLists[LT].Free;
end;

procedure TWinNTDetailForm.NewProcess(ProcessID: DWORD);
const
  AddrMask = DWORD($FFFFFF00);
var
  I, Count: Integer;
  ProcHand: THandle;
  WSPtr: Pointer;
  ModHandles: array[0..$3FFF - 1] of DWORD;
  WorkingSet: array[0..$3FFF - 1] of DWORD;
  ModInfo: TModuleInfo;
  ModName, MapFileName: array[0..MAX_PATH] of char;
begin
  ProcHand := OpenProcess(PROCESS_QUERY_INFORMATION or PROCESS_VM_READ, False,
    ProcessID);
  if ProcHand = 0 then
    raise Exception.Create('No information available for this process/driver');
  try
    EnumProcessModules(ProcHand, @ModHandles, SizeOf(ModHandles), Count);
    for I := 0 to (Count div SizeOf(DWORD)) - 1 do
      if (GetModuleFileNameEx(ProcHand, ModHandles[I], ModName,
        SizeOf(ModName)) > 0) and GetModuleInformation(ProcHand,
        ModHandles[I], @ModInfo, SizeOf(ModInfo)) then
        with ModInfo do
          DetailLists[lModules].Add(Format(SModuleStr, [ModName, lpBaseOfDll,
            SizeOfImage, EntryPoint]));
    if QueryWorkingSet(ProcHand, @WorkingSet, SizeOf(WorkingSet)) then
      for I := 1 to WorkingSet[0] do
        begin
          WSPtr := Pointer(WorkingSet[I] and AddrMask);
          GetMappedFileName(ProcHand, WSPtr, MapFileName, SizeOf(MapFileName));
          DetailLists[lMemory].Add(Format(SMemoryStr, [WSPtr,
            MemoryTypeToString(WorkingSet[I]), MapFileName]));
        end;
      end;
```

```
    finally
        CloseHandle(ProcHand);
    end;
end;

procedure TWinNTDetailForm.ShowList(ListType: TListType);
var
    I: Integer;
begin
    Screen.Cursor := crHourGlass;
    try
        with DetailLB do
            begin
                for I := 0 to 3 do
                    Sections[I].Text := HeaderStrs[ListType, i];
                Items.Clear;
                Items.Assign(DetailLists[ListType]);
            end;
            DetailSB.Panels[0].Text := Format(ACountStrs[ListType],
                [DetailLists[ListType].Count]);
        finally
            Screen.Cursor := crDefault;
        end;
    end;
end;

procedure TWinNTDetailForm.DetailTabsChange(Sender: TObject);
begin
    inherited;
    ShowList(TListType(DetailTabs.TabIndex));
end;

end.
```

Summary

This chapter demonstrated techniques for accessing system information from within your Delphi programs. It focused on the proper usage of the ToolHelp32 functions provided by Windows 95/98 and the PSAPI functions found on Windows NT. You learned how to use a few Win32 API functions to obtain other types of system information, including memory information, environment variables, and version information. Additionally, you learned how to incorporate the TListView, TImageList, THeaderListbox, and TMemView custom components into your applications. The next chapter, “Porting to Delphi 5,” discusses migrating your applications from previous versions of Delphi.

Porting to Delphi 5

CHAPTER

15

IN THIS CHAPTER

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If you're upgrading to Delphi 5 from a previous version, this chapter is written for you. The first section of this chapter discusses the issues involved in moving from any version of Delphi to Delphi 5. In the second, third, and fourth sections, you learn about the often subtle differences between the various 32-bit versions of Delphi and how to take these differences into account as you migrate applications to Delphi 5. The fourth section of this chapter is intended to help those migrating 16-bit Delphi 1.0 applications to the 32-bit world of Delphi 5. Although Borland makes a concerted effort to ensure that your code is compatible between versions, it's understandable that some changes have to be made in the name of progress, and certain situations require code changes if applications are to compile and run properly under the latest version of Delphi.

New to Delphi 5

In general, the more recent the version of Delphi you're coming from, the easier it will be for you to port to Delphi 5. However, whether you're migrating from Delphi 1, 2, 3, or 4, this section provides the information necessary for moving up to Delphi 5.

Which Version?

Although most Delphi code will compile for all versions of the compiler, in some instances language or VCL differences require that you write slightly differently to accomplish a given task for each product version. Occasionally, you might need to be able to compile for multiple versions of Delphi from one code base. For this purpose, each version of the Delphi compiler contains a `VERxxx` conditional define for which you can test in your source code. Because Borland C++Builder also ships with new versions of the Delphi compiler, these editions also contain this conditional define. Table 15.1 shows the conditional defines for the various versions of the Delphi compiler.

TABLE 15.1 Conditional Defines for Compiler Versions

<i>Product</i>	<i>Conditional Define</i>
Delphi 1	VER80
Delphi 2	VER90
C++Builder 1	VER95
Delphi 3	VER100
C++Builder 3	VER110
Delphi 4	VER120
C++Builder 4	VER120
Delphi 5	VER130

Using these defines, the source code you must write in order to compile for different compiler versions would look something like this:

```
{$IFDEF VER80}
    Delphi 1 code goes here
{$ENDIF}
{$IFDEF VER90}
    Delphi 2 code goes here
{$ENDIF}
{$IFDEF VER95}
    C++Builder 1 code goes here
{$ENDIF}
{$IFDEF VER100}
    Delphi 3 code goes here
{$ENDIF}
{$IFDEF VER110}
    C++Builder 3 code goes here
{$ENDIF}
{$IFDEF VER120}
    Delphi 4 and C++Builder 4 code goes here
{$ENDIF}
{$IFDEF VER130}
    Delphi 5 code goes here
{$ENDIF}
```

NOTE

If you're wondering why the Delphi 1.0 compiler is considered version 8, Delphi 2 version 9, and so on, it's because Delphi 1.0 is considered version 8 of Borland's Pascal compiler. The last Turbo Pascal version was 7.0, and Delphi is the evolution of that product line.

Just as you'll have to deal with differences in the language and VCL between Delphi versions, you'll also have to deal with differences in the Windows API. If you need to cope with differences in the 16-bit and 32-bit APIs from a single code base, you can take advantage of additional defines intended for this purpose. The 16-bit Delphi compiler defines `WINDOWS`, whereas the Win32 Delphi compilers define `WIN32`. The following code example demonstrates how to take advantage of these defines:

```
{$IFDEF WINDOWS}
    16-bit Windows-specific code goes here
{$ENDIF}
{$IFDEF WIN32}
    Win32-specific code goes here
{$ENDIF}
```

Units, Components, and Packages

Delphi 5 compiled units (DCU files) differ from those of all previous versions of Delphi (and C++Builder). You must have the source code to any units used in your application in order to build your application under any particular version of Delphi. This, of course, means that you won't be able to use any components used in your application—your own components or third-party components—unless you have the source to these components. If you don't have the source code to a particular third-party component, contact your vendor for a version of the component specific to your version of Delphi.

NOTE

This issue of compiler version versus unit file version is not a new situation and is the same as C++ compiler object file versioning. If you distribute (or buy) components without source code, you must understand that what you're distributing/buying is a compiler version-specific binary file that will probably need to be revised to keep up with subsequent compiler releases.

What's more, the issue of DCU versioning isn't necessarily a compiler-only issue. Even if the compiler weren't changed between versions, changes and enhancements to core VCL would probably still make it necessary that units be recompiled from source.

Delphi 3 also introduced *packages*, the idea of multiple units stored in a single binary file. Starting with Delphi 3, the component library became a collection of packages rather than one massive component library DLL. Like units, packages are not compatible across product versions, so you'll need to rebuild your packages for Delphi 5, and you'll need to contact the vendors of your third-party components for updated packages.

Migrating from Delphi 4

There are only a handful of migration issues as you take your Delphi 4 applications into Delphi 5. In many cases, you can simply load your project into Delphi 5 and hit the compile key. However, if you do run into problems, this section discusses the migration speed bumps you may face for getting things rolling in Delphi 5.

IDE Issues

Problems with IDE are likely the first you'll encounter as you migrate your applications. Here are a few of the issues you may encounter on the way:

- Delphi 4 debugger symbol files (RSM) are not compatible with Delphi 5. You'll know you're having this problem when you see the message "Error reading symbol file." If this happens, the fix is simple: Rebuild the application.

- Delphi 5 now defaults to storing form files in text mode. If you need to maintain DFM compatibility with earlier versions of Delphi, you'll need to save the forms files in binary instead. You can do this by unchecking *New Forms As Text* on the Preferences page of the Environment Options dialog.
- Code generation when importing and generating type libraries has been changed. In addition to some minor changes, the new generator has been enhanced to allow you to map symbol names; you can customize type library-to-Pascal symbol name mapping by editing the `tlbimp.sym` file. For directions, see the “Mapping Symbol Names in the Type Library” topic in the online help.

RTL Issues

The only issue you're likely to come across here deals with the setting of the floating-point unit (FPU) control word in DLLs. In previous versions of Delphi, DLLs would set the FPU control word, thereby changing the setting established by the host application. Now, DLL startup code no longer sets the FPU control word. If you need to set the control word to ensure some specific behavior by the FPU, you can do it manually using the `Set8087CW()` function in the `System` unit.

VCL Issues

There are a number of VCL issues that you may come across, but most involve some simple edits as a means to get your project on track in Delphi 5. Here's a list of these issues:

- The type of properties that represent an index into an image list has changed from `Integer` to `TImageIndex` type. `TImageIndex` is a strongly typed `Integer` defined in the `ImgList` unit as

```
TImageIndex = type Integer;
```

This should only cause problems in cases where exact type matching matters, such as when you're passing `var` parameters.
- `TCustomTreeView.CustomDrawItem()` has a new `var` parameter called `PaintImages` of type `Boolean`. If your application overrides this method, you'll need to add this parameter in order for it to compile in Delphi 5.
- The `CoInitFlags` variable in `ComObj`, which holds the flags passed to `CoInitializeEx()` in the `ComServ` unit, has been changed to properly support initialization of multithreaded COM servers. Now either the `COINIT_MULTITHREADED` or `COINIT_APARTMENTTHREADED` flags will be added when appropriate.
- If you're invoking pop-up menus in response to `WM_RBUTTONDOWN` messages or `OnMouseUp` events, you may exhibit “double” pop-up menus or no pop-up menus at all when compiling with Delphi 5. Delphi 5 now uses the `WM_CONTEXT` menu message to invoke pop-up menus.

Internet Development Issues

If you're developing applications with Internet support, we have some bad news and some good news:

- The `TWebBrowser` component, which encapsulates the Microsoft Internet Explorer ActiveX control, has replaced the `THTML` component from `Netmasters`. Although the `TWebBrowser` control is much more feature rich, you're faced with a good deal of rewrite if you used `THTML` because the interface is totally different. If you don't want to rewrite your code, you can go back to the old control by importing the `HTML.OCX` file from the `\Info\Extras\NetManage` directory on the Delphi 5 CD-ROM.
- Packages are now supported when building ISAPI and NSAPI DLLs. You can take advantage of this new support by replacing `HTTPApp` in your `uses` clause with `WebBroker`.

Database Issues

There are a few database issues that may trip you up as you migrate to Delphi 5. These involve some renaming of existing symbols and the new architecture of MIDAS:

- The type of the `TDatabase.OnLogin` event has been renamed `TDatabaseLoginEvent` from `TLoginEvent`. This is unlikely to cause problems, but you may run into troubles if you're creating and assigning to `OnLogin` in code.
- The global `FMTBCDToCurr()` and `CurrToFMTBCD()` routines have been replaced by the new `BCDToCurr` and `CurrToBCD` routines (and the corresponding protected methods on `TDataSet` have been replaced by the protected and undocumented `DataConvert` method).
- MIDAS has undergone some significant changes between Delphi 4 and 5. See Chapter 32, "MIDAS Development," for information on the changes, new features, and how to port your MIDAS applications to Delphi 5.

Migrating from Delphi 3

Although there aren't a great deal of compatibility issues between Delphi 3 and later versions, the few issues that do exist can be potentially more problematic than porting from any other previous version of Delphi to the next. Most of these issues revolve around new types and the changing behavior of certain existing types.

Unsigned 32-Bit Integers

Delphi 4 introduced the `LongWord` type, which is an unsigned 32-bit integer. In previous versions of Delphi, the largest integer type was a signed 32-bit integer. Because of this, many of

the types that you would expect to be unsigned, such as `DWORD`, `UINT`, `HResult`, `HWND`, `HINSTANCE`, and other handle types, were defined simply as `Integers`. In Delphi 4 and later, these types are redefined as `LongWords`. Additionally, the `Cardinal` type, which was previously a subrange type of `0..MaxInt`, is now also a `LongWord`. Although all this `LongWord` business won't cause problems in most circumstances, there are several problematic cases you should know about:

- `Integer` and `LongWord` are not var-parameter compatible. Therefore, you cannot pass a `LongWord` in a var `Integer` parameter, and vice versa. The compiler will give you an error in this case, so you'll need to change the parameter or variable type or typecast to get around this problem.
- Literal constants having the value of `$80000000` through `$FFFFFFFF` are considered `LongWords`. You must typecast such a literal to an `Integer` if you wish to assign it to an `Integer` type. Here's an example:

```
var
  I: Integer;
begin
  I := Integer($FFFFFFFF);
```

- Similarly, any literal having a negative value is out of range for a `LongWord`, and you'll need to typecast to assign a negative literal to a `LongWord`. Here's an example:

```
var
  L: LongWord;
begin
  L := LongWord(-1);
```

- If you mix signed and unsigned integers in arithmetic or comparison operations, the compiler will automatically promote each operand to `Int64` in order to perform the arithmetic or comparison. This can cause some very difficult-to-find bugs. Consider the following code:

```
var
  I: Integer;
  D: DWORD;
begin
  I := -1;
  D := $FFFFFFFF;
  if I = D then DoSomething;
```

Under Delphi 3, `DoSomething` would execute because `-1` and `$FFFFFFFF` are the same value when contained in an `Integer`. However, because Delphi 4 and later will promote each operand to `Int64` in order to perform the most accurate comparison, the generated code ends up comparing `$FFFFFFFFFFFFFFFF` against `$00000000FFFFFFFF`, which is definitely not what's intended. In this case, `DoSomething` will not execute.

TIP

The compiler in Delphi 4 and later generates a number of new hints, warnings, and errors that deal with these type compatibility problems and implicit type promotions. Make sure you turn on hints and warnings when compiling in order to let the compiler help you write clean code.

64-Bit Integer

Delphi 4 also introduced a new type called `Int64`, which is a signed 64-bit integer. This new type is now used in the RTL and VCL where appropriate. For example, the `Trunc()` and `Round()` standard functions now return `Int64`, and there are new versions of `IntToStr()`, `IntToHex()`, and related functions that deal with `Int64`.

The Real Type

Starting with Delphi 4, the `Real` type became an alias for the `Double` type. In previous versions of Delphi and Turbo Pascal, `Real` was a six-byte floating-point type. This shouldn't pose any problems for your code unless you have `Reals` written to some external storage (such as a file or record) with an earlier version or you have code that depends on the organization of the `Real` in memory. You can force `Real` to be the old 6-byte type by including the `{$REALCOMPATIBILITY ON}` directive in the units you want to use the old behavior. If all you need to do is force a limited number of instances of the `Real` type to use the old behavior, you can use the `Real48` type instead.

Migrating from Delphi 2

You'll find that a high degree of compatibility between Delphi 2 and the later versions means a smooth transition into a more up-to-date Delphi version. However, some changes have been made since Delphi 2, both in the language and in VCL, that you'll need to be aware of to migrate to the latest version and take full advantage of its power.

Changes to Boolean Types

The implementation of the Delphi 2 Boolean types (`Boolean`, `ByteBool`, `WordBool`, `LongBool`) dictated that `True` was ordinal value 1 and `False` ordinal value 0. To provide better compatibility with the Win32 API, the implementations of `ByteBool`, `WordBool`, and `LongBool` have changed slightly; the ordinal value of `True` is now -1 (`$FF`, `$FFFF`, and `$FFFFFFFF`, respectively). Note that no change was made to the `Boolean` type. These changes have the potential to cause problems in your code—but only if you depend on the ordinal values of these types. For example, consider the following declaration:

```
var  
  A: array[LongBool] of Integer;
```

This code is quite harmless under Delphi 2; it declares an array[False..True] (or [0..1]) of Integer, for a total of three elements. Under Delphi 3 and later, however, this declaration can cause some very unexpected results. Because True is defined as \$FFFFFFFF for a LongBool, the declaration boils down to array[0..\$FFFFFFFF] of Integer, or an array of 4 billion Integers! To avoid this problem, use the Boolean type as the array index.

Ironically, this change was necessary because a disturbing number of ActiveX controls and control containers (such Visual Basic) test BOOLEs by checking for -1 rather than testing for a zero or nonzero value.

TIP

To help ensure portability and to avoid bugs, never write code like this:

```
if BoolVar = True then ...
```

Instead, always test Boolean types like this:

```
if BoolVar then ...
```

ResourceString

If your application uses string resources, consider taking advantage of ResourceStrings as described in Chapter 2, “The Object Pascal Language.” Although this won’t improve the efficiency of your application in terms of size or speed, it will make language translation easier. ResourceStrings and the related topic of resource DLLs are required to be able to write applications displaying different language strings but have them all running on the same core VCL package.

RTL Changes

Several changes made to the runtime library (RTL) after Delphi 2 might cause problems as you migrate your applications. First, the meaning of the HInstance global variable has changed slightly: HInstance contains the instance handle of the current DLL, EXE, or package. Use the new MainInstance global variable when you want to obtain the instance handle of the main application.

The second significant change pertains to the IsLibrary global. In Delphi 2, you could check the value of IsLibrary to determine whether your code was executing within the context of a DLL or EXE. IsLibrary isn’t package aware, however, so you can no longer depend on IsLibrary to be accurate, depending on whether it’s called from an EXE, DLL, or a module

within a package. Instead, you should use the `ModuleIsLib` global, which returns `True` when called within the context of a DLL or package. You can use this in combination with the `ModuleIsPackage` global to distinguish between a DLL and a package.

TCustomForm

The Delphi 3 VCL introduced a new class between `TScrollingWinControl` and `TForm` called `TCustomForm`. In itself, that shouldn't pose a problem for you in migrating your applications from Delphi 2; however, if you have any code that manipulates instances of `TForm`, you might need to update it so that it manipulates `TCustomForms` instead of `TForms`. Some examples of these are calls to `GetParentForm()`, `ValidParentForm()`, and any usage of the `TDesigner` class.

CAUTION

The semantics for `GetParentForm()`, `ValidParentForm()`, and other VCL methods that return `Parent` pointers have changed slightly from Delphi 2. These routines can now return `nil`, even though your component has a parent window context in which to draw. For example, when your component is encapsulated as an ActiveX control, it may have a `ParentWindow`, but not a `Parent` control. This means you must watch out for Delphi 2 code that does this:

```
with GetParentForm(xx) do ...
```

`GetParentForm()` can now return `nil` depending on how your component is being contained.

GetChildren()

Component writers, be aware that the declaration of `TComponent.GetChildren()` has changed to read as follows:

```
procedure GetChildren(Proc: TGetChildProc; Root: TComponent); dynamic;
```

The new `Root` parameter holds the component's root owner—that is, the component obtained by walking up the chain of the component's owners until `Owner` is `nil`.

Automation Servers

The code required for automation has changed significantly from Delphi 2. Chapter 23, “COM-based Technologies,” describes the process of creating Automation servers in Delphi 5. Rather than describe the details of the differences here, suffice it to say that you should never mix the Delphi 2 style of creating Automation servers with the more recent style found in Delphi 3 and later.

In Delphi 2, automation is facilitated through the infrastructure provided in the `OLEAuto` and `OLE2` units. These units are present in later releases of Delphi only for backward compatibility, and you shouldn't use them for new projects. Now the same functionality is provided in the `ComObj`, `ComServ`, and `ActiveX` units. You should never mix the former units with the latter in the same project.

Migrating from Delphi 1

Most of the changes required when porting Delphi 1 applications to a later version are necessary because of the nature of programming under a new operating system. Other changes are required because of enhancements in VCL and the Object Pascal language. Some people would prefer that Delphi 1 applications simply ran without modification under Delphi 5. If that's your opinion, keep in mind that sometimes it's necessary to leave a little behind to move ahead. You should find that each new version of Delphi strikes an excellent balance in this regard.

In addition to explaining what you need to know to migrate Delphi 1 applications, this section also provides you with information about optimizing your project for 32-bit Delphi and maintaining code that's compatible with both 16- and 32-bit Delphi.

Strings and Characters

In response to customer demand for a more flexible string, Borland introduced a new string type in Delphi 2 known as `AnsiString`. Among other benefits, `AnsiString` supports the creation of virtually unlimited-length strings. Delphi 2 also introduced new character and null-terminated string types to fully support application internationalization using the Unicode double-byte format. Delphi 3 took double-byte support even further with the introduction of the `WideString` type. By far the most common issues likely to arise as you migrate from Delphi 1 are those dealing with the use and manipulation of strings.

New Character Types

Strings, of course, are made up of characters, so it's important that you understand the behavior of character types in Delphi 4 before learning about the new string types. The most important change to this portion of the language is the new character type `WideChar`, introduced in Delphi 2 to support Unicode (or "wide") character and string types. In addition to `WideChar`, Delphi 3 introduced a new type name, `AnsiChar`, which specifies a normal single-byte character.

The `AnsiChar` type is the same as the Delphi 1 `Char` type. It's a one-byte value that can contain any of 256 different values. Use `AnsiChar` only when you know that the value in question will always be one byte in size.

Use `WideChar` for a character value that's two bytes in size. `WideChar` exists for compatibility with the Unicode character standard adopted by the Win32 API to support local-language

strings. Because of its two-byte size, a `WideChar` can contain any one of 65,536 possible values, enough for even the largest alphabets.

The purpose of Unicode is to support use of local-language strings across the entire system (and across the global network) without loss of information. There are one-byte character sets for most languages (except Far Eastern languages), but converting between language character sets is not always reversible, so conversion introduces loss of information. Unicode solves that by eliminating the need to convert between character set encodings. It also addresses the Far Eastern language issue by providing a very large character set base for encoding pictograph-per-word languages such as Chinese.

Of course, the `char` type is still valid in Delphi. Currently, the `char` and `AnsiChar` types are equivalent. However, Borland reserves the right to change the definition of `char` to `WideChar` in some future version of Delphi; you should never depend on the size of a `char` being a certain length in your code—always use `SizeOf()` to determine its actual size.

New String Types

Listed here are the string types supported in Delphi 5:

- `AnsiString` (also referred to as *long string* and *huge string*) is the new default string type for Object Pascal. It's composed of `AnsiChar` characters and allows for lengths of up to 1GB. This string type is also compatible with null-terminated strings. This string is always dynamically allocated and lifetime managed.
- `ShortString` is synonymous with the standard string type in Delphi 1.0. The capacity of `ShortString` is limited to 255 characters.
- `WideString` is comprised of `WideChar` characters, and, like `AnsiString`, it's automatically allocated and lifetime managed. Chapter 2, "The Object Pascal Language," contains a complete rundown on this and other string types.
- `PAnsiChar` is a pointer to a null-terminated `AnsiChar` string.
- `PWideChar` is a pointer to a null-terminated string of `WideChar` characters, making up a Unicode, or double-byte, string.
- `PChar` is a pointer to a null-terminated `Char` string, which is fully compatible with C-style strings used in Windows API functions. This type hasn't changed from version 1.0 and is currently defined as `PAnsiChar`.

By default, strings defined in Delphi 2 and later are `AnsiStrings`. So if you declare a string, as shown here, the compiler assumes that you're creating an `AnsiString`:

```
var
  S: String; // S is an AnsiString
```

Alternatively, you can cause variables declared as `String` to instead be of type `ShortString` by using the `$H` compiler directive. When the value of the `$H` compiler directive is negative, `String` variables are `ShortStrings`; when the value of the directive is positive (the default), `String` variables are `AnsiStrings`. The following code demonstrates this behavior:

```
var
  {$H-}
  S1: String; // S1 is a ShortString
  {$H+}
  S2: String; // S2 is an AnsiString
```

The exception to the `$H` rule is that a `String` declared with an explicit size (limited to a maximum of 255 characters) is always a `ShortString`:

```
var
  S: String[63]; // A ShortString of up to 63 characters
```

CAUTION

Be careful when passing strings declared in units with `$H+` to functions and procedures defined in units with `$H-`, and vice versa. These types of errors can introduce some hard-to-find bugs into your applications.

Setting String Length

In Delphi 1, you could set the length of a string by assigning a value to the 0, byte as shown here:

```
S[0] := 23; { sets the length byte of a short string }
```

This was possible because the maximum length of a short string (255) could be stored in the leading byte. Because the maximum length of a long string is 1GB, the size obviously can't fit in one byte; the length is therefore stored differently. Because of this issue, Delphi 2 introduced a new standard procedure called `SetLength()` that you should use to set the length of a string. `SetLength()` is defined as follows:

```
procedure SetLength(var S: String; NewLength: Integer);
```

`SetLength()` can be used with short and long strings. If you want to maintain one set of source code for 16-bit Delphi 1 projects and 32-bit Delphi projects, you can define a `SetLength()` function, as follows, for 16-bit Delphi 1 projects:

```
{$IFDEF WINDOWS}
{ for 16-bit Delphi 1 projects }
```

```
procedure SetLength(var S: String; NewLength: Integer);
begin
    S[0] := Char(NewLength);
end;
{$ENDIF}
```

TIP

For more information on the physical layout of the `AnsiString` type, see Chapter 2, “The Object Pascal Language.”

Dynamically Allocated Strings

In Delphi 1, it's possible to use variables of type `PString` to implement dynamically allocated strings by allocating memory with the `NewStr()`, `GetMem()`, or `AllocMem()` standard procedure. In 32-bit Delphi, because long strings are automatically allocated dynamically from the heap, there's no need to use such techniques. Change your `PString` references to `String` (the code that dynamically creates and frees memory). You must also remove any dereferencing of the `PString` variable that appears in your code. Consider the following block of Delphi 1 code:

```
var
    S1, S2: PString;
begin
    S1 := AllocMem(SizeOf(S1^));
    S1^ := 'Give up the rock.';
    S2 := NewStr(S1^);
    FreeMem(S1, SizeOf(S1^));
    Edit1.Text := S2^;
    DisposeStr(S2);
end;
```

This code can be enormously simplified (and optimized) simply by taking advantage of long strings, as shown here:

```
var
    S1, S2: string;
begin
    S1 := 'Give up the rock.';
    S2 := S1;
    Edit1.Text := S2;
end;
```

Indexing Strings as Arrays

Sometimes you want to access a certain character in a string by indexing the string as an array. For example, the following line of code sets the fifth character in the string to `A`:

```
S[5] := 'A';
```

This type of operation is still perfectly legitimate with long strings, but there's one caveat: Because long strings are dynamically allocated, you must ensure that the length of the string is greater than or equal to the character element you attempt to index. For example, the following code is invalid:

```
var
  S: string;
begin
  S[5] := 'A'; // Space for S has not yet been allocated!!
end;
```

However, this code is quite valid:

```
var
  S: string;
begin
  S := 'Hello'; // allocates enough room for the string
  S[5] := 'A';
end;
```

This code is also valid:

```
var
  S: string;
begin
  SetLength(S, 5); // allocate 5 characters for S
  S[5] := 'A';
end;
```

CAUTION

You should not assume that a character index into a string is the same thing as the byte offset into the string. For example, `WideStringVVar[5]` accesses the fifth character (at byte offset 10).

Null-Terminated Strings

When calling Windows 3.1 API functions in Delphi 1, programmers had to be aware of the difference between the Pascal `String` type and the C-style `PChar` (the null-terminated string used in Windows). Long strings make it much easier to call Win32 API functions. Long strings are both heap allocated and guaranteed to be null terminated. For these reasons, you can simply typecast a long string variable when you need to use it as a null-terminated `PChar` in a Win32 API function call. Imagine that you have procedure `Foo()`, defined as follows:

```
procedure Foo(P: PChar);
```

In Delphi 1, you would typically call this function like this:

```
var
  S: string;           { Pascal short string }
  P: PChar;           { null terminated string }
begin
  S := 'Hello world'; { initialize S }
  P := AllocMem(255); { allocate P }
  StrPCopy(P, S);     { copy S to P }
  Foo(P);             { call Foo with P }
  FreeMem(P, 255);   { dispose P }
end;
```

Using a 32-bit version of Delphi, you can call `Foo()` using a long string variable with the following syntax:

```
var
  S: string;          // a long string is null terminated
begin
  S := 'Hello World';
  Foo(PChar(S));     // fully compatible with PChar type
end;
```

This means that you can optimize your 32-bit code by removing unnecessary temporary buffers to hold null-terminated strings.

Null-Terminated Strings as Buffers

A common use for `PChar` variables is as a buffer to be passed to an API function that fills the buffer string with information. A classic example is the `GetWindowsDirectory()` API function, defined in the Win32 API as follows:

```
function GetWindowsDirectory(lpBuffer: PChar; uSize: UINT): UINT;
```

If your goal is to store the Windows directory in a string variable, a common shortcut under Delphi 1 is to pass the address of the first element of the string as shown here:

```
var
  S: string;
begin
  GetWindowsDirectory(@S[1], 254); { 254 = room for null }
  S[0] := Chr(StrLen(@S[1]));      { adjust length }
end;
```

This technique doesn't work with long strings for two reasons. First, as mentioned earlier, you must give the string an initial length before any space is allocated. Second, because a long

string is already a pointer to heap space, using the @ operator effectively passes a pointer to a pointer to a character—definitely not what you intended! With long strings, this technique is streamlined by typecasting the string to a PChar:

```
var
  S: string;
begin
  SetLength(S, MAX_PATH + 1); // allocate space
  GetWindowsDirectory(PChar(S), MAX_PATH);
  SetLength(S, StrLen(PChar(S))); // adjust length
end;
```

PChars as Strings

Because long strings can be used as PChars, it's only fair that the reverse hold true. Null-terminated strings are assignment compatible to long strings. In Delphi 1, the following code requires a call to StrPCopy():

```
var
  S: string;
  P: PChar;
begin
  P := StrNew('Object Pascal');
  S := StrPas(P);
  StrDispose(P);
end;
```

Now you can accomplish the same thing with a simple assignment using long strings:

```
var
  S: string;
  P: PChar;
begin
  P := StrNew('Object Pascal');
  S := P;
  StrDispose(P);
end;
```

Similarly, you can also pass null-terminated strings to functions and procedures that expect String parameters. Suppose that procedure Bar() is defined as follows:

```
procedure Bar(S: string);
```

You can call Bar() using a PChar as follows:

```
var
  P: PChar;
begin
  P := StrNew('Hello');
```

```
    Bar(P);
    StrDispose(P);
end;
```

However, this technique doesn't work with procedures and functions that accept Strings by reference. Suppose that procedure `Bar()` were instead defined like this:

```
procedure Bar(var S: string);
```

The sample code just presented couldn't be used to call `Bar()`. Instead, you have to define a temporary string to pass to `Bar()`, as shown here:

```
var
    P: PChar;
    TempStr: string;
begin
    P := StrNew('Hello');
    TempStr := P;
    Bar(TempStr);
    StrDispose(P);
    P := PChar(TempStr);
end;
```

Delphi 2 introduced a standard procedure called `SetString()` that allows you to copy only a portion of a `PChar` into a string variable. `SetString()` has an advantage in that it works with both long and short strings. The definition of `SetString()` is given here:

```
procedure SetString(var S: string; Buffer: PChar; Len: Integer);
```

CAUTION

Be wary of assigning a string variable to a `PChar` variable when the lifetime of the `PChar` variable is greater than that of the string. Because the string will be deallocated when it leaves scope, the `PChar` variable will point to garbage after the string leaves scope. The following code illustrates this problem:

```
var
    P: PChar;

procedure Bar(var P: PChar);
var
    S: String;
begin
    S := 'Hola Mundo';
    P := PChar(S); // P is valid here
end;              // S is freed here
```

```

procedure Foo;
begin
  Bar(P);
  ShowMessage(P); // DANGER! P is now invalid
end;

```

Variable Size and Range

Another issue that might arise as you migrate your Delphi code is that some types change size (and therefore range) when they move from 16-bit to 32-bit environments. Tables 15.2 and 15.3 show the differences with regard to these types.

TABLE 15.2 Variable Size Differences

<i>Type</i>	<i>16-Bit Size</i>	<i>32-Bit Size</i>
Integer	Two bytes	Four bytes
Cardinal	Two bytes	Four bytes
String	256 bytes	Four bytes

TABLE 15.3 Variable Range Differences

<i>Type</i>	<i>16-Bit Range</i>	<i>32-Bit Range</i>
Integer	-32,768..32,767	-2,147,483,648..2,147,483,647
Cardinal	0..65,536	0..2,147,483,647
String	255 characters	1GB of characters

For the most part, these new variable sizes have no effect on your applications. In those areas where you depend on type sizes, make sure you use the `SizeOf()` function. Also, if you've written any of these types to binary files or BLOBs in 16-bit Delphi, you must take into account the change in size as you read the data back in with 32-bit Delphi. For this purpose, Table 15.4 indicates which 32-bit Delphi types share binary compatibility with the Delphi 1 types.

TABLE 15.4 Variable Type Compatibility

<i>16-Bit Delphi Type</i>	<i>Compatible 32-Bit Delphi Type</i>
Integer	SmallInt
Cardinal	Word
string	ShortString

Record Alignment

By default in 32-bit Delphi, records are padded so that they're aligned properly; 32-bit data (such as `Integer`) is aligned on 32-bit (`DWORD`) boundaries, and 16-bit data (such as `Word`) is aligned on addresses that are even multiples of 16.

```
type
  TX = record
    B: Byte;
    L: Longint;
  end;
```

NOTE

Data is aligned on boundaries in order to optimize processor performance when accessing memory.

With the default compiler settings, the Delphi 1 `SizeOf(TX)` function returns 5; under Delphi 2 and later, `SizeOf(TX)` function returns 8. This isn't normally an issue; however, it can be an issue if you don't use `SizeOf()` to determine the size of the record in your code or if you have records written to a binary file.

The reason that the 32-bit Delphi compiler aligns record elements on `DWORD` boundaries is that doing so enables the compiler to generate more optimized code. If there's a reason you want to block this behavior, you can use the new `packed` modifier in the `type` declaration:

```
type
  TX = packed record
    B: Byte;
    L: Longint;
  end;
```

With `TX` defined as a *packed record*, as shown here, `SizeOf(TX)` now returns 5 under Delphi 2 and later. You can make packed records the default by using the `$A-` compiler directive.

TIP

If you can reorder the fields in a record to make fields start on their natural boundaries (for example, reorder four `Byte` fields so they all come before an `Integer` field, instead of two on either side of the `Integer`), you can get optimum packing without incurring the performance cost of unaligned data.

32-Bit Math

A much more subtle issue regarding variable size is that the 32-bit Delphi compiler automatically performs optimized 32-bit math on all operands in an expression (Delphi 1 used 16-bit math). Consider the following Object Pascal code:

```
var
  L: longint;
  w1, w2: word;
begin
  w1 := $FFFE;
  w2 := 5;
  L := w1 + w2;
end;
```

Under Delphi 1.0, the value of `L` at the end of this routine is 3 because the calculation of `w1 + w2` is stored as a 16-bit value, and the operation causes the result to wrap. Under Delphi 3, the value of `L` at the end of this routine is \$10003 because the `w1 + w2` calculation is performed using 32-bit math. The repercussion of the new functionality is that if you use and depend on the compiler's range-checking logic to catch "errors" such as these in Delphi 1.0, you must use some other method for finding those errors in 32-bit versions of Delphi, because a range-check error won't occur.

The TDateTime Type

To maintain compatibility with OLE and the Win32 API, the zero value of a `TDateTime` variable has changed. Date values start at `00/00/0000` under Delphi 1; they start at `12/30/1899` under 32-bit Delphi. Although this change won't affect dates stored in a database field, it will affect binary dates stored in a binary file or database BLOB field.

Unit Finalization

Delphi 1 provides a procedure called `AddExitProc()` and a pointer called `ExitProc` that enable you to define a procedure as containing "exit code" for a particular unit. Under 32-bit Delphi, the process of adding an exit procedure to a unit is greatly simplified with the addition of the unit's finalization section. Intended as a counterpart to the unit's initialization section, the code in a finalization section is guaranteed to be called when the application closes. Although this type of change isn't necessary to compile your application under 32-bit Delphi, it does make for much cleaner code.

NOTE

Conversion of `ExitProcs` to finalization blocks is mandatory for packages. Packages can be dynamically loaded and unloaded multiple times at design time, and `ExitProcs` are not called when a package is dynamically unloaded by the IDE. Therefore, your cleanup code must go in finalization sections.

Consider the following Delphi 1 initialization section and exit code:

```
procedure MyExitProc;
begin
  MyGlobalObject.Free;
end;
initialization
  AddExitProc(MyExitProc);
  MyGlobalObject := TGlobalObject.Create;
end.
```

This code can be simplified using the finalization section in 32-bit Delphi, as shown here:

```
initialization
  MyGlobalObject := TGlobalObject.Create;
finalization
  MyGlobalObject.Free;
end.
```

Assembly Language

Because assembly language is highly dependent on the platform for which it is written, the 16-bit built-in assembly language in Delphi 1 applications doesn't work in 32-bit Delphi. You must rewrite such routines using 32-bit assembly language.

Additionally, certain interrupts might not be supported under Win32. An example of interrupts no longer supported under Win32 is the suite of DOS Protected Mode Interface (DPMI) functions provided under interrupt \$31. In some cases, Win32 API functions and procedures take the place of interrupts (the new Win32 file I/O functions are an example). If your application makes use of interrupts, refer to the Win32 documentation to check the alternatives in your specific case.

Additionally, inline hexadecimal code is no longer supported in the 32-bit Delphi compiler. If you have any routines that use inline code, replace them with 32-bit assembly language routines.

Calling Conventions

Delphi 1 can use either the `cdecl` or `pascal` calling convention for parameter passing and stack cleanup for function and procedure calls. The default calling convention for Delphi 1 is `pascal`.

Delphi 2 introduced directives representing two new calling conventions: `register` and `stdcall`. The `register` calling convention is the default for Delphi 2 and 3, offering faster performance. This method dictates that the first three 32-bit parameters be passed in the `eax`, `edx`, and `ecx` registers, respectively. Remaining parameters use the `pascal` calling convention. The `stdcall` calling convention is a hybrid of `pascal` and `cdecl` in that the parameters are passed using the `cdecl` convention but the stack is cleaned up using the `pascal` convention.

Delphi 3 introduced a new procedure directive called `safecall`. `safecall` follows the `stdcall` convention for parameter passing and also allows COM errors to be handled in a more Delphi-like manner. Most COM functions return `HRESULT` values as errors, whereas the preferred manner of error handling in Delphi is through the use of structured exception handling. When you call a `safecall` function from Delphi, the `HRESULT` return value of the function is converted into an exception that you may handle. When implementing a `safecall` function in Delphi, any exceptions raised in the function will be converted into an `HRESULT` value, which is returned to the caller.

NOTE

Although functions and procedures in the 16-bit Windows API use the `pascal` calling convention, Win32 API functions and procedures use the `stdcall` convention. Consequently, if you have any callback functions in your code, those also use the `stdcall` calling convention. Consider the following callback, intended for use with the `EnumWindows()` API function under 16-bit Windows:

```
function EnumWindowsProc(Handle: hwnd; lParam: Longint): BOOL; export;
```

It's defined as follows for 32-bit Windows:

```
function EnumWindowsProc(Handle: hwnd; lParam: Longint): BOOL; stdcall;
```

Dynamic Link Libraries (DLLs)

The creation and use of DLLs work very much the same in 32-bit Delphi as in Delphi 1, although there are a few minor differences. Some of these issues are listed here:

- Because of Win32's flat memory model, the `export` directive (necessary for callback and DLL functions in Delphi 1) is unnecessary in later versions. It's simply ignored by the compiler.

- If you're writing a DLL you intend to share with executables written using other development tools, it's a good idea to use the `stdcall` directive for maximum compatibility.
- The preferred way to export functions in a Win32 DLL is by name (instead of by ordinal). The following example exports functions by ordinal, the Delphi 1 way:

```
function SomeFunction: integer; export;
begin
.
.
.
end;

procedure SomeProcedure; export;
begin
.
.
.
end;

exports
    SomeFunction index 1,
    SomeProcedure index 2;
```

Here are the same functions exported by name, the 32-bit Delphi way:

```
function SomeFunction: integer; stdcall;
begin
.
.
.
end;

procedure SomeProcedure; stdcall;
begin
.
.
.
end;

exports
    SomeFunction name 'SomeFunction';
    SomeProcedure name 'SomeProcedure';
```

- Exported names are case sensitive. You must use proper case when importing functions by name and when calling `GetProcAddress()`.
- When you import a function or procedure and specify the library name after the external directive, the file extension can be included. If no extension is specified, `.DLL` is assumed.

- Under Windows 3.x, a DLL in memory has only one data segment that's shared by all instances of the DLL. Therefore, if applications A and B both load DLL C, changes made to global variables in DLL C from application A are visible to application B, and the reverse is also true. Under Win32, each DLL receives its own data segment, so changes made to global DLL data from one program aren't visible to another program.

TIP

See Chapter 9, "Dynamic Link Libraries," for more information on the behavior of DLLs under Win32.

Windows Operating System Changes

In several areas, changes in the 32-bit architecture of Windows can have an impact on code written in Delphi. These include changes resulting from the 32-bit memory model, changes in resource formats, unsupported features, and changes to the Windows API itself.

32-Bit Address Space

Win32 provides a 4GB flat address space for your application. The term *flat* means that all segment registers hold the same value and that the definition of a pointer is an offset into that 4GB space. Because of this, any code in your Delphi 1 applications that depends on the concept of a pointer consisting of a selector and offset must be rewritten to accommodate the new architecture.

The following elements of the Delphi 1 runtime library are 16-bit pointer specific and are not in the 32-bit Delphi runtime library: `DSeg`, `SSeg`, `CSeg`, `Seg`, `Ofs`, and `SPtr`.

Because of the way in which Win32 uses a hard disk paging file to simulate RAM on demand, the Delphi 1.0 `MemAvail()` and `MaxAvail()` functions are no longer useful for gauging available memory. If you have to obtain this information in 32-bit Delphi, use the `GetHeapStatus()` Delphi RTL function, which is defined as follows:

```
function GetHeapStatus: THeapStatus;
```

The `THeapStatus` record is designed to provide information (in bytes) on the status of the heap for your process. This record is defined as follows:

```
type
  THeapStatus = record
    TotalAddrSpace: Cardinal;
    TotalUncommitted: Cardinal;
    TotalCommitted: Cardinal;
    TotalAllocated: Cardinal;
```

```
TotalFree: Cardinal;  
FreeSmall: Cardinal;  
FreeBig: Cardinal;  
Unused: Cardinal;  
Overhead: Cardinal;  
HeapErrorCode: Cardinal;  
end;
```

Again, because the nature of Win32 is such that the amount of “free” memory has little meaning, most users will find the `TotalAllocated` field (which indicates how much heap memory has been allocated by the current process) most useful for debugging purposes.

NOTE

For more information on the internals of the Win32 operating system, see Chapter 3, “The Win32 API.”

32-Bit Resources

If you have any resources (RES or DCR files) that you link into your application or use with a component, you must create 32-bit versions of these files before you can use them with 32-bit Delphi. Typically, this is a simple matter of using the included Image Editor or a separate resource editor (such as Resource Workshop) to save the resource file in a 32-bit-compatible format.

VBX Controls

Because Microsoft doesn’t support VBX controls (which are inherently 16-bit controls) in 32-bit applications for Windows 95 and Windows NT, they aren’t supported in 32-bit Delphi. ActiveX controls (OCXs) effectively replace VBX controls in 32-bit platforms. If you want to migrate a Delphi 1.0 application that uses VBX controls, contact your VBX vendor to get an equivalent 32-bit ActiveX control.

Changes to the Windows API Functions

Some Windows APIs or features have changed from Windows 3.1 to Win32. Some 16-bit API functions no longer exist in Win32, some functions are obsolete but continue to exist for the sake of compatibility, and some accept different parameters or return different types or values. Tables 15.5 and 15.6 list these functions. For complete documentation on these functions, see the Win32 API online help that comes with Delphi.

TABLE 15.5 Obsolete Windows 3.x API Functions

<i>Windows 3.x Function</i>	<i>Win32 Replacement</i>
OpenComm()	CreateFile()
CloseComm()	CloseHandle()
FlushComm()	PurgeComm()
GetCommError()	ClearCommError()
ReadComm()	ReadFile()
WriteComm()	WriteFile()
UngetCommChar()	N/A
DlgDirSelect()	DlgDirSelectEx()
DlgDirSelectComboBox()	DlgDirSelectComboBoxEx()
GetBitmapDimension()	GetBitmapDimensionEx()
SetBitmapDimension()	SetBitmapDimensionEx()
GetBrushOrg()	GetBrushOrgEx()
GetAspectRatioFilter()	GetAspectRatioFilterEx()
GetTextExtent()	GetTextExtentPoint()
GetViewportExt()	GetViewportExtEx()
GetViewportOrg()	GetViewportOrgEx()
GetWindowExt()	GetWindowExtEx()
GetWindowOrg()	GetWindowOrgEx()
OffsetViewportOrg()	OffsetViewportOrgEx()
OffsetWindowOrg()	OffsetWindowOrgEx()
ScaleViewportExt()	ScaleViewportExtEx()
ScaleWindowExt()	ScaleWindowExtEx()
SetViewportExt()	SetViewportExtEx()
SetViewportOrg()	SetViewportOrgEx()
SetWindowExt()	SetWindowExtEx()
SetWindowOrg()	SetWindowOrgEx()
GetMetafileBits()	GetMetafileBitsEx()
SetMetafileBits()	SetMetafileBitsEx()
GetCurrentPosition()	GetCurrentPositionEx()
MoveTo()	MoveToEx()
DeviceCapabilities()	DeviceCapabilitiesEx()
DeviceMode()	DeviceModeEx()

continues

TABLE 15.5 Continued

<i>Windows 3.x Function</i>	<i>Win32 Replacement</i>
ExtDeviceMode()	ExtDeviceModeEx()
FreeSelector()	N/A
AllocSelector()	N/A
ChangeSelector()	N/A
GetCodeInfo()	N/A
GetCurrentPDB()	GetCommandLine() and/or GetEnvironmentStrings()
GlobalDOSAlloc()	N/A
GlobalDOSFree()	N/A
SwitchStackBack()	N/A
SwitchStackTo()	N/A
GetEnvironment()	(Win32 file I/O functions)
SetEnvironment()	(Win32 file I/O functions)
ValidateCodeSegments()	N/A
ValidateFreeSpaces()	N/A
GetInstanceData()	N/A
GetKBCodePage()	N/A
GetModuleUsage()	N/A
Yield()	WaitMessage() and/or Sleep()
AccessResource()	N/A
AllocResource()	N/A
SetResourceHandler()	N/A
AllocDSToCSAlias()	N/A
GetCodeHandle()	N/A
LockData()	N/A
UnlockData()	N/A
GlobalNotify()	N/A
GlobalPageLock()	VirtualLock()

TABLE 15.6 Win32 API Compatibility Function

<i>Windows 3.x Function</i>	<i>Win32 Replacement</i>
DefineHandleTable()	N/A
MakeProcInstance()	N/A

<i>Windows 3.x Function</i>	<i>Win32 Replacement</i>
FreeProcInstance()	N/A
GetFreeSpace()	GlobalMemoryStatus()
GlobalCompact()	N/A
GlobalFix()	N/A
GlobalUnfix()	N/A
GlobalWire()	N/A
GlobalUnwire()	N/A
LocalCompact()	N/A
LocalShrink()	N/A
LockSegment()	N/A
UnlockSegment()	N/A
SetSwapAreaSize()	N/A

Concurrent 16-Bit and 32-Bit Projects

This section gives you some guidelines for developing projects that compile under 16-bit Delphi 1 or any 32-bit version of Delphi. Although you can follow the directions outlined in this chapter for source code compatibility, here are some further pointers to help you along:

- The `WINDOWS` conditional is defined by the compiler under Delphi 1; the `WIN32` conditional is defined under 32-bit versions of Delphi. You can use these defines to perform conditional compilation with the `{IFDEF WINDOWS}` and `{IFDEF WIN32}` directives.
- Avoid the use of any component or feature in 32-bit Delphi that isn't supported by Windows 3.1 or Delphi 1 if you want to recompile with Delphi 1 for a 16-bit application. For example, avoid the use of Win95 components and features such as multithreading that aren't available in Windows 3.1. The easiest way to ensure compatibility with projects intended for both Delphi 1 and 32-bit versions of Delphi is to develop the project in Delphi 1 and recompile it with 32-bit Delphi for optimized 32-bit performance.
- Be wary of differences between the APIs. If you have to use an API procedure or function that's implemented differently in the different platforms, make use of the `WINDOWS` and `WIN32` conditional defines.
- Each new version often adds more properties or different properties than those found in the previous version. This means, for example, that when version 5 components are saved to a DFM file, these new properties are written as well. Although it's often possible to "ignore" the errors that occur when loading projects with these properties in Delphi 1, it's often a more favorable solution to maintain two separate sets of DFM files, one for each platform.

Win32s

One other option for leveraging a single code base into both 16- and 32-bit Windows is to attempt to run your 32-bit Delphi applications under Win32s. Win32s is an add-on to Windows 3.x, which enables a subset of the Win32 API to function on 16-bit Windows. One serious drawback to this method is that many Win32 features, such as threads, are not available under Win32s (this precludes your use of the Borland Database Engine in this circumstance because the BDE makes use of threads). If you choose this route, you should also bear in mind that Win32s is not an officially supported platform for 32-bit Delphi, so you're on your own if things don't quite function as you expect.

Summary

Armed with the information provided by this chapter, you should be able to migrate your projects smoothly from any previous version of Delphi to Delphi 5. Also, with a bit of work, you'll be able to maintain projects that work with multiple versions of Delphi.

MDI Applications

CHAPTER

16

IN THIS CHAPTER

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- **Working with Menus 806**
- **Miscellaneous MDI Techniques 807**
- **Summary 821**

The Multiple Document Interface, otherwise known as *MDI*, was introduced to Windows 2.0 in the Microsoft Excel spreadsheet program. MDI gave Excel users the ability to work on more than one spreadsheet at a time. Other uses of MDI included the Windows 3.1 Program Manager and File Manager programs. Borland Pascal for Windows is another MDI application.

During the development of Windows 95, many developers were under the impression that Microsoft was going to eliminate MDI capabilities. Much to their surprise, Microsoft kept MDI as part of Windows 95 and there has been no further word about Microsoft's intention to get rid of it.

CAUTION

Microsoft has acknowledged that the Windows MDI implementation is flawed. It advised developers against continuing to build apps in the MDI model. Since then, Microsoft has returned to building MS apps in the MDI model but does so without using the Windows MDI implementation. You can still use MDI, but be forewarned that the Windows MDI implementation is still flawed, and Microsoft has no plans to fix those problems. What we present in this chapter is a safe implementation of the MDI model.

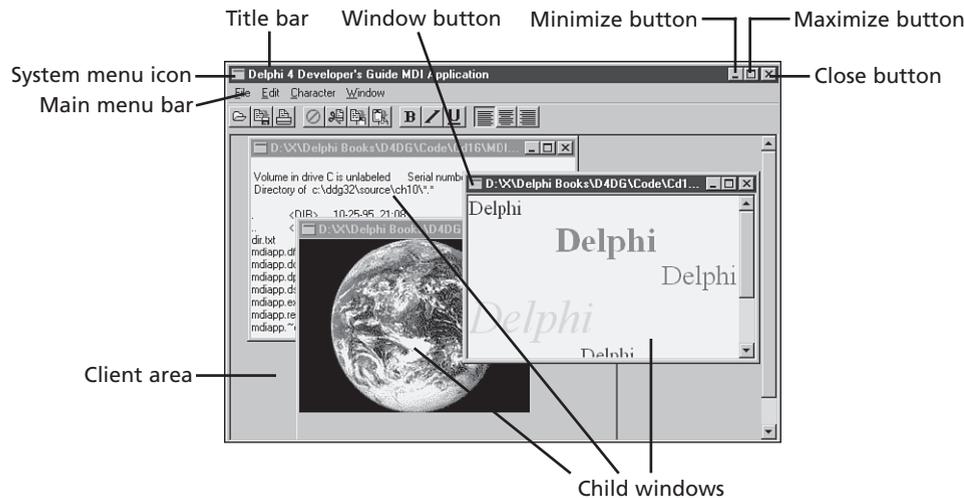
Handling events simultaneously between multiple forms might seem difficult. In traditional Windows programming, you had to have knowledge of the Windows class `MDICLIENT`, MDI data structures, and the additional functions and messages specific to MDI. With Delphi 5, creating MDI applications is greatly simplified. When you finish this chapter, you'll have a solid foundation for building MDI applications, which you can easily expand to include more advanced techniques.

Creating the MDI Application

To create MDI applications, you need familiarity with the form styles `fSMDIForm` and `fSMDIChild` and a bit of MDI programming methodology. The following sections present some basic concepts regarding MDI and show how MDI works with special MDI child forms.

Understanding MDI Basics

To understand MDI applications, first you must understand how they're constructed. Figure 16.1 shows an MDI application similar to one you'll build in this chapter.



16

MDI
APPLICATIONS**FIGURE 16.1**

The structure of an MDI application.

Here are the windows involved with an MDI application:

- *Frame window.* The application's main window. It has a caption, menu bar, and system menu. Minimize, maximize, and close buttons appear in its upper-right corner. The blank space inside the frame window is known as its *client area* and is actually the client window.
- *Client window.* The manager for MDI applications. The client window handles all MDI-specific commands and manages the child windows that reside on its surface—including the drawing of MDI child windows. The client is created automatically by the *Visual Component Library (VCL)* when you create a frame window.
- *Child windows.* MDI child windows are your actual documents—text files, spreadsheets, bitmaps, and other document types. Child windows, like frame windows, have a caption, system menu, minimize, maximize, and close buttons, and possibly a menu. It's possible to place a help button on a child window. A child window's menu is combined with the frame window's menu. Child windows never move outside the client area.

Delphi 5 does not require you to be familiar with the special MDI window's messages. The client window is responsible for managing MDI functionality, such as cascading and tiling child windows. To cascade child windows using the traditional method, for example, use the Windows API function `SendMessage()` to send a `WM_MDICASCADE` message to the client window:

```
procedure TFrameForm.Cascade1Click(Sender: TObject);
begin
```

```
    SendMessage(ClientHandle, WM_MDICASCADE, 0, 0);
end;
```

In Delphi 5, just call the `Cascade()` method:

```
procedure TFrameForm.Cascade1Click(Sender: TObject);
begin
    cascade;
end;
```

The following sections show you a complete MDI application whose child MDI windows have the functionality of a text editor, a bitmap file viewer, and a rich text format editor. The purpose of this application is to show you how to build MDI applications whose child windows each display and edit different types of information. For example, the text editor allows you to edit any text-based file. The rich text editor allows you to edit rich text–formatted (.rtf) files. Finally, the bitmap viewer allows you to view any Windows bitmapped file.

We also show you how to perform some advanced MDI techniques using the Win32 API. These techniques mainly have to do with managing MDI child forms in an MDI-based application. First, we'll discuss the building of the child forms and their functionality. Then we'll talk about the main form.

The Child Form

As mentioned earlier, this MDI application contains three types of child forms: `TMDiEditForm`, `TMDiRTFForm`, and `TMDiBMPForm`. Each of these three types descends from `TMDiChildForm`, which serves as a base class. The following section describes the `TMDiChildForm` base class. The sections after that talk about the three child forms used in the MDI application.

The TMDiChildForm Base Class

The child forms used in the MDI application have some common functionality. They all have the same File menu and their `FormStyle` property is set to `fsMDiChild`. Additionally, they all make use of a `TToolBar` component. By deriving each child form from a base form class, you can avoid having to redefine these settings for each form. We defined a base form, `TMDiChildForm`, as shown in `MdiChildFrm.pas` (refer to Listing 16.1).

LISTING 16.1 `MdiChildFrm.pas`: A Unit Defining `TMDiChildForm`

```
unit MdiChildFrm;

interface

uses
    SysUtils, Windows, Messages, Classes, Graphics, Controls,
    Forms, Dialogs, Menus, ComCtrls, ToolWin, ImgList;
```

```
type
    TMDIChildForm = class(TForm)
    (* Component list removed, refer to online source. *)
    procedure FormClose(Sender: TObject; var Action: TCloseAction);
    procedure mmiExitClick(Sender: TObject);
    procedure mmiCloseClick(Sender: TObject);
    procedure mmiOpenClick(Sender: TObject);
    procedure mmiNewClick(Sender: TObject);
    procedure FormActivate(Sender: TObject);
    procedure FormDeactivate(Sender: TObject);
end;

var
    MDIChildForm: TMDIChildForm;

implementation
uses MainFrm, Printers;

{$R *.DFM}

procedure TMDIChildForm.FormClose(Sender: TObject; var Action: TCloseAction);
begin
    Action := caFree;
    { Reassign the toolbar parent }
    tlbMain.Parent := self;
    { If this is the last child form being displayed, then make the main form's
      toolbar visible }
    if (MainForm.MDIChildCount = 1) then
        MainForm.tlbMain.Visible := True
end;

procedure TMDIChildForm.mmiExitClick(Sender: TObject);
begin
    MainForm.Close;
end;

procedure TMDIChildForm.mmiCloseClick(Sender: TObject);
begin
    Close;
end;

procedure TMDIChildForm.mmiOpenClick(Sender: TObject);
begin
    MainForm.mmiOpenClick(nil);
end;
```

continues

LISTING 16.1 Continued

```
procedure TMDIChildForm.mmiNewClick(Sender: TObject);
begin
    MainForm.mmiNewClick(nil);
end;

procedure TMDIChildForm.FormActivate(Sender: TObject);
begin
    { When the form becomes active, hide the main form's toolbar and assign
      this child form's toolbar to the parent form. Then display this
      child form's toolbar. }
    MainForm.tlbMain.Visible := False;
    tlbMain.Parent := MainForm;
    tlbMain.Visible := True;
end;

procedure TMDIChildForm.FormDeactivate(Sender: TObject);
begin
    { The child form becomes inactive when it is either destroyed or when another
      child form becomes active. Hide this form's toolbar so that the next
      form's
      toolbar will be visible. }
    tlbMain.Visible := False;
end;

end.
```

NOTE

Note that we have removed the component declarations for the `TMdiChildForm` base class from the printed text for space reasons.

`TMDIChildForm` contains event handlers for the menu items for its main menu as well as for some common tool buttons. Actually, the tool buttons are simply wired to the event handler of their corresponding menu item. Some of these event handlers call methods on the main form. For example, notice that the `mmiNewClick()` event handler calls the `MainForm.mmiNewClick()` event handler. `TMainForm.mmiNewClick()` contains functionality for creating a new MDI child form. You'll notice that there are other event handlers such as `mmiOpenClick()` and `mmiExitClick()` that call the respective event handlers on the main form. We'll cover `TMainForm`'s functionality later in the section "The Main Form."

Because each MDI child needs to have the same functionality, it makes sense to put this functionality into a base class from which the MDI child forms can descend. This way, the MDI

child forms do not have to define these same methods. They will inherit the main menu as well as the toolbar components that you see on the main form.

Notice in the `TMDIChildForm.FormClose()` event handler that you set the `Action` parameter to `caFree` to ensure that the `TMDIChildForm` instance is destroyed when closed. You do this because MDI child forms don't close automatically when you call their `Close()` method. You must specify, in the `OnClose` event handler, what you want done with the child form when its `Close()` method is called. The child form's `OnClose` event handler passes in a variable `Action`, of type `TCloseAction`, to which you must assign one of four possible values:

- `caNone`. Do nothing.
- `caHide`. Hide the form but don't destroy it.
- `caFree`. Free the form.
- `caMinimize`. Minimize the form (this is the default).

`TCloseAction` is an enumerated type.

When a form becomes active, its `OnActivate` event handler is called. You must perform some specific logic whenever a child form becomes active. Therefore, in the `TMdiChildForm.FormActivate()` event handler, you'll see that we make the main form's toolbar invisible while setting the child form's toolbar to visible. We also assign the main form as the parent to the child form's toolbar so that the toolbar appears on the main form and not on the child form. This is one way you might give the main form a different toolbar when a different type of MDI child form is active. The `OnDeactivate` event handler simply makes the child form's toolbar invisible. Finally, the `OnClose` event reassigns the child form as the parent to the toolbar, and if the current child form is the only child form, it makes the main form's toolbar visible. The effect is that the main form has a single toolbar with buttons that change depending on the type of active child form.

The Text Editor Form

The text editor form enables the user to load and edit any text file. This form, `TMdiEditForm`, is inherited from `TMDIChildForm`. `TMdiEditForm` contains a client-aligned `TMemo` component.

`TMdiEditForm` also contains `TPrintDialogs`, `TSaveDialog` and `TFontDialog` components.

`TMdiEditForm` is not an autogenerated form and is removed from the list of autogenerated forms in the Project Options dialog box.

NOTE

None of the forms, except for `TMainForm`, in the MDI project are automatically created and therefore have been removed from the list of autogenerated forms. These forms are created dynamically in the project's source code.

TMdiEditForm's source code is given in Listing 16.2.

LISTING 16.2 MdiEditFrm.pas: A Unit Defining TMdiEditForm

```
unit MdiEditFrm;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, Menus, ExtCtrls, Buttons, ComCtrls,
  ToolWin, MdiChildFrm, ImgList;

type

  TMdiEditForm = class(TMDIChildForm)
    memMainMemo: TMemo;
    SaveDialog: TSaveDialog;
    FontDialog: TFontDialog;
    mmiEdit: TMenuItem;
    mmiSelectAll: TMenuItem;
    N7: TMenuItem;
    mmiDelete: TMenuItem;
    mmiPaste: TMenuItem;
    mmiCopy: TMenuItem;
    mmiCut: TMenuItem;
    mmiCharacter: TMenuItem;
    mmiFont: TMenuItem;
    N8: TMenuItem;
    mmiWordWrap: TMenuItem;
    N9: TMenuItem;
    mmiCenter: TMenuItem;
    mmiRight: TMenuItem;
    mmiLeft: TMenuItem;
    mmiUndo: TMenuItem;
    N4: TMenuItem;
    mmiBold: TMenuItem;
    mmiItalic: TMenuItem;
    mmiUnderline: TMenuItem;
    PrintDialog: TPrintDialog;

    { File Event Handlers }
    procedure mmiSaveClick(Sender: TObject);
    procedure mmiSaveAsClick(Sender: TObject);
```

```
{ Edit Event Handlers }
procedure mmiCutClick(Sender: TObject);
procedure mmiCopyClick(Sender: TObject);
procedure mmiPasteClick(Sender: TObject);
procedure mmiDeleteClick(Sender: TObject);
procedure mmiUndoClick(Sender: TObject);
procedure mmiSelectAllClick(Sender: TObject);

{ Character Event Handlers }
procedure CharAlignClick(Sender: TObject);
procedure mmiBoldClick(Sender: TObject);
procedure mmiItalicClick(Sender: TObject);
procedure mmiUnderlineClick(Sender: TObject);
procedure mmiWordWrapClick(Sender: TObject);
procedure mmiFontClick(Sender: TObject);

{ Form Event Handlers }
procedure FormCloseQuery(Sender: TObject; var CanClose: Boolean);
procedure mmiPrintClick(Sender: TObject);
public
  { User Defined Methods }
  procedure OpenFile(FileName: String);
  procedure SetButtons;
end;

var
  MdiEditForm: TMdiEditForm;

implementation

uses Printers;

{$R *.DFM}
{ File Event Handlers }

procedure TMdiEditForm.mmiSaveClick(Sender: TObject);
begin
  inherited;
  { If there isn't a caption, then there isn't already a filename.
    Therefore, call mmiSaveAsClick since it gets a filename. }
  if Caption = '' then
    mmiSaveAsClick(nil)
  else begin
    { Save to the file specified by the form's Caption. }
    memMainMemo.Lines.SaveToFile(Caption);
    memMainMemo.Modified := false; // Set to false since the text is saved.
```

continues

LISTING 16.2 Continued

```
    end;
end;

procedure TMdiEditForm.mmiSaveAsClick(Sender: TObject);
begin
    inherited;
    SaveDialog.FileName := Caption;
    if SaveDialog.Execute then
        begin
            { Set caption to filename specified by SaveDialog1 since this
              may have changed. }
            Caption := SaveDialog.FileName;
            mmiSaveClick(nil); // Save the file.
        end;
end;

{ Edit Event Handlers }

procedure TMdiEditForm.mmiCutClick(Sender: TObject);
begin
    inherited;
    memMainMemo.CutToClipboard;
end;

procedure TMdiEditForm.mmiCopyClick(Sender: TObject);
begin
    inherited;
    memMainMemo.CopyToClipboard;
end;

procedure TMdiEditForm.mmiPasteClick(Sender: TObject);
begin
    inherited;
    memMainMemo.PasteFromClipboard;
end;

procedure TMdiEditForm.mmiDeleteClick(Sender: TObject);
begin
    inherited;
    memMainMemo.ClearSelection;
end;

procedure TMdiEditForm.mmiUndoClick(Sender: TObject);
begin
    inherited;
```

```

    memMainMemo.Perform(EM_UNDO, 0, 0);
end;

procedure TMdiEditForm.mmiSelectAllClick(Sender: TObject);
begin
    inherited;
    memMainMemo.SelectAll;
end;

{ Character Event Handlers }
procedure TMdiEditForm.CharAlignClick(Sender: TObject);
begin
    inherited;
    mmiLeft.Checked := false;
    mmiRight.Checked := false;
    mmiCenter.Checked := false;

{ TAlignment is defined by VCL as:

    TAlignment = (taLeftJustify, taRightJustify, taCenter);

Therefore each of the menu items contains the appropriate Tag property
whose value represents one of the TAlignment values: 0, 1, 2 }

{ If the menu invoked this event handler, set it to checked and
  set the alignment for the memo }
if Sender is TMenuItem then
begin
    TMenuItem(Sender).Checked := true;
    memMainMemo.Alignment := TAlignment(TMenuItem(Sender).Tag);
end
{ If a TToolButton from the main form invoked this event handler,
  set the memo's alignment and then check the appropriate TMenuItem. }
else if Sender is TToolButton then
begin
    memMainMemo.Alignment := TAlignment(TToolButton(Sender).Tag);
    case memMainMemo.Alignment of
        taLeftJustify:    mmiLeft.Checked := True;
        taRightJustify:   mmiRight.Checked := True;
        taCenter:         mmiCenter.Checked := True;
    end;
end;
SetButtons;
end;

procedure TMdiEditForm.mmiBoldClick(Sender: TObject);

```

continues

LISTING 16.2 Continued

```
begin
  inherited;
  if not mmiBold.Checked then
    memMainMemo.Font.Style := memMainMemo.Font.Style + [fsBold]
  else
    memMainMemo.Font.Style := memMainMemo.Font.Style - [fsBold];
  SetButtons;
end;

procedure TMdiEditForm.mmiItalicClick(Sender: TObject);
begin
  inherited;
  if not mmiItalic.Checked then
    memMainMemo.Font.Style := memMainMemo.Font.Style + [fsItalic]
  else
    memMainMemo.Font.Style := memMainMemo.Font.Style - [fsItalic];
  SetButtons;
end;

procedure TMdiEditForm.mmiUnderlineClick(Sender: TObject);
begin
  inherited;
  if not mmiUnderline.Checked then
    memMainMemo.Font.Style := memMainMemo.Font.Style + [fsUnderline]
  else
    memMainMemo.Font.Style := memMainMemo.Font.Style - [fsUnderline];
  SetButtons;
end;

procedure TMdiEditForm.mmiWordWrapClick(Sender: TObject);
begin
  inherited;
  with memMainMemo do
  begin
    WordWrap := not WordWrap;
    { Remove scrollbars if Memo1 is wordwrapped since they're not
      required. Otherwise, make sure scrollbars are present. }
    if WordWrap then
      ScrollBars := ssVertical
    else
      ScrollBars := ssBoth;
    mmiWordWrap.Checked := WordWrap;
  end;
end;

procedure TMdiEditForm.mmiFontClick(Sender: TObject);
```

```
begin
  inherited;
  FontDialog.Font := memMainMemo.Font;
  if FontDialog.Execute then
    memMainMemo.Font := FontDialog.Font;
end;

{ Form Event Handlers }
procedure TMdiEditForm.FormCloseQuery(Sender: TObject;
  var CanClose: Boolean);
{ This procedure ensures that the user has saved the contents of the
  memo if it was modified since the last time the file was saved. }
const
  CloseMsg = ''%s' has been modified, Save?';
var
  MsgVal: integer;
  FileName: string;
begin
  inherited;
  FileName := Caption;
  if memMainMemo.Modified then
    begin
      MsgVal := MessageDlg(Format(CloseMsg, [FileName]), mtConfirmation,
mbYesNoCancel, 0);
      case MsgVal of
        mrYes:   mmiSaveClick(Self);
        mrCancel: CanClose := false;
      end;
    end;
end;

procedure TMdiEditForm.OpenFile(FileName: string);
begin
  memMainMemo.Lines.LoadFromFile(FileName);
  Caption := FileName;
end;

procedure TMdiEditForm.SetButtons;
{ This procedure ensures that menu items and buttons on the main form
  accurately reflect various settings for the memo. }
begin
  mmiBold.Checked := fsBold in memMainMemo.Font.Style;
  mmiItalic.Checked := fsItalic in memMainMemo.Font.Style;
  mmiUnderLine.Checked := fsUnderline in memMainMemo.Font.Style;

  tbBold.Down := mmiBold.Checked;
```

continues

LISTING 16.2 Continued

```
tbItalic.Down      := mmiItalic.Checked;
tbUnderline.Down  := mmiUnderLine.Checked;
tbLAlign.Down     := mmiLeft.Checked;
tbRAlign.Down     := mmiRight.Checked;
tbCAlign.Down     := mmiCenter.Checked;
end;

procedure TMdiEditForm.mmiPrintClick(Sender: TObject);
var
  i: integer;
  PText: TextFile;
begin
  inherited;
  if PrintDialog.Execute then
  begin
    AssignPrn(PText);
    Rewrite(PText);
    try
      Printer.Canvas.Font := memMainMemo.Font;
      for i := 0 to memMainMemo.Lines.Count - 1 do
        writeln(PText, memMainMemo.Lines[i]);
      finally
        CloseFile(PText);
      end;
    end;
  end;
end;
end.
```

Most of the methods for `TMdiEditForm` are event handlers for the various menus in `TMdiEditForm`'s main menu, the same menu inherited from `TMdiChildForm`. Also notice that additional menu items have been added to the main menu that apply specifically to `TMdiEditForm`.

You'll notice that there are no event handlers for the File, New, File, Open, File, Close, and File, Exit menus because they're already linked to `TMdiChildForm`'s event handlers.

The event handlers for the Edit menu items are all single-line methods that interact with the `TMemo` component. For example, you'll notice that the event handlers `mmiCutClick()`, `mmiCopyClick()`, and `mmiPasteClick()` interact with the Windows Clipboard in order to perform cut, copy, and paste operations. The other edit event handlers perform various editing functions on the memo component that have to do with deleting, clearing, and selecting text.

The Character menu applies various formatting attributes to the memo.

Notice that we stored a unique value in the `Tag` property of the `TToolButton` components for setting text alignment. This `Tag` value represents a value in the `TAlignment` enumerated type. This value is extracted from the `Tag` value of the `TToolButton` component that invoked the event handler to set the appropriate alignment for the memo component.

All menu items and tool buttons that set text alignment are wired to the `CharAlignClick()` event handler. This is why you have to check and respond appropriately in the event handler depending on whether a `TMenuItem` or `TToolButton` component invoked the event.

`CharAlignClick()` calls the `SetButtons()` method, which sets various menu items and components accordingly based on the memo's attributes.

The `mmiWordWrapClick()` event handler simply toggles the memo's `wordwrap` attribute and then the `Checked` property for the menu item. This method also specifies whether the memo component contains scrollbars based on its word-wrapping capability.

The `mmiFontClick()` event handler invokes a `TFontDialog` component and applies the selected font to the memo. Notice that before launching the `FontDialog` component, the `Font` property is set to reflect the memo's font so that the correct font is displayed in the dialog box.

The `mmiSaveAsClick()` event handler invokes a `TSaveDialog` component to get a filename from the user to which the memo's contents will be saved. When the file is saved, the `TMdiEditForm.Caption` property is set to reflect the new filename.

The `mmiSaveClick()` event handler calls the `mmiSaveAsClick()` event handler if a filename doesn't exist. This is the case if the user creates a new file instead of opening an existing one. Otherwise, the memo's contents are saved to the existing file specified by the `MdiEditForm.Caption` property. Notice that this event handler also sets `memMainMemo.Modified` to `False`. `Modified` is automatically set to `True` whenever the user changes the contents of a `TMemo` component. However, it's not set to `False` automatically whenever its contents are saved.

The `FormCloseQuery()` method is the event handler for the `OnCloseQuery` event. This event handler evaluates the `memMainMemo.Modified` property when the user attempts to close the form. If the memo has been modified, the user is notified and asked whether he or she wants to save the contents of the memo.

The public method `TMdiEditForm.OpenFile()` loads the file specified by the `FileName` parameter and places the file's contents into the `memMainMemo.Lines` property and then sets the form's `Caption` to reflect this filename.

That completes the functionality for `TMdiEditForm`. The other forms are somewhat similar in functionality.

The Rich Text Editor Form

The rich text editor enables the user to load and edit rich text–formatted files. This form, `TMdiRtfForm`, is derived from `TMDIChild`. It contains a client-aligned `TRichEdit` component.

`TMdiRtfForm` and `TMdiEditForm` are practically identical except that `TMdiRtfForm` contains a `TRichEdit` component as its editor; `TMdiEditForm` uses a `TMemo` component. `TMdiRtfForm` differs from the text editor in that the text attributes applied to the `TRichEdit` component affect paragraphs or selected text in the `TRichEdit` component; they affect the entire text with the `TMemo` component.

The source code for `TMdiRtfForm` is shown in Listing 16.3.

LISTING 16.3 `MdiRtfFrm.pas`: A Unit Defining `TMdiRtfForm`

```
unit MdiRtfFrm;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, MdiChildFrm, StdCtrls, ComCtrls,
  ExtCtrls, Buttons, Menus, ToolWin, ImgList;

type

  TMdiRtfForm = class(TMDIChildForm)
    reMain: TRichEdit;
    FontDialog: TFontDialog;
    SaveDialog: TSaveDialog;
    mmiEdit: TMenuItem;
    mmiSelectAll: TMenuItem;
    N7: TMenuItem;
    mmiPaste: TMenuItem;
    mmiCopy: TMenuItem;
    mmiCut: TMenuItem;
    mmiCharacter: TMenuItem;
    mmiFont: TMenuItem;
    N8: TMenuItem;
    mmiWordWrap: TMenuItem;
    N9: TMenuItem;
    mmiCenter: TMenuItem;
    mmiRight: TMenuItem;
    mmiLeft: TMenuItem;
    mmiUndo: TMenuItem;
    mmiDelete: TMenuItem;
```

```
N4: TMenuItem;
mmiBold: TMenuItem;
mmiItalic: TMenuItem;
mmiUnderline: TMenuItem;

{ File Event Handlers }
procedure mmiSaveClick(Sender: TObject);
procedure mmiSaveAsClick(Sender: TObject);

{ Edit Event Handlers }
procedure mmiCutClick(Sender: TObject);
procedure mmiCopyClick(Sender: TObject);
procedure mmiPasteClick(Sender: TObject);
procedure mmiDeleteClick(Sender: TObject);
procedure mmiUndoClick(Sender: TObject);
procedure mmiSelectAllClick(Sender: TObject);

{ Character Event Handlers }
procedure CharAlignClick(Sender: TObject);
procedure mmiBoldClick(Sender: TObject);
procedure mmiItalicClick(Sender: TObject);
procedure mmiUnderlineClick(Sender: TObject);
procedure mmiWordWrapClick(Sender: TObject);
procedure mmiFontClick(Sender: TObject);

{ Form Event Handlers }
procedure FormShow(Sender: TObject);
procedure FormCloseQuery(Sender: TObject; var CanClose: Boolean);
procedure reMainSelectionChange(Sender: TObject);
procedure mmiPrintClick(Sender: TObject);
public
  { User-Defined Functions. }
  procedure OpenFile(FileName: String);
  function GetCurrentText: TTextAttributes;
  procedure SetButtons;
end;

var
  MdiRtfForm: TMdiRtfForm;

implementation
{$R *.DFM}
{ File Event Handlers }

procedure TMdiRtfForm.mmiSaveClick(Sender: TObject);
begin
```

continues

LISTING 16.2 Continued

```
    inherited;
    reMain.Lines.SaveToFile(Caption);
end;

procedure TMdiRtfForm.mmiSaveAsClick(Sender: TObject);
begin
    inherited;
    SaveDialog.FileName := Caption;
    if SaveDialog.Execute then
        begin
            Caption := SaveDialog.FileName;
            mmiSaveClick(Sender);
        end;
end;

{ Edit Event Handlers }

procedure TMdiRtfForm.mmiCutClick(Sender: TObject);
begin
    inherited;
    reMain.CutToClipboard;
end;

procedure TMdiRtfForm.mmiCopyClick(Sender: TObject);
begin
    inherited;
    reMain.CopyToClipboard;
end;

procedure TMdiRtfForm.mmiPasteClick(Sender: TObject);
begin
    inherited;
    reMain.PasteFromClipboard;
end;

procedure TMdiRtfForm.mmiDeleteClick(Sender: TObject);
begin
    inherited;
    reMain.ClearSelection;
end;

procedure TMdiRtfForm.mmiUndoClick(Sender: TObject);
begin
    inherited;
    reMain.Perform(EM_UNDO, 0, 0);
```

```
end;

procedure TMdiRtfForm.mmiSelectAllClick(Sender: TObject);
begin
    inherited;
    reMain.SelectAll;
end;

{ Character Event Handlers }

procedure TMdiRtfForm.CharAlignClick(Sender: TObject);
begin
    inherited;
    mmiLeft.Checked := false;
    mmiRight.Checked := false;
    mmiCenter.Checked := false;

    { If a TMenuItem invoked this event handler, set its checked
      property to true and set the attribute to RichEdit1's current
      paragraph. }
    if Sender is TMenuItem then
    begin
        TMenuItem(Sender).Checked := true;
        with reMain.Paragraph do
            if mmiLeft.Checked then
                Alignment := taLeftJustify
            else if mmiRight.Checked then
                Alignment := taRightJustify
            else if mmiCenter.Checked then
                Alignment := taCenter;
        end
    end
    { If one of the main form's tool buttons invoked this event handler
      set the attribute to reMain's current paragraph and set the
      alignment menu items accordingly. }
    else if Sender is TSpeedButton then
    begin
        reMain.Paragraph.Alignment :=
            TAlignment(TSpeedButton(Sender).Tag);
        case reMain.Paragraph.Alignment of
            taLeftJustify: mmiLeft.Checked := True;
            taRightJustify: mmiRight.Checked := True;
            taCenter: mmiCenter.Checked := True;
        end;
    end;
    SetButtons;
end;
```

continues

LISTING 16.2 Continued

```
procedure TMdiRtfForm.mmiBoldClick(Sender: TObject);
begin
  inherited;
  if not mmiBold.Checked then
    GetCurrentText.Style := GetCurrentText.Style + [fsBold]
  else
    GetCurrentText.Style := GetCurrentText.Style - [fsBold];
end;

procedure TMdiRtfForm.mmiItalicClick(Sender: TObject);
begin
  inherited;
  if not mmiItalic.Checked then
    GetCurrentText.Style := GetCurrentText.Style + [fsItalic]
  else
    GetCurrentText.Style := GetCurrentText.Style - [fsItalic];
end;

procedure TMdiRtfForm.mmiUnderlineClick(Sender: TObject);
begin
  inherited;
  if not mmiUnderline.Checked then
    GetCurrentText.Style := GetCurrentText.Style + [fsUnderline]
  else
    GetCurrentText.Style := GetCurrentText.Style - [fsUnderline];
end;

procedure TMdiRtfForm.mmiWordWrapClick(Sender: TObject);
begin
  inherited;
  with reMain do
  begin
    { Remove scrollbars if Memo1 is wordwrapped since they're not
      required. Otherwise, make sure scrollbars are present. }
    WordWrap := not WordWrap;    if WordWrap then
      ScrollBars := ssVertical
    else
      ScrollBars := ssNone;
    mmiWordWrap.Checked := WordWrap;
  end;
end;

procedure TMdiRtfForm.mmiFontClick(Sender: TObject);
begin
  inherited;
  FontDialog.Font.Assign(reMain.Se1Attributes);
```

```
    if FontDialog.Execute then
        GetCurrentText.Assign(FontDialog.Font);
    reMain.SetFocus;
end;

{ Form Event Handlers }

procedure TMdiRtfForm.FormShow(Sender: TObject);
begin
    inherited;
    reMain.SelectionChange(nil);
end;

procedure TMdiRtfForm.FormCloseQuery(Sender: TObject;
    var CanClose: Boolean);
{ This procedure ensures that the user has saved the contents of
  reMain if it was modified since the last time the file was saved. }
const
    CloseMsg = ''%s' has been modified, Save?';
var
    MsgVal: integer;
    FileName: string;
begin
    inherited;
    FileName := Caption;
    if reMain.Modified then
        begin
            MsgVal := MessageDlg(Format(CloseMsg, [FileName]), mtConfirmation,
mbYesNoCancel, 0);
            case MsgVal of
                mrYes: mmiSaveClick(Self);
                mrCancel: CanClose := false;
            end;
        end;
end;

procedure TMdiRtfForm.reMainSelectionChange(Sender: TObject);
begin
    inherited;
    SetButtons;
end;

procedure TMdiRtfForm.OpenFile(FileName: String);
begin
    reMain.Lines.LoadFromFile(FileName);
```

continues

LISTING 16.2 Continued

```
    Caption := FileName;
end;

function TMdiRtfForm.GetCurrentText: TTextAttributes;
{ This procedure returns the text attributes of the current paragraph
  or based on the selected text of reMain.}
begin
    if reMain.SelLength > 0 then
        Result := reMain.SelAttributes
    else
        Result := reMain.DefAttributes;
end;

procedure TMdiRtfForm.SetButtons;
{ Ensures that the controls on the form reflect the
  current attributes of the paragraph by looking at the paragraph
  attributes themselves and setting the controls accordingly. }
begin

    with reMain.Paragraph do
    begin
        mmiLeft.Checked := Alignment = taLeftJustify;
        mmiRight.Checked := Alignment = taRightJustify;
        mmiCenter.Checked := Alignment = taCenter;
    end;

    with reMain.SelAttributes do
    begin
        mmiBold.Checked := fsBold in Style;
        mmiItalic.Checked := fsItalic in Style;
        mmiUnderline.Checked := fsUnderline in Style;
    end;
    mmiWordWrap.Checked := reMain.WordWrap;

    tbBold.Down := mmiBold.Checked;
    tbItalic.Down := mmiItalic.Checked;
    tbUnderline.Down := mmiUnderline.Checked;
    tbLAlign.Down := mmiLeft.Checked;
    tbRAlign.Down := mmiRight.Checked;
    tbCAlign.Down := mmiCenter.Checked;
end;

procedure TMdiRtfForm.mmiPrintClick(Sender: TObject);
begin
```

```
    inherited;  
    reMain.Print(Caption);  
end;  
  
end.
```

Like `TMdiEditForm`, most of `TMdiRtfForm`'s methods are event handlers for the various menu items and tool buttons. These event handlers are similar to `TMdiEditForm`'s event handlers.

`TMdiRtfForm`'s File menu items invoke the File menu items of the `TMdiChildForm` base class. Recall that `TMdiChildForm` is the ancestor to `TMdiRtfForm`. The event handlers, `mmiSaveClick()` and `mmiSaveAsClick()`, both call `reMain.Lines.SaveToFile()` to save `reMain`'s contents.

The event handlers for `TMdiRtfForm`'s Edit menu items are single-line methods similar to the `TMdiEditForm`'s Edit menu event handlers except that these event handlers call methods applicable to `reMain`. The method names are the same as the memo methods that perform the same operations.

`TMdiRtfForm`'s Character menu items modify the alignment of *paragraphs* or selected text within the `TRichEdit` component (as opposed to the text within the entire component, as is the behavior with a `TMemo` component). Whether these attributes are applied to a paragraph or to selected text depends on the return value of the `GetCurrentText()` function. `GetCurrentText()` determines whether any text is selected by looking at the value of `TRichEdit.SelLength`. A zero value indicates that no text is selected. The `TRichEdit.SelAttributes` property refers to any selected text in the `TRichEdit` component. `TRichEdit.DefAttributes` refers to the current paragraph of the `TRichEdit` component.

The `mmiFontClick()` event handler allows the user to specify font attributes for a paragraph. Note that a paragraph can also refer to selected text.

Word wrapping is handled the same with the `TRichEdit` component as with the `TMemo` component in the text editor.

The `TRichEdit.OnSelectionChange` event handler is available to allow the programmer to provide some functionality whenever the selection of the component has changed. When the user moves the caret within the `TRichEdit` component, the component's `SelStart` property value changes. Because this action causes the `OnSelectionChange` event handler to be called, code was added to change the status of the various `TMenuItem` and `TSpeedButton` components on the main form to reflect the attributes of the text as the user scrolls through text in the `TRichEdit` component. This is necessary because text attributes in the `TRichEdit` component can differ; this is not the case with a `TMemo` component because attributes applied to a `TMemo` component apply to the entire component.

In functionality, the rich text editor form and the text editor form are, for the most part, very similar. The main difference is that the rich text editor allows users to change the attributes for separate paragraphs or selected text; the text editor is incapable of doing this.

The Bitmap Viewer—The Third MDI Child Form

The bitmap viewer enables the user to load and view Windows bitmap files. Like the other two MDI child forms, the bitmap viewer form, `TMdiBmpForm`, is derived from the `TMDIChildForm` base class. It contains a client-aligned `TImage` component.

`TMdiBmpForm` contains only its inherited `TMainMenu` component. Listing 16.4 shows the source code that defines `TMdiBmpForm`.

LISTING 16.4 `MdiBmpFrm.pas`: A Unit Defining `TMdiBmpForm`

```
unit MdiBmpFrm;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls, Forms, Dialogs,
  MdiChildFrm, ExtCtrls, Menus, Buttons, ComCtrls, ToolWin, ImgList;

type
  TMdiBMPForm = class(TMDIChildForm)
    mmiEdit: TMenuItem;
    mmiCopy: TMenuItem;
    mmiPaste: TMenuItem;
    imgMain: TImage;
    procedure mmiCopyClick(Sender: TObject);
    procedure mmiPasteClick(Sender: TObject);
    procedure mmiPrintClick(Sender: TObject);
  public
    procedure OpenFile(FileName: string);
  end;

var
  MdiBMPForm: TMdiBMPForm;

implementation

uses ClipBrd, Printers;

{$R *.DFM}

procedure TMdiBMPForm.OpenFile(FileName: String);
```

```
begin
  imgMain.Picture.LoadFromFile(FileName);
  Caption := FileName;
end;

procedure TMdiBMPForm.mmiCopyClick(Sender: TObject);
begin
  inherited;
  Clipboard.Assign(imgMain.Picture);
end;

procedure TMdiBMPForm.mmiPasteClick(Sender: TObject);
{ This method copies the contents from the clipboard into imgMain }
begin
  inherited;
  // Copy clipboard content to imgMain
  imgMain.Picture.Assign(Clipboard);
  ClientWidth := imgMain.Picture.Width;
  { Adjust clientwidth to adjust the scollbars }
  VertScrollBar.Range := imgMain.Picture.Height;
  HorzScrollBar.Range := imgMain.Picture.Width;
end;

procedure TMdiBMPForm.mmiPrintClick(Sender: TObject);
begin
  inherited;

  with ImgMain.Picture.Bitmap do
  begin
    Printer.BeginDoc;
    Printer.Canvas.StretchDraw(Canvas.ClipRect, imgMain.Picture.Bitmap);
    Printer.EndDoc;
  end; { with }
end;

end.
```

There is not as much code for `TMdiBmpForm` as there was for the two previous forms. The File menu items invoke the `TMDIChildForm`'s event handlers just as the `TMdiEditForm` and `TMdiRtfForm` File menu items do. The Edit menu items copy and paste the bitmap to and from the Windows Clipboard, respectively. Before calling the `TImage.Picture.Assign()` method to assign the Clipboard data to the `TImage` component. The `TImage` component recognizes both the `CF_BITMAP` and `CF_PICTURE` formats as bitmaps.

The Windows Clipboard

The Clipboard provides the easiest way for two applications to share information. It's nothing more than a global memory block that Windows maintains for any application to access through a specific set of Windows functions.

The Clipboard supports several standard formats, such as text, OEM text, bitmaps, and metafiles; it also supports other specialized formats. Additionally, you can extend the Clipboard to support application-specific formats.

Delphi 5 encapsulates the Windows Clipboard with the global variable `Clipboard` of type `TClipboard`, making it much easier for you to use. The `TClipboard` class is covered in detail in Chapter 17, "Sharing Information with the Clipboard."

The Main Form

The main form is the form with which the user initially works to create or switch between MDI child forms. This form is appropriately named `MainForm`. `MainForm` serves as the parent to the text editor, bitmap viewer, and RTF editor MDI child forms.

`TMainForm` is not a descendant of `TMDIChildForm` as are the other forms discussed so far in this chapter. `TMainForm` has the `FormStyle` of `fsMDIForm` (the other three forms inherited the style `fsMDIChild` from `TMDIChild`). `TMainForm` contains a `TMainMenu` component and a `TOpenDialog` component. `TMainForm` also contains a toolbar that contains only one button. `TMainForm`'s source code is shown in Listing 16.5.

LISTING 16.5 MdiMainForm.pas: A Unit Defining `TMainForm`

```
unit MainFrm;  
  
interface  
  
uses  
  WinTypes, WinProcs, Classes, Graphics, Forms, Controls, Menus,  
  StdCtrls, Messages, Dialogs, SysUtils, ComCtrls,  
  ToolWin, ExtCtrls, Buttons, ImgList;  
  
type  
  TMainForm = class(TForm)  
    mmMain: TMainMenu;  
    OpenDialog: TOpenDialog;  
    mmiFile: TMenuItem;  
    mmiExit: TMenuItem;  
    N3: TMenuItem;  
    mmiOpen: TMenuItem;
```

```
    mmiNew: TMenuItem;
    mmiWindow: TMenuItem;
    mmiArrangeIcons: TMenuItem;
    mmiCascade: TMenuItem;
    mmiTile: TMenuItem;
    mmiCloseAll: TMenuItem;
    tlbMain: TToolBar;
    ilMain: TImageList;
    tbFileOpen: TToolButton;

    { File Event Handlers }
    procedure mmiNewClick(Sender: TObject);
    procedure mmiOpenClick(Sender: TObject);
    procedure mmiExitClick(Sender: TObject);

    { Window Event Handlers }
    procedure mmiTileClick(Sender: TObject);
    procedure mmiArrangeIconsClick(Sender: TObject);
    procedure mmiCascadeClick(Sender: TObject);
    procedure mmiCloseAllClick(Sender: TObject);
public
    { User defined methods }
    procedure OpenTextFile(EditForm: TForm; Filename: string);
    procedure OpenBMPFile(FileName: String);
    procedure OpenRTFFile(RTFForm: TForm; FileName: string);
end;

var
    MainForm: TMainForm;

implementation
uses MDIBmpFrm, MdiEditFrm, MdiRtfFrm, FTypForm;

const
    { Define constants to represent file name extensions }
    BMPExt      = '.BMP'; // Bitmapped file
    TextExt     = '.TXT'; // Text file
    RTFExt      = '.RTF'; // Rich Text Format file

{$R *.DFM}

procedure TMainForm.mmiNewClick(Sender: TObject);
begin
    { Determine the file type the user wishes to open by calling the
      GetFileType function. Call the appropriate method based on the
      retrieved file type. }

```

continues

LISTING 16.5 Continued

```
case GetFileType of
  mrTXT: OpenTextFile(nil, ''); // Open a text file.
  mrRTF: OpenRTFFile(nil, ''); // Open an RTF file.
  mrBMP:
    begin
      { Set the default filter for OpenFileDialog for BMP files. }
      OpenFileDialog.FilterIndex := 2;
      mmiOpenClick(nil);
    end;
end;

procedure TMainForm.mmiOpenClick(Sender: TObject);
var
  Ext: string[4];
begin
  { Call the appropriate method based on the file type of the file
    selected from OpenFileDialog }
  if OpenFileDialog.Execute then
    begin
      { Get the file's extension and compare it to determine the
        file type the user is opening. Call the appropriate method and
        pass in the file name. }
      Ext := ExtractFileExt(OpenDialog.FileName);
      if CompareStr(UpperCase(Ext), TextExt) = 0 then
        OpenTextFile(ActiveMDIChild, OpenFileDialog.FileName)
      else if CompareStr(UpperCase(Ext), BMPExt) = 0 then
        OpenBMPFile(OpenDialog.FileName)
      else if CompareStr(UpperCase(Ext), RTFExt) = 0 then
        OpenRTFFile(ActiveMDIChild, OpenFileDialog.FileName);
    end;
end;

procedure TMainForm.mmiExitClick(Sender: TObject);
begin
  Close;
end;

{ Window Event Handlers }

procedure TMainForm.mmiTileClick(Sender: TObject);
begin
  Tile;
end;

procedure TMainForm.mmiArrangeIconsClick(Sender: TObject);
```

```
begin
    ArrangeIcons;
end;

procedure TMainForm.mmiCascadeClick(Sender: TObject);
begin
    Cascade;
end;

procedure TMainForm.mmiCloseAllClick(Sender: TObject);
var
    i: integer;
begin
    { Close all forms in reverse order as they appear in the
      MDIChildren property. }
    for i := MdiChildCount - 1 downto 0 do
        MDIChildren[i].Close;
    end;

    { User Defined Methods }
    procedure TMainForm.OpenTextFile(EditForm: TForm; FileName: string);
    begin
        { If EditForm is of a TEditForm type, then give the user the option
          of loading the file contents into this form. Otherwise, create a
          new TEditForm instance and load the file into that instance }
        if (EditForm <> nil) and (EditForm is TMdiEditForm) then
            if MessageDlg('Load file into current form?', mtConfirmation,
                [mbYes, mbNo], 0) = mrYes then
                begin
                    TMdiEditForm(EditForm).OpenFile(FileName);
                    Exit;
                end;
            { Create a new TEditForm and call its OpenFile() method }
            with TMdiEditForm.Create(self) do
                if FileName <> '' then
                    OpenFile(FileName)
            end;
        end;

    procedure TMainForm.OpenRTFFFile(RTFForm: TForm; FileName: string);
    begin
        { If RTFForm is of a TRTFForm type, then give the user the option
          of loading the file contents into this form. Otherwise, create a
          new TRTFForm instance and load the file into that instance }
        if (RTFForm <> nil) and (RTFForm is TMdiRTFForm) then
            if MessageDlg('Load file into current form?', mtConfirmation,
```

continues

LISTING 16.5 Continued

```

    [mbYes, mbNo], 0) = mrYes then begin
        (RTFForm as TMdiRTFForm).OpenFile(FileName);
    Exit;
end;
{ Create a new TRTFForm and call its OpenFile() method }
with TMdiRTFForm.Create(self) do
    if FileName <> '' then
        OpenFile(FileName);
end;

procedure TMainForm.OpenBMPFile(FileName: String);
begin
    { Create a new TBMPForm instances and load a BMP file into it. }
    with TMdiBmpForm.Create(self) do
        OpenFile(FileName);
end;

end.
```

TMainForm uses another form, FileTypeForm, of the type TFileTypeForm. Listing 16.6 shows the source code for this form.

LISTING 16.6 The FTYPFORM.PAS Unit Defining TFileTypeForm

```

unit FTypForm;

interface

uses
    SysUtils, Windows, Messages, Classes, Graphics, Controls,
    Forms, Dialogs, StdCtrls, ExtCtrls, Buttons;

const
    mrTXT = mrYesToAll+1;
    mrBMP = mrYesToAll+2;
    mrRTF = mrYesToAll+3;

type
    TFileTypeForm = class(TForm)
        rgFormType: TRadioGroup;
        btnOK: TButton;
        procedure btnOkClick(Sender: TObject);
    end;
```

```
var
  FileTypeForm: TFileTypeForm;

function GetFileType: Integer;

implementation

function GetFileType: Integer;
{ This function returns the file type selected by the user as
  represented by one of the above defined constants. }
begin
  FileTypeForm := TFileTypeForm.Create(Application);
  try
    Result := FileTypeForm.ShowModal;
  finally
    FileTypeForm.Free;
  end;
end;

{$R *.DFM}

procedure TFileTypeForm.btnOkClick(Sender: TObject);
begin
  { Return the correct modal result based on the selected file type }
  case rgFormType.ItemIndex of
    0: ModalResult := mrTXT;
    1: ModalResult := mrRTF;
    2: ModalResult := mrBMP;
  end;
end;

end.
```

TFileTypeForm is used to prompt the user for a file type to create. This form returns the ModalResult based on which TRadioButton the user selected to indicate the type of file. The GetFileType() function takes care of creating, showing, and freeing the TFileTypeForm instance. This function returns the TFileTypeForm.ModalResult property. This form is not automatically created and has been removed from the list of autogenerated forms for the project.

TMainForm's toolbar contains only one button, which is used to open the initial child form. When a child form becomes active, its toolbar replaces the main form's toolbar. This logic is handled by the OnActivate event of the child form. TMainForm's public methods OpenTextFile(), OpenRTFFile(), and OpenBMPFile() are called from the event handler TMainForm.mmiOpenClick(), which is invoked whenever the user selects the File, Open menu.

`OpenTextFile()` takes two parameters: a `TForm` instance and a filename. The `TForm` instance represents the currently active form for the application. The reason for passing this `TForm` instance to the `OpenTextFile()` method is so that the method can determine whether the `TForm` passed to it is of the `TMdiEditForm` class. If so, it's possible that the user is opening a text file in the existing `TMdiEditForm` instance rather than creating a new `TMdiEditForm` instance. If a `TMdiEditForm` instance is passed to this method, the user is prompted whether he or she wants the text file to be placed into this `TForm` parameter. If the user replies no or the `TMdiEditForm` parameter is `nil`, a new `TMdiEditForm` instance is created.

`OpenRTFFile()` operates the same as `OpenTextFile()` except that it checks for a `TRTFForm` class as the currently active form represented by the `TForm` parameter. The functionality is the same.

`OpenBMPFile()` always assumes that the user is opening a new file. This is because the `TMdiBmpForm` is only a viewer and not an editor. If the form allowed the user to edit a bitmapped image, the `OpenBMPFile()` method would function as do `OpenTextFile()` and `OpenRTFFile()`.

The `mmiNewClick()` event handler calls the `GetFileType()` function to retrieve a file type from the user. It then calls the appropriate `OpenXXXFile()` method based on the return value. If the file is a `.bmp` file, the `OpenDialog.Filter` property is set to the BMP filter by default and the `mmiOpenClick()` method is invoked because the user is not creating a new `.bmp` file but is opening an existing one.

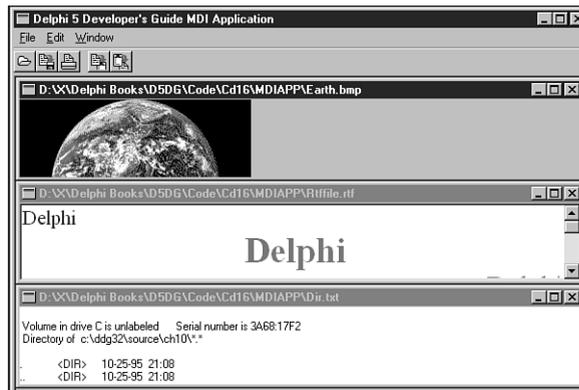
The `mmiOpenClick()` event handler invokes `OpenDialog` and calls the appropriate `OpenXXXFile()` method. Notice that `OpenTextFile()` and `OpenRTFFile()` are passed the `TMainForm.ActiveMDIChild` property as the first parameter. `ActiveMDIChild` is the MDI child that currently has focus. Recall that both these methods determine whether the user wants to open a file into an existing MDI child form. If no forms are active, `ActiveMDIChild` is `nil`. If `ActiveMDIChild` is pointing to a `TMdiRTFForm` and `OpenTextFile()` is called, `OpenTextFile()` still functions correctly because of this statement:

```
if (RTFForm <> nil) and (RTFForm is TMdiRTFForm) then
```

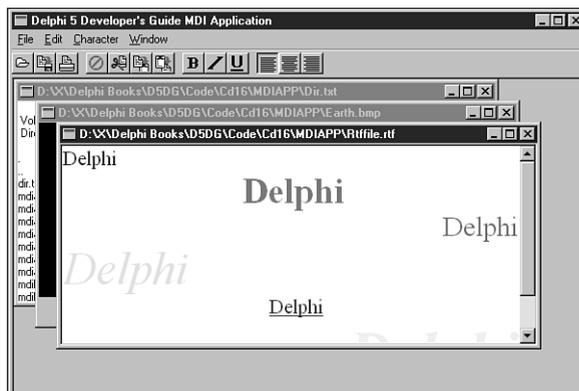
This statement determines whether `ActiveMDIChild` points to a `TMdiRtfForm`. If not, a new form is created.

The event handler, `mmiExitClick()`, calls `TMainForm.Close()`; this method not only closes the main form, it also terminates the application. If there are any child forms open at the time this event handler is invoked, the child forms are also closed and destroyed.

The Window menu event handlers are single-line methods that affect how the MDI child forms are arranged on the main form's client area. Figures 16.2 and 16.3 show tiled and cascaded forms, respectively.

**FIGURE 16.2**

Tiled child forms.

**FIGURE 16.3**

Cascaded child forms.

The `mmiArrangeIconsClick()` method simply rearranges the icons in the main form's client area so that they're evenly spaced and do not overlap.

The `mmiCloseAllClick()` event handler closes all open MDI child forms. The loop that closes the child forms loops through all child forms in reverse order as they appear in the `MDIChildren` array property. The `MDIChildren` property is a zero-based array property of all MDI children active in an application. The `MDIChildCount` property is the number of children that are active.

This completes the discussion of the functionality of the MDI application. The following sections discuss some techniques and some of the components used with the various forms in the application.

Working with Menus

Using menus in MDI applications is no more difficult than using them in any other type of application. However, there are some differences in how menus work in MDI applications. The following sections show how an MDI application allows its child forms to share the same menu bar using a method called *menu merging*. You also learn how to make non-MDI applications share the same menu bar.

Merging Menus with MDI Applications

Take a look at the `TMainMenu` for the `TMdiEditForm`. By double-clicking the `TMainMenu` icon, you bring up the menu editor.

`TMdiEditForm`'s main menu contains three menu items along the menu bar. These items are File, Edit, and Character. Each of these menu items has a `GroupIndex` property that shows up in the Object Inspector as you click a menu item in the menu editor. Notice that the File menu item has a `GroupIndex` value of 0. The Edit and Character menu items both have `GroupIndex` values of 1.

Notice that `TMainForm`'s main menu has two menu items along its menu bar: File and Window. Like `TMdiEditForm`, `TMainForm`'s File menu item has a `GroupIndex` value of 0. The Window menu item's `GroupIndex` property, on the other hand, has a value of 9.

Also notice that the File menu for `TMainForm` and the File menu for `TMdiEditForm` have different submenu items. `TMdiEditForm`'s File menu has more submenu items than does `TMainForm`'s File menu.

The `GroupIndex` property is important because it allows menus of forms to be “merged.” This means that when the main form launches a child form, the child form's main menu is merged with the main form's main menu. The `GroupIndex` property determines how the menus are ordered and which menus of the main form are replaced by menus of the child form. Note that menu merging applies only to menu items along the menu bar of a `TMainMenu` component and not to submenus.

Whenever a `GroupIndex` property for a child form's menu item has the same value as the `GroupIndex` property for a menu item on the main form, the child form's menu item replaces the main form's menu item. The remaining menus are arranged along the menu bar in the order specified by the `GroupIndex` properties of all combined menu items. When `MdiEditForm` is the active form in the project, the menu items that appear along the main form's menu bar are File, Edit, Character, and Window, in that order. Note that the File menu is `TMdiEditForm`'s File menu because both File menus have `GroupIndex` property values of 0. Therefore, `TMdiChildForm`'s File menu replaces `TMainForm`'s File menu. The order of these menus directly reflects the order of the `GroupIndex` properties for each menu item along the menu bar: 0, 1, 1, 9.

NOTE

Although we don't use them here, there are certain numbering guidelines that you should follow so that your applications will better integrate with OLE Container's menu merging. These guidelines are explained in the "Borland Delphi Library Reference Guide."

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This behavior is the same with the other forms in the MDI application. Whenever a form becomes active, the menu along the main menu bar changes to reflect the merging of menus for both the main form and child form. When you run the project, the menu bar changes depending on which child form is active.

Merging menus with MDI applications is automatic. As long as the values of the menu items' `GroupIndex` property is set in the order you specify, your menus merge correctly when you invoke MDI child forms.

For non-MDI applications, the process is just as easy but requires an extra step. We gave a quick example in Chapter 4, "Application Frameworks and Design Concepts," on merging menus in non-MDI applications when we discussed the `TNavStatForm`. However, in that application, we based this merging on child forms that were actually child windows to a control, other than the main form, and had to explicitly call the `Merge()` and `Unmerge()` functions. For merging menus with non-MDI-based applications in general, this process is not automatic, as it is with MDI applications. You must set the `AutoMerge` property to `True` for the `TMainMenu` on the form whose menus are to be merged with the main form. A sample project that shows menu merging for non-MDI forms can be found in the project `NonMDI.dpr` on the CD.

Adding a List of Open Documents to the Menu

To add a list of open documents to the Window menu, set the `WindowMenu` property of the main form to the menu item's instance that is to hold the list of open documents. For example, the `TMainForm.WindowMenu` property in the sample MDI application is set to `mmiWindow`, which refers to the Window menu along the menu bar. The selection you choose for this property must be a menu item that appears on the menu bar—it cannot be a submenu. The application displays a list of open documents in the Window menu.

Miscellaneous MDI Techniques

The following sections show various common techniques applicable to MDI applications.

Drawing a Bitmap in the MDI Client Window

When designing an MDI application, you might want to place a background image, such as a company logo, on the client area of an MDI application's main form. For regular (non-MDI) forms, this procedure is simple. You just place a `TImage` component on the form, set its `Align` property to `alClient`, and you're done (refer back to the bitmap viewer in the MDI sample application, earlier in this chapter). Placing an image on the main form of an MDI application, however, is a different story.

Recall that the client window of an MDI application is a separate window from the main form. The client window has many responsibilities of carrying out MDI-specific tasks, including the drawing of MDI child windows.

Think of it as though the main form is a transparent window over the client window. Whenever you place components such as `TButton`, `TEdit`, and `TImage` over the client area of the main form, these components are actually placed on the main form's transparent window. When the client window performs its drawing of child windows—or rather child forms—the forms are drawn *underneath* the components that appear on the main form, much like placing stickers on the glass of a picture frame (see Figure 16.4).

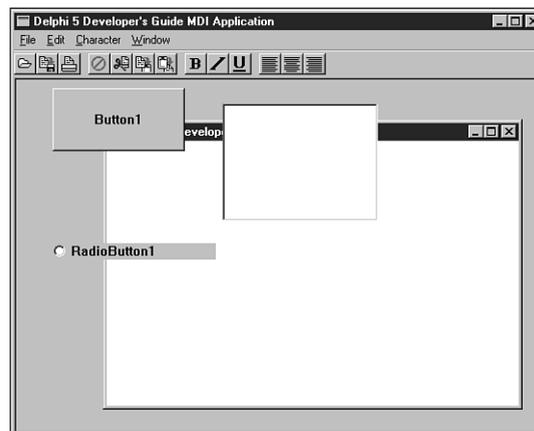


FIGURE 16.4

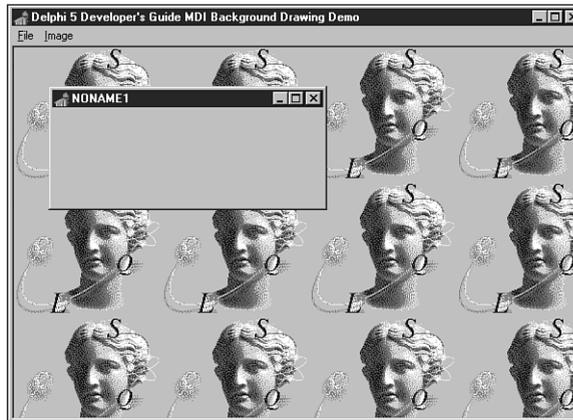
Client forms drawn underneath the main form's components.

So how do you go about drawing on the client window? Because Delphi 5 doesn't provide a VCL encapsulation of the client window, you must use the Win32 API. The method used is to subclass the client window and capture the message responsible for painting the client window's background—`WM_ERASEBKGD`. There, you take over the default behavior and perform your own custom drawing.

The following code is from the project `MdiBknd.dpr` on the CD. This project is an MDI application with a `TImage` component that contains a bitmap. From the menu, you can specify how to draw the image on the MDI client window—centered, tiled, or stretched, as shown respectively in Figures 16.5, 16.6, and 16.7.

**FIGURE 16.5**

The MDI client window with a centered image.

**FIGURE 16.6**

The MDI client window with a tiled image.

**FIGURE 16.7**

The MDI client window with a stretched image.

Listing 16.7 shows the unit code that performs the drawing.

LISTING 16.7 Drawing Images on the MDI Client Window

```
unit MainFrm;  
  
interface  
  
uses Windows, SysUtils, Classes, Graphics, Forms, Controls, Menus,  
    StdCtrls, Dialogs, Buttons, Messages, ExtCtrls, JPEG;  
  
type  
    TMainForm = class(TForm)  
        mmMain: TMainMenu;  
        mmiFile: TMenuItem;  
        mmiNew: TMenuItem;  
        mmiClose: TMenuItem;  
        N1: TMenuItem;  
        mmiExit: TMenuItem;  
        mmiImage: TMenuItem;  
        mmiTile: TMenuItem;  
        mmiCenter: TMenuItem;  
        mmiStretch: TMenuItem;  
        imgMain: TImage;  
        procedure mmiNewClick(Sender: TObject);  
        procedure mmiCloseClick(Sender: TObject);  
        procedure mmiExitClick(Sender: TObject);  
        procedure mmiTileClick(Sender: TObject);  
    end;  
end;
```

```
private
  FOldClientProc,
  FNewClientProc: TFarProc;
  FDrawDC: hDC;
  procedure CreateMDIChild(const Name: string);
  procedure ClientWndProc(var Message: TMessage);
  procedure DrawStretched;
  procedure DrawCentered;
  procedure DrawTiled;
protected
  procedure CreateWnd; override;
end;

var
  MainForm: TMainForm;

implementation

uses MdiChildFrm;

{$R *.DFM}

procedure TMainForm.CreateWnd;
begin
  inherited CreateWnd;
  // Turn the ClientWndProc method into a valid window procedure
  FNewClientProc := MakeObjectInstance(ClientWndProc);
  // Get a pointer to the original window procedure
  FOldClientProc := Pointer(GetWindowLong(ClientHandle, GWL_WNDPROC));
  // Set ClientWndProc as the new window procedure
  SetWindowLong(ClientHandle, GWL_WNDPROC, LongInt(FNewClientProc));
end;

procedure TMainForm.DrawCentered;
{ This procedure centers the image on the form's client area }
var
  CR: TRect;
begin
  GetWindowRect(ClientHandle, CR);
  with imgMain do
    BitBlt(FDrawDC, ((CR.Right - CR.Left) - Picture.Width) div 2,
           ((CR.Bottom - CR.Top) - Picture.Height) div 2,
           Picture.Graphic.Width, Picture.Graphic.Height,
           Picture.Bitmap.Canvas.Handle, 0, 0, SRCCOPY);
end;
```

continues

LISTING 16.7 Continued

```
procedure TMainForm.DrawStretched;
{ This procedure stretches the image on the form's client area }
var
  CR: TRect;
begin
  GetWindowRect(ClientHandle, CR);
  StretchBlt(FDrawDC, 0, 0, CR.Right, CR.Bottom,
            imgMain.Picture.Bitmap.Canvas.Handle, 0, 0,
            imgMain.Picture.Width, imgMain.Picture.Height, SRCCOPY);
end;

procedure TMainForm.DrawTiled;
{ This procedure tiles the image on the form's client area }
var
  Row, Col: Integer;
  CR, IR: TRect;
  NumRows, NumCols: Integer;
begin
  GetWindowRect(ClientHandle, CR);
  IR := imgMain.ClientRect;
  NumRows := CR.Bottom div IR.Bottom;
  NumCols := CR.Right div IR.Right;
  with imgMain do
    for Row := 0 to NumRows+1 do
      for Col := 0 to NumCols+1 do
        BitBlt(FDrawDC, Col * Picture.Width, Row * Picture.Height,
              Picture.Width, Picture.Height, Picture.Bitmap.Canvas.Handle,
              0, 0, SRCCOPY);
      end;
    end;
end;

procedure TMainForm.ClientWndProc(var Message: TMessage);
begin
  case Message.Msg of
    // Capture the WM_ERASEBKGD messages and perform the client area drawing
    WM_ERASEBKGD:
      begin
        CallWindowProc(FOldClientProc, ClientHandle, Message.Msg,
          Message.WParam,
            Message.LParam);
        FDrawDC := TWMEraseBkGnd(Message).DC;
        if mmiStretch.Checked then
          DrawStretched
        else if mmiCenter.Checked then
          DrawCentered
        else DrawTiled;
      end;
  end;
end;
```

```
        Message.Result := 1;
    end;
    { Capture the scrolling messages and ensure the client area
      is redrawn by calling InvalidateRect }
    WM_VSCROLL, WM_HSCROLL:
    begin
        Message.Result := CallWindowProc(FOldClientProc, ClientHandle,
Message.Msg,
        Message.wParam, Message.lParam);
        InvalidateRect(ClientHandle, nil, True);
    end;
    else
        // By Default, call the original window procedure
        Message.Result := CallWindowProc(FOldClientProc, ClientHandle,
Message.Msg,
        Message.wParam, Message.lParam);
    end; { case }
end;

procedure TMainForm.CreateMDIChild(const Name: string);
var
    MdiChild: TMDIChildForm;
begin
    MdiChild := TMDIChildForm.Create(Application);
    MdiChild.Caption := Name;
end;

procedure TMainForm.mmiNewClick(Sender: TObject);
begin
    CreateMDIChild('NONAME' + IntToStr(MDIChildCount + 1));
end;

procedure TMainForm.mmiCloseClick(Sender: TObject);
begin
    if ActiveMDIChild <> nil then
        ActiveMDIChild.Close;
end;

procedure TMainForm.mmiExitClick(Sender: TObject);
begin
    Close;
end;

procedure TMainForm.mmiTileClick(Sender: TObject);
begin
    mmiTile.Checked := false;
```

continues

LISTING 16.7 Continued

```
    mmiCenter.Checked := False;
    mmiStretch.Checked := False;
    { Set the Checked property for the menu item which invoked }
    { this event handler to Checked }
    if Sender is TMenuItem then
        TMenuItem(Sender).Checked := not TMenuItem(Sender).Checked;
        { Redraw the client area of the form }
        InvalidateRect(ClientHandle, nil, True);
    end;

end.
```

To paint the image to the client window of the MDI application, you must use a technique called *subclassing*. Subclassing is discussed in Chapter 5, “Understanding Messages.” To subclass the client window, you must store the client window’s original window procedure so that you can call it. You must also have a pointer to the new window procedure. The form variable `FOldClientProc` stores the original window procedure, and the variable `FNewClientProc` points to the new window procedure.

The procedure `ClientWndProc()` is the procedure to which `FNewClientProc` points. Actually, because `ClientWndProc()` is a method of `TMainForm`, you must use the `MakeObjectInstance()` function to return a pointer to a window procedure created from the method `MakeObjectInstance()`, as discussed in Chapter 13, “Hard-core Techniques.”

The `TMainForm.CreateWnd()` method was overridden when the main form’s client window was subclassed by using the `GetWindowLong()` and `SetWindowLong()` Win32 API functions. `ClientWndProc()` is the new window procedure.

`TMainForm` contains three private methods: `DrawCentered()`, `DrawTiled()`, and `DrawStretched()`. Each of these methods uses Win32 API functions to perform the GDI drawing routines to paint the bitmap. Win32 API functions are used because the client window’s device context isn’t encapsulated by `TCanvas`, so you can’t normally use the built-in Delphi 5 methods. Actually, it’s possible to assign the device context to a `TCanvas.Handle` property. You would have to instantiate a `TCanvas` instance in order to do this, but it is possible.

You must capture three messages to perform the background drawing: `WM_ERASEBKGDND`, `WM_VSCROLL`, and `WM_HSCROLL`. The `WM_ERASEBKGDND` message is sent to a window when it’s to be erased. This is an opportune time to perform the specialized drawing of the image. In the procedure, you determine which drawing procedure to call based on which menu item is selected. The `WM_VSCROLL` and `WM_HSCROLL` messages are captured to ensure that the background image

is properly drawn when the user scrolls the main form. Finally, all other messages are sent to the original window procedure with this statement:

```
Message.Result := CallWindowProc(FOldClientProc, ClientHandle, Message.Msg,  
    Message.WParam, Message.LParam);
```

This example not only demonstrates how you can visually enhance your applications; it also shows how you can perform API-level development with techniques not provided by the VCL.

Creating a Hidden MDI Child Form

Delphi 5 returns an error if you ever attempt to hide an MDI child form using a statement such as this one:

```
ChildForm.Hide;
```

The error indicates that hiding an MDI child form is not allowed. The reason for this is because the Delphi developers found that in the Windows implementation of MDI, hiding MDI child forms corrupts the z-order of the child windows. Unless you're extremely careful about when you use such a technique, trying to hide an MDI child form can wreak havoc with your application. Nevertheless, you might have the need to hide a child form. There are two ways in which you can hide MDI child forms. Just be aware of the anomaly and use these techniques with caution.

One way to hide an MDI child form is to prevent the client window from drawing the child form altogether. Do this by using the `LockWindowUpdate()` Win32 API function to disable drawing to the MDI client window. This technique is useful if you want to create an MDI child form but don't want to show that form to the user unless some process has completed successfully. For example, such a process might be a database query; if the process fails, you might want to free the form. Unless you use some method to hide the form, you'll see a flicker on the screen as the form is created before you have an opportunity to destroy it. The `LockWindowUpdate()` function disables drawing to a window's canvas. Only one window can be locked at any given time. Passing `0` to `LockWindowUpdate` reenables drawing to the window's canvas.

The other method of hiding an MDI child form is to actually hide the child form by using the Win32 API function `ShowWindow()`. You hide the form by specifying the `SW_HIDE` flag along with the function. You must then use the `SetWindowPos()` function to restore the child window. You can use this technique to hide the MDI child form if it's already created and displayed to the user.

Listing 16.8 illustrates the techniques just described and is the main form for the project `MdiHide.dpr` on the CD.

LISTING 16.8 A Unit Showing MDI Child Form–Hiding Techniques

```
unit MainFrm;

interface

uses Windows, SysUtils, Classes, Graphics, Forms, Controls, Menus,
    StdCtrls, Dialogs, Buttons, Messages, ExtCtrls, ComCtrls, MdiChildFrm;

type
  TMainForm = class(TForm)
    mmMain: TMainMenu;
    mmiFile: TMenuItem;
    mmiNew: TMenuItem;
    mmiClose: TMenuItem;
    mmiWindow: TMenuItem;
    N1: TMenuItem;
    mmiExit: TMenuItem;
    mmiHide: TMenuItem;
    mmiShow: TMenuItem;
    mmiHideForm: TMenuItem;
    procedure mmiNewClick(Sender: TObject);
    procedure mmiCloseClick(Sender: TObject);
    procedure mmiExitClick(Sender: TObject);
    procedure mmiHideClick(Sender: TObject);
    procedure mmiShowClick(Sender: TObject);
    procedure mmiHideFormClick(Sender: TObject);
  private
    procedure CreateMDIChild(const Name: string);
  public
    HideForm: TMDIChildForm;
    Hidden: Boolean;
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.CreateMDIChild(const Name: string);
var
  MdiChild: TMDIChildForm;
begin
  MdiChild := TMDIChildForm.Create(Application);
  MdiChild.Caption := Name;
```

```
end;

procedure TMainForm.mmiNewClick(Sender: TObject);
begin
  CreateMDIChild('NONAME' + IntToStr(MDIChildCount + 1));
end;

procedure TMainForm.mmiCloseClick(Sender: TObject);
begin
  if ActiveMDIChild <> nil then
    ActiveMDIChild.Close;
end;

procedure TMainForm.mmiExitClick(Sender: TObject);
begin
  Close;
end;

procedure TMainForm.mmiHideClick(Sender: TObject);
begin
  if Assigned(HideForm) then
    ShowWindow(HideForm.Handle, SW_HIDE);
  Hidden := True;
end;

procedure TMainForm.mmiShowClick(Sender: TObject);
begin
  if Assigned(HideForm) then
    SetWindowPos(HideForm.handle, HWND_TOP, 0, 0, 0, 0, SWP_NOSIZE
      or SWP_NOMOVE or SWP_SHOWWINDOW);
  Hidden := False;
end;

procedure TMainForm.mmiHideFormClick(Sender: TObject);
begin
  if not Assigned(HideForm) then
    begin
      if MessageDlg('Create Hidden?', mtConfirmation, [mbYes, mbNo], 0) = mrYes
    then
      begin
        LockWindowUpdate(Handle);
        try
          HideForm := TMDIChildForm.Create(Application);
          HideForm.Caption := 'HideForm';
          ShowMessage('Form created and hidden. Press OK to show form');
        finally

```

continues

LISTING 16.8 Continued

```
        LockWindowUpdate(0);
    end;
end
else begin
    HideForm := TMDIChildForm.Create(Application);
    HideForm.Caption := 'HideForm';
end;
end
else if not Hidden then
    HideForm.SetFocus;
end;

end.
```

The project is a simple MDI application. The event handler `mmiHideFormClick()` creates a child form that can either be created and hidden or hidden by the user after it's displayed.

When `mmiHideFormClick()` is invoked, it checks whether an instance of `THideForm` has been created. If so, it displays only the `THideForm` instance, provided that it has not been hidden by the user. If there is no instance of `THideForm` present, the user is prompted whether it should be created and hidden. If the user responds affirmatively, drawing to the client window is disabled before the form is created. If drawing to the client window is not disabled, the form is displayed as it's created. The user is then shown a message box indicating that the form is created. When the user closes the message box, drawing to the client window is reenabled and the child form is displayed by forcing the client window to repaint itself. You can replace the message box telling the user that the form is created with some lengthy process that requires the child form to be created but not displayed. If the user chooses not to create the form as hidden, it's created normally.

The second method used to hide the form after it has already been displayed calls the Win32 API function `ShowWindow()` and passes the child form's handle and the `SW_HIDE` flag. This effectively hides the form. To redisplay the form, call the Win32 API function `SetWindowPos()`, using the child form's handle and the flags specified in the listing. `SetWindowPos()` is used to change a window's size, position, or z-order. In this example, `SetWindowPos()` is used to redisplay the hidden window by setting its z-order; in this case, the z-order of the hidden form is set to be the top window by specifying the `HWND_TOP` flag.

Minimizing, Maximizing, and Restoring All MDI Child Windows

Often, you need to perform a task across all active MDI forms in the project. Changing the form's `WindowState` property is a typical example of a process to be performed on every

instance of an MDI child form. This task is quite simple and only requires that you walk through the forms using the main form's `MDIChildren` array property. The main form's `MDIChildren` property holds the number of active MDI child forms. Listing 16.9 shows the event handlers that minimize, maximize, and restore all MDI child windows in an application. This project can be found on the CD as the `Min_Max.dpr` project.

LISTING 16.9 Minimizing, Maximizing, and Restoring All MDI Child Forms

```
unit MainFrm;

interface

uses Windows, SysUtils, Classes, Graphics, Forms, Controls, Menus,
    StdCtrls, Dialogs, Buttons, Messages, ExtCtrls, ComCtrls;

type
  TMainForm = class(TForm)
    MainMenu1: TMainMenu;
    mmiFile: TMenuItem;
    mmiNew: TMenuItem;
    mmiClose: TMenuItem;
    mmiWindow: TMenuItem;
    N1: TMenuItem;
    mmiExit: TMenuItem;
    mmiMinimizeAll: TMenuItem;
    mmiMaximizeAll: TMenuItem;
    mmiRestoreAll: TMenuItem;
    procedure mmiNewClick(Sender: TObject);
    procedure mmiCloseClick(Sender: TObject);
    procedure mmiExitClick(Sender: TObject);
    procedure mmiMinimizeAllClick(Sender: TObject);
    procedure mmiMaximizeAllClick(Sender: TObject);
    procedure mmiRestoreAllClick(Sender: TObject);
  private
    { Private declarations }
    procedure CreateMDIChild(const Name: string);
  public
    { Public declarations }
  end;

var
  MainForm: TMainForm;

implementation
uses MdiChildFrm;
```

continues

LISTING 16.9 Continued

```
{SR *.DFM}

procedure TMainForm.CreateMDIChild(const Name: string);
var
  Child: TMDIChildForm;
begin
  Child := TMDIChildForm.Create(Application);
  Child.Caption := Name;
end;

procedure TMainForm.mmiNewClick(Sender: TObject);
begin
  CreateMDIChild('NONAME' + IntToStr(MDIChildCount + 1));
end;

procedure TMainForm.mmiCloseClick(Sender: TObject);
begin
  if ActiveMDIChild <> nil then
    ActiveMDIChild.Close;
end;

procedure TMainForm.mmiExitClick(Sender: TObject);
begin
  Close;
end;

procedure TMainForm.mmiMinimizeAllClick(Sender: TObject);
var
  i: integer;
begin
  for i := MDIChildCount - 1 downto 0 do
    MDIChildren[i].WindowState := wsMinimized;
end;

procedure TMainForm.mmiMaximizeAllClick(Sender: TObject);
var
  i: integer;
begin
  for i := 0 to MDIChildCount - 1 do
    MDIChildren[i].WindowState := wsMaximized;
end;

procedure TMainForm.mmiRestoreAllClick(Sender: TObject);
var
```

```
    i: integer;
begin
    for i := 0 to MDIChildCount - 1 do
        MDIChildren[i].WindowState := wsNormal;
    end;

end.
```

Summary

This chapter showed you how to build MDI applications in Delphi 5. You also learned some advanced techniques specific to MDI applications. With the foundation you received in this chapter, you should be well on your way to creating professional-looking MDI applications.

Sharing Information with the Clipboard

CHAPTER

17

IN THIS CHAPTER

- **In the Beginning, There Was the Clipboard** 824
- **Creating Your Own Clipboard Format** 827
- **Summary** 836

Once upon a time, humankind struggled just to survive. People lived in dark caves, hunted for food with spears and rocks, and communicated with grunt-like sounds and hand motions. They worshipped fire because it gave them light under which they worked on their very slow computers. Computers back then could run only one application at a time due to hardware and software limitations. The only way to share information was to save it on disk and to pass the disk along for others to copy to their machines.

Nowadays, at least the equipment and software have improved. With operating systems such as Windows 95/98 and Windows NT/2000, multiple applications can be run simultaneously, which makes life much easier and more productive for the computer user. One of the advantages gained from Windows is that information can be shared between applications on the same machine. Two of the earlier technologies for sharing information are the Win32 Clipboard and Dynamic Data Exchange (DDE). You can make it possible for your users to copy information from one application to another with little effort using either of these.

This chapter shows you how to use Delphi's encapsulation of the Win32 Clipboard. Previous editions of this book covered DDE as well. However, with powerful interprocess communication technologies such as COM, we can't, in all good conscience, refer you back to a dead technology. Later, in Chapter 23, "COM and ActiveX," we'll discuss COM in greater depth. For simple implementations of sharing information between applications, the Clipboard is still a very solid solution.

In the Beginning, There Was the Clipboard

If you're an experienced Windows programmer, you might already be familiar with the Win32 Clipboard—at least in functionality. If you're new to Windows programming but have been using Windows, you've probably been using the Clipboard all along but never really understood how it's implemented.

Almost any application that has an Edit menu makes use of the Clipboard. So what exactly is the Clipboard? It's simply an area of memory and a set of Win32 API functions that enable applications to store and retrieve information to and from that area in memory. You can copy a portion of your source code from the Delphi editor, for example, and paste that same code into the Windows Notepad or any other editor.

Why does Win32 require a special set of functions and messages in order to use the Clipboard? Copying data to the Clipboard is more than just allocating an area of memory and placing data in that area. Other applications have to know how to retrieve that data and whether the data is in a format that the application supports. Win32 takes care of the memory management and enables you to copy, paste, and query about the information on the Clipboard.

Clipboard Formats

Win32 supports 25 predefined formats that applications can copy to or paste from the Clipboard. The most common formats are as follows:

CF_BITMAP	Specifies bitmap data.
CF_DIB	Specifies bitmap data along with the bitmap's palette information.
CF_PALETTE	Specifies a color palette.
CF_TEXT	Specifies a character array where each line ends with a carriage return/linefeed. This is the most commonly used format.

You can refer to the Win32 API online help under "SetClipboardData" if you're curious about less-common formats. Additionally, Win32 enables you to define your own private Clipboard formats, as illustrated later in this chapter.

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Before Delphi, you had to call various Clipboard functions directly and were responsible for ensuring that your application didn't do anything ill-advised with the Clipboard's contents. With Delphi, you just use the global variable `Clipboard`. `Clipboard` is a Delphi class that encapsulates the Win32 Clipboard.

Using the Clipboard with Text

We already showed you how to use the Clipboard with text in Chapter 16, "MDI Applications." Specifically, this had to do with the text editor in the MDI application. We created menu items for cutting, copying, pasting, deleting, and selecting text.

In the MDI application, the editor, a `TMemo` component, covers the client area of the form. The `TMemo` component has its own functions that interact with the global `Clipboard` object. These functions are `CutToClipboard()`, `CopyToClipboard()`, and `PasteFromClipboard()`. The methods `ClearSelection()` and `SelectAll()` aren't necessarily Clipboard interface routines, but they enable you to select the text you want to copy to the Clipboard. Listing 17.1 shows the event handlers for the Edit menu items.

LISTING 17.1 Clipboard Operations on Text

```
procedure TMdiEditForm.mmiCutClick(Sender: TObject);
begin
    inherited;
    memMainMemo.CutToClipboard;
end;
```

continues

LISTING 17.1 Continued

```
procedure TMdiEditForm.mmiCopyClick(Sender: TObject);
begin
    inherited;
    memMainMemo.CopyToClipboard;
end;

procedure TMdiEditForm.mmiPasteClick(Sender: TObject);
begin
    inherited;
    memMainMemo.PasteFromClipboard;
end;
```

As illustrated in Listing 17.1, you need only call the `TMemo` methods to perform the `Clipboard` functions. You also can place text on the `Clipboard` manually by using the `Clipboard.AsText` property. Back in the 16-bit environment, the `AsText` property was limited to 255 characters and you had to use the `SetTextBuf()` and `GetTextBuf()` methods to copy larger strings to the `Clipboard`. This is no longer the case in 32-bit Delphi because the `AsText` property's string type now means long strings. You'll notice that `SetTextBuf()` and `GetTextBuf()` are still supported as well.

```
Clipboard.AsText := 'Delphi Rules';
```

NOTE

The `Clipboard` function's `GetTextBuf()` and `SetTextBuf()` methods use Pascal `PChar` types as buffers to pass and retrieve data from the `Clipboard`. When using such methods, you can typecast long strings as `PChar` types so that you don't have to do any converting of `String` types to `PChar` types.

Using the Clipboard with Images

The `Clipboard` can also copy and paste images. You saw how this can be done in the same MDI sample program. The event handlers that performed the `Clipboard` operations are shown in Listing 17.2.

LISTING 17.2 Clipboard Operations on a Bitmap

```
procedure TMdiBMPForm.mmiCopyClick(Sender: TObject);
begin
    inherited;
    Clipboard.Assign(imgMain.Picture);
end;
```

```
procedure TMdiBMPForm.mmiPasteClick(Sender: TObject);
{ This method copies the contents from the clipboard into imgMain }
begin
  inherited;
  // Copy clipboard content to imgMain
  imgMain.Picture.Assign(ClipBoard);
  ClientWidth := imgMain.Picture.Width;
  { Adjust clientwidth to adjust the scollbars }
  VertScrollBar.Range := imgMain.Picture.Height;
  HorzScrollBar.Range := imgMain.Picture.Width;
end;
```

TIP

In order to access the Clipboard global variable, you must include `ClipBrd` in the uses clause of the unit that will be using Clipboard.

In Listing 17.2, the `mmiCopyClick()` event handler uses the `Clipboard.Assign()` method to copy the image to the Clipboard. Using this approach, you can paste the image into another Win32 application that supports the `CF_BITMAP` format, such as Windows Paint (`PBrush.EXE`).

`mmiPasteClick()` uses the `Image.Assign()` method to copy the image from the Clipboard and readjusts the scrollbars accordingly.

NOTE

`CF_PICTURE` is not a standard Win32 Clipboard format. Instead, it's a private format used by Delphi applications to determine whether the Clipboard data is in a `TPicture`-compatible format, such as bitmaps and metafiles. If you were to register your own graphic format, `TPicture` will support that format as well. Look up `TPicture` in Delphi's online help for further information on `TPicture`-compatible formats.

Creating Your Own Clipboard Format

Imagine working with an address entry program. Suppose that you're entering a record that differs only slightly from the record previously entered. It would be convenient if you could copy the contents from the previous record and paste them to the current record, instead of having to enter each field again. You might want to use the same information in other applications as well, perhaps as the address in a letter. The next example shows you how to create an object that knows about the Win32 Clipboard and can save its special formatted data to the

Clipboard. You also learn how to store your information as `CF_TEXT` format so that you can retrieve the same data in other applications that support the `CF_TEXT` format.

Creating a Clipboard-Aware Object

You might be thinking that one way to define custom Clipboard formats would be to create a descendant `TClipboard` class that knows about the newly defined format. This special `TClipboard` class could contain the specialized methods for dealing with the custom format. Although such a class would suffice in an isolated case, it would become tedious to maintain as you continue to need additional formats or as you need to redefine your data. If 70 different vendors came up with their own `TClipboard` descendant classes for their custom Clipboard formats, you'd have a major problem trying to use just two of the formats. The `TClipboard` descendants would conflict with each other.

A better approach would be to define an object around your data and then make the object aware of the `TClipboard` object, rather than the reverse. This singleton pattern to the Clipboard is the approach that Borland uses with its Delphi components. A `TMemo` component knows how to place its data on the Clipboard, just as a `TImage` component knows how to place its data on the Clipboard. All components use the same `TClipboard` object, so there's no conflict. This is the approach we'll show you in this section to define a custom Clipboard format, which is basically a record with a person's name, age, and birth date information. The unit for defining the data, along with the Clipboard methods to copy and paste the data to and from the Clipboard, is shown in Listing 17.3.

LISTING 17.3 A Unit That Defines Custom Clipboard Data

```
unit cbdata;
interface
uses
  SysUtils, Windows, clipbrd;

const

  DDGData = 'CF_DDG'; // constant for registering the clipboard format.
type

  // Record data to be stored to the clipboard
  TDataRec = packed record
    LName: string[10];
    FName: string[10];
    MI: string[2];
    Age: Integer;
    BirthDate: TDateTime;
  end;
```

```
{ Define an object around the TDataRec that contains the methods
  for copying and pasting the data to and from the clipboard }
TData = class
public
  Rec: TDataRec;
  procedure CopyToClipboard;
  procedure GetFromClipboard;
end;

var
  CF_DDGDATA: word; // Receives the return value of RegisterClipboardFormat().

implementation

procedure TData.CopyToClipboard;
{ This function copies the contents of the TDataRec field, Rec, to the
  clipboard as both binary data, as text. Both formats will be
  available from the clipboard }
const
  CRLF = #13#10;
var
  Data: THandle;
  DataPtr: Pointer;
  TempStr: String[50];
begin
  // Allocate SizeOf(TDataRec) bytes from the heap
  Data := GlobalAlloc(GMEM_MOVEABLE, SizeOf(TDataRec));
  try
    // Obtain a pointer to the first byte of the allocated memory
    DataPtr := GlobalLock(Data);
    try
      // Move the data in Rec to the memory block
      Move(Rec, DataPtr^, SizeOf(TDataRec));
      { Clipboard.Open must be called if multiple clipboard formats are
        being copied to the clipboard at once. Otherwise, if only one
        format is being copied the call isn't necessary }
      Clipboard.Open;
      // First copy the data as its custom format
      Clipboard.SetAsHandle(CF_DDGDATA, Data);
      // Now copy the data as text format
      with Rec do
        TempStr := FName+CRLF+LName+CRLF+MI+CRLF+IntToStr(Age)+CRLF+
          DateTimeToStr(BirthDate);
      Clipboard.AsText := TempStr;
      { If a call to Clipboard.Open is made you must match it
        with a call to Clipboard.Close }
    end;
  end;
end;
```

LISTING 17.3 Continued

```
        Clipboard.Close
    finally
        // Unlock the globally allocated memory
        GlobalUnlock(Data);
    end;
except
    { A call to GlobalFree is required only if an exception occurs.
      Otherwise, the clipboard takes over managing any allocated
      memory to it.}
    GlobalFree(Data);
    raise;
end;
end;

procedure TData.GetFromClipboard;
{ This method pastes memory saved in the clipboard if it is of the
  format CF_DDGDData. This data is stored in the TDataRec field of
  this object. }
var
    Data: THandle;
    DataPtr: Pointer;
    Size: Integer;
begin
    // Obtain a handle to the clipboard
    Data := ClipBoard.GetAsHandle(CF_DDGDData);
    if Data = 0 then Exit;
    // Obtain a pointer to the memory block referred to by Data
    DataPtr := GlobalLock(Data);
    try
        // Obtain the size of the data to retrieve
        if SizeOf(TDataRec) > GlobalSize(Data) then
            Size := GlobalSize(Data)
        else
            Size := SizeOf(TDataRec);
        // Copy the data to the TDataRec field
        Move(DataPtr^, Rec, Size)
    finally
        // Free the pointer to the memory block.
        GlobalUnlock(Data);
    end;
end;

initialization
    // Register the custom clipboard format
    CF_DDGDData := RegisterClipboardFormat(DDGDData);
end.
```

This unit performs several tasks. First, it registers the new format with the Win32 Clipboard by calling the `RegisterClipboardFormat()` function. This function returns a value that identifies this new format. Any application that registers this same format, as specified by the string parameter, will obtain the same value when calling this function. The new format is also available on the `Clipboard`'s list of formats, which can be accessed by the `Clipboard.Formats` property.

The unit also defines the record containing the data to be placed onto the Clipboard and the object that encapsulates this record. The record, `TDataRec`, has string fields to hold a person's name, an integer field to hold the person's age, and a `TDateTime` field to hold the person's birth date.

The object encapsulating `TDataRec`, `TData`, defines the methods `CopyToClipboard()` and `GetFromClipboard()`.

`TData.CopyToClipboard()` places the contents of the field `TData.Rec` onto the Clipboard as two formats: `CF_DDGDATA` and `CF_TEXT`. `CF_TEXT`, which, as you know, is an already-defined Clipboard format. The text version of `TData.Rec`'s contents are placed on the Clipboard by concatenating its fields as strings separated by carriage return/line feed characters. The non-string fields are converted to strings before formulating the final string that gets saved to the Clipboard. `Clipboard.SetAsHandle()` first places a given handle onto the Clipboard in the format specified by its parameter. In this case, the parameter is the newly defined Clipboard format `CF_DDGDATA`.

Before calling `Clipboard.SetAsHandle()`, however, the method prepares a valid `THandle` that it must pass to `SetAsHandle()`. This handle represents the block of memory that contains the data being sent to the Clipboard. See the sidebar titled "Working with `THandles`." The following line tells the Win32 system to allocate `SizeOf(TDataRec)` bytes of memory that may be moved, if necessary, and to return a handle to that memory to the variable `Data`:

```
Data := GlobalAlloc(GMEM_MOVEABLE, SizeOf(TDataRec));
```

A pointer to the memory is obtained with the following statement:

```
DataPtr := GlobalLock(Data);
```

The data is then moved to the memory block with the `Move()` function. In the remaining lines of code, the `Clipboard.Open()` method opens the Clipboard to prevent other applications from using it while it's being given data:

```
Clipboard.Open;
try
  Clipboard.SetAsHandle(CF_DDGDATA, Data);
  with Rec do
    TempStr := FName+CRLF+LName+CRLF+MI+CRLF+IntToStr(Age)+CRLF+
      DateTimeToStr(BirthDate);
  Clipboard.AsText := TempStr;
```

```
finally  
    Clipboard.Close  
End;
```

Typically, it's not necessary to call `Open()` unless you're sending multiple formats to the Clipboard, as you're doing here. This is because each assignment to the Clipboard using one of its methods (such as `Clipboard.SetTextBuf()`) or properties (such as `Clipboard.AsText`) causes the Clipboard to erase its previous contents because they, too, call `Open()` and `Close()` internally. By calling `Clipboard.Open()` first, you prevent this from happening and therefore can assign multiple formats simultaneously. Had you not called the `Open()` method, only the `CF_TEXT` format would be available on the Clipboard after executing this method. The lines after the call to `Open()` simply assign the data to the Clipboard and then call the `Clipboard.Close()` method accordingly.

At this point, the Win32 system is responsible for managing memory allocated for the Clipboard with the `GlobalAlloc()` function. A call to `GlobalFree()` would be necessary only if an exception occurred during the copy process. Don't call `GlobalFree()` otherwise because Win32 has taken over that memory management for the Clipboard.

With both `CF_DDGDATA` and `CF_TEXT` formats available on the Clipboard, you can paste the data back into either this sample program or other applications, as we'll illustrate momentarily.

`TData.GetFromClipboard()` does just the opposite—it retrieves data from the Clipboard in the `CF_DDGDATA` format and places that data in the `TData.Rec` field. The commentary in the listing explains how this method operates. The sample application that we'll show next illustrates how to use this unit. Notice that this Clipboard object can be easily modified to store any type of record you might define.

NOTE

Do not free the handle returned from `GetAsHandle()`; it doesn't belong to your application—it belongs to the Clipboard. Therefore, the data that the handle references should be copied.

Working with THandles

A `THandle` is nothing more than a 32-bit variable that represents an index of a table where the Win32 system maintains information about a memory block. There are many types of `THandles`, and Delphi encapsulates most of them with `TIcons`, `TBitmaps`, `TCanvas`, and so on.

Certain Win32 functions, like the various Clipboard functions, use the heap to manipulate Clipboard data. To get access to heap memory, you make use of the memory allocation function shown in the following list:

<code>GlobalAlloc()</code>	Allocates a number of bytes specified from the heap and returns a <code>THandle</code> to that memory object
<code>GlobalFree()</code>	Frees the memory allocated with <code>GlobalAlloc()</code>
<code>GlobalLock()</code>	Returns a pointer to a global memory object received from <code>GlobalAlloc()</code>
<code>GlobalUnlock()</code>	Unlocks memory previously locked with <code>GlobalLock()</code>

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Using the Custom Clipboard Format

The main form for the project that illustrates the use of the custom Clipboard format is shown in Figure 17.1.

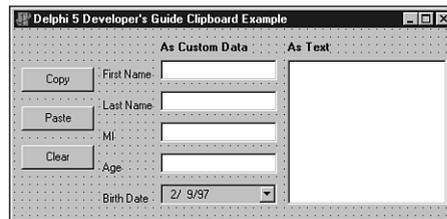


FIGURE 17.1

The main form for the custom Clipboard format example.

As shown, this form contains the controls required to fill the `TDataRec` field of the `TData` object. Listing 17.4 shows the source code for this form. The project resides on the CD as `Ddgcbb.dpr`.

LISTING 17.4 Source Code for the Custom Clipboard Format Example

```
unit MainFrm;

interface

uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, clipbrd, Mask, ComCtrls;
type
```

continues

LISTING 17.4 Continued

```
TMainForm = class(TForm)
  edtFirstName: TEdit;
  edtLastName: TEdit;
  edtMI: TEdit;
  btnCopy: TButton;
  btnPaste: TButton;
  meAge: TMaskEdit;
  btnClear: TButton;
  lblFirstName: TLabel;
  lblLastName: TLabel;
  lblMI: TLabel;
  lblAge: TLabel;
  lblBirthDate: TLabel;
  memAsText: TMemo;
  lblCustom: TLabel;
  lblText: TLabel;
  dtpBirthDate: TDateTimePicker;
  procedure btnCopyClick(Sender: TObject);
  procedure btnPasteClick(Sender: TObject);
  procedure btnClearClick(Sender: TObject);
end;

var
  MainForm: TMainForm;

implementation
uses cbdata;

{$R *.DFM}

procedure TMainForm.btnCopyClick(Sender: TObject);
// This method copies the data in the form's controls onto the clipboard
var
  DataObj: TData;
begin
  DataObj := TData.Create;
  try
    with DataObj.Rec do
      begin
        FName      := edtFirstName.Text;
        LName      := edtLastName.Text;
        MI         := edtMI.Text;
        Age        := StrToInt(meAge.Text);
        BirthDate := dtpBirthDate.Date;
        DataObj.CopyToClipboard;
      end;
    end;
  end;
```

```
    finally
        DataObj.Free;
    end;
end;

procedure TMainForm.btnPasteClick(Sender: TObject);
{ This method pastes CF_DDGDATA formatted data from the clipboard to
  the form's controls. The text version of this data is copied to the
  form's TMemo component. }
var
    DataObj: TData;
begin
    btnClearClick(nil);
    DataObj := TData.Create;
    try
        // Check if the CF_DDGDATA format is available
        if Clipboard.HasFormat(CF_DDGDATA) then
            // Copy the CF_DDGDATA formatted data to the form's controls
            with DataObj.Rec do
                begin
                    DataObj.GetFromClipboard;
                    edtFirstName.Text := FName;
                    edtLastName.Text := LName;
                    edtMI.Text := MI;
                    meAge.Text := IntToStr(Age);
                    dtpBirthDate.Date := BirthDate;
                end;
            finally
                DataObj.Free;
            end;
            // Now copy the text version of the data to form's TMemo component.
            if Clipboard.HasFormat(CF_TEXT) then
                memAsText.PasteFromClipboard;
    end;

procedure TMainForm.btnClearClick(Sender: TObject);
var
    i: integer;
begin
    // Clear the contents of all controls on the form
    for i := 0 to ComponentCount - 1 do
        if Components[i] is TCustomEdit then
            TCustomEdit(Components[i]).Text := '';
    end;

end.
```

When the user clicks the Copy button, it copies the data contained in the TEdit, TDateTimePicker, and TMaskEdit controls to the TDataRec field of a TData object. It then invokes the TData.CopyToClipboard() method, which places the data onto the Clipboard.

When the Paste button is clicked, the opposite happens. First, if the data in the Clipboard is of the type CF_DDGDATA, it's copied from the Clipboard and placed into the edit controls on the form. The text representation of the data is also copied and placed into the main form's TMemo component. The result of a paste operation is shown in Figure 17.2. You can also paste the text representation of the data into another Windows application, such as Notepad.

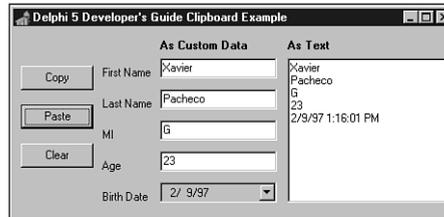


FIGURE 17.2

Pasted data on the main form.

The Clear button empties the contents of all controls on the main form.

Summary

Sharing data with other applications is an extremely useful technique. By enabling your applications to share data with other applications, you make it more usable and your users more productive. This chapter shows you how to use the Clipboard's built-in functions to work with Delphi controls. It also demonstrates how to create your own custom Clipboard formats. Another even more powerful method of interprocess communication is COM, which we'll cover in depth in later chapters.

Multimedia Programming with Delphi

CHAPTER

18

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Delphi's `TMediaPlayer` component is proof that good things come in small packages. In the guise of this little component, Delphi encapsulates a great deal of the functionality of the Windows *Media Control Interface* (MCI)—the portion of the Windows API that provides control for multimedia devices.

Delphi makes multimedia programming so easy that the traditional and boring “Hello World” program may be a thing of the past. Why write `Hello World` to the screen when it's almost as easy to play a sound or video file that offers its greetings?

In this chapter, you learn how to write a simple yet powerful media player, and you even construct a fully functional audio CD player. This chapter explains the uses and nuances of the `TMediaPlayer` component. Of course, your computer must be equipped with multimedia devices, such as a sound card and CD-ROM, for this chapter to be of real use to you.

Creating a Simple Media Player

The best way to learn is by doing. This application demonstrates how quickly you can create a media player by placing `TMediaPlayer`, `TButton`, and `TOpenDialog` components on a form. This form is shown in Figure 18.1.



FIGURE 18.1

The EasyMM Media Player.

The EasyMM Media Player works like this: After you click `Button1`, the `OpenDialog` dialog box appears, and you choose a file from it. The Media Player prepares itself to play the file you chose in `OpenDialog`. You then can click the Play button on the Media Player to play the file. The following code belongs to the button's `OnClick` method, and it opens the Media Player with the file you chose:

```
procedure TMainForm.BtnOpenClick(Sender: TObject);
begin
    if OpenDialog1.Execute then
    begin
        MediaPlayer1.FileName := OpenDialog1.FileName;
        MediaPlayer1.Open;
    end;
end;
```

This code executes the `OpenDialog1` dialog box, and if a filename is chosen, `OpenDialog1`'s `FileName` property is copied to `MediaPlayer1`'s `FileName` property. The `MediaPlayer`'s `Open` method is then called to prepare it to play the file.

You might also want to limit the files to browse through with the `OpenDialog` dialog box to only multimedia files. `TMediaPlayer` supports a whole gaggle of multimedia device types, but for now, you'll just browse WAV, AVI, and MIDI files. This capability exists in the `TOpenDialog` component, and you take advantage of it by selecting `OpenDialog1` in the Object Inspector, choosing the `Mask` property, and clicking the ellipsis to the right of this item to invoke the Filter Editor. Fill in the `.WAV`, `.AVI`, and `.MID` extensions, as shown in Figure 18.2.

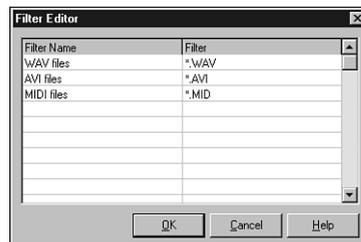


FIGURE 18.2

The Filter Editor.

The project is saved as `EasyMM.dpr` and the main unit as `Main.pas`. The Media Player is now ready to run. Run the program, and try it out using one of the multimedia files on your hard disk. Other people might have convinced you—or perhaps you had convinced yourself—that multimedia programming is difficult, but now you have firsthand proof that this just isn't true.

Using WAV Files in Your Applications

WAV files (pronounced *wave*, which is short for *waveform*) are the standard file format for sharing audio in Windows. As the name implies, WAV files store sounds in a binary format that resembles a mathematical wave. The great thing about WAV files is that they have gained industry acceptance, and you can find them everywhere. The bad thing about WAV files is that they tend to be bulky, and just a few of those Homer Simpson WAV files can take up a hefty chunk of hard disk space.

The `TMediaPlayer` component enables you to easily integrate WAV sounds into your applications. As just illustrated, playing WAV files in your program is no sweat—just feed a `TMediaPlayer` component a filename, open it, and play it. A little audio capability can be just the thing your applications need to go from neat to way cool.

If playing WAV files is all you want to do, you might not need the overhead of a `TMediaPlayer` component. Instead, you can use the `PlaySound()` API function found in the `MMSYSTEM` unit. `PlaySound()` is defined this way:

```
function PlaySound(pszSound: PChar; hmod: HMODULE;
    fdwSound: DWORD): BOOL; stdcall;
```

`PlaySound()` has the capability to play a WAV sound from a file, from memory, or from a resource file linked into the application. `PlaySound()` accepts three parameters:

- The first parameter, `pszSound`, is a `PChar` variable that represents a filename, alias name, resource name, Registry entry, entry from the [sounds] section of your `WIN.INI` file, or pointer to a WAV sound located somewhere in memory.
- The second parameter, `hmod`, represents the handle of the executable file that contains the resource to be loaded. This parameter must be zero unless `snd_Resource` is specified in the `fdwSound` parameter.
- The third parameter, `fdwSound`, contains flags that describe how the sound should be played. These flags can contain a combination of any of the following values:

<i>Flag</i>	<i>Description</i>
<code>SND_APPLICATION</code>	The sound is played using an application-specific association.
<code>SND_ALIAS</code>	The <code>pszSound</code> parameter is a system-event alias in the Registry or the <code>WIN.INI</code> file. Don't use this flag with either <code>SND_FILENAME</code> or <code>SND_RESOURCE</code> , because they're mutually exclusive.
<code>SND_ALIAS_ID</code>	The <code>pszSound</code> parameter is a predefined sound identifier.
<code>SND_FILENAME</code>	The <code>pszSound</code> parameter is a filename.
<code>SND_NOWAIT</code>	This flag indicates that if the driver is busy, it returns immediately without playing the sound.
<code>SND_PURGE</code>	All sounds are stopped for the calling task. If <code>pszSound</code> is not zero, all instances of the specified sound are stopped. If <code>pszSound</code> is zero, all sounds invoked by the current task are stopped. You must also specify the proper instance handle to stop <code>SND_RESOURCE</code> events.
<code>SND_RESOURCE</code>	The <code>pszSound</code> parameter is a resource identifier. When you're using this flag, the <code>hmod</code> parameter must contain the instance that contains the specified resource.
<code>SND_ASYNC</code>	Plays the sound asynchronously and returns the function almost immediately. This achieves a background music effect.
<code>SND_LOOP</code>	Plays the sound over and over until you make it stop or you go insane. <code>SND_ASYNC</code> also must be specified when using this flag.

SND_MEMORY	Plays the WAV sound in the memory area pointed to by the pszSound parameter.
SND_NODEFAULT	If the sound can't be found, PlaySound() returns immediately without playing the default sound, as specified in the Registry.
SND_NOSTOP	Plays the sound only if it isn't already playing. PlaySound() returns True if the sound is played and False if the sound is not played. If this flag is not specified, Win32 will stop any currently playing sound before attempting to play the sound specified in pszSound.
SND_SYNC	Plays the sound synchronously and doesn't return from the function until the sound finishes playing.

TIP

To terminate a WAV sound currently playing asynchronously, call PlaySound() and pass Nil or zero for all parameters, as follows:

```
PlaySound(Nil, 0, 0); // stop currently playing WAV
```

To terminate even non-waveform sounds for a given task, add the snd_Purge flag:

```
PlaySound(Nil, 0, snd_Purge); // stop all currently playing sounds
```

NOTE

The Win32 API still supports the sndPlaySound() function, which was a part of the Windows 3.x API. This function is only supported for backward compatibility, however, and it might not be available in future implementations of the Win32 API. Use the Win32 PlaySound() function rather than sndPlaySound() for future compatibility.

Playing Video

AVI (short for *audio-video interleave*) is one of the most common file formats used to exchange audio and video information simultaneously. In fact, you'll find a couple of AVI files in the \Runimage\Delphi50\Demos\Coolstuff directory of the CD-ROM that contains your copy of Delphi 5.

You can use the simple multimedia player program you wrote earlier in this chapter to display AVI files. Simply select an AVI file when OpenDialog1 is invoked and click the Play button. Note that the AVI file plays in its own window.

Showing the First Frame

You might want to display the first frame of an AVI file in a window before you actually play the file. This achieves a sort of freeze-frame effect. To do this after opening the `TMediaPlayer` component, just set the `Frames` property of `TMediaPlayer` to 1 and then call the `Step()` method. The `Frames` property tells `TMediaPlayer` how many frames to move when `Step()` and `Back()` methods are called. `Step()` advances the `TMediaPlayer` frames and displays the current frame. This is the code:

```
procedure TForm1.Button1Click(Sender: TObject);
begin
  if OpenFileDialog1.Execute then
    with MediaPlayer1 do
      begin
        Filename := OpenFileDialog1.Filename;
        Open;
        Frames := 1;
        Step;
        Notify := True;
      end;
end;
```

Using the Display Property

You can assign a value to `TMediaPlayer`'s `Display` property to cause the AVI file to play to a specific window, instead of creating its own window. To do this, you add a `TPanel` component to your Media Player, as shown in Figure 18.3. After adding the panel, you can save the project in a new directory as `DDGMP1ay.dpr`.



FIGURE 18.3

The DDGMP1ay main window.

Click the drop-down arrow button for `MediaPlayer1`'s `Display` property and notice that all the components in this project appear in the list box. Set the value of the `Display` property to `Panel1`.

Now notice that when you run the program and select and play an AVI file, the AVI file output appears in the panel. Also notice that the AVI file doesn't take up the whole area of the panel; the AVI file has a certain default size programmed into it.

Using the DisplayRect Property

`DisplayRect` is a property of type `TRect` that determines the size of the AVI file output window. You can use the `DisplayRect` property to cause your AVI file's output to stretch or shrink to a certain size. If you want the AVI file to take up the whole area of `Panel1`, for example, you can assign `DisplayRect` to the size of the panel:

```
MediaPlayer1.DisplayRect := Rect(0, 0, Panel1.Width, Panel1.Height);
```

You can add this line of code to the `OnClick` handler for `Button1`, like this:

```
procedure TForm1.Button1Click(Sender: TObject);
begin
  if OpenFileDialog1.Execute then begin
    MediaPlayer1.FileName := OpenFileDialog1.FileName;
    MediaPlayer1.Open;
    MediaPlayer1.DisplayRect := Rect(0, 0, Panel1.Width, Panel1.Height);
  end;
end;
```

CAUTION

You can set the `DisplayRect` property only after the `TMediaPlayer`'s `Open()` method is called.

Understanding TMediaPlayer Events

`TMediaPlayer` has two unique events: `OnPostClick` and `OnNotify`.

The `OnPostClick` event is very similar to `OnClick`, but `OnClick` occurs as soon as the component is clicked, and `OnPostClick` executes only after some action occurs that was caused by a click. If you click the Play button on `TMediaPlayer` at runtime, for example, an `OnClick` event is generated, but an `OnPostClick` event is generated only after the media device is done playing.

The `OnNotify` event is a little more interesting. The `OnNotify` event executes whenever the `TMediaPlayer` completes a media-control method (such as `Back`, `Close`, `Eject`, `Next`, `Open`, `Pause`, `PauseOnly`, `Play`, `Previous`, `Resume`, `Rewind`, `StartRecording`, `Step`, or `Stop`) and only when `TMediaPlayer`'s `Notify` property is set to `True`. To illustrate `OnNotify`, add a handler for this event to the `DDGMPlay` project. In the event handler method, you cause a message dialog box to appear after a command executes:

```
procedure TForm1.MediaPlayer1Notify(Sender: TObject);
begin
  MessageDlg('Media control method executed', mtInformation, [mbOk], 0);
end;
```

Don't forget to also set the `Notify` property to `True` in `Button1`'s `OnClick` handler after opening the Media Player:

```
procedure TForm1.Button1Click(Sender: TObject);
begin
  if OpenFileDialog1.Execute then
    with MediaPlayer1 do
      begin
        Filename := OpenFileDialog1.Filename;
        Open;
        DisplayRect := Rect(0, 0, Panel1.Width, Panel1.Height);
        Notify := True;
      end;
end;
```

TIP

Notice that you moved the code dealing with `MediaPlayer1` into a `with..do` construct. As you learned in earlier chapters, this construct offers advantages in code clarity and performance over simply qualifying each property and method name.

Viewing the Source Code for DDGMPlay

By now, you should know the basics of how to play WAV and AVI files. Listings 18.1 and 18.2 show the complete source code for the `DDGMPlay` project.

LISTING 18.1 The Source Code for `DDGMPlay.dpr`

```
program DDGMPlay;

uses
  Forms,
  Main in 'MAIN.PAS' {MainForm};

{$R *.RES}

begin
  Application.CreateForm(TMainForm, MainForm);
  Application.Run;
end.
```

LISTING 18.2 The Source Code for Main.pas

```
unit Main;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, MPlayer, ExtCtrls;

type
  TMainForm = class(TForm)
    MediaPlayer1: TMediaPlayer;
    OpenFileDialog1: TOpenDialog;
    Button1: TButton;
    Panel1: TPanel;
    procedure Button1Click(Sender: TObject);
    procedure MediaPlayer1Notify(Sender: TObject);
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.Button1Click(Sender: TObject);
begin
  if OpenFileDialog1.Execute then
    with MediaPlayer1 do
      begin
        Filename := OpenFileDialog1.Filename;
        Open;
        DisplayRect := Rect(0, 0, Panel1.Width, Panel1.Height);
        Notify := True;
      end;
end;

procedure TMainForm.MediaPlayer1Notify(Sender: TObject);
begin
  MessageDlg('Media control method executed', mtInformation, [mbOk], 0);
```

continues

LISTING 18.2 Continued

end;

end.

Device Support

TMediaPlayer supports the vast array of media devices supported by MCI. The type of device that TMediaPlayer controls is determined by its DeviceType property. Table 18.1 describes the different values of the DeviceType property.

TABLE 18.1 Values of TMediaPlayer's DeviceType Property

<i>DeviceType Value</i>	<i>Media Device</i>
dtAutoSelect	The TMediaPlayer automatically should select the correct device type based on the filename to be played.
dtAVIVideo	AVI file. These files have the .AVI extension and contain both sound and full-motion video.
dtCDAudio	An audio CD played from your computer's CD-ROM drive.
dtDAT	A digital audio tape (DAT) player connected to your PC.
dtDigitalVideo	A digital video device, such as a digital video camera.
dtMMMovie	A multimedia movie format.
dtOther	An unspecified multimedia format.
dtOverlay	A video overlay device.
dtScanner	A scanner connected to your PC.
dtSequencer	A sequencer device capable of playing MIDI files. MIDI files typically end in a .MID or .RMI extension.
dtVCR	A video cassette recorder (VCR) connected to your PC.
dtVideodisc	A video disc player connected to your PC.
dtWaveAudio	A WAV audio file. These files end in the .WAV extension.

Although you can see that TMediaPlayer supports many formats, this chapter focuses primarily on the WAV, AVI, and CD Audio formats because those are the most common under Windows.

NOTE

The TMediaPlayer component is a TWinControl descendant, which means it can be easily encapsulated as an ActiveX control through the Delphi 5 wizards. One possible

benefit of doing this is the ability to embed a Media Player in a Web page to extend your pages with custom multimedia. Additionally, with a few lines of JavaScript or VBScript, you could provide a CD player for everyone on the Internet or your intranet running a Windows browser.

Creating an Audio CD Player

You'll learn about the finer points of the `TMediaPlayer` component by creating a full-featured audio CD player. Figure 18.4 shows the main form for this application, which is called `CDPlayer.dpr`. The main unit for this form is called `CDMain.pas`.



FIGURE 18.4

The audio CD player's main form.

Table 18.2 shows the important properties to be set for the components contained on the CD player's main form.

TABLE 18.2 Important Properties for the CD Player's Components

<i>Component</i>	<i>Property</i>	<i>Value</i>
<code>mpCDPlayer</code>	<code>DeviceType</code>	<code>dtAudioCD</code>
<code>sbTrack1-sbTrack20</code>	<code>Caption</code>	'1' - '20'
<code>sbTrack1-sbTrack20</code>	<code>Tag</code>	1 - 20

Displaying a Splash Screen

When the CD player is run, it takes a couple seconds for it to load, and it might take several more seconds for the `TMediaPlayer` component to initialize after calling its `Open()` method. This delay from the time the user clicks the icon in Explorer to the time he or she actually sees the program often gives the user an “is my program gonna start, or isn't it?” feeling. This delay is caused by the time Windows takes to load its multimedia subsystem, which occurs

when `TMediaPlayer` is opened. To avoid this problem, you can give the CD player program a splash screen that displays as the program starts. The splash screen tells users that, yes, the program will eventually start—it's just taking a moment to load, so enjoy this little screen in the meantime.

The first step in creating a splash screen is to create a form that you want to use as the splash screen. Generally, you want this form to contain a panel but not a border or title bar; this gives it a 3D, floating-panel appearance. On the panel, place one or more `TLabel` components and perhaps a `TImage` component that displays a bitmap or icon.

The splash screen form for the CD player is shown in Figure 18.5, and the unit, `Splash.pas`, is shown in Listing 18.3.



FIGURE 18.5

The CD player's splash screen form.

LISTING 18.3 The Source Code for `SPLASH.PAS`

```
unit Splash;
interface

uses Windows, Classes, Graphics, Forms, Controls, StdCtrls,
    ExtCtrls;

type
    TSplashScreen = class(TForm)
        StatusPanel: TPanel;
    end;

var
    SplashScreen: TSplashScreen;

implementation

{$R *.DFM}

begin
    { Since the splash screen is displayed before the main screen is created,
      it must be created before the main screen. }
    SplashScreen := TSplashScreen.Create(Application);
    SplashScreen.Show;
```

```
SplashScreen.Update;  
end.
```

Unlike a normal form, the splash screen is created and shown in the initialization section of its unit. Because the initialization section for all units is executed before the main program block in the DPR file, this form is displayed before the main portion of the program runs.

CAUTION

Do *not* use `Application.CreateForm()` to create your splash screen form instance. The first time `Application.CreateForm()` is called in an application, Delphi makes that form the main application form. It would be a “bad thing” to make your splash screen the main form.

Beginning the CD Player

Create an event handler for the form’s `OnCreate` method. In this method, you open and initialize the CD player program. First, call `CDPlayer.Open()` method. `Open()` checks to make sure that the system is capable of playing audio CDs and then initializes the device. If `Open()` fails, it raises an exception of type `EMCIDeviceError`. In the event of an exception opening the device, you should terminate the application. Here’s the code:

```
try  
    mpCDPlayer.Open; { Open the CD Player device. }  
except  
    { If an error occurred, the system may be incapable of playing CDs. }  
    on EMCIDeviceError do  
        begin  
            MessageDlg('Error Initializing CD Player. Program will now exit.',  
                       mtError, [mbOK], 0);  
            Application.Terminate; { bail out }  
        end;  
end;  
end;
```

NOTE

The preferred way to end a Delphi application is by calling the main form’s `Close()` method or by calling `Application.Terminate`.

After opening `CDPlayer`, you should set its `EnabledButtons` property to ensure that the proper buttons are enabled for the device. Which buttons to enable, however, depends on the current state of the CD device. If a CD is already playing when you call `Open()`, for example, you obviously don't want to enable the Play button. To perform a check on the current status of the CD device, you can inspect `CDPlayer`'s `Mode` property. The `Mode` property, which has all its possible values laid out nicely in the online help, provides information on whether a CD device is currently playing, stopped, paused, seeking, and so on. In this case, your concern is only whether the device is stopped, paused, or playing. The following code enables the proper buttons:

```
case mpCDPlayer.Mode of
  mpPlaying: mpCDPlayer.EnabledButtons := [btPause, btStop, btNext, btPrev];
  mpStopped,      { show default buttons if stopped }
  mpPaused : mpCDPlayer.EnabledButtons := [btPlay, btNext, btPrev];
end;
```

The following is the completed source code for the `TMainForm.FormCreate()` method. Notice that you make calls to several methods after successfully opening `CDPlayer`. The purpose of these methods is to update various aspects of the CD player application, such as the number of tracks on the current CD and the current track position. (These methods are described in more detail later in this chapter.) Here's the code:

```
procedure TMainForm.FormCreate(Sender: TObject);
{ This method is called when the form is created. It opens and initializes the
  player }
begin
  try
    mpCDPlayer.Open;    // Open the CD Player device.
    { If a CD is already playing at startup, show playing status. }
    if mpCDPlayer.Mode = mpPlaying then
      LblStatus.Caption := 'Playing';
    GetCDTotals;       // Show total time and tracks on current CD
    ShowTrackNumber;  // Show current track
    ShowTrackTime;    // Show the minutes and seconds for the current track
    ShowCurrentTime;  // Show the current position of the CD
    ShowPlayerStatus; // Update the CD Player's status
  except
    { If an error occurred, the system may be incapable of playing CDs. }
    on EMCIDeviceError do
      begin
        MessageDlg('Error Initializing CD Player. Program will now exit.',
          mtError, [mbOk], 0);
        Application.Terminate;
      end;
  end;
end;
{ Check the current mode of the CD-ROM and enable the appropriate buttons. }
case mpCDPlayer.Mode of
```

```
    mpPlaying: mpCDPlayer.EnabledButtons := PlayButtons;
    mpStopped, mpPaused: mpCDPlayer.EnabledButtons := StopButtons;
end;
SplashScreen.Release; // Close and free the splash screen
end;
```

Notice that the last line of code in this method closes the splash screen form. The `OnCreate` event of the main form is generally the best place to do this.

Updating the CD Player Information

As the CD device plays, you can keep the information on `CDPlayerForm` up-to-date by using a `TTimer` component. Every time a timer event occurs, you can call the necessary updating methods, as shown in the form's `OnCreate` method, to ensure that the display stays current. Double-click `Timer1` to generate a method skeleton for its `OnTimer` event. Here's the source code you use for this event:

```
procedure TMainForm.tmUpdateTimerTimer(Sender: TObject);
{ This method is the heart of the CD Player. It updates all information at
  every timer interval. }
begin
  if mpCDPlayer.EnabledButtons = PlayButtons then
  begin
    mpCDPlayer.TimeFormat := tfMSF;
    ggDiskDone.Progress := (mci_msf_minute(mpCDPlayer.Position) * 60 +
                           mci_msf_second(mpCDPlayer.Position));
    mpCDPlayer.TimeFormat := tfTMSF;
    ShowTrackNumber; // Show track number the CD player is currently on
    ShowTrackTime; // Show total time for the current track
    ShowCurrentTime; // Show elapsed time for the current track
  end;
end;
```

Notice that, in addition to calling the various updating methods, this method also updates the `DiskDoneGauge` control for the amount of time elapsed on the current CD. To get the elapsed time, the method changes `CDPlayer`'s `TimeFormat` property to `tfMSF` and gets the minute and second value from the `Position` property by using the `mci_msf_Minute()` and `mci_msf_Second()` functions. This merits a bit more explanation.

TimeFormat

The `TimeFormat` property of a `TMediaPlayer` component determines how the values of the `StartPos`, `Length`, `Position`, `Start`, and `EndPos` properties should be interpreted. Table 18.3 lists the possible values for `TimeFormat`. These values represent information packed into a `Longint` type variable.

TABLE 18.3 Values for the `TMediaPlayer.TimeFormat` Property

<i>Value</i>	<i>Time Storage Format</i>
<code>tfBytes</code>	Number of bytes
<code>tfFrames</code>	Frames
<code>tfHMS</code>	Hours, minutes, and seconds
<code>tfMilliseconds</code>	Time in milliseconds
<code>tfMSF</code>	Minutes, seconds, and frames
<code>tfSamples</code>	Number of samples
<code>tfSMPTE24</code>	Hours, minutes, seconds, and frames based on 24 frames per second
<code>tfSMPTE25</code>	Hours, minutes, seconds, and frames based on 25 frames per second
<code>tfSMPTE30</code>	Hours, minutes, seconds, and frames based on 30 frames per second
<code>tfSMPTE30Drop</code>	Hours, minutes, seconds, and frames based on 30 drop frames per second
<code>tfTMSF</code>	Tracks, minutes, seconds, and frames

Time-Conversion Routines

The Windows API provides routines to retrieve the time information from the different packed formats shown in Table 18.4. *Packed format* means that multiple data values are packed (encoded) into one `Longint` value. These functions are located in `MMSystem.dll`, so be sure to have `MMSystem` in your `uses` clause when using them.

TABLE 18.4 Functions to Unpack Multimedia Time Formats

<i>Function</i>	<i>Works With</i>	<i>Returns</i>
<code>mci_HMS_Hour()</code>	<code>tfHMS</code>	Hours
<code>mci_HMS_Minute()</code>	<code>tfHMS</code>	Minutes
<code>mci_HMS_Second()</code>	<code>tfHMS</code>	Seconds
<code>mci_MSFFrame()</code>	<code>tfMSF</code>	Frames
<code>mci_MSFF_Minute()</code>	<code>tfMSF</code>	Minutes
<code>mci_MSFF_Second()</code>	<code>tfMSF</code>	Seconds
<code>mci_TMSFFrame()</code>	<code>tfTMSF</code>	Frames
<code>mci_TMSFF_Minute()</code>	<code>tfTMSF</code>	Minutes
<code>mci_TMSFF_Second()</code>	<code>tfTMSF</code>	Seconds
<code>mci_TMSFF_Track()</code>	<code>tfTMSF</code>	Tracks

Methods for Updating the CD Player

As you learned earlier in this chapter, you use several methods to help keep the information displayed by the CD player up-to-date. The primary purpose of each of these methods is to update the labels in the top portion of the CD player form and to update the gauges in the middle portion of that form.

GetCDTotals()

The purpose of the `GetCDTotals()` method, shown in the following code, is to retrieve the length and total number of tracks on the current CD. This information is then used to update several labels and `DiskDoneGauge`. This code also calls the `AdjustSpeedButtons()` method, which enables the same number of speedbuttons as tracks. Notice that this method also makes use of the `TimeFormat` and time-conversion routines discussed earlier:

```
procedure TMainForm.GetCDTotals;
{ This method gets the total time and tracks of the CD and displays them. }
var
  TimeValue: longint;
begin
  mpCDPlayer.TimeFormat := tfTMSF;           // set time format
  TimeValue := mpCDPlayer.Length;           // get CD length
  TotalTracks := mci_Tmsf_Track(mpCDPlayer.Tracks); // get total tracks
  TotalLengthM := mci_msf_Minute(TimeValue); // get total length in mins
  TotalLengthS := mci_msf_Second(TimeValue); // get total length in secs
  { set caption of Total Tracks label }
  LblTotTrk.Caption := TrackNumToString(TotalTracks);
  { set caption of Total Time label }
  LblTotalLen.Caption := Format(MSFormatStr, [TotalLengthM, TotalLengthS]);
  { initialize gauge }
  ggDiskDone.MaxValue := (TotalLengthM * 60) + TotalLengthS;
  { enable the correct number of speed buttons }
  AdjustSpeedButtons;
end;
```

ShowCurrentTime()

The `ShowCurrentTime()` method is shown in the following code. This method is designed to obtain the elapsed minutes and seconds for the currently playing track as well as to update the necessary controls. Here, you also use the time-conversion routines provided by `MMSystem`:

```
procedure TMainForm.ShowCurrentTime;
{ This method displays the current time of the current track }
begin
  { Minutes for this track }
  m := mci_Tmsf_Minute(mpCDPlayer.Position);
  { Seconds for this track }
  s := mci_Tmsf_Second(mpCDPlayer.Position);
```

```
    { update track time label }
    LblTrackTime.Caption := Format(MSFormatStr, [m, s]);
    { update track gauge }
    ggTrackDone.Progress := (60 * m) + s;
end;
```

ShowTrackTime()

The `ShowTrackTime()` method, shown in the following code, obtains the total length of the current track in minutes and seconds, and it updates a label control. Again, you make use of the time-conversion routines. Also notice that you check to make sure that the track isn't the same as when this function was last called. This comparison ensures that you don't make unnecessary function calls or repaint components unnecessarily. Here's the code:

```
procedure TMainForm.ShowTrackTime;
{ This method changes the track time to display the total length of the
  currently selected track. }
var
    Min, Sec: Byte;
    Len: Longint;
begin
    { Don't update the information if player is still on the same track }
    if CurrentTrack <> OldTrack then
    begin
        Len := mpCDPlayer.TrackLength[mci_Tmsf_Track(mpCDPlayer.Position)];
        Min := mci_msf_Minute(Len);
        Sec := mci_msf_Second(Len);
        ggTrackDone.MaxValue := (60 * Min) + Sec;
        LblTrackLen.Caption := Format(MSFormatStr, [m, s]);
    end;
    OldTrack := CurrentTrack;
end;
```

CD Player Source

You've now seen all aspects of the CD player as they relate to multimedia. Listings 18.4 and 18.5 show the complete source code for the `CDPlayer.dpr` and `CDMain.pas` modules. The `CDMain` unit also shows some of the techniques you use to manipulate the speedbuttons using their `Tag` properties as well as other techniques for updating the controls.

LISTING 18.4 The Source Code for `CDPlayer.dpr`

```
program CDPlayer;

uses
    Forms,
    Splash in 'Splash.pas' {SplashScreen},
```

```
CDMain in 'CDMain.pas' {MainForm};

begin
  Application.CreateForm(TMainForm, MainForm);
  Application.Run;
end.
```

LISTING 18.5 The Source Code for CDMain.pas

```
unit CDMain;

interface

uses
  SysUtils, Windows, Classes, Graphics, Forms, Controls, MPlayer, StdCtrls,
  Menus, MMSystem, Messages, Buttons, Dialogs, ExtCtrls, Splash, Gauges;

type
  TMainForm = class(TForm)
    tmUpdateTimer: TTimer;
    MainScreenPanel: TPanel;
    Lbl1Status: TLabel;
    Label2: TLabel;
    LblCurTrk: TLabel;
    Label4: TLabel;
    LblTrackTime: TLabel;
    Label7: TLabel;
    Label8: TLabel;
    LblTotTrk: TLabel;
    LblTotalLen: TLabel;
    Label12: TLabel;
    LblTrackLen: TLabel;
    Label15: TLabel;
    CDInfo: TPanel;
    SBPanel: TPanel;
    Panel1: TPanel;
    mpCDPlayer: TMediaPlayer;
    sbTrack1: TSpeedButton;
    sbTrack2: TSpeedButton;
    sbTrack3: TSpeedButton;
    sbTrack4: TSpeedButton;
    sbTrack5: TSpeedButton;
    sbTrack6: TSpeedButton;
    sbTrack7: TSpeedButton;
    sbTrack8: TSpeedButton;
    sbTrack9: TSpeedButton;
```

LISTING 18.5 Continued

```
    sbTrack10: TSpeedButton;
    sbTrack11: TSpeedButton;
    sbTrack12: TSpeedButton;
    sbTrack13: TSpeedButton;
    sbTrack14: TSpeedButton;
    sbTrack15: TSpeedButton;
    sbTrack16: TSpeedButton;
    sbTrack17: TSpeedButton;
    sbTrack18: TSpeedButton;
    sbTrack19: TSpeedButton;
    sbTrack20: TSpeedButton;
    ggTrackDone: TGauge;
    ggDiskDone: TGauge;
    Label1: TLabel;
    Label3: TLabel;
    procedure tmUpdateTimerTimer(Sender: TObject);
    procedure mpCDPlayerPostClick(Sender: TObject; Button: TMPBtnType);
    procedure FormCreate(Sender: TObject);
    procedure sbTrack1Click(Sender: TObject);
    procedure FormClose(Sender: TObject; var Action: TCloseAction);
private
    { Private declarations }
    OldTrack, CurrentTrack: Byte;
    m, s: Byte;
    TotalTracks: Byte;
    TotalLengthM: Byte;
    TotalLengthS: Byte;
    procedure GetCDTotals;
    procedure ShowTrackNumber;
    procedure ShowTrackTime;
    procedure ShowCurrentTime;
    procedure ShowPlayerStatus;
    procedure AdjustSpeedButtons;
    procedure HighlightTrackButton;
    function TrackNumToString(InNum: Byte): String;
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

const
```

```

{ Array of strings representing numbers from one to twenty: }
NumStrings: array[1..20] of String[10] =
    ('One', 'Two', 'Three', 'Four', 'Five', 'Six', 'Seven', 'Eight', 'Nine',
    'Ten', 'Eleven', 'Twelve', 'Thirteen', 'Fourteen', 'Fifteen', 'Sixteen',
    'Seventeen', 'Eighteen', 'Nineteen', 'Twenty');
MSFormatStr = '%dm %ds';
PlayButtons: TButtonSet = [btPause, btStop, btNext, btPrev];
StopButtons: TButtonSet = [btPlay, btNext, btPrev];

function TMainForm.TrackNumToString(InNum: Byte): String;
{ This function returns a string corresponding to a integer between 1 and 20.
  If the number is greater than 20, then the integer is returned as a string. }
begin
    if (InNum > High(NumStrings)) or (InNum < Low(NumStrings)) then
        Result := IntToStr(InNum) { if not in array, then just return number }
    else
        Result := NumStrings[InNum]; { return the string from NumStrings array }
end;

procedure TMainForm.AdjustSpeedButtons;
{ This method enables the proper number of speed buttons }
var
    i: integer;
begin
    { iterate through form's Components array... }
    for i := 0 to SBPanel.ControlCount - 1 do
        if SBPanel.Controls[i] is TSpeedButton then // is it a speed button?
            { disable buttons higher than number of tracks on CD }
            with TSpeedButton(SBPanel.Controls[i]) do Enabled := Tag <= TotalTracks;
end;

procedure TMainForm.GetCDTotals;
{ This method gets the total time and tracks of the CD and displays them. }
var
    TimeValue: longint;
begin
    mpCDPlayer.TimeFormat := tfTMSF; // set time format
    TimeValue := mpCDPlayer.Length; // get CD length
    TotalTracks := mci_Tmsf_Track(mpCDPlayer.Tracks); // get total tracks
    TotalLengthM := mci_msf_Minute(TimeValue); // get total length in mins
    TotalLengthS := mci_msf_Second(TimeValue); // get total length in secs
    { set caption of Total Tracks label }
    LblTotTrk.Caption := TrackNumToString(TotalTracks);
    { set caption of Total Time label }
    LblTotalLen.Caption := Format(MSFormatStr, [TotalLengthM, TotalLengthS]);

```

continues

LISTING 18.5 Continued

```
{ initialize gauge }
ggDiskDone.MaxValue := (TotalLengthM * 60) + TotalLengthS;
{ enable the correct number of speed buttons }
AdjustSpeedButtons;
end;

procedure TMainForm.ShowPlayerStatus;
{ This method displays the status of the CD Player and the CD that
  is currently being played. }
begin
  if mpCDPlayer.EnabledButtons = PlayButtons then
    with LblStatus do
      begin
        case mpCDPlayer.Mode of
          mpNotReady: Caption := 'Not Ready';
          mpStopped:  Caption := 'Stopped';
          mpSeeking:  Caption := 'Seeking';
          mpPaused:   Caption := 'Paused';
          mpPlaying:  Caption := 'Playing';
        end;
      end
    { If these buttons are displayed the CD Player must be stopped... }
    else if mpCDPlayer.EnabledButtons = StopButtons then
      LblStatus.Caption := 'Stopped';
end;

procedure TMainForm.ShowCurrentTime;
{ This method displays the current time of the current track }
begin
  { Minutes for this track }
  m := mci_Tmsf_Minute(mpCDPlayer.Position);
  { Seconds for this track }
  s := mci_Tmsf_Second(mpCDPlayer.Position);
  { update track time label }
  LblTrackTime.Caption := Format(MSFormatStr, [m, s]);
  { update track gauge }
  ggTrackDone.Progress := (60 * m) + s;
end;

procedure TMainForm.ShowTrackTime;
{ This method changes the track time to display the total length of the
  currently selected track. }
var
  Min, Sec: Byte;
  Len: Longint;
```

```

begin
  { Don't update the information if player is still on the same track }
  if CurrentTrack <> OldTrack then
  begin
    Len := mpCDPlayer.TrackLength[mci_Tmsf_Track(mpCDPlayer.Position)];
    Min := mci_msf_Minute(Len);
    Sec := mci_msf_Second(Len);
    ggTrackDone.MaxValue := (60 * Min) + Sec;
    LblTrackLen.Caption := Format(MSFormatStr, [m, s]);
  end;
  OldTrack := CurrentTrack;
end;

procedure TMainForm.HighlightTrackButton;
{ This procedure changes the color of the speedbutton font for the current
  track to red, while changing other speedbuttons to navy blue. }
var
  i: longint;
begin
  { iterate through form's components }
  for i := 0 to ComponentCount - 1 do
  { is it a speedbutton? }
  if Components[i] is TSpeedButton then
  if TSpeedButton(Components[i]).Tag = CurrentTrack then
  { turn red if current track }
  TSpeedButton(Components[i]).Font.Color := clRed
  else
  { turn blue if not current track }
  TSpeedButton(Components[i]).Font.Color := clNavy;
end;

procedure TMainForm.ShowTrackNumber;
{ This method displays the currently playing track number. }
var
  t: byte;
begin
  t := mci_Tmsf_Track(mpCDPlayer.Position); // get current track
  CurrentTrack := t; // set instance variable
  LblCurTrk.Caption := TrackNumToString(t); // set Curr Track label caption
  HighlightTrackButton; // Highlight current speedbutton
end;

procedure TMainForm.tmUpdateTimerTimer(Sender: TObject);
{ This method is the heart of the CD Player. It updates all information at
  every timer interval. }
begin

```

LISTING 18.5 Continued

```
if mpCDPlayer.EnabledButtons = PlayButtons then
begin
  mpCDPlayer.TimeFormat := tfMSF;
  ggDiskDone.Progress := (mci_msf_minute(mpCDPlayer.Position) * 60 +
    mci_msf_second(mpCDPlayer.Position));
  mpCDPlayer.TimeFormat := tfTMSF;
  ShowTrackNumber; // Show track number the CD player is currently on
  ShowTrackTime; // Show total time for the current track
  ShowCurrentTime; // Show elapsed time for the current track
end;
end;

procedure TMainForm.mpCDPlayerPostClick(Sender: TObject;
  Button: TMPBtnType);
{ This method displays the correct CD Player buttons when one of the buttons
  are clicked. }
begin
  Case Button of
    btPlay:
      begin
        mpCDPlayer.EnabledButtons := PlayButtons;
        LblStatus.Caption := 'Playing';
      end;
    btPause:
      begin
        mpCDPlayer.EnabledButtons := StopButtons;
        LblStatus.Caption := 'Paused';
      end;
    btStop:
      begin
        mpCDPlayer.Rewind;
        mpCDPlayer.EnabledButtons := StopButtons;
        LblCurTrk.Caption := 'One';
        LblTrackTime.Caption := '0m 0s';
        ggTrackDone.Progress := 0;
        ggDiskDone.Progress := 0;
        LblStatus.Caption := 'Stopped';
      end;
    btPrev, btNext:
      begin
        mpCDPlayer.Play;
        mpCDPlayer.EnabledButtons := PlayButtons;
        LblStatus.Caption := 'Playing';
      end;
  end;
end;
```

```
end;

procedure TMainForm.FormCreate(Sender: TObject);
{ This method is called when the form is created. It opens and initializes the
  player }
begin
  try
    mpCDPlayer.Open;    // Open the CD Player device.
    { If a CD is already playing at startup, show playing status. }
    if mpCDPlayer.Mode = mpPlaying then
      LblStatus.Caption := 'Playing';
    GetCDTotals;       // Show total time and tracks on current CD
    ShowTrackNumber;  // Show current track
    ShowTrackTime;    // Show the minutes and seconds for the current track
    ShowCurrentTime;  // Show the current position of the CD
    ShowPlayerStatus; // Update the CD Player's status
  except
    { If an error occurred, the system may be incapable of playing CDs. }
    on EMCIDeviceError do
      begin
        MessageDlg('Error Initializing CD Player. Program will now exit.',
          mtError, [mbOk], 0);
        Application.Terminate;
      end;
  end;
  { Check the current mode of the CD-ROM and enable the appropriate buttons. }
  case mpCDPlayer.Mode of
    mpPlaying: mpCDPlayer.EnabledButtons := PlayButtons;
    mpStopped, mpPaused: mpCDPlayer.EnabledButtons := StopButtons;
  end;
  SplashScreen.Release; // Close and free the splash screen
end;

procedure TMainForm.sbTrack1Click(Sender: TObject);
{ This method sets the current track when the user presses one of the track
  speed buttons. This method works with all 20 speed buttons, so by looking at
  the 'Sender' it can tell which button was pressed by the button's tag. }
begin
  mpCDPlayer.Stop;
  { Set the start position on the CD to the start of the newly selected track }
  Track := (Sender as TSpeedButton).Tag;
  mpCDPlayer.StartPos := mpCDPlayer.TrackPosition[Track];
  { Start playing CD at new position }
  mpCDPlayer.Play;
  mpCDPlayer.EnabledButtons := PlayButtons;
  LblStatus.Caption := 'Playing';
end;
```

continues

LISTING 18.5 Continued

```
end;  
  
procedure TMainForm.FormClose(Sender: TObject;  
    var Action: TCloseAction);  
begin  
    mpCDPlayer.Close;  
end;  
  
end.
```

Summary

That about wraps up the basic concepts of Delphi's `TMediaPlayer` component. This chapter demonstrates the power and simplicity of this component through several examples. In particular, you learned about the common multimedia formats of WAV audio, AVI audio/video, and CD audio.

Testing and Debugging

CHAPTER

19

IN THIS CHAPTER

- **Common Program Bugs** 865
- **Using the Integrated Debugger** 869
- **Summary** 880

Some programmers in the industry believe that the knowledge and application of good programming practice make the need for debugging expertise unnecessary. In reality, however, the two complement each other, and whoever masters both will reap the greatest benefits. This is especially true when multiple programmers are working on different parts of the same program. It's simply impossible to completely remove the possibility of human error.

A surprising number of people say, "My code compiles all right, so I don't have any bugs, right?" Wrong. There's no correlation between whether a program compiles and whether it has bugs; there's a big difference between code that's syntactically correct and code that's logically correct and bug-free. Also, don't assume that because a particular piece of code worked yesterday or on another system that it's bug-free. When it comes to hunting software bugs, everything should be presumed guilty until proven innocent.

During the development of any application, you should allow the compiler to help you as much as possible. You can do this in Delphi by enabling all the runtime error-checking options in Project, Options, Compiler, as shown in Figure 19.1, or by enabling the necessary directives in your code. Additionally, you should have the Show Hints and Show Warnings options enabled in that same dialog box in order to receive more information on your code. It's common for a developer to spend needless hours trying to track down "that impossible bug," when he or she could have found the error immediately by simply employing these effective compiler-aided tools. (Of course, the authors would never be guilty of failing to remember to use these aids. You believe us, right?)

Table 19.1 describes the different runtime error options available through Delphi.

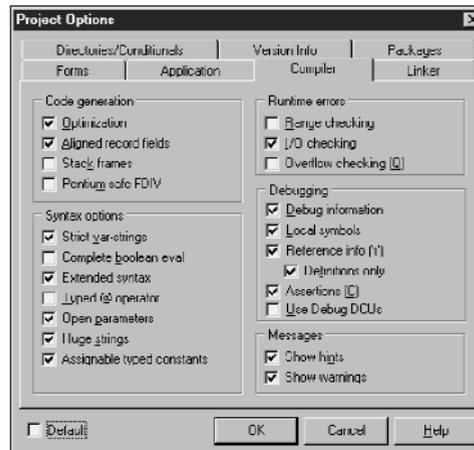


FIGURE 19.1

The Compiler page of the Project Options dialog box.

TABLE 19.1 Delphi Runtime Errors

<i>Runtime Error</i>	<i>Directive</i>	<i>Function</i>
Range Checking	{R+}	Checks to ensure that you don't index an array or string beyond its bounds and that assignments don't assign a value to a scalar variable that's outside its range.
I/O Checking	{I+}	Checks for an input/output error after every I/O call (<code>ReadLn()</code> and <code>WriteLn()</code> , for example). This almost always should be enabled.
Overflow Checking	{Q+}	Checks to ensure that calculation results are not larger than the register size.

TIP

Keep in mind that each of these runtime errors exacts a performance penalty on your application. Therefore, once you're out of the debugging phase of development and are ready to ship a final product, you can improve performance by disabling some of the runtime error checks. It's common practice for developers to disable all of them except I/O Checking for the final product.

Common Program Bugs

This section shows some commonly made mistakes that cause programs to fail or crash. If you know what to look for when you're debugging code, you can lessen the time needed to find errors.

Using a Class Variable Before It's Created

One of the most common bugs that creeps up when you develop in Delphi occurs because you've used a class variable before it has been created. For example, take a look at the following code:

```
procedure TForm1.Button1Click(Sender: TObject);
var
  MyStringList: TStringList;
begin
  MyStringList.Assign(ListBox1.Items);
end;
```

The `TStringList` class `MyStringList` has been declared; however, it's used before it's instantiated. This is a sure way to cause an access violation. You must be sure to instantiate any class

variables before you try to use them. The following code shows the correct way to instantiate and use a class variable. However, it also introduces another bug. Can you see it?

```
procedure TForm1.Button1Click(Sender: TObject);
var
  MyStringList: TStringList;
begin
  MyStringList := TStringList.Create;
  MyStringList.Assign(ListBox1.Items);
end;
```

If your answer was, “You didn’t free your `TStringList` class,” you’re correct. This won’t cause your program to fail or crash, but it will eat up memory because, every time you call this method, another `TStringList` is created and thrown away, thereby leaking memory. Although the Win32 API will free all memory allocated by your process at the time it terminates, leaking memory while running an application can cause serious problems. For example, a leaky application will continue to eat more and more of the system’s memory resources as it runs, causing the OS to have to perform more disk swapping, which ultimately slows down the entire system.

The corrected version of the preceding code listing is shown in the following code (minus a necessary enhancement discussed in the next topic):

```
procedure TForm1.Button1Click(Sender: TObject);
var
  MyStringList: TStringList;
begin
  MyStringList := TStringList.Create;           // Create it!
  MyStringList.Assign(ListBox1.Items);        // Use it!
  { Do your stuff with your TStringList instance }
  MyStringList.Free;                          // Free it!
end;
```

Ensuring That Class Instances Are Freed

Suppose that in the previous code example, an exception occurs just after `TStringList` is created. The exception would cause the flow of execution to immediately exit the procedure, and none of the procedure’s remaining code would be executed, which would cause a memory loss. Make sure your class instances are freed, even if an exception occurs, by using a `try..finally` construct, as shown here:

```
procedure TForm1.Button1Click(Sender: TObject);
var
  MyStringList: TStringList;
begin
  MyStringList := TStringList.Create;           // Create it!
  try
    MyStringList.Assign(ListBox1.Items);        // Use it!
```

```
    { Do your stuff with your TStringList instance }  
  finally  
    MyStringList.Free;           // Free it!  
  end;  
end;
```

After you read the section “Breakpoints” later in the chapter, try an experiment and place the following line right after the line where you assign the `Listbox1` items to the `TStringList`:

```
raise Exception.Create('Test Exception');
```

Then place a breakpoint at the beginning of the method’s code and step through the code. You’ll see that `TStringList` still gets freed, even after the exception is raised.

Taming the Wild Pointer

The *wild pointer bug* is a common error that clobbers some part of memory when you use the pointer to write to memory. The wild pointer genus has two common species: the uninitialized pointer and the stale pointer.

An *uninitialized pointer* is a pointer variable that’s used before memory has been allocated for it. When such a pointer is used, you end up writing to whatever address happens to live at the location of the pointer variable. The following code example illustrates an uninitialized pointer:

```
var  
  P: ^Integer;  
begin  
  P^ := 1971; // Eeek! P is uninitialized!
```

A *stale pointer* is a pointer that references an area of memory that was once properly allocated but has been freed. The following code shows a stale pointer:

```
var  
  P: ^Integer;  
begin  
  New(P);  
  P^ := 1971;  
  Dispose(P);  
  P^ := 4; // Eeek! P is stale!
```

If you’re lucky, you’ll receive an access violation when you attempt to write to a wild pointer. If you’re not so lucky, you’ll end up writing over data used by some other part of your application. This type of error is absolutely no fun to debug. On one machine, the pointer may appear to run just fine until you transfer it to another machine (and maybe make a few code changes in the process), where it begins to malfunction. This may lead you to believe that the recent changes you made are faulty or that the second machine has a hardware problem. Once you’ve fallen into this trap, all the good programming practice in the world won’t save you. You may start adding instances of `ShowMessage()` to portions of your code in an attempt to find the

problem, but this serves only to modify the code's location in memory and might cause the bug to move around—or worse, disappear! Your best defense against wild pointer bugs is to avoid them in the first place. Whenever you need to work with pointers and manual memory allocation, make sure you check and double-check your algorithms to avoid the silly mistake that may introduce a bug.

Using Uninitialized PChar-Type Variables

You'll often see wild pointer errors when you use PChar-type variables. Because a PChar is just a pointer to a string, you have to remember to allocate memory for the PChar by using the `StrAlloc()`, `GetMem()`, `StrNew()`, `GlobalAlloc()`, or `VirtualAlloc()` function, as well as using the `FreeMem()`, `StrDispose()`, `GlobalFree()`, or `VirtualFree()` function to free it.

TIP

You can avoid potential bugs in your program by using `string`-type variables where possible, instead of PChars. You can typecast a `string` to a PChar, so the code involved is simple, and because `strings` are automatically allocated and freed, you don't have to concern yourself with memory allocation.

This holds true especially for Delphi 1.0 applications that you're porting to 32-bit Delphi. In Delphi 1.0, PChars are a necessary evil. In 32-bit Delphi, they're necessary only on rare occasions. Take the time to move to `strings` as you port your applications to 32-bit Delphi.

Dereferencing a nil Pointer

In addition to the wild pointer, another common mistake is dereferencing a `nil` (zero-value) pointer. Dereferencing a `nil` pointer always causes the operating system to issue an access violation error. Although this isn't an error that you want to have in your application, it's generally not fatal. Because it doesn't actually corrupt memory, it's safe to use exception handling to take care of the exception and move along. The sample procedure in the following code listing illustrates this point:

```
procedure I_AV;
var
  P: PByte;
begin
  P := Nil;
  try
    P^ := 1;
  except
```

```
    on EAccessViolation do
        MessageDlg('You can''t do that!!', mtError, [mbOk], 0);
    end;
end;
```

If you put this procedure in a program, you'll see that the message dialog box appears to inform you of the problem, but your program continues to run.

Using the Integrated Debugger

Delphi provides a feature-rich debugger built right into the IDE. Most of the facilities of the integrated debugger can be found on the Run menu. These facilities include all the features you would expect of a professional debugger, including the ability to specify command-line parameters for your application, set breakpoints, perform trace and step, add and view watches, evaluate and modify data, and view call stack information.

Using Command-Line Parameters

If your program is designed to use command-line parameters, you can specify them in the Run Parameters dialog box. In this dialog box, simply type the parameters as you would on the command line or in the Windows Start menu's Run dialog box.

Breakpoints

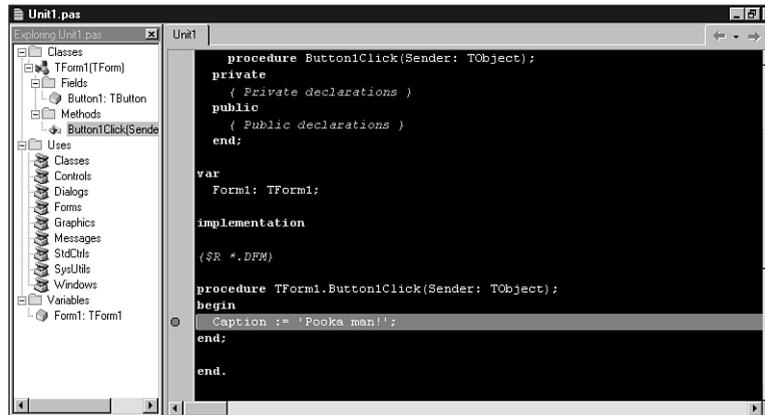
Breakpoints enable you to suspend the execution of your program whenever a certain condition is met. The most common type of breakpoint is a *source breakpoint*, which occurs when a particular line of code is about to be executed. You can set a source breakpoint by clicking to the far left of a line of code in the Code Editor, by using the local menu, or by selecting Run, Add Breakpoint. Whenever you want to see how your program is behaving inside a particular procedure or function, just set a breakpoint on the first line of code in that routine. Figure 19.2 shows a source breakpoint set on a line of program code.

Conditional Breakpoints

You can add additional information to a source breakpoint to suspend the execution of your program when some condition occurs in addition to when a line of code is reached. A typical example is when you want to examine the code inside a loop construct. You probably don't want to suspend and resume execution every time your code passes through the loop, especially if the loop occurs hundreds, or perhaps thousands, of times. Instead of continually pressing the F9 key to run, just set a breakpoint to occur whenever a variable reaches a certain value. For example, in a new project, place a TButton on the main form and add the following code to the button's event handler:

```
procedure TForm1.Button1Click(Sender: TObject);
var
```

```
I: Integer;
begin
  for I := 1 to 100 do
  begin
    Caption := IntToStr(I);           // update form
    Button1.Caption := IntToStr(I); // update button
    Application.ProcessMessages;     // let updates happen
  end;
end;
```

**FIGURE 19.2**

A source breakpoint set in the Code Editor.

Now set a breakpoint on the following line:

```
Caption := IntToStr(I);           // update form
```

After you've set a breakpoint, select View, Debug Windows, Breakpoints, which will bring up a Breakpoint List dialog box. Your breakpoint should show up in this list. Right-click your breakpoint and select Properties from the local menu. This will invoke the Edit Breakpoint dialog box, as shown in Figure 19.3. In the Condition input line, enter `I = 50` and select OK. This will cause the breakpoint that you previously set to suspend program execution only when the variable `I` contains the value 50.

TIP

Figure 19.3 provides a glimpse into the breakpoint actions feature, which is new to Delphi 5. Breakpoint actions enable you to specify the exact behavior of the debugger when a breakpoint is encountered. These actions are controlled using the three

checkboxes shown in the figure. Break, as you might imagine, instructs the debugger to break when the breakpoint is encountered. Ignore Subsequent Exceptions causes the debugger to refrain from breaking when exceptions are encountered from the breakpoint forward. Handle Subsequent Exceptions causes the debugger to resume the default behavior of breaking when exceptions are encountered from the breakpoint forward.

The latter two options are designed to be used in tandem. If you have a particular bit of code that is causing you problems by raising exceptions in the debugger and you don't want to be notified about it, you can use these breakpoint options to instruct the debugger to ignore exceptions before entering the code block and begin handling exceptions once again after leaving the block.

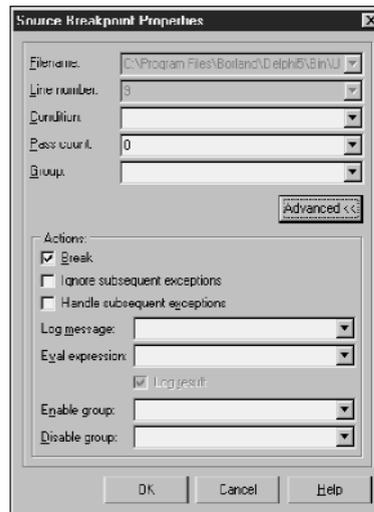


FIGURE 19.3

The Edit Breakpoint dialog box.

Data Breakpoints

Data breakpoints are breakpoints you can set to occur when memory at a particular address is modified. This is useful for low-level debugging, when you need to track down bugs that perhaps occur when a variable gets assigned. You can set data breakpoints by selecting Run, Add Breakpoint, Data Breakpoint from the main menu or by using the local menu on the Breakpoint List dialog box. This invokes the Add Data Breakpoint dialog box, as shown in Figure 19.4. In this dialog box, you can enter the start address of the area of memory you want to monitor and the length (number of bytes) to monitor after that address. By specifying the

number of bytes, you can watch anything from a Char (one byte) to an Integer (four bytes) to an array or record (any number of bytes). In a manner similar to source breakpoints, the Add Data Breakpoint dialog box also allows you to enter an expression that will be evaluated when the memory region is written to so that you can find those bugs that occur on the *n*th time a memory region is set. If you want the debugger to break when a specific variable is modified, just enter the name of the variable in the address field.

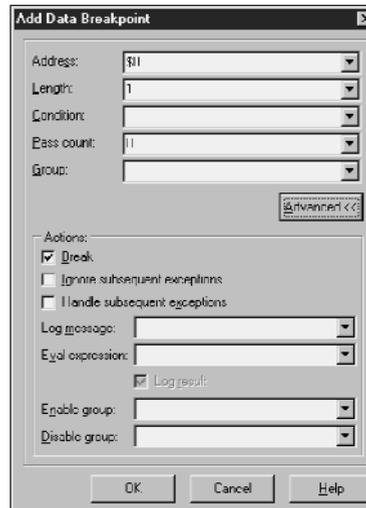


FIGURE 19.4

The Add Data Breakpoint dialog box.

Address Breakpoints

An *address breakpoint* is a breakpoint you can set to occur when code residing at a particular address is executed. These types of breakpoints are normally set from the local menu in the CPU view when you can't set a source breakpoint because you don't have the source code for a particular module. As with other types of breakpoints, you can also specify a condition for address breakpoints in order to fine-tune your breakpoints.

Module Load Breakpoints

As you can probably surmise from the name, *module load breakpoints* enable you to set breakpoints that occur when a specified module is loaded in the debugged application's process. This allows you to be notified immediately when a DLL or package is loaded by an application. The most common place to set module load breakpoints is the local menu in the Modules window, but they can also be set by using the Run, Add Breakpoint item on the main menu.

Breakpoint Groups

Breakpoint groups are one of the most powerful and time-saving features the integrated debugger offers. Using groups, any breakpoint can be set up to enable or disable any other breakpoint so that a very complex algorithm of breakpoints can be created to find very specific bugs. Suppose you suspect that a bug shows up in your `Paint()` method only after you choose a particular menu option. You could add a breakpoint to the `Paint()` method, run the program, and constantly tell the debugger to continue when you get barraged with hundreds of calls to your `Paint()` method. Alternatively, you could keep that breakpoint on your `Paint()` method, disable it so that it doesn't fire, and then add another breakpoint to your menu-select event handler to enable the `Paint()` method breakpoint. Now you can run full speed in the debugger and not break in your `Paint()` handler until after you select the menu choice.

Executing Code Line by Line

You can execute code line by line by using either the Step Over or Trace Into option (F8 and F7 keys, respectively, in the Default and IDE classic keymapping). Trace Into steps into your procedures and functions as they're called; Step Over executes the procedure or function immediately without stepping into it. Typically, you use these options after stopping somewhere in your code with a breakpoint. Get to know the F7 and F8 keys; they are your friends.

You can also tell Delphi to run your program up to the line that the cursor currently inhabits by using the Run To Cursor (F4) option. This is particularly useful when you want to bypass a loop that's iterated many times, in which case using F7 or F8 becomes tedious. Keep in mind that you can set breakpoints at any time in the Code Editor—even as your program executes; you don't have to set all the breakpoints up front.

TIP

If you accidentally step into a function that will be very difficult or time-consuming to step out of, choose Run, Run Until Return from the main menu to cause the debugger to break after the current procedure or function returns.

You can breakpoint your code dynamically by using the Program Pause option. This option often helps you determine whether your program is in an infinite loop. Keep in mind that VCL code is being run most of your program's life, so you often won't stop on a line of your program's code with this option.

TIP

When you debug your application, you've probably noticed the blue dots shown in the "gutter" on the left side of the Code Editor window. One of these blue dots is shown next to each line of code for which machine code is generated. You can't set a breakpoint on or step to a particular line of code if it doesn't have a blue dot next to it because no machine code is associated with the line.

Using the Watch Window

You can use the Watch window to track the values of your program's variables as your code executes. Keep in mind that you must be in a code view of your program (a breakpoint should be executed) for the contents of the Watch window to be accurate. You can enter an Object Pascal expression or register name into the Watch window. This is shown in Figure 19.5.

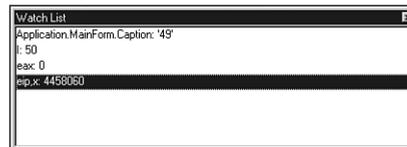


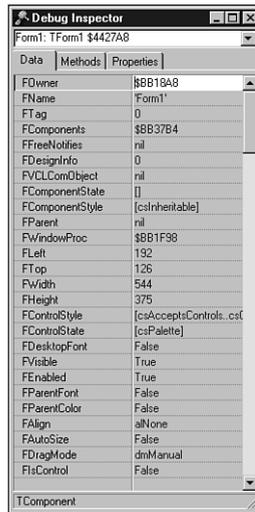
FIGURE 19.5

Using the Watch List window.

Debug Inspectors

A debug inspector is a kind of data inspector that's perhaps easier to use and more powerful in some ways than the Watch window. To use this feature, select Run, Inspect while debugging an application. This will invoke a simple dialog box into which you can enter an expression. Click OK, and you'll be presented with a Debug Inspector window for the expression you entered. For example, Figure 19.6 shows a Debug Inspector for the main form of a do-nothing Delphi application.

The Debug Inspector window provides a means for conveniently viewing data that consists of many individual elements, such as classes and records. Click the ellipses on the right of the value column in the Inspector to modify the value of a field. You can even drill down into record or class data members by double-clicking a field of this type in the list.

**FIGURE 19.6**

Inspecting a form using a Debug Inspector.

Using the Evaluate and Modify Options

The Evaluate and Modify options enable you to inspect and change the contents of variables, including arrays and records, on the fly as your application executes in the integrated debugger. Keep in mind that this feature doesn't enable you to access functions or variables that are out of scope.

CAUTION

Evaluating and modifying variables is perhaps one of the more powerful features of the integrated debugger, but with that power comes the responsibility of having direct access to memory. You must be careful when changing the values of variables, because changes can affect the behavior of your program later.

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Accessing the Call Stack

You can access the call stack by choosing View, Debug Windows, Call Stack. This enables you to view function and procedure calls along with the parameters passed to them. The call stack is useful for seeing a road map of functions that were called up to the current point in your source code. Figure 19.7 shows a typical view of the Call Stack window.

**FIGURE 19.7**

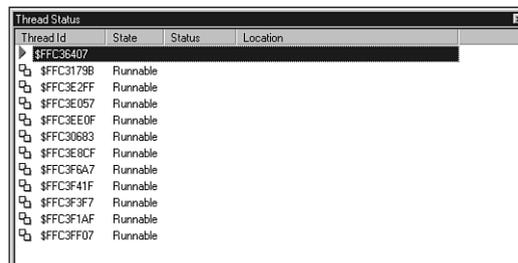
The Call Stack window.

TIP

To view any procedure or function listed in the Call Stack window, simply right-click inside the window. This is a good trick for getting back to a function when you accidentally trace in too far.

Viewing Threads

If your application makes use of multiple threads, the integrated debugger allows you to obtain information on the various threads in your application through the Thread Status window. Select View, Debug Windows, Threads from the main menu to invoke this window. When your application is paused (has hit a breakpoint), you can use the local menu provided by this window to make another thread current or to view the source associated with a particular thread. Remember that whenever you modify the current thread, the next run or step command you issue is relative to that thread. Figure 19.8 shows the Thread Status window.

**FIGURE 19.8**

The Thread Status window.

Event Log

The Event Log provides a place into which the debugger will log a record for the occurrence of various events. The Event Log, shown in Figure 19.9, is accessible from the View, Debug menu. You can configure the Event Log by using its local menu or the Debugger page of the Tools, Environment Options dialog box.

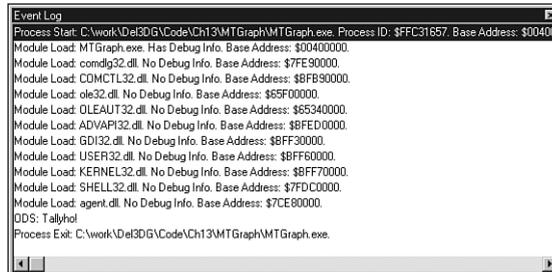


FIGURE 19.9

The Event Log.

The types of events you can log include process information such as process start, process stop, and module load debugger breakpoints, as well as Windows messages sent to the application and application output using `OutputDebugString()`.

TIP

The `OutputDebugString()` API function provides a handy means to help you debug applications. The single parameter to `OutputDebugString()` is a `PChar`. The string passed in this parameter will be passed on to the debugger, and in the case of Delphi, the string will be added to the Event Log. This allows you to keep track of variable values or similar debug information without having to use watches or displaying intrusive debug dialog boxes.

Modules View

The Modules view enables you to obtain information on all the modules (EXE, DLL, BPL, and so on) loaded into the debugged application's process. Shown in Figure 19.10, this window provides you with a list of who's who in your application's process, permits you to set module load breakpoints, and provides you with various types of information on each module.

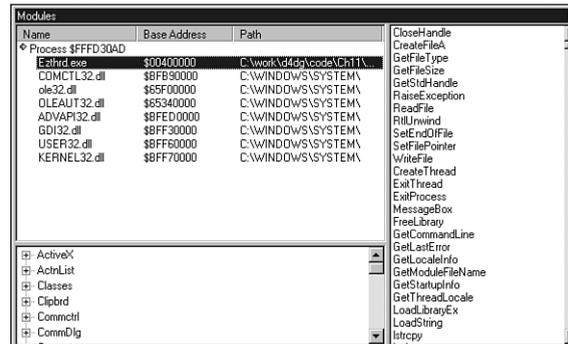


FIGURE 19.10

The Modules view.

DLL Debugging

The Delphi integrated debugger provides you with the ability to debug your DLL projects using any arbitrary application as the host. In fact, it's quite easy. Open your DLL project and select Run, Parameters from the main menu. Then specify a host application in the Run Parameters dialog box, as shown in Figure 19.11.

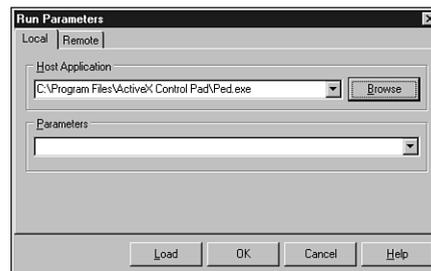


FIGURE 19.11

Specifying a host application.

The host application is an executable file that loads and uses the DLL you're currently debugging. After specifying a proper host application, you can use the integrated debugger much as you would for debugging a normal executable; you can set breakpoints, step, trace, and so on.

This feature is most useful for debugging ActiveX controls and in-process COM servers that are executed from within the context of another process. For example, you can use this feature to debug your ActiveX control from within Visual Basic.

The CPU View

The CPU view, found by selecting View, Debug Windows, CPU from the main menu, provides a developer's-eye view of what's going on inside the machine's CPU. The CPU view consists of five panes of information: the CPU pane, the Memory Dump pane, the Register pane, the Flags pane, and the Stack pane (see Figure 19.12). Each of these panes enables the user to view important aspects of the processor as an aid to debugging.

The screenshot shows the CPU view of a debugger. The main pane displays assembly code for a thread. The code includes instructions like `lea edx,[ebp-0x04]`, `mov eax,ebx`, `call IntToStr`, `call TControl.SetText`, and a `for` loop. The right pane shows the state of registers (EAX, EBX, ECX, etc.) and flags (PF, AF, ZF, etc.). The bottom pane shows a memory dump.

```

CPU
[81627FB4]={00000005 Thread #FFC56D6B
Unit1.pas.32: Caption := IntToStr(I); // update form
0044064C 8D55FC      lea edx,[ebp-0x04]
0044064F 8BC3        mov eax,ebx
00440651 E8827AFCFF   call IntToStr
00440656 8B55FC      mov edx,[ebp-0x04]
00440659 8BC6        mov eax,esi
0044065B E8AC21FEFF   call TControl.SetText
Unit1.pas.33: Button1.Caption := IntToStr(I); // update button
00440660 8D55FC      lea edx,[ebp-0x04]
00440663 8BC3        mov eax,ebx
00440665 E8E77AFCFF   call IntToStr
0044066A 8B55FC      mov edx,[ebp-0x04]
0044066D 8B66A8020000 mov eax,[esi+0x000002a8]
00440673 E89421FEFF   call TControl.SetText
Unit1.pas.34: Application.ProcessMessages; // let updates happen
00440678 A18C1B4400   mov eax,[0x00441bbc]
0044067D 8B00        mov eax,[eax]
0044067F E888E5FFFF   call TApplication.ProcessMessages
Unit1.pas.35: end;
00440684 43         inc ebx
Unit1.pas.30: for I := 1 to 100 do
00440685 83FB65     cmp ebx,0x65
00440688 75C2      jnz TForm1.Button1Click + $1C
0044068A 33C0     xor eax,eax
0044068C 5A      pop edx
0044068D 59      pop ecx
0044068E 59      pop ecx
00410000 04 D0 89 45 F0 8B 45 F0 .P.E6:E6
00410008 33 D2 89 10 8B 45 F0 33 30<...E63
00410010 D2 89 50 04 8B 45 F0 8B 0&P...E6<
00410018 55 F4 E8 ED 40 FF FF 8B U6e18yy<
00410020 45 FC FE 40 10 8B 45 FC F&W...Fu
EAX 00000000 CF 0
EBX 00000001 PF 1
ECX 00BB1F98 AF 0
EDX 00BB35CC ZF 1
ESI 00BB1F98 SF 0
EDI 0067F574 TF 0
EBP 0067F3FC IF 1
ESP 0067F3E4 DF 0
EIP 0044064C OF 0
EFL 00000246 IO 0
CS 0137 NF 0
DS 013F RF 0
SS 013F VM 0
ES 013F AC 0
0067FD00 81640B8C .d
0067FDBC 0067FDE4 .g
0067FDB8 0043F53F .C
0067FDB4 0067FE14 .g
0067FDB0 BFF93D01 <U
0067FDAC 0067FDE4 .d
0067FDA8 00570000 .W
0067FDA4 81627FB4 .b
0067FDA0 81640B8C .d
0067FD9C 0067FDB4 .g
0067FD98 00000001 .j
0067FD94 00000000 .j
0067FD90 0043F364 .C
0067FD8C 00677000 .g
0067FD88 BFF61DA7 <U
0067FD84 00000000 .j
0067FD80 00BB1F98 .j
0067FD7C 0043C802 .g
0067FD78 0067FDBC .C
0067FD74 0043D0CC .C

```

FIGURE 19.12

The CPU view.

The CPU pane shows the opcodes and mnemonics of the disassembled assembly code that's being executed. You can position the CPU pane at any address in your process to view instructions, or you can set the current instruction pointer to any new location, from which execution then continues. It's helpful to be able to understand the assembly code that the CPU pane displays, and experienced developers will attest to the fact that many bugs have been found and exterminated by examining the assembly code generated for a routine and realizing that it wasn't performing the desired operation. Someone who doesn't understand assembly language obviously wouldn't be able to find such a bug as quickly.

The local menu of the CPU view allows you to change the way items are displayed, look at a different address, go back to the current instruction pointer (EIP), search, go back to the source code, and so on. You can also pick the thread context in which to view the CPU information.

The Memory Dump pane enables you to view the contents of any range of memory. There are many ways in which it can be viewed—as Byte, Word, DWORD, QWORD, Single, Double, or Extended. You can search memory for a sequence of bytes as well as modify the data or follow it as code or data pointers.

The Register and Flags panes are pretty straightforward. All the CPU registers and flags are displayed here and can be modified.

The Stack pane gives you a stack-based view of the memory that's used for your program stack. In this pane, you can change values of data on the stack and follow addresses.

Summary

This chapter gives you some insight into the debugging process. It shows you the common problems you might run into while developing applications, and discusses the useful features of both the integrated and standalone debuggers. It's important to remember that debugging is as much a part of programming as is writing code. Your debugger can be one of your most powerful allies in writing clean code, so take the time to know it well.

In the next part of the book, you'll move into the realm of component-based development with COM and VCL components.

Component-Based Development

PART



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- 21 Writing Delphi Custom Components 929
- 22 Advanced Component Design Techniques 1007
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Key Elements of the VCL and Runtime Type Information

CHAPTER

20

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- **Component Types 885**
- **The Component Structure 887**
- **The Visual Component Hierarchy 894**
- **Runtime Type Information 903**
- **Summary 928**

When Borland first introduced the Object Windows Library (OWL) with Turbo Pascal for Windows, it ushered in a drastic simplification over traditional Windows programming. OWL objects automated and streamlined many tedious tasks you otherwise were required to code yourself. No longer did you have to write huge case statements to capture messages or big chunks of code to manage Windows classes; OWL did this for you. On the other hand, you had to learn a new programming methodology—object-oriented programming.

The Visual Component Library (VCL), introduced in Delphi 1, was OWL's successor. It was based on an object model similar to OWL's in principle but radically different in implementation. The VCL in Delphi 5 is the same as its predecessors in Delphi 1, 2, 3, and 4, with quite a few enhancements and additions.

The VCL is designed specifically to work within Delphi's visual environment. Instead of creating a window or dialog box and adding its behavior in code, you modify the behavioral and visual characteristics of components as you design your program visually.

The level of knowledge required about the VCL really depends on how you use it. First, you must realize that there are two types of Delphi developers: applications developers and visual component writers. *Applications developers* create complete applications by interacting with the Delphi visual environment (a concept nonexistent in many other frameworks). These people use the VCL to create their user interface and other elements of their application such as database connectivity. *Component writers*, on the other hand, expand the existing VCL by developing more components. Such components are made available through third-party companies.

Whether you plan to create applications with Delphi or to create Delphi components, understanding the Visual Component Library is essential. An applications developer should know which properties, events, and methods are available for each component. Additionally, it's advantageous to fully understand the object model inherent in a Delphi application that's provided by the VCL. A common problem we see with Delphi developers is that they tend to fight the tool—a symptom of not understanding it completely. Component writers take this knowledge one step further to determine whether to write a new component or to extend an existing one by knowing how VCL handles window messages, internal notifications, component ownership, parenting/ownership issues, property editors, and so on.

This chapter introduces you to the Visual Component Library. It discusses the component hierarchy and explains the purpose of the key levels within the hierarchy. It also discusses the purposes of the common properties, methods, and events that appear at the different component levels. Finally, we complete this chapter by covering Runtime Type Information (RTTI).

What Is a Component?

Components are the building blocks developers use to design the user interface and provide some nonvisual capability to their applications. As far as applications developers are concerned, a component is something developers get from the Component Palette and place on their forms. From there, they can manipulate the various properties and add event handlers to give the component a specific appearance or behavior. From the perspective of a component writer, components are objects in Object Pascal code. These objects can encapsulate the behavior of elements provided by the system (such as the standard Windows 95/98 controls). Other objects can introduce entirely new visual or nonvisual elements, in which case a component's code makes up the entire behavior of the component.

The complexity of components varies widely. Some components are simple; others encapsulate elaborate tasks. There's no limit to what a component can do or be made up of. You can have a simple component such as a `TLabel`, or you can have a much more complex component that encapsulates the complete functionality of a spreadsheet.

The key to understanding the VCL is to know what types of components exist. You should understand the common elements of components. You should also understand the component hierarchy and the purpose of each level within the hierarchy. The following sections provide this information.

Component Types

There are four basic types of components you use and/or create in Delphi: standard controls, custom controls, graphical controls, and nonvisual components.

NOTE

You'll often see the terms *component* and *control* used interchangeably, although they're not always the same. A *control* refers to a visual user-interface element. In Delphi, controls are always components because they descend from the `TComponent` class. *Components* are the objects whose basic behavior allows them to appear on the Component Palette and be manipulated in the form designer. Components are of the type `TComponent` and are not always controls—that is, they aren't always visual user-interface elements.

Standard Components

Delphi provides *standard components* that encapsulate the behavior of Windows 95/98 controls, such as `TRichEdit`, `TTrackBar`, and `TListView` (to name a few). These components exist

on the Win95 page of the Component Palette. These components are actually Object Pascal wrappers around the Windows 95/98 common controls. If you're an owner of the VCL source code, you can view Borland's method for wrapping these controls in the file `ComCtrls.pas`.

TIP

Having the source code to the VCL is essential to understanding the VCL, especially if you plan to write components. There probably is no better way to learn how to write components than to see how Borland has done it. If you don't have the Runtime Library (RTL), it's strongly recommended that you obtain it from Borland.

Custom Components

Custom components is a general term that refers to components that aren't part of the standard Delphi component library. In other words, these are components that either you or other programmers write and add to the existing set of components. We'll get more into designing custom components later in this chapter.

Graphical Components

Graphical components let you have or create visual controls that don't receive the input focus from the user. These components are useful when you want to display something to the user but don't want the component to use up Windows resources, as standard and custom components do. Graphical components don't use Windows resources because they require no window handle, which is also the reason they can't get the focus. Examples of graphical components are `TLabel` and `TShape`. Such components can't serve as container components either; that is, they can't own other components placed on top of them. Other examples of graphical components are `TImage`, `TBevel`, and `TPaintBox`.

Handles

Handles are 32-bit numbers issued by Win32 that refer to certain object instances. The term *objects* here refers to Win32 objects, not Delphi objects. There are different types of objects under Win32: kernel objects, user objects, and GDI objects. Kernel objects apply to items such as events, file-mapping objects, and processes. User objects refer to window objects such as edit controls, list boxes, and buttons. GDI objects refer to bitmaps, brushes, fonts, and so on.

In the Win32 environment, every window has a unique handle. Many Windows API functions require a handle so that they know the window on which they are to perform the operation. Delphi encapsulates much of the Win32 API and performs handle

management. If you want to use a Windows API function that requires a window handle, you must use descendants of `TWinControl` and `TCustomControl`, which both have a `Handle` property.

Nonvisual Components

As the name implies, *nonvisual components* don't have a visual characteristic. Such components give you the capability to encapsulate the functionality of an entity within an object and allow you to modify certain characteristics of that component through the Object Inspector at design time by modifying its properties and providing event handlers for its events. Examples of such components are `TOpenDialog`, `TTable`, and `TTimer`.

The Component Structure

As mentioned earlier, components are Object Pascal classes that encapsulate the functionality and behavior of elements that developers use to add visual and behavioral characteristics to their programs. All components have a certain structure. The following sections discuss the makeup of Delphi components.

NOTE

Understand the distinction between a component and a class. A *component* is a class that can be manipulated within the Delphi environment. A *class* is an Object Pascal structure, as explained in Chapter 2, "The Object Pascal Language."

Properties

Chapter 2 introduced you to properties. Properties give the user an interface to a component's internal storage fields. Using properties, the component user can modify or read storage field values. Typically, the user doesn't have direct access to component storage fields because they're declared in the `private` section of a component's class definition.

Properties: Storage Field Accessors

Properties provide access to storage fields by either accessing the storage fields directly or through *access methods*. Take a look at the following property definition:

```
TCustomEdit = class(TWinControl)
private
    FMaxLength: Integer;
```

```
protected
  procedure SetMaxLength(Value: Integer);
...
published
  property MaxLength: Integer read FMaxLength write SetMaxLength default 0;
...
end;
```

The property `MaxLength` is the access to the storage field `FMaxLength`. The parts of a property definition consist of the property name, the property type, a read declaration, a write declaration, and an optional `default` value. The read declaration specifies how the component's storage fields are read. The `MaxLength` property directly reads the value from the `FMaxLength` storage field. The write declaration specifies the method by which the storage fields are assigned values. For the property `MaxLength`, the writer access method `SetMaxLength()` is used to assign the value to the storage field `FMaxLength`. A property may also contain a reader access method, in which case the `MaxLength` property would be declared as this:

```
property MaxLength: Integer read GetMaxLength write SetMaxLength default 0;
```

The reader access method `GetMaxLength()` would be declared as follows:

```
function GetMaxLength: Integer;
```

Property Access Methods

Access methods take a single parameter of the same type as the property. The purpose of the writer access method is to assign the value of the parameter to the internal storage field to which the property refers. The reason for using the method layer to assign values is to protect the storage field from receiving erroneous data as well as to perform various side effects, if required. For example, examine the implementation of the following `SetMaxLength()` method:

```
procedure TCustomEdit.SetMaxLength(Value: Integer);
begin
  if FMaxLength <> Value then
  begin
    FMaxLength := Value;
    if HandleAllocated then SendMessage(Handle, EM_LIMITTEXT, Value, 0);
  end;
end;
```

This method first checks to verify that the component user isn't attempting to assign the same value that the property already holds. If not, it makes the assignment to the internal storage field `FMaxLength` and then calls the `SendMessage()` function to pass the `EM_LIMITTEXT` Windows message to the window that the `TCustomEdit` encapsulates. This message limits the amount of text that a user can enter into an edit control. Calling `SendMessage()` in the property's writer access method is known as a *side effect* when assigning property values.

Side effects are any actions affected by the assignment of a value to a property. In assigning a value to the `MaxLength` property of `TCustomEdit`, the side effect is that the encapsulated edit control is given an entry limit. Side effects can be much more sophisticated than this.

One key advantage to providing access to a component's internal storage fields through properties is that the component writer can change the implementation of the field access without affecting the behavior for the component user.

A reader access method, for example, can change the type of the returned value to something different from the type of the storage field to which the property refers.

Another fundamental reason for the use of properties is to make modifications available to them during design time. When a property appears in the `published` section of a component's declaration, it also appears in the Object Inspector so that the component user can make modifications to this property.

You learn much more about properties and how to create them and their access methods in Chapter 21, "Writing Delphi Custom Components."

Types of Properties

The standard rules that apply to Object Pascal data types apply to properties as well. The important point about properties is that their types also determine how they're edited in the Object Inspector. Properties can be of the types shown in Table 20.1. For more detailed information, look up "properties" in the online help.

TABLE 20.1 Property Types

<i>Property Type</i>	<i>Object Inspector Treatment</i>
Simple	Numeric, character, and string properties appear in the Object Inspector as numbers, characters, and strings, respectively. The user can type and edit the value of the property directly.
Enumerated	Properties of enumerated types (including <code>Boolean</code>) display the value as defined in the source code. The user can cycle through the possible values by double-clicking the Value column. There's also a drop-down list that shows all possible values of the enumerated type.
Set	Properties of set types appear in the Object Inspector grouped as a set. By expanding the set, the user can treat each element of the set as a <code>Boolean</code> value: <code>True</code> if the element is included in the set and <code>False</code> if it's not included.
Object	Properties that are themselves objects often have their own property editors. However, if the object that's a property also has published properties, the Object Inspector allows the user to expand the list of object properties and edit them individually. Object properties must descend from <code>TPersistent</code> .

TABLE 20.1 Continued

<i>Property Type</i>	<i>Object Inspector Treatment</i>
Array	Array properties must have their own property editors. The Object Inspector has no built-in support for editing array properties.

Methods

Because components are objects, they can therefore have methods. You've already seen information on object methods in Chapter 2 (that information is not repeated here). The later section "The Visual Component Hierarchy" describes some of the key methods of the different component levels in the component hierarchy.

Events

Events are occurrences of an action, typically a system action such as a button control click or a keypress on a keyboard. Components contain special properties called *events*; component users can plug code into the event that executes when the event occurs.

Plugging Code into Events at Design Time

If you look at the events page of a TEdit component, you'll find events such as OnChange, OnClick, and OnDblClick. To component writers, events are really pointers to methods. When users of a component assign code to an event, they create an *event handler*. For example, when you double-click an event in the Object Inspector's events page for a component, Delphi generates a method to which you add your code, such as the following code for the OnClick event of a TButton component:

```
TForm1 = class(TForm)
  Button1: Tbutton;
  procedure Button1Click(Sender: TObject);
end;
...
procedure TForm1.Button1Click(Sender: TObject);
begin
  { Event code goes here }
end;
```

This code is generated by Delphi.

Plugging Code into Events at Runtime

It becomes clear how events are method pointers when you assign an event handler to an event programmatically. For example, to link your own event handler to an OnClick event of a

TButton component, you first declare and define the method you intend to assign to the button's OnClick event. This method might belong to the form that owns the TButton component, as shown here:

```
TForm1 = class(TForm)
  Button1: TButton;
  ...
private
  MyOnClickEvent(Sender: TObject); // Your method declaration
end;
...
{ Your method definition below }
procedure TForm1.MyOnClickEvent(Sender: TObject);
begin
  { Your code goes here }
end;
```

The preceding example shows a user-defined method called MyOnClickEvent() that serves as the event handler for Button1.OnClick. The following line shows how you assign this method to the Button1.OnClick event in code, which is usually done in the form's OnCreate event handler:

```
procedure TForm1.FormCreate(Sender: TObject);
begin
  Button1.OnClick := MyOnClickEvent;
end;
```

This technique can be used to add different event handlers to events, based on various conditions in your code. Additionally, you can disable an event handler from an event by assigning nil to the event, as shown here:

```
Button1.OnClick := nil;
```

Assigning event handlers at runtime is essentially what happens when you create an event handler through Delphi's Object Inspector—except that Delphi generates the method declaration. You can't just assign any method to a particular event handler. Because event properties are method pointers, they have specific method signatures, depending on the type of event. For example, an OnMouseDown method is of the type TMouseEvent, a procedure definition shown here:

```
TMouseEvent = procedure (Sender: TObject; Button: TMouseButton; Shift:
  TShiftState; X, Y: Integer) of object;
```

Therefore, the methods that become event handlers for certain events must follow the same signature as the event types. They must contain the same type, number, and order of parameters.

Earlier, we said that events are properties. Like data properties, events refer to private data fields of a component. This data field is of the procedure type, such as `TMouseEvent`. Examine this code:

```
TControl = class(TComponent)
private
    FOnMouseDown: TMouseEvent;
protected
    property OnMouseDown: TMouseEvent read FOnMouseDown write FOnMouseDown;
public
end;
```

Recall the discussion of properties and how they refer to private data fields of a component. You can see how events, being properties, refer to private method pointer fields of a component.

You learn much more about creating events and event handlers in Chapter 21.

Streamability

One characteristic of components is that they must have the capability to be streamed. *Streaming* is a way to store a component and information regarding its properties' values to a file. Delphi's streaming capabilities take care of all this for you. In fact, the DFM file created by Delphi is nothing more than a resource file containing the streamed information on the form and its components as an RCDATA resource. As a component writer, however, you must sometimes go beyond what Delphi can do automatically. The streaming mechanism of Delphi is explained in greater depth in Chapter 22, "Advanced Component Techniques."

Ownership

Components have the capability of owning other components. A component's owner is specified by its `Owner` property. When a component owns other components, it's responsible for freeing the components it owns when it's destroyed. Typically, the form owns all components that appear on it. When you place a component on a form in the form designer, the form automatically becomes the component's owner. When you create a component at runtime, you must pass the ownership of the component to the component's `Create` constructor; it's assigned to the new component's `Owner` property. The following line shows how to pass the form's implicit `Self` variable to a `TButton.Create()` constructor, thus making the form the owner of the newly created component:

```
MyButton := TButton.Create(self);
```

When the form is destroyed, the `TButton` instance to which `MyButton` refers is also destroyed. This is handled internally in the VCL. Essentially, the form iterates through the components referred to by its `Components` array property (explained in more detail shortly) and destroys them.

It's possible to create a component without an owner by passing `nil` to the component's `Create()` method. However, when this is done, it's your responsibility to destroy the component programmatically. The following code shows this technique:

```
MyTable := TTable.Create(nil)
try
  { Do stuff with MyTable }
finally
  MyTable.Free;
end;
```

When using this technique, you should use a `try..finally` block to ensure that you free up any allocated resources if an exception is raised. You wouldn't use this technique except in specific circumstances when it's impossible to pass an owner to the component.

Another property associated with ownership is the `Components` property. The `Components` property is an array property that maintains a list of all components belonging to a component. For example, to loop through all the components on a form to show their class names, execute the following code:

```
var
  i: integer;
begin
  for i := 0 to ComponentCount - 1 do
    ShowMessage(Components[i].ClassName);
end;
```

Obviously, you'll probably perform a more meaningful operation on these components. The preceding code merely illustrates the technique.

Parenthood

Not to be confused with ownership is the concept of *parenthood*. Components can be *parents* to other components. Only windowed components such as `TWinControl` descendants can serve as parents to other components. Parent components are responsible for calling the child component methods to force them to draw themselves. Parent components are responsible for the proper painting of child components. A component's parent is specified through its `Parent` property.

A component's parent doesn't necessarily have to be its owner. It's perfectly legal for a component to have different parents and owners.

The Visual Component Hierarchy

Remember from Chapter 2 that the abstract class `TObject` is the base class from which all classes descend.

Figure 20.1 shows a skeleton hierarchy of the VCL from the Delphi help file.

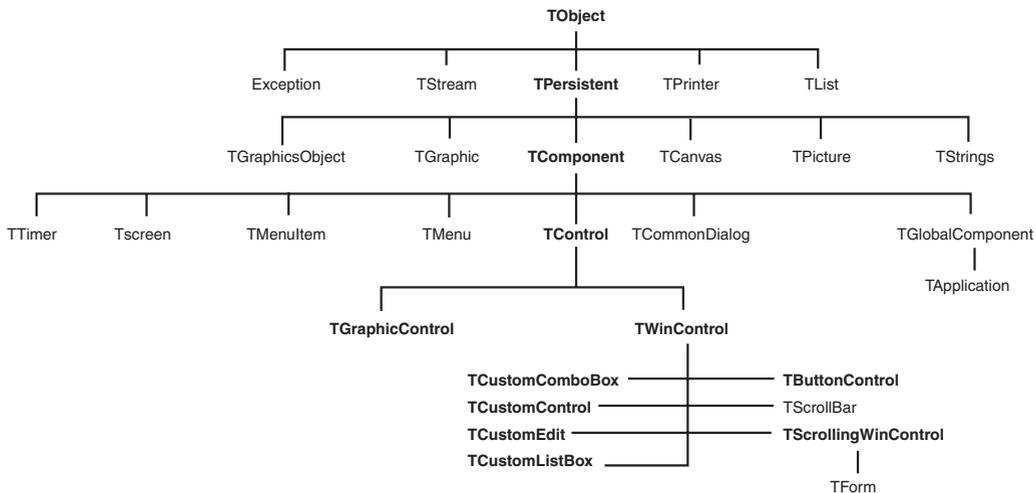


FIGURE 20.1

The hierarchy of the Visual Component Library.

As a component writer, you don't descend your components directly from `TObject`. The VCL already has `TObject` class descendants from which your new components can be derived. These existing classes provide much of the functionality you require for your own components. Only when you create noncomponent classes do your classes descend from `TObject`.

`TObject`'s `Create()` and `Destroy()` methods are responsible for allocating and deallocating memory for an object instance. In fact, the `TObject.Create()` constructor returns a reference to the object being created. `TObject` has several functions that return useful information about a specific object.

The VCL uses most of `TObject`'s methods internally. You can obtain useful information about an instance of a `TObject` or `TObject` descendant such as the instance's class type, class name, and ancestor classes.

CAUTION

Use `TObject.Free` instead of `TObject.Destroy`. The `Free` method calls `Destroy` for you but first checks to see whether the object is `nil` before calling `Destroy`. This method ensures that you won't generate an exception by attempting to destroy an invalid object.

The TPersistent Class

The `TPersistent` class descends directly from `TObject`. The special characteristic of `TPersistent` is that objects descending from it can read and write their properties from and to a stream after they're created. Because all components are descendants of `TPersistent`, they are all streamable. `TPersistent` defines no special properties or events, although it does define some methods that are useful to both the component user and writer.

TPersistent Methods

Table 20.2 lists some methods of interest defined by the `TPersistent` class.

TABLE 20.2 Methods of the `TPersistent` Class

<i>Method</i>	<i>Purpose</i>
<code>Assign()</code>	This public method allows a component to assign to itself the data associated with another component.
<code>AssignTo()</code>	This protected method is where <code>TPersistent</code> descendants must implement the VCL definition for <code>AssignTo()</code> . <code>TPersistent</code> , itself, raises an exception when this method is called. <code>AssignTo()</code> is where a component can assign its data values to another instance or class—the reverse of <code>Assign()</code> .
<code>DefineProperties()</code>	This protected method allows component writers to define how the component stores extra or unpublished properties. This method is typically used to provide a way for a component to store data that's not a simple data type, such as binary data.

The streamability of components is described in greater depth in Chapter 12, “Working with Files.” For now, it's enough to know that components can be stored and retrieved from a disk file by means of streaming.

The TComponent Class

The TComponent class descends directly from TPersistent. TComponent's special characteristics are that its properties can be manipulated at design time through the Object Inspector and that it can own other components.

Nonvisual components also descend from TComponent so that they inherit the capability to be manipulated at design time. A good example of a nonvisual TComponent descendant is the TTimer component. TTimer components are not visual controls but are still available on the Component Palette.

TComponent defines several properties and methods of interest, as described in the following sections.

TComponent Properties

The properties defined by TComponent and their purposes are shown in Table 20.3.

TABLE 20.3 The Special Properties of TComponent

<i>Property Name</i>	<i>Purpose</i>
Owner	Points to the component's owner.
ComponentCount	Holds the number of components that the component owns.
ComponentIndex	The position of this component in its owner's list of components. The first component in this list has the value 0.
Components	A property array containing a list of components owned by this component. The first component in this list has the value 0.
ComponentState	This property holds the current state of a component of the type TComponentState. Additional information about TComponentState can be found in the online help and in Chapter 21.
ComponentStyle	Governs various behavioral characteristics of the component. csInheritable and csCheckPropAvail are two values that can be assigned to this property, both of which are explained in the online help.
Name	Holds the name of a component.
Tag	An integer property that has no defined meaning. This property should not be used by component writers—it's intended to be used by application writers. Because this value is an integer type, pointers to data structures—or even object instances—can be referred to by this property.
DesignInfo	Used by the form designer. Do not access this property.

TComponent Methods

TComponent defines several methods having to do with its capacity to own other components and to be manipulated on the form designer.

TComponent defines the component's `Create()` constructor, which was discussed earlier in this chapter. This constructor is responsible for creating an instance of the component and giving it an owner based on the parameter passed to it. Unlike `TObject.Create()`, `TComponent.Create()` is virtual. TComponent descendants that implement a constructor must declare the `Create()` constructor with the `override` directive. Although you can declare other constructors on a component class, `TComponent.Create()` is the only constructor VCL will use to create an instance of the class at design time and at runtime when loading the component from a stream.

The `TComponent.Destroy()` destructor is responsible for freeing the component and any resources allocated by the component.

The `TComponent.Destroying()` method is responsible for setting a component and its owned components to a state indicating that they are being destroyed; the `TComponent.DestroyComponents()` method is responsible for destroying the components. You probably won't have to deal with these methods.

The `TComponent.FindComponent()` method is handy when you want to refer to a component for which you know only the name. Suppose you know that the main form has a `TEdit` component named `Edit1`. When you don't have a reference to this component, you can retrieve a pointer to its instance by executing the following code:

```
EditInstance := FindComponent('Edit1');
```

In this example, `EditInstance` is a `TEdit` type. `FindComponent()` will return `nil` if the name does not exist.

The `TComponent.GetParentComponent()` method retrieves an instance to the component's parent component. This method can return `nil` if there is no parent to a component.

The `TComponent.HasParent()` method returns a Boolean value indicating whether the component has a parent component. Note that this method doesn't refer to whether this component has an owner.

The `TComponent.InsertComponent()` method adds a component so that it's owned by the calling component; `TComponent.RemoveComponent()` removes an owned component from the calling component. You wouldn't normally use these methods because they're called automatically by the component's `Create()` constructor and `Destroy()` destructor.

The TControl Class

The `TControl` class defines many properties, methods, and events commonly used by visual components. For example, `TControl` introduces the capability for a control to display itself. The `TControl` class includes position properties such as `Top` and `Left` as well as size properties such as `Width` and `Height`, which hold the horizontal and vertical sizes. Other properties include `ClientRect`, `ClientWidth`, and `ClientHeight`.

`TControl` also introduces properties regarding appearances and accessibility, such as `Visible`, `Enabled`, and `Color`. You can even specify a font for the text of a `TControl` through its `Font` property. This text is provided through the `TControl` properties `Text` and `Caption`.

`TControl` also introduces some standard events, such as the mouse events `OnClick`, `OnDbClick`, `OnMouseDown`, `OnMouseMove`, and `OnMouseUp`. It also introduces drag events such as `OnDragOver`, `OnDragDrop`, and `OnEndDrag`.

`TControl` itself isn't very useful at the `TControl` level. You'll never create descendants of `TControl`.

Another concept introduced by `TControl` is that it may have a parent component. Although `TControl` may have a parent, its parent must be a `TWinControl` (parent controls must be *windowed* controls). The `TControl` introduces the `Parent` property.

Most of Delphi's controls are derived from `TControl`'s descendants: `TWinControl` and `TGraphicControl`.

The TWinControl Class

Standard Windows controls descend from the class `TWinControl`. Standard controls are the user-interface objects you see in most Windows applications. Items such as edit controls, list boxes, combo boxes, and buttons are examples of these controls. Because Delphi encapsulates the behavior of standard controls instead of using Windows API functions to manipulate them, you use the properties provided by each of the various control components.

The three basic characteristics of `TWinControl` objects are that they have a Windows handle, can receive input focus, and can be parents to other controls. You'll find that the properties, methods, and events belonging to `TWinControl` support focus changing, keyboard events, the drawing of controls, and other functions required of `TWinControl`.

An applications developer primarily uses `TWinControl` descendants. A component writer must understand the `TCustomControl` descendant of `TWinControl`.

TWinControl Properties

`TWinControl` defines several properties applicable to changing the focus and appearance of the control.

The `TWinControl.Brush` property is used to draw the patterns and shapes of the control. We discussed this property in Chapter 8, “Graphics Programming.”

The `TWinControl.Controls` property is an array property that maintains a list of all controls to which the calling `TWinControl` is a parent.

The `TWinControl.ControlCount` property holds the count of controls to which it is a parent.

`TWinControl.Ct13D` is a property that specifies whether to draw the control using a three-dimensional appearance.

The `TWinControl.Handle` property corresponds to the handle of the Windows object that the `TWinControl` encapsulates. This is the handle you would pass to Win32 API functions requiring a window handle parameter.

`TWinControl.HelpContext` holds a help context number that corresponds to a help screen in a help file. This is used to provide context-sensitive help for individual controls.

`TWinControl.Showing` indicates whether a control is visible.

The `TWinControl.TabStop` property holds a Boolean value to determine whether a user can tab to the said control. The `TWinControl.TabOrder` property specifies where in the parent’s list of tabbed controls the control exists.

TWinControl Methods

The `TWinControl` component also offers several methods that have to do with window creation, focus control, event dispatching, and positioning. There are too many methods to discuss in depth in this chapter; however, they’re all documented in Delphi’s online help. We’ll list only those methods of particular interest in the following paragraphs.

Methods that relate to window creation, re-creation, and destruction apply mainly to component writers and are discussed in Chapter 21, “Writing Delphi Custom Components.” These methods are `CreateParams()`, `CreateWnd()`, `CreateWindowHandle()`, `DestroyWnd()`, `DestroyWindowHandle()`, and `RecreateWnd()`.

Methods having to do with window focusing, positioning, and alignment are `CanFocus()`, `Focused()`, `AlignControls()`, `EnableAlign()`, `DisableAlign()`, and `ReAlign()`.

TWinControl Events

`TWinControl` introduces events for keyboard interaction and focus change. Keyboard events are `OnKeyDown`, `OnKeyPress`, and `OnKeyUp`. Focus-change events are `OnEnter` and `OnExit`. All these events are documented in Delphi’s online help.

The TGraphicControl Class

TGraphicControls, unlike TWinControls, don't have a window handle and therefore can't receive input focus. They also can't be parents to other controls. TGraphicControls are used when you want to display something to the user on the form, but you don't want this control to function as a regular user-input control. The advantage of TGraphicControls is that they don't request a handle from Windows that uses up system resources. Additionally, not having a window handle means that TGraphicControls don't have to go through the convoluted Windows paint process. This makes drawing with TGraphicControls much faster than using the TWinControl equivalents.

TGraphicControls can respond to mouse events. Actually, the TGraphicControl parent processes the mouse message and sends it to its child controls.

TGraphicControl allows you to paint the control and therefore provides the property Canvas, which is of the type TCanvas. TGraphicControl also provides a Paint() method that its descendants must override.

The TCustomControl Class

You might have noticed that the names of some TWinControl descendants begin with TCustom, such as TCustomComboBox, TCustomControl, TCustomEdit, and TCustomListBox.

Custom controls have the same functionality as other TWinControl descendants, except that with specialized visual and interactive characteristics, custom controls provide you with a base from which you can derive and create your own customized components. You provide the functionality for the custom control to draw itself if you're a component writer.

Other Classes

Several classes aren't components but serve as supporting classes to the existing component. These classes are typically properties of other components and descend directly from TPersistent. Some of these classes are of the type TStrings, TCanvas, and TCollection.

The TStrings and TStringLists Classes

The TStrings abstract class gives you the capability to manipulate lists of strings that belong to a component such as a TListBox. TStrings doesn't actually maintain the memory for the strings (that's done by the native control that owns the TStrings class). Instead, TStrings defines the methods and properties to access and manipulate the control's strings without having to use the control's set of Win32 API functions and messages.

Notice that we said TStrings is an abstract class. This means that TStrings doesn't really implement the code required to manipulate the strings—it just defines the methods that must be there. It's up to the descendant components to implement the actual string-manipulation methods.

To explain this point further, some examples of components and their TStrings properties are TListBox.Items, TMemo.Lines, and TComboBox.Items. Each of these properties is of the type TStrings. You might wonder, if their properties are TStrings, how you can call methods of these properties when these methods have yet to be implemented in code? Good question. The answer is that, even though each of these properties is defined as TStrings, the variable to which the property refers (TListBox.FItems, for example) was instantiated as a descendant class. To clarify this, FItems is the private storage field for the Items property of TListBox:

```
TCustomListBox = class(TWinControl)
private
    FItems: TStrings;
```

NOTE

Although the class type shown in the preceding code snippet is a TCustomListBox, the TListBox descends directly from TCustomListBox in the same unit and therefore has access to its private fields.

The unit StdCtrls.pas, which is part of the Delphi VCL, defines a descendant class TListBoxStrings, which is a descendant of TStrings. Listing 20.1 shows its definition.

LISTING 20.1 The Declaration of the TListBoxStrings Class

```
TListBoxStrings = class(TStrings)
private
    ListBox: TCustomListBox;
protected
    procedure Put(Index: Integer; const S: string); override;
    function Get(Index: Integer): string; override;
    function GetCount: Integer; override;
    function GetObject(Index: Integer): TObject; override;
    procedure PutObject(Index: Integer; AObject: TObject); override;
    procedure SetUpdateState(Updating: Boolean); override;
public
    function Add(const S: string): Integer; override;
    procedure Clear; override;
    procedure Delete(Index: Integer); override;
    procedure Exchange(Index1, Index2: Integer); override;
    function IndexOf(const S: string): Integer; override;
    procedure Insert(Index: Integer; const S: string); override;
    procedure Move(CurIndex, NewIndex: Integer); override;
end;
```

StdCtrls.pas then defines the implementation of each method of this descendant class. When TListBox creates its class instances for its FItems variable, it actually creates an instance of this descendant class and refers to it with the FItems property:

```
constructor TCustomListBox.Create(AOwner: TComponent);
begin
    inherited Create(AOwner);
    ...
    // An instance of TListBoxStrings is created
    FItems := TListBoxStrings.Create;
    ...
end;
```

We want to make it clear that although the TStrings class defines its methods, it doesn't implement these methods to manipulate strings. The TStrings descendant class does the implementation of these methods. This is important if you're a component writer because you must know how to perform this technique as the Delphi components did it. It's always good to refer to the VCL source code to see how Borland performs these techniques when you're unsure.

If you're not a component writer but want to manipulate a list of strings, you can use the TStringList class, another descendant of TStrings, with which you can instantiate a completely self-contained class. TStringList maintains a list of strings external to components. The best part is that TStringList is totally compatible with TStrings. This means that you can directly assign a TStringList instance to a control's TStrings property. The following code shows how you can create an instance of TStringList:

```
var
    MyStringList: TStringList;
begin
    MyStringList := TStringList.Create;
```

To add strings to this TStringList instance, do the following:

```
MyStringList.Add('Red');
MyStringList.Add('White');
MyStringList.Add('Blue');
```

If you want to add these same strings to both a TMemo component and a TListBox component, all you have to do is take advantage of the compatibility between the different components' TStrings properties and make the assignments in one line of code each:

```
Memo1.Lines.Assign(MyStringList);
ListBox1.Items.Assign(MyStringList);
```

You use the Assign() method to copy TStrings instances instead of making a direct assignment such as Memo1.Lines := MyStringList.

Table 20.4 shows some common methods of TStrings classes.

TABLE 20.4 Some Common TStrings Methods

<i>TStrings Method</i>	<i>Description</i>
Add(const S: String): Integer	Adds the string S to the string's list and returns the string's position in the list.
AddObject(const S: string; AObject: TObject): Integer	Appends both a string and an object to a string or string list object.
AddStrings(Strings: TStrings)	Copies strings from one TStrings to the end of its existing list of strings.
Assign(Source: TPersistent)	Replaces the existing strings with those specified by the Source parameter.
Clear	Removes all strings from the list.
Delete(Index: Integer)	Removes the string at the location specified by Index.
Exchange(Index1, Index2: Integer)	Switches the location of the two strings specified by the two index values.
IndexOf(const S: String): Integer	Returns the position of the string S on the list.
Insert(Index: Integer; const S: String)	Inserts the string S into the position in the list specified by Index.
Move(CurIndex, NewIndex: Integer)	Moves the string at the position CurIndex to the position NewIndex.
LoadFromFile(const FileName: String)	Reads the text file, FileName, and places its lines into the string list.
SaveToFile(const FileName: string)	Saves the string list to the text file, FileName.

The TCanvas Class

The Canvas property, of type TCanvas, is provided for windowed controls and represents the drawing surface of the control. TCanvas encapsulates what's called the *device context* of a window. It provides many of the functions and objects required for drawing to the window's surface. Chapter 8 went into detail about the TCanvas class.

Runtime Type Information

Back in Chapter 2 you were introduced to RTTI. This chapter delves much deeper into the RTTI innards that will allow you to take advantage of RTTI beyond what you get in the normal usage of the Object Pascal language. In other words, we're going to show you how to obtain

type information on objects and data types much like the way the Delphi IDE obtains the same information.

So how does RTTI manifest itself? You'll see RTTI at work in at least two areas with which you normally work. The first place is right in the Delphi IDE, as stated earlier. Through RTTI, the IDE magically knows everything about the object and components with which you work (see the Object Inspector). Actually, there's more to it than just RTTI, but for the sake of this discussion, we're covering only the RTTI aspect. The second area is in the runtime code that you write. Already, in Chapter 2, you read about the `is` and `as` operators.

Let's examine the `is` operator to illustrate typical usage of RTTI.

Suppose you need to make all `TEdit` components read-only on a given form. This is simple enough—just loop through all components, use the `is` operator to determine whether the component is a `TEdit` class, and then set the `ReadOnly` property accordingly. Here's an example:

```
for i := 0 to ComponentCount - 1 do
  if Components[i] is TEdit then
    TEdit(Components[i]).ReadOnly := True;
```

A typical usage for the `as` operator would be to perform an action on the `Sender` parameter of an event handler, where the handler is attached to several different components. Assuming that you know that all components are derived from a common ancestor whose property you want to access, the event handler can use the `as` operator to safely typecast `Sender` as the desired descendant, thus surfacing the wanted property. Here's an example:

```
procedure TForm1.ControlOnClickEvent(Sender: TObject);
var
  i: integer;
begin
  (Sender as TControl).Enabled := False;
end;
```

These examples of *typesafe programming* illustrate enhancements to the Object Pascal language that indirectly use RTTI. Now let's look at a problem that would call for direct usage of RTTI.

Suppose you have a form containing components that are data-aware and components that are not data-aware. However, you need to perform some action on the data-aware components only. Certainly, you could loop through the `Components` array for the form and test for each data-aware component type. However, this could get messy to maintain because you would have to test against every type of data-aware component. Also, you don't have a base class to test against that's common to only data-aware components. For instance, something like `TDataAwareControl` would have been nice, but it doesn't exist.

A clean way to determine whether a component is data-aware is to test for the existence of a `DataSource` property. To do this, however, you need to use RTTI directly.

The following sections discuss RTTI in more depth to give you the background knowledge needed to solve problems such as the one mentioned earlier.

The TypInfo.pas Unit: Definer of Runtime Type Information

Type information exists for any object (a descendant of `TObject`). This information exists in memory and is queried by the IDE and the Runtime Library to obtain information about objects. The `TypeInfo.pas` unit defines the structures that allow you to query for type information. The `TObject` methods shown in Table 20.5 are repeated from Chapter 2.

TABLE 20.5 TObject Methods

<i>Function</i>	<i>Return Type</i>	<i>Returns</i>
<code>ClassName()</code>	<code>string</code>	The name of the object's class
<code>ClassType()</code>	<code>TClass</code>	The object's type
<code>InheritsFrom()</code>	<code>Boolean</code>	A Boolean to indicate whether the class descends from a given class
<code>ClassParent()</code>	<code>TClass</code>	The object ancestor's type
<code>InstanceSize()</code>	<code>word</code>	The size, in bytes, of an instance
<code>ClassInfo()</code>	<code>Pointer</code>	A pointer to the object's in-memory RTTI

For now, we want to focus on the `ClassInfo()` function, which is defined as follows:

```
class function ClassInfo: Pointer;
```

This function returns a pointer to the RTTI for the calling class. The structure to which this pointer refers is of the type `PTypeInfo`. This type is defined in the `TypeInfo.pas` unit as a pointer to a `TTypeInfo` structure. Both definitions are given in the following code as they appear in `TypeInfo.pas`:

```
PTypeInfo = ^PTypeInfo;
PTypeInfo = ^TTypeInfo;
TTypeInfo = record
  Kind: TTypeKind;
  Name: ShortString;
  {TypeData: TTypeData}
end;
```

The commented field, `TypeData`, represents the actual reference to the type information for the given class. The type to which it actually refers depends on the value of the `Kind` field. `Kind` can be any of the enumerated values defined in the `TTypeKind`:

```
TTypeKind = (tkUnknown, tkInteger, tkChar, tkEnumeration, tkFloat,
  tkString, tkSet, tkClass, tkMethod, tkWChar, tkLString, tkWString,
  tkVariant, tkArray, tkRecord, tkInterface);
```

Take a look at the `TypeInfo.pas` unit at this time to examine the subtypes of some of the preceding enumerated values to get yourself familiar with them. For example, the `tkFloat` value can be further broken down into one of the following:

```
TFloatType = (ftSingle, ftDouble, ftExtended, ftComp, ftCurr);
```

Now you know that `Kind` determines to which type `TypeData` refers. The `TTypeData` structure is defined in `TypeInfo.pas`, as shown in Listing 20.2.

LISTING 20.2 The TTypeData Structure

```
TTypeData = ^TTypeData;
TTypeData = packed record
  case TTypeKind of
    tkUnknown, tkLString, tkWString, tkVariant: ();
    tkInteger, tkChar, tkEnumeration, tkSet, tkWChar: (
      OrdType: TOrdType;
      case TTypeKind of
        tkInteger, tkChar, tkEnumeration, tkWChar: (
          MinValue: Longint;
          MaxValue: Longint;
          case TTypeKind of
            tkInteger, tkChar, tkWChar: ();
            tkEnumeration: (
              BaseType: PTypeInfo;
              NameList: ShortStringBase));
        tkSet: (
          CompType: PTypeInfo));
    tkFloat: (FloatType: TFloatType);
    tkString: (MaxLength: Byte);
    tkClass: (
      ClassType: TClass;
      ParentInfo: PTypeInfo;
      PropCount: SmallInt;
      UnitName: ShortStringBase;
      {PropData: TPropData});
    tkMethod: (
      MethodKind: TMethodKind;
      ParamCount: Byte;
      ParamList: array[0..1023] of Char
      {ParamList: array[1..ParamCount] of
        record
          Flags: TParamFlags;
          ParamName: ShortString;
          TypeName: ShortString;
        end;
```

```
    ResultType: ShortString});  
tkInterface: (  
    IntfParent : PTypeInfo; { ancestor }  
    IntfFlags : TIntfFlagsBase;  
    Guid : TGUID;  
    IntfUnit : ShortStringBase;  
    {PropData: TPropData});  
tkInt64: (  
    MinInt64Value, MaxInt64Value: Int64);  
end;
```

As you can see, the `TTypeInfo` structure is really just a big variant record. If you're familiar with working with variant records and pointers, you'll see that dealing with RTTI is really simple. It just seems complex because it's an undocumented feature.

NOTE

Often, Borland doesn't document a feature because it might change between versions. When using features such as the undocumented RTTI, realize that your code might not be fully portable between versions of Delphi.

At this point, we're ready to demonstrate how to use these structures of RTTI to obtain type information.

Obtaining Type Information

To demonstrate how to obtain RTTI on an object, we've created a project whose main form is defined in Listing 20.3.

LISTING 20.3 Main Form for `ClassInfo.dpr`

```
unit MainFrm;  
  
interface  
  
uses  
    Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,  
    StdCtrls, ExtCtrls, DBClient, MidasCon, MConnect;  
  
type  
  
    TMainForm = class(TForm)
```

continues

LISTING 20.3 Continued

```
    pnlTop: TPanel;
    pnlLeft: TPanel;
    lbBaseClassInfo: TListBox;
    spSplit: TSplitter;
    lblBaseClassInfo: TLabel;
    pnlRight: TPanel;
    lblClassProperties: TLabel;
    lbPropList: TListBox;
    lbSampClasses: TListBox;
    procedure FormCreate(Sender: TObject);
    procedure lbSampClassesClick(Sender: TObject);
private
    { Private declarations }
public
    { Public declarations }
end;

var
    MainForm: TMainForm;

implementation
uses TypInfo;

{$R *.DFM}

function CreateAClass(const AClassName: string): TObject;
{ This method illustrates how you can create a class from the class name. Note
  that this requires that you register the class using RegisterClasses() as
  shown in the initialization method of this unit. }
var
    C : TFormClass;
    SomeObject: TObject;
begin
    C := TFormClass(FindClass(AClassName));
    SomeObject := C.Create(nil);
    Result := SomeObject;
end;

procedure GetBaseClassInfo(AClass: TObject; AStrings: TStrings);
{ This method obtains some basic RTTI data from the given object and adds that
  information to the AStrings parameter. }
var
    ClassTypeInfo: PTypeInfo;
    ClassTypeData: PTypeData;
    EnumName: String;
```

```
begin
  ClassTypeInfo := AClass.ClassInfo;
  ClassTypeData := GetTypeData(ClassTypeInfo);
  with AStrings do
  begin
    Add(Format('Class Name:      %s', [ClassTypeInfo.Name]));
    EnumName := GetEnumName(TypeInfo(TTypeKind), Integer(ClassTypeInfo.Kind));
    Add(Format('Kind:          %s', [EnumName]));
    Add(Format('Size:          %d', [AClass.InstanceSize]));
    Add(Format('Defined in:     %s.pas', [ClassTypeData.UnitName]));
    Add(Format('Num Properties: %d', [ClassTypeData.PropCount]));
  end;
end;

procedure GetClassAncestry(AClass: TObject; AStrings: TStrings);
{ This method retrieves the ancestry of a given object and adds the
  class names of the ancestry to the AStrings parameter. }
var
  AncestorClass: TClass;
begin
  AncestorClass := AClass.ClassParent;
  { Iterate through the Parent classes starting with Sender's
    Parent until the end of the ancestry is reached. }
  AStrings.Add('Class Ancestry');
  while AncestorClass <> nil do
  begin
    AStrings.Add(Format('      %s', [AncestorClass.ClassName]));
    AncestorClass := AncestorClass.ClassParent;
  end;
end;

procedure GetClassProperties(AClass: TObject; AStrings: TStrings);
{ This method retrieves the property names and types for the given object
  and adds that information to the AStrings parameter. }
var
  PropList: PPropList;
  ClassTypeInfo: PTypeInfo;
  ClassTypeData: PTypeData;
  i: integer;
  NumProps: Integer;
begin

  ClassTypeInfo := AClass.ClassInfo;
  ClassTypeData := GetTypeData(ClassTypeInfo);
```

continues

LISTING 20.3 Continued

```

if ClassTypeData.PropCount <> 0 then
begin
  // allocate the memory needed to hold the references to the TPropInfo
  // structures on the number of properties.
  GetMem(PropList, SizeOf(PPropInfo) * ClassTypeData.PropCount);
  try
    // fill PropList with the pointer references to the TPropInfo structures
    GetPropInfos(AClass.ClassInfo, PropList);
    for i := 0 to ClassTypeData.PropCount - 1 do
      // filter out properties that are events ( method pointer properties)
      if not (PropList[i]^PropType^.Kind = tkMethod) then
        AStrings.Add(Format('%s: %s', [PropList[i]^Name,
          PropList[i]^PropType^.Name]));

    // Now get properties that are events (method pointer properties)
    NumProps := GetPropList(AClass.ClassInfo, [tkMethod], PropList);
    if NumProps <> 0 then begin
      AStrings.Add('');
      AStrings.Add('  EVENTS  ===== ');
      AStrings.Add('');
    end;
    // Fill the AStrings with the events.
    for i := 0 to NumProps - 1 do
      AStrings.Add(Format('%s: %s', [PropList[i]^Name,
        PropList[i]^PropType^.Name]));

    finally
      FreeMem(PropList, SizeOf(PPropInfo) * ClassTypeData.PropCount);
    end;
  end;
end;

end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
  // Add some example classes to the list box.
  lbSampClasses.Items.Add('TApplication');
  lbSampClasses.Items.Add('TButton');
  lbSampClasses.Items.Add('TForm');
  lbSampClasses.Items.Add('TListBox');
  lbSampClasses.Items.Add('TPaintBox');
  lbSampClasses.Items.Add('TMidasConnection');
  lbSampClasses.Items.Add('TFindDialog');
  lbSampClasses.Items.Add('TOpenDialog');
  lbSampClasses.Items.Add('Timer');

```

```
    lbSampClasses.Items.Add('TComponent');
    lbSampClasses.Items.Add('TGraphicControl');
end;

procedure TMainForm.lbSampClassesClick(Sender: TObject);
var
    SomeComp: TObject;
begin
    lbBaseClassInfo.Items.Clear;
    lbPropList.Items.Clear;

    // Create an instance of the selected class.
    SomeComp := CreateAClass(lbSampClasses.Items[lbSampClasses.ItemIndex]);
    try
        GetBaseClassInfo(SomeComp, lbBaseClassInfo.Items);
        GetClassAncestry(SomeComp, lbBaseClassInfo.Items);
        GetClassProperties(SomeComp, lbPropList.Items);
    finally
        SomeComp.Free;
    end;
end;

initialization
begin
    RegisterClasses([TApplication, TButton, TForm, TListBox, TPaintBox,
        TMidasConnection, TFindDialog, TOpenDialog, TTimer, TComponent,
        TGraphicControl]);
end;

end.
```

This main form contains three list boxes. `lbSampClasses` contains class names for a few sample objects whose type information we'll retrieve. On selecting an object from `lbSampClasses`, `lbBaseClassInfo` will be populated with basic information about the selected object, such as its size and ancestry. `lbPropList` will display the properties belonging to the selected object from `lbSampClasses`.

Three helper procedures are used to obtain class information:

- `GetBaseClassInfo()` populates a string list with basic information about an object, such as its type, size, defining unit, and number of properties.
- `GetClassAncestry()` populates a string list with the object names of a given object's ancestry.
- `GetClassProperties()` populates a string list with the properties and their types for a given class.

Each procedure takes an object instance and a string list as parameters.

As the user selects one of the classes from `lbSampClasses`, its `OnClick` event, `lbSampClassesClick()`, calls a helper function, `CreateAClass()`, which creates an instance of a class given the name of the class type. It then passes the object instance and the appropriate `TListBox.Items` property to be populated.

TIP

The `CreateAClass()` function can be used to create any class by its name. However, as demonstrated, you must make sure that any classes passed to it have been registered by calling the `RegisterClasses()` procedure.

Obtaining Runtime Type Information for Objects

`GetBaseClassInfo()` passes the return value from `TObject.ClassInfo()` to the function `GetTypeData()`. `GetTypeData()` is defined in `TypInfo.pas`. Its purpose is to return a pointer to the `TTypeData` structure based on the class whose `PTypeInfo` structure was passed to it (see Listing 20.2). `GetBaseClassInfo()` simply refers to the various fields of both the `TTypeInfo` and `TTypeData` structures to populate the `AStrings` string list. Note the use of the function `GetEnumName()` to return the string for an enumerated type. This is also a function of `RTTI` defined in `TypInfo.pas`. Type information on enumerated types is discussed in a later section.

TIP

Use the `GetTypeData()` function defined in `TypInfo.pas` to return a pointer to the `TTypeInfo` structure for a given class. You must pass the result of `TObject.ClassInfo()` to `GetTypeData()`.

TIP

You can use the `GetEnumName()` function to obtain the name of an enumeration value as a string. `GetEnumValue()` returns the enumeration value, given its name.

Obtaining the Ancestry for an Object

The `GetClassAncestry()` procedure populates a string list with the class names of the given object's ancestry. This is a simple operation that uses the `ClassParent()` class procedure on the given object. `ClassParent()` will return a `TClass` reference to the given class's parent or

nil if the top of the ancestry is reached. `GetClassAncestry()` simply walks up the ancestry and adds each class name to the string list until the top is reached.

Obtaining Type Information on Object Properties

If an object has properties, its `TTypeData.PropCount` value will contain the number of properties it has. There are several approaches you can use to obtain the property information for a given class—we demonstrate two.

The `GetClassProperties()` procedure begins much like the previous two methods in that it passes the `ClassInfo()` result to `GetTypeData()` to obtain the reference to the `TTypeData` structure for the class. It then allocates memory for the `PropList` variable based on the value of `ClassTypeData.PropCount`. `PropList` is defined as the type `PPropList`. `PPropList` is defined in `TypInfo.pas` as follows:

```
type
  PPropList = ^TPropList;
  TPropList = array[0..16379] of PPropInfo;
```

The `TPropList` array stores pointers to the `TPropInfo` data for each property. `TPropInfo` is defined in `TypInfo.pas` as follows:

```
PPropInfo = ^TPropInfo;
TPropInfo = packed record
  PropType: PTypeInfo;
  GetProc: Pointer;
  SetProc: Pointer;
  StoredProc: Pointer;
  Index: Integer;
  Default: Longint;
  NameIndex: SmallInt;
  Name: ShortString;
end;
```

`TPropInfo` is the RTTI for a property.

`GetClassProperties()` uses the `GetPropInfos()` function to fill this array with pointers to the RTTI information for all properties for the given object. It then loops through the array and writes out the name and type of the property by accessing that property's type information. Note the following line:

```
if not (PropList[i]^PropType^.Kind = tkMethod) then
```

This is used to filter out properties that are events (method pointers). We populate these properties last, which allows us to demonstrate an alternative method for retrieving property RTTI. In the final part of the `GetClassProperties()` method, we use the `GetPropList()` function to return the `TPropList` for properties of a specific type. In this case, we want only properties of

the type `tkMethod.GetPropList()` is also defined in `TypInfo.pas`. Refer to the source commentary for additional information.

TIP

Use `GetPropInfos()` when you want to retrieve a pointer to the property RTTI for *all* properties of a given object. Use `GetPropList()` if you want to retrieve the same information, except for properties of a specific type.

Figure 20.2 shows the output of the main form with RTTI for a selected class.

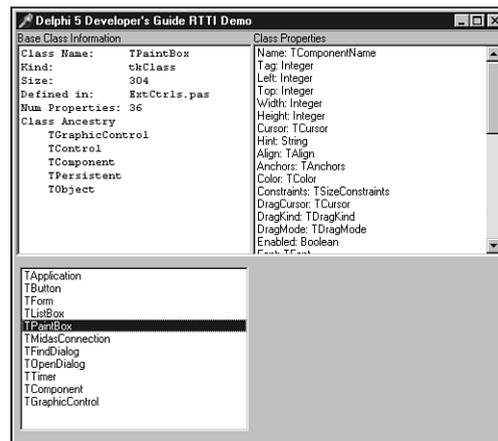


FIGURE 20.2

Output of a class's RTTI.

Checking for the Existence of a Property for an Object

Earlier we presented the problem of needing to check for the existence of a property for a given object. Specifically, we were referring to the `DataSource` property. Using functions defined in `TypInfo.pas`, we could write the following function to determine whether a control is data-aware:

```
function IsDataAware(AComponent: TComponent): Boolean;
var
  PropInfo: PPropInfo;
begin
  // Find the property named datasource.
  PropInfo := GetPropInfo(AComponent.ClassInfo, 'DataSource');
```

```
Result := PropInfo <> nil;

// Double check, make sure it descends from TDataSource
if Result then
  if not ((PropInfo^.Proptype^.Kind = tkClass) and
    (GetTypeData(PropInfo^.PropType^.ClassType.InheritsFrom(TDataSource)))
    then
    Result := False;
end;
```

Here, we're using the `GetPropInfo()` function to return the `TPropInfo` pointer on a given property. This function returns `nil` if the property does not exist. As an additional check, we make sure that the property named `DataSource` is actually a descendant of `TDataSource`.

We also could have written this function more generically to check for the existence of any property by its name, like this:

```
function HasProperty(AComponent: TComponent; APropertyName: String): Boolean;
var
  PropInfo: PPropInfo;
begin
  PropInfo := GetPropInfo(AComponent.ClassInfo, APropertyName);
  Result := PropInfo <> nil;
end;
```

Note, however, that this works only on properties that are published. RTTI does not exist for unpublished properties.

Obtaining Type Information on Method Pointers

RTTI can be obtained on method pointers. For example, you can determine the type of method (procedure, function, and so on) and its parameters. Listing 20.4 demonstrates how to obtain RTTI for a selected group of methods.

LISTING 20.4 Obtaining RTTI for Methods

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ExtCtrls, DBClient, MidasCon, MConnect;

type
```

continues

LISTING 20.4 Continued

```

TMainForm = class(TForm)
  lbSampMethods: TListBox;
  lbMethodInfo: TMemo;
  lblBasicMethodInfo: TLabel;
  procedure FormCreate(Sender: TObject);
  procedure lbSampMethodsClick(Sender: TObject);
private
  { Private declarations }
public
  { Public declarations }
end;

var
  MainForm: TMainForm;

implementation
uses TypInfo, DBTables, Provider;

{$R *.DFM}

type
  // It is necessary to redefine this record as it is commented out in
  // typinfo.pas.

  PParamRecord = ^TParamRecord;
  TParamRecord = record
    Flags:      TParamFlags;
    ParamName: ShortString;
    TypeName:  ShortString;
  end;

procedure GetBaseMethodInfo(ATypeInfo: PTypeInfo; AStrings: TStrings);
{ This method obtains some basic RTTI data from the TTypeInfo and adds that
information to the AStrings parameter. }
var
  MethodTypeData: PTypeData;
  EnumName: String;
begin
  MethodTypeData := GetTypeData(ATypeInfo);
  with AStrings do
  begin
    Add(Format('Class Name:      %s', [ATypeInfo^.Name]));
    EnumName := GetEnumName(TypeInfo(TTypeKind), Integer(ATypeInfo^.Kind));
    Add(Format('Kind:          %s', [EnumName]));
    Add(Format('Num Parameters: %d', [MethodTypeData.ParamCount]));
  end;
end;

```

```

    end;
end;

procedure GetMethodDefinition(ATypeInfo: PTypeInfo; AStrings: TStrings);
{ This method retrieves the property info on a method pointer. We use this
  information to reconstruct the method definition. }
var
  MethodTypeData: PTypeData;
  MethodDefine:   String;
  ParamRecord:   PParamRecord;
  TypeStr:       ^ShortString;
  ReturnStr:     ^ShortString;
  i: integer;
begin
  MethodTypeData := GetTypeData(ATypeInfo);

  // Determine the type of method
  case MethodTypeData.MethodKind of
    mkProcedure:   MethodDefine := 'procedure ';
    mkFunction:   MethodDefine := 'function ';
    mkConstructor: MethodDefine := 'constructor ';
    mkDestructor: MethodDefine := 'destructor ';
    mkClassProcedure: MethodDefine := 'class procedure ';
    mkClassFunction: MethodDefine := 'class function ';
  end;

  // point to the first parameter
  ParamRecord := @MethodTypeData.ParamList;
  i := 1; // first parameter

  // loop through the method's parameters and add them to the string list as
  // they would be normally defined.
  while i <= MethodTypeData.ParamCount do
  begin
    if i = 1 then
      MethodDefine := MethodDefine+'(';

    if pfVar in ParamRecord.Flags then
      MethodDefine := MethodDefine+('var ');
    if pfConst in ParamRecord.Flags then
      MethodDefine := MethodDefine+('const ');
    if pfArray in ParamRecord.Flags then
      MethodDefine := MethodDefine+('array of ');

    // we won't do anything for the pfAddress but know that the Self parameter
    // gets passed with this flag set.
  {

```

continues

LISTING 20.4 Continued

```
    if pfAddress in ParamRecord.Flags then
        MethodDefine := MethodDefine+('*address* ');
    }
    if pfout in ParamRecord.Flags then
        MethodDefine := MethodDefine+('out ');

    // Use pointer arithmetic to get the type string for the parameter.
    TypeStr := Pointer(Integer(@ParamRecord^.ParamName) +
        Length(ParamRecord^.ParamName)+1);

    MethodDefine := Format('%s%s: %s', [MethodDefine, ParamRecord^.ParamName,
        TypeStr^]);

    inc(i); // Increment the counter.

    // Go the next parameter. Notice that use of pointer arithmetic to
    // get to the appropriate location of the next parameter.
    ParamRecord := PParamRecord(Integer(ParamRecord) + SizeOf(TParamFlags) +
        (Length(ParamRecord^.ParamName) + 1) + (Length(TypeStr^)+1));

    // if there are still parameters then setup
    if i <= MethodTypeData.ParamCount then
    begin
        MethodDefine := MethodDefine + ' ';
    end
    else
        MethodDefine := MethodDefine + ')';
end;

// If the method type is a function, it has a return value. This is also
// placed in the method definition string. The return value will be at the
// location following the last parameter.
if MethodTypeData.MethodKind = mkFunction then
begin
    ReturnStr := Pointer(ParamRecord);
    MethodDefine := Format('%s: %s;', [MethodDefine, ReturnStr^])
end
else
    MethodDefine := MethodDefine+' ';

// finally, add the string to the listbox.
with AStrings do
```

```
begin
    Add(MethodDefine)
end;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
    { Add some method types to the list box. Also, store the pointer to the RTTI
      data in listBox's Objects array }
    with lbSampMethods.Items do
    begin
        AddObject('TNotifyEvent', TypeInfo(TNotifyEvent));
        AddObject('TMouseEvent', TypeInfo(TMouseEvent));
        AddObject('TBDECallbackEvent', TypeInfo(TBDECallbackEvent));
        AddObject('TDataRequestEvent', TypeInfo(TDataRequestEvent));
        AddObject('TGetModuleProc', TypeInfo(TGetModuleProc));
        AddObject('TReaderError', TypeInfo(TReaderError));
    end;
end;

procedure TMainForm.lbSampMethodsClick(Sender: TObject);
begin
    lbMethodInfo.Lines.Clear;
    with lbSampMethods do
    begin
        GetBaseMethodInfo(PTypeInfo(Items.Objects[ItemIndex]), lbMethodInfo.Lines);
        GetMethodDefinition(PTypeInfo(Items.Objects[ItemIndex]),
            lbMethodInfo.Lines);
    end;
end;
end.
```

In Listing 20.4, we populate a list box, `lbSampMethods`, with some sample method names. We also store the references to those methods' RTTI data in the `Objects` array of the list box. We do this by using the `TypeInfo()` function, which is a special function that can retrieve a pointer to RTTI for a given type identifier. When the user selects one of these methods, we use that RTTI data from the `Objects` array to retrieve and reconstruct the method definition from the information we have about the method and its parameters in the RTTI data. Refer to the listing's commentary for further information. Figure 20.3 shows this form's output when a method is selected.

**FIGURE 20.3**

Output of a method's RTTI.

TIP

Use the `TypeInfo()` function to retrieve a pointer to the compiler-generated RTTI for a given type identifier. For example, the following line retrieves a pointer to the RTTI for the `TButton` type:

```
TypeInfoPointer := TypeInfo(TButton);
```

Obtaining Type Information for Ordinal Types

We've already covered the more difficult pieces of RTTI. However, you can also obtain RTTI for ordinal types. The following sections illustrate how to obtain RTTI data on integer, enumerated, and set types.

Type Information for Integer Types

Obtaining type information for integer types is simple. Listing 20.5 illustrates this process.

LISTING 20.5 Obtaining RTTI for Integers

```

procedure TMainForm.lbSampsClick(Sender: TObject);
var
  OrdTypeInfo: PTypeInfo;
  OrdTypeData: PTypeData;

  TypeNameStr: String;
  
```

```
TypeKindStr: String;
MinVal, MaxVal: Integer;
begin
  memInfo.Lines.Clear;
  with lbSamps do
  begin
    // Get the TTypeInfo pointer
    OrdTypeInfo := PTypeInfo(Items.Objects[ItemIndex]);
    // Get the TTypeData pointer
    OrdTypeData := GetTypeData(OrdTypeInfo);

    // Get the type name string
    TypeNameStr := OrdTypeInfo.Name;
    // Get the type kind string
    TypeKindStr := GetEnumName(TypeInfo(TTypeKind),
  ↪Integer(OrdTypeInfo^.Kind));

    // Get the minimum and maximum values for the type
    MinVal := OrdTypeData^.MinValue;
    MaxVal := OrdTypeData^.MaxValue;

    // Add the information to the memo
    with memInfo.Lines do
    begin
      Add('Type Name: '+TypeNameStr);
      Add('Type Kind: '+TypeKindStr);

      Add('Min Val: '+IntToStr(MinVal));
      Add('Max Val: '+IntToStr(MaxVal));
    end;
  end;
end;
```

Here, we use the `TypeInfo()` function to obtain a pointer to the `TTypeInfo` structure for the integer data type. We then pass that reference to the `GetTypeData()` function to obtain a pointer to the `TTypeData` structure. We use both these structures to populate a list box with the integer's RTTI. See the demo named `IntegerRTTI.dpr` in the directory for this chapter on the CD-ROM accompanying this book for a more detailed demonstration.

Type Information for Enumerated Types

Obtaining RTTI for enumerated types is just as easy as it is for integers. In fact, you'll see that Listing 20.6 is almost identical to Listing 20.5, with the exception of the additional `for` loop to show the values of the enumeration type.

LISTING 20.6 Obtaining RTTI for an Enumerated Type

```
procedure TMainForm.lbSampsClick(Sender: TObject);
var
  OrdTypeInfo: PTypeInfo;
  OrdTypeData: PTypeData;

  TypeNameStr: String;
  TypeKindStr: String;
  MinVal, MaxVal: Integer;
  i: integer;
begin
  memInfo.Lines.Clear;
  with lbSamps do
  begin
    // Get the TTypeInfo pointer
    OrdTypeInfo := PTypeInfo(Items.Objects[ItemIndex]);
    // Get the TTypeData pointer
    OrdTypeData := GetTypeData(OrdTypeInfo);

    // Get the type name string
    TypeNameStr := OrdTypeInfo.Name;
    // Get the type kind string
    TypeKindStr := GetEnumName(TypeInfo(TTypeKind),
    ➔Integer(OrdTypeInfo^.Kind));

    // Get the minimum and maximum values for the type
    MinVal := OrdTypeData^.MinValue;
    MaxVal := OrdTypeData^.MaxValue;

    // Add the information to the memo
    with memInfo.Lines do
    begin
      Add('Type Name: '+TypeNameStr);
      Add('Type Kind: '+TypeKindStr);

      Add('Min Val: '+IntToStr(MinVal));
      Add('Max Val: '+IntToStr(MaxVal));

      // Show the values and names of the enumerated types
      if OrdTypeInfo^.Kind = tkEnumeration then
        for i := MinVal to MaxVal do
          Add(Format(' Value: %d Name: %s', [i,
            GetEnumName(OrdTypeInfo, i)]));
```

```
    end;  
  end;  
end;
```

You'll find a more detailed demo named `EnumRTTI.dpr` on the CD-ROM in the directory for this chapter.

Type Information for Set Types

Obtaining RTTI for set types is only slightly more complex than the two previous techniques. Listing 20.7 is the main form for the project `SetRTTI.dpr`, which you'll find on the CD-ROM in the directory for this chapter.

LISTING 20.7 Obtaining RTTI for Set Types

```
unit MainFrm;  
  
interface  
  
uses  
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,  
  StdCtrls, Grids;  
  
type  
  TMainForm = class(TForm)  
    lbSamps: TListBox;  
    memInfo: TMemo;  
    procedure FormCreate(Sender: TObject);  
    procedure lbSampsClick(Sender: TObject);  
  private  
    { Private declarations }  
  public  
    { Public declarations }  
  end;  
  
var  
  MainForm: TMainForm;  
  
implementation  
uses TypInfo, Buttons;  
  
{ $R *.DFM }  
  
procedure TMainForm.FormCreate(Sender: TObject);
```

continues

LISTING 20.7 Continued

```
begin
  // Add some example enumerated types
  with lbSamps.Items do
  begin
    AddObject('TBorderIcons', TypeInfo(TBorderIcons));
    AddObject('TGridOptions', TypeInfo(TGridOptions));
  end;
end;

procedure GetTypeInfoForOrdinal(AOrdTypeInfo: PTypeInfo; AStrings: TStrings);
var
  // OrdTypeInfo: PTypeInfo;
  OrdTypeData: PTypeData;

  TypeNameStr: String;
  TypeKindStr: String;
  MinVal, MaxVal: Integer;
  i: integer;
begin

  // Get the TTypeData pointer
  OrdTypeData := GetTypeData(AOrdTypeInfo);

  // Get the type name string
  TypeNameStr := AOrdTypeInfo.Name;
  // Get the type kind string
  TypeKindStr := GetEnumName(TypeInfo(TTypeKind), Integer(AOrdTypeInfo^.Kind));

  // Get the minimum and maximum values for the type
  MinVal := OrdTypeData^.MinValue;
  MaxVal := OrdTypeData^.MaxValue;

  // Add the information to the memo
  with AStrings do
  begin
    Add('Type Name: '+TypeNameStr);
    Add('Type Kind: '+TypeKindStr);

    // Call this function recursively to show the enumeration
    // values for this set type.
    if AOrdTypeInfo^.Kind = tkSet then
    begin
      Add('=====');
      Add('');
```

```
    GetTypeInfoForOrdinal(OrdTypeData^.CompType^, AStrings);
end;

// Show the values and names of the enumerated types belonging to the
// set.
if AOrdTypeInfo^.Kind = tkEnumeration then
begin
    Add('Min Val: '+IntToStr(MinVal));
    Add('Max Val: '+IntToStr(MaxVal));

    for i := MinVal to MaxVal do
        Add(Format(' Value: %d Name: %s', [i,
            GetEnumName(AOrdTypeInfo, i)]));
    end;
end;

end;

procedure TMainForm.lbSampsClick(Sender: TObject);
begin
    memInfo.Lines.Clear;
    with lbSamps do
        GetTypeInfoForOrdinal(PTypeInfo(Items.Objects[ItemIndex]), memInfo.Lines);
end;
end.
```

In this demo, we set up two set types in a list box. We add the pointer to the `TTypeInfo` structures for these two types to the `Objects` array of the list box by using the `TypeInfo()` function. When the user selects one of the items in the list box, the `GetTypeInfoForOrdinal()` procedure is called, passing both the `PTypeInfo` pointer and the `memInfo.Lines` property that's populated with the RTTI data.

The `GetTypeInfoForOrdinal()` procedure goes through the same steps you've already seen for getting the pointer to the type's `TTypeData` structure. This initial type information is stored to the `TStrings` parameter and then the `GetTypeInfoForOrdinal()` is called recursively, passing `OrdTypeData^.CompType^`, which refers to the enumerated data type for the set. This RTTI data is also added to the same `TStrings` property.

Assigning Values to Properties Through RTTI

Now that we've shown you how to find and determine which published properties exist for components, we ought to show you how to assign values to properties through RTTI. This task is simple. The `TypeInfo.pas` unit contains many helper routines to allow you to interrogate and manipulate component-published properties. These are the same helper routines used by the Delphi IDE (Object Inspector). It would be a good idea to open `TypeInfo.pas` and to familiarize yourself with these routines. We'll demonstrate a few of them here.

Suppose you want to assign an integer value to a property for a given component. Also suppose that you do not know whether this property exists on that component. Here's a procedure that assigns an integer value to a property for a given component, but only if that property exists:

```

procedure SetIntegerPropertyIfExists(AComp: TComponent; APropName: String;
  AValue: Integer);
var
  PropInfo: PPropInfo;
begin
  PropInfo := GetPropInfo(AComp.ClassInfo, APropName);
  if PropInfo <> nil then
    begin
      if PropInfo^.PropType^.Kind = tkInteger then
        SetOrdProp(AComp, PropInfo, Integer(AValue));
    end;
end;

```

This procedure takes three parameters. The first, `AComp`, is the component whose property you want to modify. The second parameter, `APropName`, is the name of the property to which you want to assign the value of the third parameter, `AValue`. This procedure uses the `GetPropInfo()` function to retrieve the `TPropInfo` pointer on the specified property. `GetPropInfo()` will return `nil` if the property does not exist. If the property does exist, the second `if` clause determines whether the property is of the correct type. The property type `tkInteger` is defined in the `TypeInfo.pas` unit along with other possible property types, as shown here:

```

TTypeKind = (tkUnknown, tkInteger, tkChar, tkEnumeration, tkFloat,
  tkString, tkSet, tkClass, tkMethod, tkWChar, tkLString, tkWString,
  tkVariant, tkArray, tkRecord, tkInterface, tkInt64, tkDynArray);

```

Finally, the assignment is made to the property using the `SetOrdProp()` procedure, another helper routine from `TypeInfo.pas` used to set values to ordinal-type properties. The call to this procedure might look something like the following:

```

SetIntegerPropertyIfExists(Button2, 'Width', 50);

```

`SetOrdProp()` is referred to as a “setter” method, a method used to set a value to a property. There is also a “getter” method, which retrieves the property value. There are several of these `SetXXXProp()` helper routines in the `TypeInfo.pas` unit for the possible property types, as shown in Table 20.6.

TABLE 20.6 Getter and Setter methods.

<i>Property Type</i>	<i>Setter Method</i>	<i>Getter Method</i>
Ordinal	<code>SetOrdProp()</code>	<code>GetOrdProp()</code>
Enumerated	<code>SetEnumProp()</code>	<code>GetEnumProp()</code>

<i>Property Type</i>	<i>Setter Method</i>	<i>Getter Method</i>
Objects	SetObjectProp()	GetObjectProp()
String	SetStrProp()	GetStrProp()
Floating Point	SetFloatProp()	GetFloatProp()
Variant	SetVariantProp()	GetVariantProp()
Methods (Events)	SetMethodProp()	GetMethodProp()
Int64	SetInt64Prop()	GetInt64Prop()

Again, there are many other helper routines you'll find useful in `TypeInfo.pas`.

The following code shows how to assign an object property:

```
procedure SetObjectPropertyIfExists(AComponent: TComponent; APropName: String;
  AValue: TObject);
var
  PropInfo: PPropInfo;
begin
  PropInfo := GetPropInfo(AComponent.ClassInfo, APropName);
  if PropInfo <> nil then
    begin
      if PropInfo^.PropType^.Kind = tkClass then
        SetObjectProp(AComponent, PropInfo, AValue);
    end;
end;
```

This method might be called as follows:

```
var
  F: TFont;
begin
  F := TFont.Create;
  F.Name := 'Arial';
  F.Size := 24;
  F.Color := clRed;
  SetObjectPropertyIfExists(Pane11, 'Font', F);
end;
```

The following code shows how to assign a method property:

```
procedure SetMethodPropertyIfExists(AComp: TComponent; APropName: String;
  AMethod: TMethod);
var
  PropInfo: PPropInfo;
begin
  PropInfo := GetPropInfo(AComp.ClassInfo, APropName);
  if PropInfo <> nil then
```

```
begin
  if PropInfo^.PropType^.Kind = tkMethod then
    SetMethodProp(AComp, PropInfo, AMethod);
end;
end;
```

This method requires the use of the `TMethod` type, which is defined in the `SysUtils.pas` unit. To call this method to assign an event handler from one component to another, you can use `GetMethodProp` to retrieve the `TMethod` value from the source component, as shown here:

```
SetMethodPropertyIfExists(Button5, 'OnClick',
  GetMethodProp(Pane11, 'OnClick'));
```

The accompanying CD-ROM has a project, `SetProperties.dpr`, that demonstrates these routines.

Summary

This chapter introduced you to the Visual Component Library. We discussed the VCL hierarchy and the special characteristics of components at different levels in the hierarchy. We also covered RTTI in depth. This chapter prepared you for the following chapters, which cover component writing.

Writing Delphi Custom Components

CHAPTER

21

IN THIS CHAPTER

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Container Components 976**
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The ability to easily write custom components in Delphi 5 is a chief productivity advantage that you wield over other programmers. In most other environments, folks are stuck using the standard controls available through Windows or else have to use an entirely different set of complex controls that were developed by somebody else. Being able to incorporate your custom components into your Delphi applications means that you have complete control over the application's user interface. Custom controls give you the final say in your application's look and feel.

If your forte is component design, you will appreciate all the information this chapter has to offer. You will learn about all aspects of component design from concept to integration into the Delphi environment. You will also learn about the pitfalls of component design, as well as some tips and tricks to developing highly functional and extensible components.

Even if your primary interest is application development and not component design, you will get a great deal out of this chapter. Incorporating a custom component or two into your programs is an ideal way to spice up and enhance the productivity of your applications. Invariably, you will get caught in a situation while writing your application where, of all the components at your disposal, none is quite right for some particular task. That's where component design comes in. You will be able to tailor a component to meet your exact needs, and hopefully design it smart enough to use again and again in subsequent applications.

Component Building Basics

The following sections teach you the basic skills required to get you started in writing components. Then, we show you how to apply those skills by demonstrating how we designed some useful components.

Deciding Whether to Write a Component

Why go through the trouble of writing a custom control in the first place when it's probably less work to make do with an existing component or hack together something quick and dirty that "will do"? There are a number of reasons to write your own custom control:

- You want to design a new user-interface element that can be used in more than one application.
- You want to make your application more robust by separating its elements into logical object-oriented classes.
- You cannot find an existing Delphi component or ActiveX control that suits your needs for a particular situation.
- You recognize a market for a particular component, and you want to create a component to share with other Delphi developers for fun or profit.
- You want to increase your knowledge of Delphi, VCL internals, and the Win32 API.

One of the best ways to learn how to create custom components is from the people who invented them. Delphi's VCL source code is an invaluable resource for component writers, and it is highly recommended for anyone who is serious about creating custom components. The VCL source code is included in the Client Server and Professional versions of Delphi.

Writing custom components can seem like a pretty daunting task, but don't believe the hype. Writing a custom component is only as hard or as easy as you make it. Components can be tough to write, of course, but you also can create very useful components fairly easily.

Component Writing Steps

Assuming that you have already defined a problem and have a component-based solution, here are the important points in creating a component—from concept to deployment.

- First, you need an idea for a useful and hopefully unique component.
- Next, sit down and map out the algorithm for how the component will work.
- Start with the preliminaries—don't jump right into the component. Ask yourself, "What do I need up front to make this component work?"
- Try to break up the construction of your component into logical portions. This will not only modularize and simplify the creation of the component, but it also will help you to write cleaner, more organized code. Design your component with the thought that someone else might try to create a descendant component.
- Test your component in a test project first. You will be sorry if you immediately add it to the Component Palette.
- Finally, add the component and an optional bitmap to the Component Palette. After a little fine-tuning, it will be ready for you to drop into your Delphi applications.

There are six basic steps to writing your Delphi component.

1. Deciding on an ancestor class.
2. Creating the Component Unit.
3. Adding properties, methods, and events to your new component.
4. Testing your component.
5. Registering your component with the Delphi environment.
6. Creating a help file for your component.

In this chapter, we will discuss the first five steps; however, it is beyond the scope of this chapter to get into the topic of writing help files. However, this does not mean that this step is any less important than the others. We recommend that you look into some of the third-party tools available that simplify writing help files. Also, Borland provides information on how to do this

in their online help. Look up “Providing Help for Your Component” in the online help for more information.

Deciding on an Ancestor Class

In Chapter 20, “Key Elements of the Visual Component Library,” we discussed the VCL hierarchy and the special purposes of the different classes at the different hierarchical levels. We wrote about four basic components from which your components will descend: standard controls, custom controls, graphical controls, and non-visual components. For instance, if you need to simply extend the behavior of an existing Win32 control such as `TMemo`, you’ll be extending a standard control. If you need to define an entirely new component class, you’ll be dealing with a custom control. Graphical controls let you create components that have a visual effect, but don’t take up Win32 resources. Finally, if you want to create a component that can be edited from Delphi’s Object Inspector but doesn’t necessarily have a visual characteristic, you’ll be creating a non-visual component. Different VCL classes represent these different types of components. You might want to review Chapter 20 unless you’re quite comfortable with these concepts. Table 21.1 gives you a quick reference.

Table 21.1 VCL Classes as Component-Based Classes

<i>VCL Class</i>	<i>Types of Custom Controls</i>
<code>TObject</code>	Although classes descending directly from <code>TObject</code> are not components, strictly speaking, they do merit mention. You will use <code>TObject</code> as a base class for many things that you don’t need to work with at design time. A good example is the <code>TIniFile</code> object.
<code>TComponent</code>	A starting point for many non-visual components. Its forte is that it offers built-in streaming capability to load and save itself in the IDE at design time.
<code>TGraphicControl</code>	Use this class when you want to create a custom component that has no window handle. <code>TGraphicControl</code> descendants are drawn on their parent’s client surface, so they are easier on resources.
<code>TWinControl</code>	This is the base class for all components that require a window handle. It provides you with common properties and events specific to windowed controls.
<code>TCustomControl</code>	This class descends from <code>TWinControl</code> . It introduces the concepts of a canvas and a <code>Paint()</code> method to give you greater control over the component’s appearance. Use this class for most of your window-handled custom component needs.

<i>VCL Class</i>	<i>Types of Custom Controls</i>
<code>TCustomClassName</code>	The VCL contains several classes that do not publish all their properties; they leave it up to descendant classes to do. This allows component developers to create “custom” components from the same base class and to publish only the predefined properties required for each customized class.
<code>TComponentName</code>	An existing class such as <code>TEdit</code> , <code>TPanel</code> , or <code>TScrollBar</code> . Use an already established component as a base class for your class (such as <code>TEdit</code>) and custom components when you want to extend the behavior of a control rather than create a new one from scratch. Many of your custom components will fall into this category.

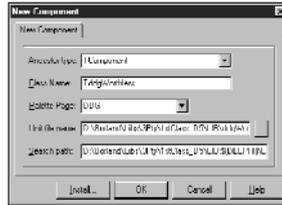
It is extremely important that you understand these various classes and also the capabilities of the existing components. The majority of the time, you’ll find that an existing component already provides most of the functionality you require of your new component. Only by knowing the capabilities of existing components will you be able to decide from which component to derive your new component. We can’t inject this knowledge into your brain from this book. What we can do is to tell you that you must make every effort to learn about each component and class within Delphi’s VCL, and the only way to do that is to use it, even if only experimentally.

Creating a Component Unit

When you have decided on a component from which your new component will descend, you can go ahead and create a unit for your new component. We’re going to go through the steps of designing a new component in the next several sections. Because we want to focus on the steps, and not on component functionality, this component will do nothing other than to illustrate these necessary steps.

The component is appropriately named `TddgWorthless`. `TddgWorthless` will descend from `TCustomControl` and will therefore have both a window handle and the capability to paint itself. This component will also inherit several properties, methods, and events already belonging to `TCustomControl`.

The easiest way to get started is to use the Component Expert, shown in Figure 21.1, to create a component unit.

**FIGURE 21.1**

The Component Expert.

You invoke the Component Expert by selecting Component, New Component. In the Component Expert, you enter the component's ancestor class name, the component's class name, the palette page on which you want the component to appear, and the unit name for the component. When you select OK, Delphi automatically creates the component unit that has the component's type declaration and a register procedure. Listing 21.1 shows the unit created by Delphi.

LISTING 21.1 Worthless.pas, a Sample Delphi Component

```

unit Worthless;
interface
uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs;
type
  TddgWorthless = class(TCustomControl)
  private
    { Private declarations }
  protected
    { Protected declarations }
  public
    { Public declarations }
  published
    { Published declarations }
  end;
procedure Register;
implementation
procedure Register;
begin
  RegisterComponents('DDG', [TddgWorthless]);
end;
end.

```

You can see that at this point `TddgWorthless` is nothing more than a skeleton component. In the following sections, you'll add properties, methods, and events to `TddgWorthless`.

Creating Properties

Chapter 20 discusses the use and advantages of using properties with your components. This section shows you how to add the various types of properties to your components.

Types of Properties

Table 20.1 in Chapter 20 lists the various property types. We're going to add properties of each of these types to the `TddgWorthless` component to illustrate the differences between each type. Each different type of property is edited a bit differently from the Object Inspector. You will examine each of these types and how they are edited.

Adding Simple Properties to Components

Simple properties refer to numbers, strings, and characters. They can be edited directly by the user from within the Object Inspector and require no special access method. Listing 21.2 shows the `TddgWorthless` component with three simple properties.

LISTING 21.2 Simple Properties

```
TddgWorthless = class(TCustomControl)
private
    // Internal Data Storage
    FIntegerProp: Integer;
    FStringProp: String;
    FCharProp: Char;
published
    // Simple property types
    property IntegerProp: Integer read FIntegerProp write FIntegerProp;
    property StringProp: String read FStringProp write FStringProp;
    property CharProp: Char read FCharProp write FCharProp;
end;
```

You should already be familiar with the syntax used here because it was discussed previously in Chapter 20. Here, you have your internal data storage for the component declared in the `private` section. The properties that refer to these storage fields are declared in the `published` section, meaning that when you install the component in Delphi, you can edit the properties in the Object Inspector.

NOTE

When writing components, the convention is to make private field names begin with the letter *F*. For components and types in general, give the object or type a name starting with the letter *T*. Your code will be much more clear if you follow these simple conventions.

Adding Enumerated Properties to Components

You can edit user-defined enumerated properties and Boolean properties in the Object Inspector by double-clicking in the `Value` section or by selecting the property value from a drop-down list. An example of such a property is the `Align` property that exists on most visual components. To create an enumerated property, you must first define the enumerated type as follows:

```
TEnumProp = (epZero, epOne, epTwo, epThree);
```

You then define the internal storage field to hold the value specified by the user. Listing 21.3 shows two enumerated property types for the `TddgWorthless` component:

LISTING 21.3 Enumerated Properties

```
TddgWorthless = class(TCustomControl)
private
    // Enumerated data types
    FEnumProp: TEnumProp;
    FBooleanProp: Boolean;
published
    property EnumProp: TEnumProp read FEnumProp write FEnumProp;
    property BooleanProp: Boolean read FBooleanProp write FBooleanProp;
end;
```

We've excluded the other properties for illustrative purposes. If you were to install this component, its enumerated properties would appear in the Object Inspector, as shown in Figure 21.2.

Adding Set Properties to Components

Set properties, when edited in the Object Inspector, appear as a set in Pascal syntax. An easier way to edit them is to expand the properties in the Object Inspector. Each set item then works in the Object Inspector like a Boolean property. To create a set property for the `TddgWorthless` component, we must first define a set type as follows:

```
TSetPropOption = (poOne, poTwo, poThree, poFour, poFive);
TSetPropOptions = set of TSetPropOption;
```


must be descendants of `TPersistent` so that their published properties can be streamed and displayed in the Object Inspector.

To define an object property for the `TddgWorthless` component, you must first define an object that will serve as this property's type. This object is shown in Listing 21.4.

LISTING 21.4 `TSomeObject` Definition

```
TSomeObject = class(TPersistent)
  private
    FProp1: Integer;
    FProp2: String;
  public
    procedure Assign(Source: TPersistent)
  published
    property Prop1: Integer read FProp1 write FProp1;
    property Prop2: String read FProp2 write FProp2;
end;
```

The `TSomeObject` class descends directly from `TPersistent`, although it does not have to. As long as the object from which the new class descends is a descendant of `TPersistent`, it can be used as another object's property.

We've given this class two properties of its own: `Prop1` and `Prop2`, which are both simple property types. We've also added a procedure, `Assign()`, to `TSomeObject`, which we'll discuss momentarily.

Now you can add a field of the type `TSomeObject` to the `TddgWorthless` component. However, because this property is an object, it must be created. Otherwise, when the user places a `TddgWorthless` component on the form, there won't be an instance of `TSomeObject` that the user can edit. Therefore, it is necessary to override the `Create()` constructor for `TddgWorthless` to create an instance of `TSomeObject`. Listing 21.5 shows the declaration of `TddgWorthless` with its new object property.

LISTING 21.5 Adding Object Properties

```
TddgWorthless = class(TCustomControl)
  private
    FSomeObject: TSomeObject;
    procedure SetSomeObject(Value: TSomeObject);
  public
    constructor Create(AOwner: TComponent); override;
    destructor Destroy; override;
  published
```

```
property SomeObject: TSomeObject read FSomeObject write SetSomeObject;  
end;
```

Notice that we've included the overridden `Create()` constructor and `Destroy()` destructor. Also, notice that we've declared a write access method, `SetSomeObject()`, for the `SomeObject` property. A write access method is often referred to as a *writer method* or *setter method*. Read access methods are called *reader* or *getter methods*. If you recall from Chapter 20, writer methods must have one parameter of the same type as the property to which they belong. By convention, the name of the writer method usually begins with `Set`.

We've defined the `TddgWorthless.Create()` constructor as follows:

```
constructor TddgWorthless.Create(AOwner: TComponent);  
begin  
    inherited Create(AOwner);  
    FSomeObject := TSomeObject.Create;  
end;
```

Here, we first call the inherited `Create()` constructor and then create the instance of the `TSomeObject` class. Because `Create()` is called both when the user drops the component on the form at design time and when the application is run, you can be assured that `FSomeObject` will always be valid.

You must also override the `Destroy()` destructor to free the object before you free the `TddgWorthless` component. The code to do this follows.

```
destructor TddgWorthless.Destroy;  
begin  
    FSomeObject.Free;  
    inherited Destroy;  
end;
```

Now that we've shown how to create the instance of `TSomeObject`, consider what would happen if at runtime the user executes the following code:

```
var  
    MySomeObject: TSomeObject;  
begin  
    MySomeObject := TSomeObject.Create;  
    ddgWorthless.SomeObjectj := MySomeObject;  
end;
```

If the `TddgWorthless.SomeObject` property were defined without a writer method like the following, when the user assigns their own object to the `SomeObject` field, the previous instance that `FSomeObject` referred to would be lost:

```
property SomeObject: TSomeObject read FSomeObject write FSomeObject;
```

If you recall from Chapter 2, “The Object Pascal Language,” object instances are really pointer references to the actual object. When you make an assignment, as shown in the preceding example, you refer the pointer to another object instance while the previous object instance still hangs around. When designing components, you want to avoid having to place conditions on your users when accessing properties. To prevent this pitfall, you foolproof your component by creating access methods for properties that are objects. These access methods can then ensure that no resources get lost when the user assigns new values to these properties. The access method for `SomeObject` does just that and is shown here:

```
procedure TddgWorthLess.SetSomeObject(Value: TSomeObject);
begin
    if Assigned(Value) then
        FSomeObject.Assign(Value);
end;
```

The `SetSomeObject()` method calls the `FSomeObject.Assign()`, passing it the new `TSomeObject` reference. `TSomeObject.Assign()` is implemented as follows:

```
procedure TSomeObject.Assign(Source: TPersistent);
begin
    if Source is TSomeObject then
        begin
            FProp1 := TSomeObject(Source).Prop1;
            FProp2 := TSomeObject(Source).Prop2;
            inherited Assign(Source);
        end;
end;
```

In `TSomeObject.Assign()`, you first ensure that the user has passed in a valid `TSomeObject` instance. If so, you then copy the property values from `Source` accordingly. This illustrates another technique you’ll see throughout the VCL for assigning objects to other objects. If you have the VCL source code, you might take a look at the various `Assign()` methods such as `TBrush` and `TShape` to see how they are implemented. This would give you some ideas on how to implement them in your components.

CAUTION

Never make an assignment to a property in a property’s writer method. For example, examine the following property declaration:

```
property SomeProp: integer read FSomeProp write SetSomeProp;
    ....
    procedure SetSomeProp(Value:integer);
    begin
        SomeProp := Value; // This causes infinite recursion }
    end;
```

Because you are accessing the property itself (not the internal storage field), you cause the `SetSomeProp()` method to be called again, which results in a recursive loop. Eventually, the program will crash with a stack overflow. Always access the internal storage field in the writer method of a property.

Adding Array Properties to Components

Some properties lend themselves to being accessed as though they were arrays. That is, they contain a list of items that can be referenced with an index value. The actual items referenced can be of any object type. Examples of such properties are `TScreen.Fonts`, `TMemo.Lines`, and `TDBGrid.Columns`. Such properties require their own property editors. We will get into creating property editors later in the next chapter. Therefore, we will not go into detail on creating array properties that have a list of different object types until later. For now, we'll show a simple method for defining a property that can be indexed as though it were an array of items, yet contains no list at all.

We're going to put aside the `TddgWorthless` component for a moment and instead look at the `TddgPlanets` component. `TddgPlanets` contains two properties: `PlanetName` and `PlanetPosition`. `PlanetName` will be an array property that returns the name of the planet based on the value of an integer index. `PlanetPosition` won't use an integer index, but rather a string index. If this string is one of the planet names, the result will be the planet's position in the solar system.

For example, the following statement will display the string "Neptune" by using the `TddgPlanets.PlanetName` property:

```
ShowMessage(ddgPlanets.PlanetName[8]);
```

Compare the difference when the sentence "From the sun, Neptune is planet number: 8" is generated from the following statement:

```
ShowMessage('From the sun, Neptune is planet number: '+  
  IntToStr(ddgPlanets.PlanetPosition['Neptune']));
```

Before we show you this component, we list some key characteristics of array properties that differ from the other properties we've mentioned.

- Array properties are declared with one or more index parameters. These indexes can be of any simple type. For example, the index may be an integer or a string, but not a record or a class.
- Both the read and write property access directives must be methods. They cannot be one of the component's fields.

- If the array property is indexed by multiple index values, that is, the property represents a multidimensional array, the access method must include parameters for each index in the same order as defined by the property.

Now we'll get to the actual component shown in Listing 21.6.

LISTING 21.6 Using TddgPlanets to Illustrate Array Properties

```
unit planets;

interface

uses
  Classes, SysUtils;

type

  TddgPlanets = class(TComponent)
  private
    // Array property access methods
    function GetPlanetName(const AIndex: Integer): String;
    function GetPlanetPosition(const APlanetName: String): Integer;
  public
    { Array property indexed by an integer value. This will be the default
      array property. }
    property PlanetName[const AIndex: Integer]: String
      read GetPlanetName; default;
    // Array property index by a string value
    property PlanetPosition[const APlanetName: String]: Integer
      read GetPlanetPosition;
  end;

implementation

const
  // Declare a constant array containing planet names
  PlanetNames: array[1..9] of String[7] =
    ('Mercury', 'Venus', 'Earth', 'Mars', 'Jupiter', 'Saturn',
     'Uranus', 'Neptune', 'Pluto');

function TddgPlanets.GetPlanetName(const AIndex: Integer): String;
begin
  { Return the name of the planet specified by Index. If Index is
    out of the range, then raise an exception }
  if (AIndex < 0) or (AIndex > 9) then
    raise Exception.Create('Wrong Planet number, enter a number 1-9')
```

```
    else
        Result := PlanetNames[AIndex];
end;

function TddgPlanets.GetPlanetPosition(const APlanetName: String): Integer;
var
    i: integer;
begin
    Result := 0;
    i := 0;
    { Compare PName to each planet name and return the index of the
      appropriate position where PName appears in the constant array.
      Otherwise return zero. }
    repeat
        inc(i);
    until (i = 10) or (CompareStr(UpperCase(APlanetName),
        UpperCase(PlanetNames[i])) = 0);

    if i <> 10 then // A Planet name was found
        Result := i;
end;

end.
```

This component gives you an idea of how you would create an array property with both an integer and a string being used as an index. Notice how the value returned from reading the property's value is based on the function return value and not a value from a storage field, as is the case with the other properties. You can refer to the code's comments for additional explanation on this component.

Default Values

You can give a property a default value by assigning a value to the property in the component's constructor. Therefore, if we added the following statement to the constructor of the `TddgWorthless` component, its `FIntegerProp` property would always default to 100 when the component is first placed onto the form:

```
FIntegerProp := 100;
```

This is probably the best place to mention the `Default` and `NoDefault` directives for property declarations. If you've looked at Delphi's VCL source code, you've probably noticed that some property declarations contain the `Default` directive, as is the case with the `TComponent.FTag` property:

```
property Tag: Longint read FTag write FTag default 0;
```

Don't confuse this statement with the default value specified in the component's constructor that actually sets the property value. For example, change the declaration of the `IntegerProp` property for the `TddgWorthless` component to read as follows:

```
property IntegerProp: Integer read FIntegerProp write FIntegerProp default 100;
```

This statement does not set the value of the property to `100`. This only affects whether or not the property value is saved when you save a form containing the `TddgWorthless` component. If `IntegerProp`'s value is not `100`, the value will be saved to the DFM file. Otherwise, it does not get saved (because `100` is what the property value will be in a newly constructed object prior to reading its properties from the stream). It is recommended that you use the `Default` directive whenever possible because it may speed up the load time of your forms. It is important that you realize that the `Default` directive does not set the value of the property. You must do that in the component's constructor, as was shown previously.

The `NoDefault` directive is used to re-declare a property that specifies a default value, so that it will always be written to the stream regardless of its value. For example, you can re-declare your component to not specify a default value for the `Tag` property:

```
TSample = class(TComponent)
published
    property Tag NoDefault;
```

Note that you should never declare anything `NoDefault` unless you have a specific reason. An example of such a property is `TForm.PixelsPerInch`, which must always be stored so that scaling will work right at runtime. Also, string, floating point, and `int64` type properties cannot declare default values.

To change a property's default value, you re-declare it by using the new default value (but no reader or writer methods).

Default Array Properties

You can declare an array property so that it is the default property for the component to which it belongs. This allows the component user to use the object instance as though it were an array variable. For example, using the `TddgPlanets` component, we declared the `TddgPlanets.PlanetName` property with the `default` keyword. By doing this, the component user is not required to use the property name, `PlanetName`, in order to retrieve a value. One simply has to place the index next to the object identifier. Therefore, the following two lines of code will produce the same result:

```
ShowMessage(ddgPlanets.PlanetName[8]);
ShowMessage(ddgPlanets[8]);
```

Only one default array property can be declared for an object, and it cannot be overridden in descendants.

Creating Events

In Chapter 20, we introduced events and told you that events were special properties linked to code that gets executed whenever a particular action occurs. In this section, we're going to discuss events in more detail. We'll show you how events are generated and how you can define your own event properties for your custom components.

Where Do Events Come From?

The general definition of an event is basically any type of occurrence that might result from user interaction, the system, or from code logic. The event is linked to some code that responds to that occurrence. The linkage of the event to code that responds to an event is called an *event property* and is provided in the form of a method pointer. The method to which an event property points is called an *event handler*.

For example, when the user clicks the mouse button, a `WM_MOUSEBUTTONDOWN` message is sent to the Win32 system. Win32 passes that message to the control for which the message was intended. This control can then respond to the message. The control can respond to this event by first checking to see whether there is any code to execute. It does this by checking to see whether the event property points to any code. If so, it executes that code, or rather, the event handler.

The `OnClick` event is just one of the standard event properties defined by Delphi. `OnClick` and other event properties each have a corresponding *event-dispatching method*. This method is typically a protected method of the component to which it belongs. This method performs the logic to determine whether the event property refers to any code provided by the user of the component. For the `OnClick` property, this would be the `Click()` method. Both the `OnClick` property and the `Click()` method are defined by `TControl` as follows:

```
TControl = class(TComponent)
private
    FOnClick: TNotifyEvent;
protected
    procedure Click; dynamic;
    property OnClick: TNotifyEvent read FOnClick write FOnClick;
end;
```

Here is the `TControl.Click()` method:

```
procedure TControl.Click;
begin
    if Assigned(FOnClick) then FOnClick(Self);
end;
```

One bit of essential information that you must understand is that event properties are nothing more than method pointers. Notice that the `FOnClick` property is defined to be a `TNotifyEvent`. `TNotifyEvent` is defined as follows:

```
TNotifyEvent = procedure(Sender: TObject) of object;
```

This says that `TNotifyEvent` is a procedure that takes one parameter, `Sender`, which is of the type `TObject`. The directive, `of object`, is what makes this procedure become a method. This means that an additional *implicit* parameter that you do not see in the parameter list also gets passed to this procedure. This is the `Self` parameter that refers to the object to which this method belongs. When the `Click()` method of a component is called, it checks to see if `FOnClick` actually points to a method and, if so, calls that method.

As a component writer, you write all the code that defines your event, your event property, and your dispatching methods. The component user will provide the event handler when they use your component. Your event-dispatching method will check to see whether the user has assigned any code to your event property and then execute it when code exists.

In Chapter 20, we discussed how event handlers are assigned to event properties either at run-time or at design time. In the following section, we show you how to create your own events, event properties, and dispatching methods.

Defining Event Properties

Before you define an event property, you need to determine whether you need a special event type. It helps to be familiar with the common event properties that exist in the Delphi VCL. Most of the time, you'll be able to have your component descend from one of the existing components and just use its event properties, or you might have to surface a protected event property. If you determine that none of the existing events meet your needs, you can define your own.

As an example, consider the following scenario. Suppose you want a component that contains an event that gets called every half-minute based on the system clock. That is, it gets invoked on the minute and on the half-minute. Well, you can certainly use a `TTimer` component to check the system time and then perform some action whenever the time is at the minute or half-minute. However, you might want to incorporate this code into your own component and then make that component available to your users so that all they have to do is add code to your `OnHalfMinute` event.

The `TddgHalfMinute` component shown in Listing 21.7 illustrates how you would design such a component. More importantly, it shows how you would go about creating your own event type.

LISTING 21.7 TddgHalfMinute Event Creation

```
unit halfmin;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, ExtCtrls;

type
  { Define a procedure for the event handler. The event property will
    be of this procedure type. This type will take two parameters, the
    object that invoked the event and a TDateTime value to represent
    the time that the event occurred. For our component this will be
    every half-minute. }
  TTimeEvent = procedure(Sender: TObject; TheTime: TDateTime) of object;

  TddgHalfMinute = class(TComponent)
  private
    FTimer: TTimer;
    { Define a storage field to point to the user's event handler.
      The user's event handler must be of the procedural type
      TTimeEvent. }
    FOnHalfMinute: TTimeEvent;
    FOldSecond, FSecond: Word; // Variables used in the code
    { Define a procedure, FTimerTimer that will be assigned to
      FTimer.OnClick. This procedure must be of the type TNotifyEvent
      which is the type of TTimer.OnClick. }
    procedure FTimerTimer(Sender: TObject);
  protected
    { Define the dispatching method for the OnHalfMinute event. }
    procedure DoHalfMinute(TheTime: TDateTime); dynamic;
  public
    constructor Create(AOwner: TComponent); override;
    destructor Destroy; override;
  published
    // Define the actual property that will show in the Object Inspector
    property OnHalfMinute: TTimeEvent read FOnHalfMinute write FOnHalfMinute;
  end;

implementation

constructor TddgHalfMinute.Create(AOwner: TComponent);
{ The Create constructor, creates the TTimer instanced for FTimer. It
  then sets up the various properties of FTimer, including its OnTimer
```

continues

LISTING 21.7 Continued

```
    event handler which is TddgHalfMinute's FTimerTimer() method. Notice
    that FTimer.Enabled is set to true only if the component is running
    and not while the component is in design mode. }
begin
    inherited Create(AOwner);
    // If the component is in design mode, do not enable FTimer.
    if not (csDesigning in ComponentState) then
    begin
        FTimer := TTimer.Create(self);
        FTimer.Enabled := True;
        // Set up the other properties, including the FTimer.OnTimer event handler
        FTimer.Interval := 500;
        FTimer.OnTimer := FTimerTimer;
    end;
end;

destructor TddgHalfMinute.Destroy;
begin
    FTimer.Free;
    inherited Destroy;
end;

procedure TddgHalfMinute.FTimerTimer(Sender: TObject);
{ This method serves as the FTimer.OnTimer event handler and is assigned
  to FTimer.OnTimer at run-time in TddgHalfMinute's constructor.

  This method gets the system time, and then determines whether or not
  the time is on the minute, or on the half-minute. If either of these
  conditions are true, it calls the OnHalfMinute dispatching method,
  DoHalfMinute. }
var
    DT: TDateTime;
    Temp: Word;
begin
    DT := Now; // Get the system time.
    FOldSecond := FSecond; // Save the old second.
    // Get the time values, needed is the second value
    DecodeTime(DT, Temp, Temp, FSecond, Temp);

    { If not the same second when this method was last called, and if
      it is a half minute, call DoOnHalfMinute. }
    if FSecond <> FOldSecond then
        if ((FSecond = 30) or (FSecond = 0)) then
            DoHalfMinute(DT)
```

```
end;

procedure TddgHalfMinute.DoHalfMinute(TheTime: TDateTime);
{ This method is the dispatching method for the OnHalfMinute event.
  it checks to see if the user of the component has attached an
  event handler to OnHalfMinute and if so, calls that code. }
begin
  if Assigned(FOnHalfMinute) then
    FOnHalfMinute(Self, TheTime);
end;

end.
```

When creating your own events, you must determine what information you want to provide to users of your component as a parameter in the event handler. For example, when you create an event handler for the `TEdit.OnKeyPress` event, your event handler looks like the following code:

```
procedure TForm1.Edit1KeyPress(Sender: TObject; var Key: Char);
begin
end;
```

Not only do you get a reference to the object that caused the event, but you also get a `Char` parameter specifying the key that was pressed. Deep in the Delphi VCL, this event occurred as a result of a `WM_CHAR Win32` message that drags along some additional information relating to the key pressed. Delphi takes care of extracting the necessary data and making it available to component users as event handler parameters. One of the nice things about the whole scheme is that it enables component writers to take information that might be somewhat complex to understand and make it available to component users in a much more understandable and easy-to-use format.

Notice the `var` parameter in the preceding `Edit1KeyPress()` method. You might be wondering why this method was not declared as a function that returns a `Char` type instead of a procedure. Although method types can be functions, you should not declare events as functions because it will introduce ambiguity; when you refer to a method pointer that is a function, you can't know whether you're referring to the function result or to the function pointer value itself. By the way, there is one function event in the VCL that slipped past the developers from the Delphi 1 days and now it must remain. This event is the `TApplication.OnHelp` event.

Looking at Listing 21.7, you'll see that we've defined the procedure type `TOnHalfMinute` as this:

```
TTimeEvent = procedure(Sender: TObject; TheTime: TDateTime) of object;
```

This procedure type defines the procedure type for the `OnHalfMinute` event handler. Here, we decided that we want the user to have a reference to the object causing the event to occur and the `TDateTime` value of when the event occurred.

The `FOnHalfMinute` storage field is the reference to the user's event handler and is surfaced to the Object Inspector at design time through the `OnHalfMinute` property.

The basic functionality of the component uses a `TTimer` object to check the seconds value every half second. If the seconds value is 0 or 30, it invokes the `DoHalfMinute()` method, which is responsible for checking for the existence of an event handler and then calling it. Much of this is explained in the code's comments, which you should read over.

After installing this component to Delphi's Component Palette, you can place the component on the form and add the following event handler to the `OnHalfMinute` event:

```
procedure TForm1.ddgHalfMinuteHalfMinute(Sender: TObject; TheTime: TDateTime);
begin
    ShowMessage('The Time is '+TimeToStr(TheTime));
end;
```

This should illustrate how your newly defined event type becomes an event handler.

Creating Methods

Adding methods to components is no different than adding methods to other objects. However, there are a few guidelines that you should always take into account when designing components.

No Interdependencies!

One of the key goals behind creating components is to simplify the use of the component for the end user. Therefore, you will want to avoid any method interdependencies as much as possible. For example, you never want to force the user to have to call a particular method in order to use the component, and methods should not have to be called in any particular order. Also, methods called by the user should not place the component in a state that makes other events or methods invalid. Finally, you will want to give your methods meaningful names so that the user does not have to try to guess what a method does.

Method Exposure

Part of designing a component is to know what methods to make private, public, or protected. You must take into account not only users of your component, but also those who might use your component as an ancestor for yet another custom component. Table 21.2 will help you decide what goes where in your custom component.

Table 21.2 Private, Protected, Public, or Published?

<i>Directive</i>	<i>What Goes There?</i>
Private	Instance variables and methods that you do not want the descendant type to be able to access or modify. Typically, you will give access to some private instance variables through properties that have <code>read</code> and <code>write</code> directives set in such a way as to help prevent the users from shooting themselves in the foot. Therefore, you want to avoid giving access to any methods that are property-implementation methods.
Protected	Instance variables, methods, and properties that you want descendant classes to be able to access and modify—but not users of your class. It is a common practice to place properties in the protected section of a base class for descendant classes to publish at their discretion.
Public	Methods and properties that you want to have accessible to any user of your class. If you have properties that you want to be accessible at runtime, but not at design time, this is the place to put them.
Published	Properties that you want to be placed on the Object Inspector at design time. <i>Runtime Type Information (RTTI)</i> is generated for all properties in this section.

Constructors and Destructors

When creating a new component, you have the option of overriding the ancestor component's constructor and defining your own. You should keep a few precautions in mind when doing so.

Overriding Constructors

Always make sure to include the `override` directive when declaring a constructor on a `TComponent` descendant class. Here's an example:

```
TSomeComponent = class(TComponent)
private
  { Private declarations }
protected
  { Protected declarations }
public
  constructor Create(AOwner: TComponent); override;
published
  { Published declarations }
end;
```

NOTE

The `Create()` constructor is made virtual at the `TComponent` level. Non-component classes have static constructors that are invoked from within the constructor of `TComponent` classes. Therefore, if you are creating a non-component, descendant class such as the following, the constructor cannot be overridden because it is not virtual:

```
TMyObject = class(TPersistent)
```

You simply re-declare the constructor in this instance.

Although not adding the override directive is syntactically legal, it can cause problems when using your component. This is because when you use the component (both at design time and at runtime), the non-virtual constructor won't be called by code that creates the component through a class reference (such as the streaming system).

Also, be sure that you call the inherited constructor inside your constructor's code:

```
constructor TSomeComponent.Create(AOwner: TComponent);
begin
    inherited Create(AOwner);
    // Place your code here.
end;
```

Design-Time Behavior

Remember that your component's constructor is called whenever the component is created. This includes the component's design-time creation—when you place it on the form. You might want to prevent certain actions from occurring when the component is being designed. For example, in the `TddgHalfMinute` component, you created a `TTimer` component inside the component's constructor. Although it doesn't hurt to do this, it can be avoided by making sure that the `TTimer` is only created at runtime.

You can check the `ComponentState` property of a component to determine its current state. Table 21.3 lists the various component states, as shown in Delphi 5's online help.

Table 21.3 Component State Values

<i>Flag</i>	<i>Component State</i>
<code>csAncestor</code>	Set if the component was introduced in an ancestor form. Only set if <code>csDesigning</code> is also set.
<code>csDesigning</code>	Design mode, meaning it is in a form being manipulated by a form designer.
<code>csDestroying</code>	The component is about to be destroyed.

<i>Flag</i>	<i>Component State</i>
csFixups	Set if the component is linked to a component in another form that has not yet been loaded. This flag is cleared when all pending fixups are resolved.
csLoading	Loading from a filer object.
csReading	Reading its property values from a stream.
csUpdating	The component is being updated to reflect changes in an ancestor form. Only set if csAncestor is also set.
csWriting	Writing its property values to a stream.

You will mostly use the `csDesigning` state to determine whether your component is in design mode. You can do this with the following statement:

```
inherited Create(AOwner);  
if csDesigning in ComponentState then  
  { Do your stuff }
```

You should note that the `csDesigning` state is uncertain until after the inherited constructor has been called and the component is being created with an owner. This is almost always the case in the IDE form designer.

Overriding Destructors

The general guideline to follow when overriding destructors is to make sure you call the inherited destructor only after you free up resources allocated by your component, not before. The following code illustrates this:

```
destructor TMyComponent.Destroy;  
begin  
  FTimer.Free;  
  MyStrings.Free;  
  inherited Destroy;  
end;
```

TIP

As a rule of thumb, when you override constructors, you usually call the inherited constructor first, and when you override destructors, you usually call the inherited destructor last. This ensures that the class has been set up before you modify it and that all dependent resources have been cleaned up before you dispose of a class.

There are exceptions to this rule, but you generally should stick with it unless you have good reason not to.

Registering Your Component

Registering the component tells Delphi which component to place on the Component Palette. If you used the Component Expert to design your component, you don't have to do anything here because Delphi has already generated the code for you. However, if you are creating your component manually, you'll need to add the `Register()` procedure to your component's unit.

All you have to do is add the procedure `Register()` to the interface section of the component's unit.

The `Register` procedure simply calls the `RegisterComponents()` procedure for every component that you are registering in Delphi. The `RegisterComponents()` procedure takes two parameters: the name of the page on which to place the components, and an array of component types. Listing 21.8 shows how to do this.

LISTING 21.8 Registering Components

```
Unit MyComp;
interface
type
  TMyComp = class(TComponent)
    ...
  end;
  TOtherComp = class(TComponent)
    ...
  end;
procedure Register;
implementation
{ TMyComp methods }
{ TOtherCompMethods }
procedure Register;
begin
  RegisterComponents('DDG', [TMyComp, TOtherComp]);
end;
end.
```

The preceding code registers the components `TMyComp` and `TOtherComp` and places them on Delphi's Component Palette on a page labeled `DDG`.

The Component Palette

In Delphi 1 and 2, Delphi maintained a single component library file that stored all components, icons, and editors for design-time usage. Although it was sometimes convenient to have everything dealing with design in one file, it could easily get

unwieldy when many components were placed in the component library. Additionally, the more components you added to the palette, the longer it would take to rebuild the component library when adding new components.

Thanks to packages, introduced with Delphi 3, you can split up your components into several design packages. Although it's slightly more complex to deal with multiple files, this solution is significantly more configurable, and the time required to rebuild a package after adding a component is a fraction of the time it took to rebuild the component library.

By default, new components are added to a package called `DCLUSR50`, but you can create and install new design packages using the File, New, Package menu item. The CD accompanying this book contains a prebuilt design package called `DdgDsgn50.dpk` which includes the components from this book. The runtime package is named `DdgStd50.dpk`.

If your design-time support involves anything more than a call to `RegisterComponents()` (like property editors or component editors or expert registrations), you should move the `Register()` procedure and the stuff it registers into a separate unit from your component. The reason for this is that if you compile your all-in-one unit into a runtime package, and your all-in-one unit's `Register` procedure refers to classes or procedures that exist only in design-time IDE packages, your runtime package is unusable. Design-time support should be packaged separately from runtime material.

Testing the Component

Although it's very exciting when you finally write a component and are in the testing stages, don't get carried away by trying to add your component to the Component Palette before it has been debugged sufficiently. You should do all preliminary testing with your component by creating a project that creates and uses a dynamic instance of the component. The reason for this is that your component lives inside the IDE when it is used at design time. If your component contains a bug that corrupts memory, for example, it might crash the IDE as well. Listing 21.9 depicts a unit for testing the `TddgExtendedMemo` component that will be created later in this chapter. This project can be found on the CD in the project `TestEMem.dpr`.

LISTING 21.9 Testing the `TddgExtendedMemo` Component

```
unit MainFrm;  
  
interface  
  
uses
```

continues

LISTING 21.9 Continued

```
Windows, Messages, SysUtils, Classes, Graphics, Controls,
Forms, Dialogs, StdCtrls, exmemo, ExtCtrls;

type

  TMainForm = class(TForm)
    btnCreateMemo: TButton;
    btnGetRowCol: TButton;
    btnSetRowCol: TButton;
    edtColumn: TEdit;
    edtRow: TEdit;
    Panel1: TPanel;
    procedure btnCreateMemoClick(Sender: TObject);
    procedure btnGetRowColClick(Sender: TObject);
    procedure btnSetRowColClick(Sender: TObject);
  public
    EMemo: TddgExtendedMemo; // Declare the component.
    procedure OnScroll(Sender: TObject);
  end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.btnCreateMemoClick(Sender: TObject);
begin
  { Dynamically create the component. Make sure to make the appropriate
    property assignments so that the component can be used normally.
    These assignments depend on the component being tested }
  if not Assigned(EMemo) then
  begin
    EMemo := TddgExtendedMemo.Create(self);
    EMemo.Parent := Panel1;
    EMemo.ScrollBars := ssBoth;
    EMemo.WordWrap := True;
    EMemo.Align := alClient;
    // Assign event handlers to untested events.
    EMemo.OnVScroll := OnScroll;
    EMemo.OnHScroll := OnScroll;
  end;
end;
```

```
{ Write whatever methods are required to test the run-time behavior
  of the component. This includes methods to access each of the
  new properties and methods belonging to the component.
```

Also, create event handlers for user-defined events so that you can test them. Since you're creating the component at run-time, you have to manually assign the event handlers as was done in the above `Create()` constructor.

```
}
procedure TMainForm.btnGetRowColClick(Sender: TObject);
begin
  if Assigned(EMemo) then
    ShowMessage(Format('Row: %d Column: %d', [EMemo.Row, EMemo.Column]));
  EMemo.SetFocus;
end;

procedure TMainForm.btnSetRowColClick(Sender: TObject);
begin
  if Assigned(EMemo) then
  begin
    EMemo.Row := StrToInt(edtRow.Text);
    EMemo.Column := StrToInt(edtColumn.Text);
    EMemo.SetFocus;
  end;
end;

procedure TMainForm.OnScroll(Sender: TObject);
begin
  MessageBeep(0);
end;

end.
```

Keep in mind that even testing the component at design time doesn't mean that your component is foolproof. Some design-time behavior can still raise havoc with the Delphi IDE, such as not calling the inherited `Create()` constructor.

NOTE

You cannot assume that your component has been created and set up by the design-time environment. Your component must be fully usable after only the `Create()` constructor has executed. Therefore, you should not treat the `Loaded()` method as part of the component construction process. The `Loaded()` method is called only when the

continues

component is loaded from a stream—such as when it is placed in a form built at design time. `Loaded()` marks the end of the streaming process. If your component was simply created (not streamed), `Loaded()` is not called.

Providing a Component Icon

No custom component would be complete without its own icon for the Component Palette. To create one of these icons, use Delphi's Image Editor (or your favorite bitmap editor) to create a 24×24 bitmap on which you will draw the component's icon. This bitmap must be stored within a DCR file. A file with a `.dcr` extension is nothing more than a renamed RES file. Therefore, if you store your icon in a RES file, you can simply rename it to a DCR file.

TIP

Even if you have a 256 or higher color driver, save your Component Palette icon as a 16-color bitmap if you plan on releasing the component to others. Your 256-color bitmaps most likely will look awful on machines running 16-color drivers.

After you create the bitmap in the DCR file, give the bitmap the same name as the class name of your component—in ALL CAPS. Save the resource file as the same name as your component's unit with a `.dcr` extension. Therefore, if your component is named `XYZComponent`, the bitmap name is `XYZCOMPONENT`. If the component's unit name is `XYZCOMP.PAS`, name the resource file `XYZCOMP.DCR`. Place this file in the same directory as the unit, and when you recompile the unit, the bitmap automatically is linked into the component library.

Sample Components

The remaining sections of this chapter give some real examples of component creation. The components created here serve two primary purposes. First, they illustrate the techniques explained in the first part of this chapter. Secondly, you can actually use these components in your applications. You might even decide to extend their functionality to meet your needs.

Extending Win32 Component Wrapper Capabilities

In some cases, you might want to extend the functionality of existing components, especially those components that wrap the Win32 control classes. We're going to show you how to do this by creating two components that extend the behavior of the `TMemo` control and the `TListBox` control.

TddgExtendedMemo: Extending the TMemo Component

Although the TMemo component is quite robust, there are a few features it doesn't make available that would be useful. For starters, it's not capable of providing the caret position in terms of the row and column on which the caret sits. We'll extend the TMemo component to provide these as public properties.

Additionally, it is sometimes convenient to perform some action whenever the user touches the TMemo's scrollbars. You'll create events to which the user can attach code whenever these scrolling events occur.

The source code for the TddgExtendedMemo component is shown in Listing 21.10.

LISTING 21.10 ExtMemo.pas: The Source for the TddgExtendedMemo Component

```
unit ExMemo;

interface

uses
  Windows, Messages, Classes, StdCtrls;

type

  TddgExtendedMemo = class(TMemo)
  private
    FRow: Longint;
    FColumn: Longint;
    FOnHScroll: TNotifyEvent;
    FOnVScroll: TNotifyEvent;
    procedure WMHScroll(var Msg: TWMHScroll); message WM_HSCROLL;
    procedure WMVScroll(var Msg: TWMVScroll); message WM_VSCROLL;
    procedure SetRow(Value: Longint);
    procedure SetColumn(Value: Longint);
    function GetRow: Longint;
    function GetColumn: Longint;
  protected
    // Event dispatching methods
    procedure HScroll; dynamic;
    procedure VScroll; dynamic;
  public
    property Row: Longint read GetRow write SetRow;
    property Column: Longint read GetColumn write SetColumn;
  published
    property OnHScroll: TNotifyEvent read FOnHScroll write FOnHScroll;
    property OnVScroll: TNotifyEvent read FOnVScroll write FOnVScroll;
```

LISTING 21.10 Continued

```
end;

implementation

procedure TddgExtendedMemo.WMHSroll(var Msg: TWMHSroll);
begin
    inherited;
    HSroll;
end;

procedure TddgExtendedMemo.WMVSroll(var Msg: TWMVSroll);
begin
    inherited;
    VSroll;
end;

procedure TddgExtendedMemo.HSroll;
{ This is the OnHSroll event dispatch method. It checks to see
  if OnHSroll points to an event handler and calls it if it does. }
begin
    if Assigned(FOnHSroll) then
        FOnHSroll(self);
end;

procedure TddgExtendedMemo.VSroll;
{ This is the OnVSroll event dispatch method. It checks to see
  if OnVSroll points to an event handler and calls it if it does. }
begin
    if Assigned(FOnVSroll) then
        FOnVSroll(self);
end;

procedure TddgExtendedMemo.SetRow(Value: Longint);
{ The EM_LINEINDEX returns the character position of the first
  character in the line specified by wParam. The Value is used for
  wParam in this instance. Setting SelStart to this return value
  positions the caret on the line specified by Value. }
begin
    SelStart := Perform(EM_LINEINDEX, Value, 0);
    FRow := SelStart;
end;

function TddgExtendedMemo.GetRow: Longint;
{ The EM_LINEFROMCHAR returns the line in which the character specified
```

```
    by wParam sits. If -1 is passed as wParam, the line number at which
    the caret sits is returned. }
begin
    Result := Perform(EM_LINEFROMCHAR, -1, 0);
end;

procedure TddgExtendedMemo.SetColumn(Value: Longint);
begin
    { Get the length of the current line using the EM_LINELENGTH
    message. This message takes a character position as wParam.
    The length of the line in which that character sits is returned. }
    FColumn := Perform(EM_LINELENGTH, Perform(EM_LINEINDEX, GetRow, 0), 0);
    { If the FColumn is greater than the value passed in, then set
    FColumn to the value passed in }
    if FColumn > Value then
        FColumn := Value;
    // Now set SelStart to the newly specified position
    SelStart := Perform(EM_LINEINDEX, GetRow, 0) + FColumn;
end;

function TddgExtendedMemo.GetColumn: Longint;
begin
    { The EM_LINEINDEX message returns the line index of a specified
    character passed in as wParam. When wParam is -1 then it
    returns the index of the current line. Subtracting SelStart from this
    value returns the column position }
    Result := SelStart - Perform(EM_LINEINDEX, -1, 0);
end;

end.
```

First, we'll discuss adding the capability to provide row and column information to `TddgExtendedMemo`. Notice that we've added two private fields to the component, `FRow` and `FColumn`. These fields will hold the row and column of the `TddgExtendedMemo`'s caret position. Notice that we've also provided the `Row` and `Column` public properties. These properties are made public because there's really no use for them at design time. The `Row` and `Column` properties have both reader and writer access methods. For the `Row` property, these access methods are `GetRow()` and `SetRow()`. The `Column` access methods are `GetColumn()` and `SetColumn()`. For all practical purposes, you probably could do away with the `FRow` and `FColumn` storage fields because the values for `Row` and `Column` are provided through access methods. However, we've left them here because they offer the opportunity to extend this component.

The four access methods make use of various `EM_XXXX` messages. The code comments explain what is going on in each method and how these messages are used to provide `Row` and `Column` information for the component.

The `TddgExtendedMemo` component also provides two new events: `OnHScroll` and `OnVScroll`. The `OnHScroll` event occurs whenever the user clicks the horizontal scrollbar of the control. Likewise, the `OnVScroll` occurs when the user clicks the vertical scrollbar. To surface such events, you have to capture the `WM_HSCROLL` and `WM_VSCROLL` Win32 messages that are passed to the control whenever the user clicks either scrollbar. Thus, you've created the two message handlers: `WMHScroll()` and `WMVScroll()`. These two message handlers call the event-dispatching methods `HScroll()` and `VScroll()`. These methods are responsible for checking whether the component user has provided event handlers for the `OnHScroll` and `OnVScroll` events and then calling those event handlers. If you're wondering why we didn't just perform this check in the message handler methods, it's because you'll often want to be able to invoke an event handler as a result of a different action, such as when the user changes the caret position.

You can install and use the `TddgExtendedMemo` with your applications. You might even consider extending this component; for example, whenever the user changes the caret position, a `WM_COMMAND` message is sent to the control's owner. The `HiWord(wParam)` carries a notification code indicating the action that occurred. This code would have the value of `EN_CHANGE`, which stands for edit-notification message change. It is possible to have your component subclass its parent and capture this message in the parent's window procedure. It can then automatically update the `FRow` and `FColumn` fields. Subclassing is an altogether different and advanced topic that is discussed later.

TddgTabbedListBox: Extending the TListBox Component

VCL's `TListBox` component is merely an Object Pascal wrapper around the standard Win32 API `LISTBOX` control. Although it does do a fair job encapsulating most of that functionality, there is a little bit of room for improvement. This section takes you through the steps in creating a custom component based on `TListBox`.

The Idea

The idea for this component, like most, was born out of necessity. A list box was needed with the capability to use tab stops (which is supported in the Win32 API, but not in a `TListBox`), and a horizontal scrollbar was needed to view strings that were longer than the list box width (also supported by the API but not a `TListBox`). This component will be called a `TddgTabListBox`.

The plan for the `TddgTabListBox` component isn't terribly complex; we did this by creating a `TListBox` descendant component containing the correct field properties, overridden methods, and new methods to achieve the desired behavior.

The Code

The first step in creating a scrollable list box with tab stops is to include those window styles in the `TddgTabListBox`'s style when the `listbox` window is created. The window styles needed

are `lbs_UseTabStops` for tabs and `ws_HScroll` to allow a horizontal scrollbar. Whenever you add window styles to a descendant of `TWinControl`, do so by overriding the `CreateParams()` method, as shown in the following code:

```
procedure TddgTabListbox.CreateParams(var Params: TCreateParams);
begin
    inherited CreateParams(Params);
    Params.Style := Params.Style or lbs_UseTabStops or ws_HScroll;
end;
```

CreateParams()

Whenever you need to modify any of the parameters—such as the style or window class—that are passed to the `CreateWindowEx()` API function, you should do so in the `CreateParams()` method. `CreateWindowEx()` is the function used to create the window handle associated with a `TWinControl` descendant. By overriding `CreateParams()`, you can control the creation of a window on the API level.

`CreateParams` accepts one parameter of type `TCreateParams`, which follows:

```
TCreateParams = record
    Caption: PChar;
    Style: Longint;
    ExStyle: Longint;
    X, Y: Integer;
    Width, Height: Integer;
    WndParent: HWND;
    Param: Pointer;
    WindowClass: TWndClass;
    WinClassName: array[0..63] of Char;
end;
```

As a component writer, you will override `CreateParams()` frequently—whenever you need to control the creation of a component on the API level. Make sure that you call the inherited `CreateParams()` first in order to fill up the `Params` record for you.

To set the tab stops, the `TddgTabListbox` performs an `lb_SetTabStops` message, passing the number of tab stops and a pointer to an array of tabs as the `wParam` and `lParam` (these two variables will be stored in the class as `FNumTabStops` and `FTabStops`). The only catch is that `list-box` tab stops are handled in a unit of measure called *dialog box units*. Because dialog box units don't make sense for the Delphi programmer, you will surface tabs only in pixels. With the help of the `PxDlg.pas` unit shown in Listing 21.11, you can convert back and forth between dialog box units and screen pixels in both the X and Y planes.

LISTING 21.11 The Source Code for PixDlg.pas

```
unit Pixdlg;

interface

function DialogUnitsToPixelsX(DlgUnits: word): word;
function DialogUnitsToPixelsY(DlgUnits: word): word;
function PixelsToDialogUnitsX(PixUnits: word): word;
function PixelsToDialogUnitsY(PixUnits: word): word;

implementation
uses WinProcs;

function DialogUnitsToPixelsX(DlgUnits: word): word;
begin
  Result := (DlgUnits * LoWord(GetDialogBaseUnits)) div 4;
end;

function DialogUnitsToPixelsY(DlgUnits: word): word;
begin
  Result := (DlgUnits * HiWord(GetDialogBaseUnits)) div 8;
end;

function PixelsToDialogUnitsX(PixUnits: word): word;
begin
  Result := PixUnits * 4 div LoWord(GetDialogBaseUnits);
end;

function PixelsToDialogUnitsY(PixUnits: word): word;
begin
  Result := PixUnits * 8 div HiWord(GetDialogBaseUnits);
end;

end.
```

When you know the tab stops, you can calculate the extent of the horizontal scrollbar. The scrollbar should extend at least to the end of the longest string in the listbox. Luckily, the Win32 API provides a function called `GetTabbedTextExtent()` that retrieves just the information you need. When you know the length of the longest string, you can set the scrollbar range by performing the `lb_SetHorizontalExtent` message, passing the desired extent as the `wParam`.

You also need to write message handlers for some special Win32 messages. In particular, you need to handle the messages that control inserting and deleting, because you need to be able to

measure the length of any new string or know when a long string has been deleted. The messages you're concerned with are `lb_AddString`, `lb_InsertString`, and `lb_DeleteString`. Listing 21.12 contains the source code for the `LbTab.pas` unit, which contains the `TddgTabListBox` component.

LISTING 21.12 `LbTab.pas`, the `TddgTabListBox`

```
unit Lbtab;

interface

uses
  SysUtils, Windows, Messages, Classes, Controls, StdCtrls;

type

  EddgTabListBoxError = class(Exception);

  TddgTabListBox = class(TListBox)
  private
    FLongestString: Word;
    FNumTabStops: Word;
    FTabStops: PWord;
    FSizeAfterDel: Boolean;
    function GetLBStringLength(S: String): word;
    procedure FindLongestString;
    procedure SetScrollLength(S: String);
    procedure LBAddString(var Msg: TMessage); message lb_AddString;
    procedure LBInsertString(var Msg: TMessage); message lb_InsertString;
    procedure LBDeleteString(var Msg: TMessage); message lb_DeleteString;
  protected
    procedure CreateParams(var Params: TCreateParams); override;
  public
    constructor Create(AOwner: TComponent); override;
    procedure SetTabStops(A: array of word);
  published
    property SizeAfterDel: Boolean read FSizeAfterDel write FSizeAfterDel
      default True;
  end;

implementation

uses PixDlg;

constructor TddgTabListBox.Create(AOwner: TComponent);
```

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continues

LISTING 21.12 Continued

```

begin
  inherited Create(AOwner);
  FSizeAfterDel := True;
  { set tab stops to Windows defaults... }
  FNumTabStops := 1;
  GetMem(FTabStops, SizeOf(Word) * FNumTabStops);
  FTabStops^ := DialogUnitsToPixelsX(32);
end;

procedure TddgTabListBox.SetTabStops(A: array of word);
{ This procedure sets the listbox's tabstops to those specified
  in the open array of word, A. New tabstops are in pixels, and must
  be in ascending order. An exception will be raised if new tabs
  fail to set. }
var
  i: word;
  TempTab: word;
  TempBuf: PWord;
begin
  { Store new values in temps in case exception occurs in setting tabs }
  TempTab := High(A) + 1;      // Figure number of tabstops
  GetMem(TempBuf, SizeOf(A)); // Allocate new tabstops
  Move(A, TempBuf^, SizeOf(A)); // copy new tabstops }
  { convert from pixels to dialog units, and... }
  for i := 0 to TempTab - 1 do
    A[i] := PixelsToDialogUnitsX(A[i]);
  { Send new tabstops to listbox. Note that we must use dialog units. }
  if Perform(lb_SetTabStops, TempTab, Longint(@A)) = 0 then
  begin
    { if zero, then failed to set new tabstops, free temp
      tabstop buffer and raise an exception }
    FreeMem(TempBuf, SizeOf(Word) * TempTab);
    raise EddgTabListboxError.Create('Failed to set tabs.')
  end
  else begin
    { if nonzero, then new tabstops set okay, so
      Free previous tabstops }
    FreeMem(FTabStops, SizeOf(Word) * FNumTabStops);
    { copy values from temps... }
    FNumTabStops := TempTab; // set number of tabstops
    FTabStops := TempBuf;    // set tabstop buffer
    FindLongestString;      // reset scrollbar
    Invalidate;            // repaint
  end;
end;

```

```

end;

procedure TddgTabListBox.CreateParams(var Params: TCreateParams);
{ We must OR in the styles necessary for tabs and horizontal scrolling
  These styles will be used by the API CreateWindowEx() function. }
begin
  inherited CreateParams(Params);
  { lbs_UseTabStops style allows tabs in listbox
    ws_HScroll style allows horizontal scrollbar in listbox }
  Params.Style := Params.Style or lbs_UseTabStops or ws_HScroll;
end;

function TddgTabListBox.GetLBStringLength(S: String): word;
{ This function returns the length of the listbox string S in pixels }
var
  Size: Integer;
begin
  // Get the length of the text string
  Canvas.Font := Font;
  Result := LoWord(GetTabbedTextExtent(Canvas.Handle, PChar(S),
    StrLen(PChar(S)), FNumTabStops, FTabStops^));
  // Add a little bit of space to the end of the scrollbar extent for looks
  Size := Canvas.TextWidth('X');
  Inc(Result, Size);
end;

procedure TddgTabListBox.SetScrollLength(S: String);
{ This procedure resets the scrollbar extent if S is longer than the }
{ previous longest string }
var
  Extent: Word;
begin
  Extent := GetLBStringLength(S);
  // If this turns out to be the longest string...
  if Extent > FLongestString then
  begin
    // reset longest string
    FLongestString := Extent;
    //reset scrollbar extent
    Perform(lb_SetHorizontalExtent, Extent, 0);
  end;
end;

procedure TddgTabListBox.LBInsertString(var Msg: TMessage);
{ This procedure is called in response to a lb_InsertString message.
  This message is sent to the listbox every time a string is inserted.

```

continues

LISTING 21.12 Continued

```
Msg.lParam holds a pointer to the null-terminated string being
inserted. This will cause the scrollbar length to be adjusted if
the new string is longer than any of the existing strings. }
begin
  inherited;
  SetScrollLength(PChar(Msg.lParam));
end;

procedure TddgTabListBox.LBAddString(var Msg: TMessage);
{ This procedure is called in response to a lb_AddString message.
  This message is sent to the listbox every time a string is added.
  Msg.lParam holds a pointer to the null-terminated string being
  added. This will cause the scrollbar length to be adjusted if the
  new string is longer than any of the existing strings.}
begin
  inherited;
  SetScrollLength(PChar(Msg.lParam));
end;

procedure TddgTabListBox.FindLongestString;
var
  i: word;
  Strg: String;
begin
  FLongestString := 0;
  { iterate through strings and look for new longest string }
  for i := 0 to Items.Count - 1 do
  begin
    Strg := Items[i];
    SetScrollLength(Strg);
  end;
end;

procedure TddgTabListBox.LBDeleteString(var Msg: TMessage);
{ This procedure is called in response to a lb_DeleteString message.
  This message is sent to the listbox everytime a string is deleted.
  Msg.wParam holds the index of the item being deleted. Note that
  by setting the SizeAfterDel property to False, you can cause the
  scrollbar update to not occur. This will improve performance
  if you're deleting often. }
var
  Str: String;
begin
  if FSizeAfterDel then
```

```
begin
  Str := Items[Msg.wParam]; // Get string to be deleted
  inherited;               // Delete string
  { Is deleted string the longest? }
  if GetLBStringLength(Str) = FLongestString then
    FindLongestString;
end
else
  inherited;
end;

end.
```

One particular point of interest in this component is the `SetTabStops()` method, which accepts an open array of word as a parameter. This enables users to pass in as many tab stops as they want. Here is an example:

```
ddgTabListBoxInstance.SetTabStops([50, 75, 150, 300]);
```

If the text in the listbox extends beyond the viewable window, the horizontal scrollbar will appear automatically.

TddgRunButton: Creating Properties

If you wanted to run another executable program in 16-bit Windows, you could use the `WinExec()` API function. Although these functions still work in Win32, it is not the recommended approach. Now you should use the `CreateProcess()` or `ShellExecute()` functions to launch another application. `CreateProcess()` can be a somewhat daunting task when needed just for that purpose. Therefore, we've provided the `ProcessExecute()` method, which we'll show in a moment.

To illustrate the use of `ProcessExecute()`, we've created the component `TddgRunButton`. All that is required of the user is to click the button and the application executes.

The `TddgRunButton` component is an ideal example of creating properties, validating property values, and encapsulating complex operations. Additionally, we'll show you how to grab the application icon from an executable file and how to display it in the `TddgRunButton` at design time. One other thing; `TddgRunButton` descends from `TSpeedButton`. Because `TSpeedButton` contains certain properties that you don't want accessible at design time through the Object Inspector, we'll show you how you can hide (sort of) existing properties from the component user. Admittedly, this technique is not exactly the cleanest approach to use. Typically, you would create a component of your own if you want to take the purist approach—of which the authors are advocates. However, this is one of those instances where Borland, in all its infinite

wisdom, did not provide an intermediate component in between `TSpeedButton` and `TCustomControl` (from which `TSpeedButton` descends), as Borland did with its other components. Therefore, the choice was either to roll our own component that pretty much duplicates the functionality you get from `TSpeedButton`, or borrow from `TSpeedButton`'s functionality and hide a few properties that aren't applicable for your needs. We opted for the latter, but only out of necessity. However, this should clue you in to practice careful forethought as to how component writers might want to extend your own components.

The code to `TddgRunButton` is shown in Listing 21.13.

LISTING 21.13 `RunBtn.pas`, the Source to the `TddgRunButton` Component

```
{
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Teixeira
}

unit RunBtn;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, Buttons;

type

  TCommandLine = type string;

  TddgRunButton = class(TSpeedButton)
  private
    FCommandLine: TCommandLine;
    // Hiding Properties from the Object Inspector
    FCaption: TCaption;
    FAllowAllUp: Boolean;
    FFont: TFont;
    FGroupIndex: Integer;
    FLayout: TButtonLayout;
    procedure SetCommandLine(Value: TCommandLine);
  public
    constructor Create(AOwner: TComponent); override;
    procedure Click; override;
  published
    property CommandLine: TCommandLine read FCommandLine write SetCommandLine;
    // Read only properties are hidden
```

```

    property Caption: TCaption read FCaption;
    property AllowAllUp: Boolean read FAllowAllUp;
    property Font: TFont read FFont;
    property GroupIndex: Integer read FGroupIndex;
    property LayOut: TButtonLayOut read FLayOut;
end;

```

implementation

```
uses ShellAPI;
```

```
const
```

```
  EXEExtension = '.EXE';
```

```
function ProcessExecute(CommandLine: TCommandLine; cShow: Word): Integer;
```

```
{ This method encapsulates the call to CreateProcess() which creates
  a new process and its primary thread. This is the method used in
  Win32 to execute another application. This method requires the use
  of the TStartupInfo and TProcessInformation structures. These structures
  are not documented as part of the Delphi 5 online help but rather
  the Win32 help as STARTUPINFO and PROCESS_INFORMATION.
}
```

The CommandLine parameter specifies the pathname of the file to execute.

The cShow parameter specifies one of the SW_XXXX constants which specifies how to display the window. This value is assigned to the sShowWindow field of the TStartupInfo structure. }

```
var
```

```
  Rslt: LongBool;
```

```
  StartupInfo: TStartupInfo; // documented as STARTUPINFO
```

```
  ProcessInfo: TProcessInformation; // documented as PROCESS_INFORMATION
```

```
begin
```

```
  { Clear the StartupInfo structure }
```

```
  FillChar(StartupInfo, SizeOf(TStartupInfo), 0);
```

```
  { Initialize the StartupInfo structure with required data.
```

```
    Here, we assign the SW_XXXX constant to the wShowWindow field
    of StartupInfo. When specifying a value to this field the
    STARTF_USESHOWWINDOW flag must be set in the dwFlags field.
```

```
    Additional information on the TStartupInfo is provided in the Win32
    online help under STARTUPINFO. }
```

```
  with StartupInfo do
```

```
  begin
```

```
    cb := SizeOf(TStartupInfo); // Specify size of structure
```

```
    dwFlags := STARTF_USESHOWWINDOW or STARTF_FORCEONFEEDBACK;
```

```
    wShowWindow := cShow
```

continues

LISTING 21.13 Continued

```
end;

{ Create the process by calling CreateProcess(). This function
  fills the ProcessInfo structure with information about the new
  process and its primary thread. Detailed information is provided
  in the Win32 online help for the TProcessInfo structure under
  PROCESS_INFORMATION. }
Rslt := CreateProcess(PChar(CommandLine), nil, nil, nil, False,
  NORMAL_PRIORITY_CLASS, nil, nil, StartupInfo, ProcessInfo);
{ If Rslt is true, then the CreateProcess call was successful.
  Otherwise, GetLastError will return an error code representing the
  error which occurred. }
if Rslt then
  with ProcessInfo do
  begin
    { Wait until the process is in idle. }
    WaitForInputIdle(hProcess, INFINITE);
    CloseHandle(hThread); // Free the hThread handle
    CloseHandle(hProcess); // Free the hProcess handle
    Result := 0; // Set Result to 0, meaning successful
  end
  else Result := GetLastError; // Set result to the error code.
end;

function IsExecutableFile(Value: TCommandLine): Boolean;
{ This method returns whether or not the Value represents a valid
  executable file by ensuring that its file extension is 'EXE' }
var
  Ext: String[4];
begin
  Ext := ExtractFileExt(Value);
  Result := (UpperCase(Ext) = EXEExtension);
end;

constructor TddgRunButton.Create(AOwner: TComponent);
{ The constructor sets the default height and width properties
  to 45x45 }
begin
  inherited Create(AOwner);
  Height := 45;
  Width := 45;
end;

procedure TddgRunButton.SetCommandLine(Value: TCommandLine);
```

```
{ This write access method sets the FCommandLine field to Value, but
only if Value represents a valid executable file name. It also
set the icon for the TddgRunButton to the application icon of the
file specified by Value. }
var
  Icon: TIcon;
begin
  { First check to see that Value *is* an executable file and that
  it actually exists where specified. }
  if not IsExecutableFile(Value) then
    Raise Exception.Create(Value+' is not an executable file. ');
  if not FileExists(Value) then
    Raise Exception.Create('The file: '+Value+' cannot be found. ');

  FCommandLine := Value; // Store the Value in FCommandLine

  { Now draw the application icon for the file specified by Value
  on the TddgRunButton icon. This requires us to create a TIcon
  instance to which to load the icon. It is then copied from this
  TIcon instance to the TddgRunButton's Canvas.

  We must use the Win32 API function ExtractIcon() to retrieve the
  icon for the application. }
  Icon := TIcon.Create; // Create the TIcon instance
  try
    { Retrieve the icon from the application's file }
    Icon.Handle := ExtractIcon(hInstance, PChar(FCommandLine), 0);
    with Glyph do
      begin
        { Set the TddgRunButton properties so that the icon held by Icon
        can be copied onto it. }
        { First, clear the canvas. This is required in case another
        icon was previously drawn on the canvas }
        Canvas.Brush.Style := bsSolid;
        Canvas.FillRect(Canvas.ClipRect);
        { Set the Icon's width and height }
        Width := Icon.Width;
        Height := Icon.Height;
        Canvas.Draw(0, 0, Icon); // Draw the icon to TddgRunButton's Canvas
      end;
    finally
      Icon.Free; // Free the TIcon instance.
    end;
end;

procedure TddgRunButton.Click;
```

continues

LISTING 21.13 Continued

```
var
  WERetVal: Word;
begin
  inherited Click; // Call the inherited Click method
  { Execute the ProcessExecute method and check it's return value.
    if the return value is <> 0 then raise an exception because
      an error occurred. The error code is shown in the exception }
  WERetVal := ProcessExecute(FCommandLine, sw_ShowNormal);
  if WERetVal <> 0 then begin
    raise Exception.Create('Error executing program. Error Code:; '+
      IntToStr(WERetVal));
  end;
end;

end.
```

TddgRunButton has one property, `CommandLine`, which is defined to be of the type `String`. The private storage field for `CommandLine` is `FCommandLine`.

TIP

It is worth discussing the special definition of `TCommandLine`. Here is the syntax used:

```
TCommandLine = type string;
```

By defining `TCommandLine` as such, you tell the compiler to treat `TCommandLine` as a unique type that is still compatible with other string types. The new type will get its own runtime type information and therefore can have its own property editor. This same technique can be used with other types as well. Here is an example:

```
TMySpecialInt = type Integer;
```

We will show you how we use this to create a property editor for the `CommandLine` property in the next chapter. We do not show you this technique in this chapter because creating property editors is an advanced topic that we want to talk about in more depth.

The write access method for `CommandLine` is `SetCommandLine()`. We've provided two helper functions: `IsExecutableFile()` and `ProcessExecute()`.

`IsExecutableFile()` is a function that determines whether a filename passed to it is an executable file based on the file's extension.

Creating and Executing a Process

`ProcessExecute()` is a function that encapsulates the `CreateProcess()` Win32 API function that enables you to launch another application. The application to launch is specified by the `CommandLine` parameter, which holds the filename path. The second parameter contains one of the `SW_XXXX` constants that indicates how the process's main windows are to be displayed. Table 21.4 lists the various `SW_XXXX` constants and their meanings, as explained in the online help.

Table 21.4 `SW_XXXX` Constants

<i>SW_XXXX Constant</i>	<i>Meaning</i>
<code>SW_HIDE</code>	Hides the window. Another window will become active.
<code>SW_MAXIMIZE</code>	Displays the window as maximized.
<code>SW_MINIMIZE</code>	Minimizes the window.
<code>SW_RESTORE</code>	Displays a window at its size before it was maximized/minimized.
<code>SW_SHOW</code>	Displays a window at its current size/position.
<code>SW_SHOWDEFAULT</code>	Shows a window at the state specified by the <code>TStartupInfo</code> structure passed to <code>CreateProcess()</code> .
<code>SW_SHOWMAXIMIZED</code>	Activates/displays the window as maximized.
<code>SW_SHOWMINIMIZED</code>	Activates/displays the window as minimized.
<code>SW_SHOWMINNOACTIVE</code>	Displays the window as minimized but the currently active window remains active.
<code>SW_SHOWNA</code>	Display the window at its current state. The currently active window remains active.
<code>SW_SHOWNOACTIVATE</code>	Displays the window at the most recent size/position. The currently active window remains active.
<code>SW_SHOWNORMAL</code>	Activates/displays the window at its more recent size/position. This position is restored if the window was previously maximized/minimized.

`ProcessExecute()` is a handy utility function that you might want to keep around in a separate unit that may be shared by other applications.

TddgRunButton Methods

The `TddgRunButton.Create()` constructor simply sets a default size for itself after calling the inherited constructor.

The `SetCommandLine()` method, which is the writer access method for the `CommandLine` parameter, performs several tasks. First, it determines whether the value being assigned to `CommandLine` is a valid executable filename. If not, it raises an exception.

If the entry is valid, it is assigned to the `FCommandLine` field. `SetCommandLine()` then extracts the icon from the application file and draws it to `TddgRunButton`'s canvas. The Win32 API function `ExtractIcon()` is used to do this. The technique used is explained in the commentary.

`TddgRunButton.Click()` is the event-dispatching method for the `TSpeedButton.OnClick` event. It is necessary to call the inherited `Click()` method that will invoke the `OnClick` event handler if assigned. After calling the inherited `Click()`, you call `ProcessExecute()` and examine its result value to determine whether the call was successful. If not, an exception is raised.

TddgButtonEdit—Container Components

Occasionally you might like to create a component that is composed of one or more other components. Delphi's `TDBNavigator` is a good example of such a component, as it consists of a `TPanel` and a number of `TSpeedButton` components. Specifically, this section illustrates this concept by creating a component that is a combination of a `TEdit` and a `TSpeedButton` component. We will call this component `TddgButtonEdit`.

Design Decisions

Considering that Object Pascal is based upon a single-inheritance object model, `TddgButtonEdit` will need to be a component in its own right, which must contain both a `TEdit` and a `TSpeedButton`. Furthermore, because it's necessary that this component contain windowed controls, it will need to be a windowed control itself. For these reasons, we chose to descend `TddgButtonEdit` from `TWinControl`. We created both the `TEdit` and `TSpeedButton` in `TddgButtonEdit`'s constructor using the following code:

```
constructor TddgButtonEdit.Create(AOwner: TComponent);
begin
    inherited Create(AOwner);
    FEdit      := TEdit.Create(Self);
    FEdit.Parent := self;
    FEdit.Height := 21;

    FSpeedButton := TSpeedButton.Create(Self);
    FSpeedButton.Left := FEdit.Width;
    FSpeedButton.Height := 19; // two less than TEdit's Height
    FSpeedButton.Width := 19;
    FSpeedButton.Caption := '...';
    FSpeedButton.Parent := Self;

    Width := FEdit.Width+FSpeedButton.Width;
    Height := FEdit.Height;
end;
```

The challenge when creating a component that contains other components is surfacing the properties of the “inner” components from the container component. For example, the `TddgButtonEdit` will need a `Text` property. You also might want to be able to change the font for the text in the control; therefore, a `Font` property is needed. Finally, there needs to be an `OnClick` event for the button in the control. You wouldn’t want to attempt to implement this yourself in the container component when it is already available from the inner components. The goal, then, is to surface the appropriate properties of the inner controls without rewriting the interfaces to these controls.

Surfacing Properties

This usually boils down to the simple but time-consuming task of writing reader and writer methods for each of the inner component properties you want to resurface through the container component. In the case of the `Text` property, for example, you might give the `TddgButtonEdit` a `Text` property with read and write methods:

```
TddgButtonEdit = class(TWinControl)
private
    FEdit: TEdit;
protected
    procedure SetText(Value: String);
    function GetText: String;
published
    property Text: String read GetText write SetText;
end;
```

The `SetText()` and `GetText()` methods directly access the `Text` property of the contained `TEdit` control, as shown here:

```
function TddgButtonEdit.GetText: String;
begin
    Result := FEdit.Text;
end;

procedure TddgButtonEdit.SetText(Value: String);
begin
    FEdit.Text := Value;
end;
```

Surfacing Events

In addition to properties, it’s also quite likely that you might want to resurface events that exist in the inner components. For example, when the user clicks on the `TSpeedButton` control, you would want to surface its `OnClick` event. Resurfacing events is just as straightforward as resurfacing properties—after all, events are properties.

You need to first give the `TddgButtonEdit` its own `OnClick` event. For clarity, we named this event `OnButtonClick`. The read and write methods for this event simply redirect the assignment to the `OnClick` event of the internal `TSpeedButton`.

Listing 21.14 shows the `TddgButtonEdit` container component.

LISTING 21.14 `TddgButtonEdit`, a Container Component

```
unit ButtonEdit;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, Buttons;

type
  TddgButtonEdit = class(TWinControl)
  private
    FSpeedButton: TSpeedButton;
    FEdit: TEdit;
  protected
    procedure WMSize(var Message: TWMSize); message WM_SIZE;
    procedure SetText(Value: String);
    function GetText: String;
    function GetFont: TFont;
    procedure SetFont(Value: TFont);
    function GetOnButtonClick: TNotifyEvent;
    procedure SetOnButtonClick(Value: TNotifyEvent);
  public
    constructor Create(AOwner: TComponent); override;
    destructor Destroy; override;
  published
    property Text: String read GetText write SetText;
    property Font: TFont read GetFont write SetFont;
    property OnButtonClick: TNotifyEvent read GetOnButtonClick
      write SetOnButtonClick;
  end;

implementation

procedure TddgButtonEdit.WMSize(var Message: TWMSize);
begin
  inherited;
  FEdit.Width := Message.Width - FSpeedButton.Width;
  FSpeedButton.Left := FEdit.Width;
```

```
end;

constructor TddgButtonEdit.Create(AOwner: TComponent);
begin
  inherited Create(AOwner);
  FEdit      := TEdit.Create(Self);
  FEdit.Parent := self;
  FEdit.Height := 21;

  FSpeedButton := TSpeedButton.Create(Self);
  FSpeedButton.Left := FEdit.Width;
  FSpeedButton.Height := 19; // two less than TEdit's Height
  FSpeedButton.Width := 19;
  FSpeedButton.Caption := '...';
  FSpeedButton.Parent := Self;

  Width := FEdit.Width+FSpeedButton.Width;
  Height := FEdit.Height;
end;

destructor TddgButtonEdit.Destroy;
begin
  FSpeedButton.Free;
  FEdit.Free;
  inherited Destroy;
end;

function TddgButtonEdit.GetText: String;
begin
  Result := FEdit.Text;
end;

procedure TddgButtonEdit.SetText(Value: String);
begin
  FEdit.Text := Value;
end;

function TddgButtonEdit.GetFont: TFont;
begin
  Result := FEdit.Font;
end;

procedure TddgButtonEdit.SetFont(Value: TFont);
begin
  if Assigned(FEdit.Font) then
    FEdit.Font.Assign(Value);
```

continues

LISTING 21.14 Continued

```
end;

function TddgButtonEdit.GetOnButtonClick: TNotifyEvent;
begin
  Result := FSpeedButton.OnClick;
end;

procedure TddgButtonEdit.SetOnButtonClick(Value: TNotifyEvent);
begin
  FSpeedButton.OnClick := Value;
end;

end.
```

TddgDigitalClock—Creating Component Events

`TddgDigitalClock` illustrates the process of creating and making available user-defined events. We will use the same technique discussed earlier when we discussed creating events with the `TddgHalfMinute` component.

`TddgDigitalClock` descends from `TPanel`. We decided that `TPanel` was an ideal component from which `TddgDigitalClock` could descend because `TPanel` has the `BevelXXXX` properties. This enables you to give the `TddgDigitalClock` a pleasing visual appearance. Also, you can use the `TPanel.Caption` property to display the system time.

`TddgDigitalClock` contains the following events to which the user can assign code:

<code>OnHour</code>	Occurs on the hour, every hour.
<code>OnHalfPast</code>	Occurs on the half-hour.
<code>OnMinute</code>	Occurs on the minute.
<code>OnHalfMinute</code>	Occurs every 30 seconds: on the minute and on the half minute.
<code>OnSecond</code>	Occurs on the second.

`TddgDigitalClock` uses a `TTimer` component internally. Its `OnTimer` event handler performs the logic to display the time information and to invoke the event-dispatching methods for the previously listed events accordingly. Listing 21.15 shows the source code for `DdgClock.pas`.

LISTING 21.15 `DdgClock.pas`: Source for the `TddgDigitalClock` Component

```
{
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Teixeira
}
```

```
{$IFDEF VER110}
{$OBJEXPORTALL ON}
{$ENDIF}

unit DDGClock;

interface

uses
  Windows, Messages, Controls, Forms, SysUtils, Classes, ExtCtrls;

type

  { Declare an event type which takes the sender of the event, and
    a TDateTime variable as parameters }
  TTimeEvent = procedure(Sender: TObject; DDGTime: TDateTime) of object;

  TddgDigitalClock = class(TPanel)
  private
    { Data fields }
    FHour,
    FMinute,
    FSecond: Word;
    FDateTime: TDateTime;
    FOldMinute,
    FOldSecond: Word;
    FTimer: TTimer;
    { Event handlers }
    FOnHour: TTimeEvent;      // Occurs on the hour
    FOnHalfPast: TTimeEvent; // Occurs every half-hour
    FOnMinute: TTimeEvent;   // Occurs on the minute
    FOnSecond: TTimeEvent;   // Occurs every second
    FOnHalfMinute: TTimeEvent; // Occurs every 30 seconds
    { Define OnTimer event handler for internal TTimer, FTimer }
    procedure TimerProc(Sender: TObject);
  protected
    { Override the Paint methods }
    procedure Paint; override;

    { Define the various event dispatching methods }
    procedure DoHour(Tm: TDateTime); dynamic;
    procedure DoHalfPast(Tm: TDateTime); dynamic;
    procedure DoMinute(Tm: TDateTime); dynamic;
    procedure DoHalfMinute(Tm: TDateTime); dynamic;
    procedure DoSecond(Tm: TDateTime); dynamic;
```

continues

LISTING 21.15 Continued

```
public
  { Override the Create constructor and Destroy destructor }
  constructor Create(AOwner: TComponent); override;
  destructor Destroy; override;
published
  { Define event properties }
  property OnHour: TTimeEvent read FOnHour write FOnHour;
  property OnHalfPast: TTimeEvent read FOnHalfPast write FOnHalfPast;
  property OnMinute: TTimeEvent read FOnMinute write FOnMinute;
  property OnHalfMinute: TTimeEvent read FOnHalfMinute
    write FOnHalfMinute;
  property OnSecond: TTimeEvent read FOnSecond write FOnSecond;
end;

implementation

constructor TddgDigitalClock.Create(AOwner: TComponent);
begin
  inherited Create(AOwner); // Call the inherited constructor
  Height := 25; // Set default width and height properties
  Width := 120;
  BevelInner := bvLowered; // Set Default bevel properties
  BevelOuter := bvLowered;
  { Set the inherited Caption property to an empty string }
  inherited Caption := '';
  { Create the TTimer instance and set both its Interval property and
    OnTime event handler. }
  FTimer := TTimer.Create(self);
  FTimer.interval := 200;
  FTimer.OnTimer := TimerProc;
end;

destructor TddgDigitalClock.Destroy;
begin
  FTimer.Free; // Free the TTimer instance.
  inherited Destroy; // Call inherited Destroy method
end;

procedure TddgDigitalClock.Paint;
begin
  inherited Paint; // Call the inherited Paint method
  { Now set the inherited Caption property to current time. }
  inherited Caption := TimeToStr(FDateTime);
end;
```

```

end;

procedure TddgDigitalClock.TimerProc(Sender: TObject);
var
  HSec: Word;
begin
  { Save the old minute and second for later use }
  FOldMinute := FMinute;
  FOldSecond := FSecond;
  FDateTime := Now; // Get the current time.
  { Extract the individual time elements }
  DecodeTime(FDateTime, FHour, FMinute, FSecond, Hsec);

  refresh; // Redraw the component so that the new time is displayed.

  { Now call the event handlers depending on the time }
  if FMinute = 0 then
    DoHour(FDateTime);
  if FMinute = 30 then
    DoHalfPast(FDateTime);
  if (FMinute <> FOldMinute) then
    DoMinute(FDateTime);
  if FSecond <> FOldSecond then
    if ((FSecond = 30) or (FSecond = 0)) then
      DoHalfMinute(FDateTime)
    else
      DoSecond(FDateTime);
end;

{ The event dispatching methods below determine if component user has
  attached event handlers to the various clock events and calls them
  if they exist }
procedure TddgDigitalClock.DoHour(Tm: TDateTime);
begin
  if Assigned(FOnHour) then
    TTimeEvent(FOnHour)(Self, Tm);
end;

procedure TddgDigitalClock.DoHalfPast(Tm: TDateTime);
begin
  if Assigned(FOnHalfPast) then
    TTimeEvent(FOnHalfPast)(Self, Tm);
end;

procedure TddgDigitalClock.DoMinute(Tm: TDateTime);

```

continues

LISTING 21.15 Continued

```
begin
  if Assigned(FOnMinute) then
    TTimeEvent(FOnMinute)(Self, Tm);
end;

procedure TddgDigitalClock.DoHalfMinute(Tm: TDateTime);
begin
  if Assigned(FOnHalfMinute) then
    TTimeEvent(FOnHalfMinute)(Self, Tm);
end;

procedure TddgDigitalClock.DoSecond(Tm: TDateTime);
begin
  if Assigned(FOnSecond) then
    TTimeEvent(FOnSecond)(Self, Tm);
end;

end.
```

The logic behind this component is explained in the source commentary. The methods used are no different than those that were previously explained when we discussed creating events. `TddgDigitalClock` only adds more events and contains logic to determine when each event is invoked.

Adding Forms to the Component Palette

Adding forms to the Object Repository is a convenient way to give forms a starting point. But what if you develop a form that you reuse often that does not need to be inherited and does not require added functionality? Delphi 5 provides a way you can reuse your forms as components on the Component Palette. In fact, the `TFontDialog` and `TOpenDialog` components are examples of forms that are accessible from the Component Palette. Actually, these dialogs are not Delphi forms; these are dialogs provided by the `CommDlg.dll`. Nevertheless, the concept is the same.

To add forms to the Component Palette, you must wrap your form with a component to make it a separate, installable component. The process as described here uses a simple password dialog whose functionality will verify your password automatically. Although this is a very simple project, the purpose of this discussion is not to show you how to install a complex dialog as a component, but rather to show you the general method for adding dialog boxes to the Component Palette. The same method applies to dialog boxes of any complexity.

First, you must create the form that is going to be wrapped by the component. The form we used is defined in the file `PwDlg.pas`. This unit also shows a component wrapper for this form.

Listing 21.16 shows the unit defining the `TPasswordDlg` form and its wrapper component, `TddgPasswordDialog`.

LISTING 21.16 `PwDlg.pas`—`TPasswordDlg` Form and Its Component Wrapper
`TddgPasswordDialog`

```
unit PwDlg;

interface

uses Windows, SysUtils, Classes, Graphics, Forms, Controls, StdCtrls,
    Buttons;

type

    TPasswordDlg = class(TForm)
        Label1: TLabel;
        Password: TEdit;
        OKBtn: TButton;
        CancelBtn: TButton;
    end;

    { Now declare the wrapper component. }
    TddgPasswordDialog = class(TComponent)
    private
        PassWordDlg: TPasswordDlg; // TPassWordDlg instance
        FPassWord: String;        // Place holder for the password
    public
        function Execute: Boolean; // Function to launch the dialog
    published
        property PassWord: String read FPassword write FPassword;
    end;

implementation
{$R *.DFM}

function TddgPasswordDialog.Execute: Boolean;
begin
    { Create a TPasswordDlg instance }
    PasswordDlg := TPasswordDlg.Create(Application);
    try
        Result := False; // Initialize the result to false
    end;
end;
```

continues

LISTING 21.16 Continued

```
    { Show the dialog and return true if the password
      is correct. }
    if PasswordDlg.ShowModal = mrOk then
      Result := PasswordDlg.Password.Text = FPassword;
    finally
      PasswordDlg.Free; // Free instance of PasswordDlg
    end;
end;

end.
```

The `TddgPasswordDialog` is called a *wrapper* component because it wraps the form with a component that can be installed into Delphi 5's Component Palette.

`TddgPasswordDialog` descends directly from `TComponent`. You might recall from the last chapter that `TComponent` is the lowest-level class that can be manipulated by the Form Designer in the IDE. This class has two private variables: `PasswordDlg` of type `TPasswordDlg` and `FPassword` of type `string`. `PasswordDlg` is the `TPasswordDlg` instance that this wrapper component displays. `FPassword` is an *internal storage field* that holds a password string.

`FPassword` gets its data through the property `Password`. Thus, `Password` doesn't actually store data; rather, it serves as an interface to the storage variable `FPassword`.

`TddgPasswordDialog`'s `Execute()` function creates a `TPasswordDlg` instance and displays it as a modal dialog box. When the dialog box terminates, the string entered in the password `TEdit` control is compared against the string stored in `FPassword`.

The code here is contained within a `try..finally` construct. The `finally` portion ensures that the `TPasswordDlg` component is disposed of, regardless of any error that might occur.

After you have added `TddgPasswordDialog` to the Component Palette, you can create a project that uses it. As with any other component, you select `TddgPasswordDialog` from the Component Palette and place it on your form. The project created in the preceding section contains a `TddgPasswordDialog` and one button whose `OnClick` event handler does the following:

```
procedure TForm1.Button1Click(Sender: TObject);
begin
  if ddgPasswordDialog.Execute then           // Launch the PasswordDialog
    ShowMessage('You got it!')              // Correct password
  else
    ShowMessage('Sorry, wrong answer!'); // Incorrect password
end;
```

The Object Inspector contains three properties for the `TddgPasswordDialog` component: `Name`, `Password`, and `Tag`. To use the component, you must set the `Password` property to some string value. When you run the project, `TddgPasswordDialog` prompts the user for a password and compares it against the password you entered for the `Password` property.

Component Packages

Delphi 3 introduced *packages*, which enable you to place portions of your application into separate modules that can be shared across multiple applications. Packages are similar to dynamic link libraries (DLLs) but differ in their usage. Packages are primarily used to store collections of components in a separate, shareable module (a Borland Package Library, or `.bpl` file). As you or other developers create Delphi applications, the packages you create can be used by the application at runtime instead of being directly linked at compile/link time. Because the code for these units resides in the `.bpl` file, rather than in your `.exe` or `.dll`, the size of your `.exe` or `.dll` can become very small.

Packages differ from DLLs in that they are specific to Delphi VCL; that is, applications written in other languages can't use packages created by Delphi (with the exception of CBuilder). One of the reasons behind packages is to get around a limitation of Delphi 1 and 2. In these prior versions of Delphi, the VCL added a minimum of 150KB to 200KB of code to every executable. Therefore, even if you were to separate a piece of your application into a DLL, both the DLL and the application would contain redundant code. This is especially a problem if you are providing a suite of applications on one machine. Packages enable you to reduce the footprint of your applications and provide a convenient way for you to distribute your component collections.

Why Use Packages?

There are several reasons why you might want to use packages. Three are discussed in the following sections.

Code Reduction

A primary reason behind using packages is to reduce the size of your applications and DLLs. Delphi already ships with several predefined packages that break up the VCL into logical groupings. In fact, you can choose to compile your application so that it assumes the existence of many of these Delphi packages.

A Smaller Distribution of Applications—Application Partitioning

You'll find that many applications are available over the Internet as full-blown applications, downloadable demos, or updates to existing applications. Consider the benefit of giving users

the option of downloading smaller versions of the application when pieces of the application might already exist on their system, such as when they have a prior installation.

By partitioning your applications using packages, you also allow your users to obtain updates to only those parts of the application that they need. Note, however, that there are some versioning issues that you'll have to take into account. We'll cover versioning issues momentarily.

Component Containment

Probably one of the most common reasons for using packages is the distribution of third-party components. If you are a component vendor, you must know how to create packages. The reason for this is that certain design-time elements—such as component and property editors, wizards, and experts—are all provided by packages.

Why Not to Use Packages

You shouldn't use runtime packages unless you are sure that other applications will be using these packages. Otherwise, these packages will end up using more disk space than if you were just compiling the source code into your final executable. Why is this so? If you create a packaged application resulting in a code reduction from 200KB to roughly 30KB, it might seem like you've saved quite a bit of space. However, you still have to distribute your packages and possibly even the `Vc150.dcp` package, which is roughly 2MB in size. You can see that this isn't quite the saving you had hoped for. Our point is that you should use packages to share code when that code will be used by multiple executables. Note that this only applies to runtime packages. If you are a component writer, you must provide a design package that contains the component you want to make available to the Delphi IDE.

Types of Packages

There are four types of packages available for you to create and use:

- **Runtime package.** Runtime packages contain code, components, and so on needed by an application at runtime. If you write an application that depends on a particular runtime package, the application won't run in the absence of that package.
- **Design package.** Design packages contain components, property/component editors, experts, and so on necessary for application design in the Delphi IDE. This type of package is used only by Delphi and is never distributed with your applications.
- **Runtime and design package.** A package that is both design- and runtime-enabled is typically used when there are no design-specific elements such as property/component editors and experts. You can create this type of package to simplify application development and deployment. However, if this package does contain design elements, its runtime use will carry the extra baggage of the design support in your deployed applications. We

recommend creating both a design and runtime package to separate design-specific elements when they are present.

- Neither runtime nor design package. This rare breed of package is intended to be used only by other packages and is not intended to be referenced directly by an application or used in the design environment. This implies that packages can use or include other packages.

21

WRITING DELPHI
CUSTOM
COMPONENTS

Package Files

Table 21.5 lists and describes the package-specific files based on their file extensions.

Table 21.5 Package Files

<i>File Extension</i>	<i>File Type</i>	<i>Description</i>
.dpk	Package source file	This file is created when you invoke the Package Editor. You can think of this as you might think of the .dpr file for a Delphi project.
.dcp	Runtime/design package symbol file	This is the compiled version of the package that contains the symbol information for the package and its units. Additionally, there is header information required by the Delphi IDE.
.dcu	Compiled unit	A compiled version of a unit contained in a package. One .dcu file will be created for each unit contained in the package.
.bpl	Runtime/design package library	This is the runtime or design package, equivalent to a Windows DLL. If this is a runtime package, you will distribute the file along with your applications (if they are enabled for runtime packages). If this file represents a design package, you will distribute it along with its runtime partner to programmers that will use it to write programs. Note that if you aren't distributing source code, you must distribute the corresponding .dcp files.

Package-Enable Your Delphi 5 Applications

Package-enabling your Delphi applications is easy. Simply check the Build with Runtime Packages check box found in the Project, Options dialog on the Packages page. The next time you build your application after this option is selected, your application will be linked dynamically to runtime packages, instead of having units linked statically into your .exe or .dll. The

result will be a much more svelte application (although bear in mind that you will have to deploy the necessary packages with your application).

Installing Packages into Delphi's IDE

Installing packages into the Delphi IDE is simple. You might need to do this if you obtain a third-party set of components. First, however, you need to place the package files in their appropriate location. Table 21.6 shows where package files are typically located.

Table 21.6 Package File Locations

<i>Package File</i>	<i>Location</i>
Runtime packages (*.bp1)	Runtime package files should be placed in the \Windows\System\ directory (Windows 95/98) or \WinNT\System32\ directory (Windows NT).
Design packages (*.bp1)	Because it is possible that you will obtain several packages from various vendors, design packages should be placed in a common directory where they can be properly managed. For example, create a \PKG directory off your \Delphi 5\ directory and place design packages in that location.
Package symbol files (*.dcp)	You can place package symbol files in the same location as design package files (*.bp1).
Compiled units (*.dcu)	You must distribute compiled units if you are distributing design packages. We recommend keeping DCUs from third-party vendors in a directory similar to the \Delphi 5\Lib directory. For example, you can create the directory \Delphi 5\3PrtyLib in which third-party components' *.dcus will reside. Your search path will have to point to this directory.

To install a package, you simply invoke the Packages page of the Project Options dialog by selecting Component, Install Packages from the Delphi 5 menu.

By selecting the Add button, you can select the specific .bp1 file. Upon doing so, this file will become the selected file on the Project page. When you click OK, the new package is installed into the Delphi IDE. If this package contains components, you will see the new Component page on the Component Palette along with any newly installed components.

Designing Your Own Packages

Before creating a new package, you'll need to decide on a few things. First, you need to know what type of package you're going to create (runtime, design, and so on). This will be based on

one or more of the scenarios that we present momentarily. Second, you need to know what you intend on naming your newly created package and where you want to store the package project. Keep in mind that the directory where your deployed package exists will probably not be the same as where you create your package. Finally, you need to know which units your package will contain and which other packages your new package will require.

The Package Editor

Packages are most commonly created using the Package Editor, which you invoke by selecting the Packages icon from the New Items dialog. (Select File, New from the Delphi main menu.) You'll notice that the Package Editor contains two folders: Contains and Requires.

The Contains Folder

In the Contains folder, you specify units that need to be compiled into your new package. There are a few rules for placing units into the Contains page of a package:

- The package must not be listed in the contains clause of another package or in the uses clause of a unit within another package.
- The units listed in the contains clause of a package, either directly or indirectly (they exist in uses clauses of units listed in the package's contains clause), cannot be listed in the package's requires clause. This is because these units are already bound to the package when it is compiled.
- You cannot list a unit in a package's contains clause if it is already listed in the contains clause of another package used by the same application.

The Requires Page

In the Requires page, you specify other packages that are required by the new package. This is similar to the uses clause of a Delphi unit. In most cases, any packages you create will have VCL50—the package that hosts Delphi's standard VCL components—in its requires clause. The typical arrangement here, for example, is that you place all your components into a runtime package. Then you create a design package that includes the runtime package in its requires clause. There are a few rules for placing packages on the Requires page of another package:

- Avoid circular references: Package1 cannot have Package1 in its requires clause, nor can it contain another package that has Package1 in its requires clause.
- The chain of references must not refer back to a package previously referenced in the chain.

The Package Editor has a toolbar and context-sensitive menus. Refer to the Delphi 5 online help under "Package Editor" for an explanation of what these buttons do. We won't repeat that information here.

Package Design Scenarios

Earlier we said that you must know what type of package you want to create based on a particular scenario. In this section, we're going to present three possible scenarios in which you would use design and/or runtime packages.

Scenario 1—Design and Runtime Packages for Components

The design and runtime packages for components scenario is the case if you are a component writer and one or both of the following conditions apply:

- You want Delphi programmers to be able to compile/link your components right into their applications or to distribute them separately along with their applications.
- You have a component package, and you don't want to force your users to have to compile design features (component/property editors and so on) into their application code.

Given this scenario, you would create both a design and runtime package. Figure 21.4 depicts this arrangement. As the figure illustrates, the design package (DDGDsgn50.dpk) encompasses both the design features (property and component editors) and the runtime package (DDGStd50.dpk). The runtime package (DDGStd50.dpk) includes only your components. This arrangement is accomplished by listing the runtime package in the `requires` section of the design package, as shown in Figure 21.4.

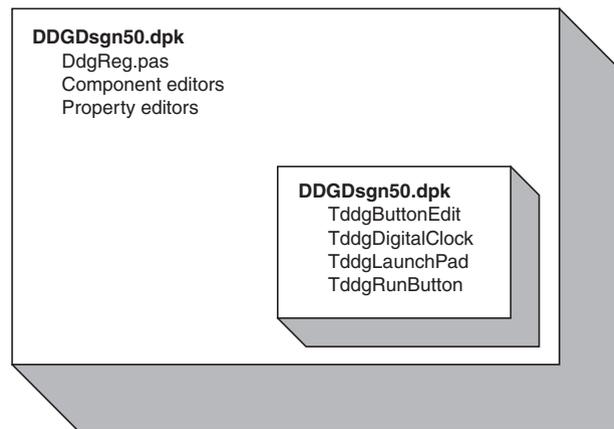


FIGURE 21.4

Design packages host design elements and runtime packages.

You must also apply the appropriate usage options for each package before compiling that package. You do this from the Package Options dialog. (You access the Package Options dialog by right-clicking within the Package Editor to invoke the local menu. Select Options to get

to the dialog.) For the runtime package, `DDGStd50.dpk`, the usage option should be set to Runtime Only. This ensures that the package cannot be installed in the IDE as a design package (see the sidebar “Component Security” later in this chapter). For the design package, `DDGDsgn50.dpk`, the usage option Design Time Only should be selected. This enables users to install the package into the Delphi IDE, yet prevents them from using the package as a runtime package.

Adding the runtime package to the design package doesn’t make the components contained in the runtime package available to the Delphi IDE yet. You must still register your components with the IDE. As you already know, whenever you create a component, Delphi automatically inserts a `Register()` procedure into the component unit, which in turn calls the `RegisterComponents()` procedure. `RegisterComponents()` is the procedure that actually registers your component with the Delphi IDE when you install the component. When working with packages, the recommended approach is to move the `Register()` procedure from the component unit into a separate registration unit. This registration unit registers all your components by calling `RegisterComponents()`. This not only makes it easier for you to manage the registration of your components, but it also prevents anyone from being able to install and use your runtime package illegally because the components won’t be available to the Delphi IDE.

As an example, the components used in this book are hosted by the runtime package `DDGStd50.dpk`. The property editors, component editors, and registration unit (`DdgReg.pas`) for our components exist in the design package `DDGDsgn50.dpk`. `DDGDsgn50.dpk` also includes `DDGStd50.dpk` in its `requires` clause. Listing 21.17 shows what our registration unit looks like.

LISTING 21.17 Registration Unit for *Delphi 5 Developer’s Guide* Components

```
unit DDGReg;

interface

procedure Register;

implementation

uses Classes, ExptIntf, DsgnIntf, TrayIcon, AppBars, ABExpt, Worthless,
    RunBtn, PwDlg, Planets, LbTab, HalfMin, DDGClock, ExMemo, MemView,
    Marquee, PlanetPE, RunBtnPE, CompEdit, DefProp, Wavez,
    WavezEd, LnchPad, LPadPE, Cards, ButtonEdit, Planet, DrwPnel;

procedure Register;
begin
    // Register the components.
```

continues

LISTING 21.17 Continued

```
RegisterComponents('DDG',
[ TddgTrayNotifyIcon, TddgDigitalClock, TddgHalfMinute, tddgButtonEdit,
  TddgExtendedMemo, TddgTabListbox, TddgRunButton, TddgLaunchPad,
  TddgMemView, TddgMarquee, TddgWaveFile, TddgCard, TddgPasswordDialog,
  TddgPlanet, TddgPlanets, TddgWorthLess, TddgDrawPanel,
  TComponentEditorSample, TDefinePropTest]);

// Register any property editors.
RegisterPropertyEditor(TypeInfo(TRunButtons), TddgLaunchPad, '',
  TRunButtonsProperty);
RegisterPropertyEditor(TypeInfo(TWaveFileString), TddgWaveFile, 'WaveName',
  TWaveFileStringProperty);
RegisterComponentEditor(TddgWaveFile, TWaveEditor);
RegisterComponentEditor(TComponentEditorSample, TSampleEditor);
RegisterPropertyEditor(TypeInfo(TPlanetName), TddgPlanet,
  'PlanetName', TPlanetNameProperty);
RegisterPropertyEditor(TypeInfo(TCommandLine), TddgRunButton, '',
  TCommandLineProperty);

// Register any custom modules, library experts.
RegisterCustomModule(TAppBar, TCustomModule);
RegisterLibraryExpert(TAppBarExpert.Create);

end;

end.
```

Component Security

It is possible for someone to register your components, even though he has only your runtime package. He would do this by creating his own registration unit in which he would register your components. He would then add this unit to a separate package that would also have your runtime package in the `requires` clause. After he installs this new package into the Delphi IDE, your components will appear on the Component Palette. However, it is still not possible to compile any applications using your components because the required `*.dcb` files for your component units will be missing.

Package Distribution

When distributing your packages to component writers without the source code, you must distribute both compiled packages, `DDGdsgn50.bp1` and `DDGStd50.bp1`, both `*.dcb` files, and any

compiled units (*.dcu) necessary to compile your components. Programmers using your components who want their applications' runtime packages enabled must distribute the DDGS+d50.bp1 package along with their applications and any other runtime package that they might be using.

Scenario 2—Design Package Only for Components

The design package only for components scenario is when you want to distribute components that you don't want to be distributed in runtime packages. In this case, you will include the components, component editors, property editors, component registration unit, and so on in one package file.

Package Distribution

When distributing your package to component writers without the source code, you must distribute the compiled package, DDGDsgn50.bp1, the DDGDsgn50.dcp file, and any compiled units (*.dcu) necessary to compile your components. Programmers using your components must compile your components into their applications. They will not be distributing any of your components as runtime packages.

Scenario 3—Design Features Only (No Components) IDE Enhancements

The design features only (no components) IDE enhancements scenario is the case if you are providing enhancements to the Delphi IDE, such as experts. For this scenario, you will register your expert with the IDE in your registration unit. The distribution for this scenario is simple; you only have to distribute the compiled *.bp1 file.

Scenario 4—Application Partitioning

The application partitioning scenario is the case if you want to partition your application into logical pieces, each of which can be distributed separately. There are several reasons why you might want to do this:

- This scenario is easier to maintain.
- Users can purchase only the needed functionality when they need it. Later, when they need added functionality, they can download the necessary package only, which will be much smaller than downloading the entire application.
- You can provide fixes (patches) to parts of the application more easily without requiring users to obtain a new version of the application altogether.

In this scenario, you will provide only the *.bp1 files required by your application. This scenario is similar to the last with the difference being that instead of providing a package for the Delphi IDE, you will be providing a package for your own application. When partitioning your applications as such, you must pay attention to the issues regarding package versioning that we discuss in the next section.

Package Versioning

Package versioning is a topic that is not well understood. You can think of package versioning in much the same way as you think of unit versioning. That is, any package that you provide for your application must be compiled using the same Delphi version used to compile the application. Therefore, you cannot provide a package written in Delphi 5 to be used by an application written in Delphi 4. The Inprise developers refer to the version of a package as a *code base*. So a package written in Delphi 5 has a code base of 5.0. This concept should influence the naming convention that you use for your package files.

Package Compiler Directives

There are some specific compiler directives that you can insert into the source code of your packages. Some of these directives are specific to units that are being packaged; others are specific to the package file. These directives are listed and described in Tables 21.7 and 21.8.

Table 21.7 Compiler Directives for Units Being Packaged

<i>Directive</i>	<i>Meaning</i>
{ <i>\$G</i> } or {IMPORTEDDATA OFF}	Use this when you want to prevent the unit from being packaged—when you want it to be linked directly to the application. Contrast this to the {\$WEAKPACKAGEUNIT} directive, which allows a unit to be included in a package but whose code gets statically linked to the application.
{\$DENYPACKAGEUNIT}	Same as { <i>\$G</i> }.
{\$WEAKPACKAGEUNIT}	See the section “More on the {\$WEAKPACKAGEUNIT} Directive.”

Table 21.8 Compiler Directives for the Package .dpc File

<i>Directive</i>	<i>Meaning</i>
{\$DESIGNONLY ON}	Compiles package as a design-time only package.
{\$RUNONLY ON}	Compiles package as a runtime only package.
{\$IMPLICITBUILD OFF}	Prevents the package from being rebuilt later. Use this option when the package is not changed frequently.

More on the {\$WEAKPACKAGEUNIT} Directive

The concept of a weak package is simple. Basically, it is used where your package may be referencing libraries (DLLs) that may not be present. For example, `Vc140` makes calls to the core

Win32 API included with the Windows operating system. Many of these calls exist in DLLs that aren't present on every machine. These calls are exposed by units that contain the `{$WEAKPACKAGEUNIT}` directive. By including this directive, you keep the unit's source code in the package but place it into the DCP file, rather than in the BPL file (think of a DCP as a DCU and a BPL as a DLL). Therefore, any references to functions of these weakly packaged units get statically linked to the application, rather than dynamically referenced through the package.

The `{$WEAKPACKAGEUNIT}` directive is one that you will rarely use, if at all. It was created out of necessity by the Delphi developers to handle a specific situation. The problem exists if there are two components, each in a separate package that reference the same interface unit of a DLL. When an application uses both of the components, this causes two instances of the DLL to be loaded, which raises havoc with initialization and global variable referencing. The solution is to include the interface unit in one of the standard Delphi packages, such as `Vc150.bp1`. However, this raises the other problem for specialized DLLs that may not be present, such as `PENWIN.DLL`. If `Vc150.bp1` contains the interface unit for a DLL that isn't present, it will render `Vc150.bp1`, and Delphi for that matter, unusable. The Delphi developers addressed this by allowing `Vc150.bp1` to contain the interface unit in a single package, but to make it statically linked when used and not dynamically loaded whenever `Vc150` is used with the Delphi IDE.

As stated, you'll most likely never have to use this directive, unless you anticipate a similar scenario that the Delphi developers faced or if you want to make certain that a particular unit is included with a package but statically linked to the using application. A reason for the latter might be for optimization purposes. Note that any units that are weakly packaged cannot have global variables or code in their initialization/finalization sections. You must also distribute any `*.dcu` files for weakly packaged units along with your packages.

Package-Naming Conventions

Earlier we said that the package-versioning issue should influence how you name your packages. There isn't a set rule as to how you name your packages, but we suggest using a naming convention that incorporates the code base into the package's name. For example, the components for this book are contained in a runtime package whose name contains the `50` qualifier for Delphi 5 (`DDGStd50.dpk`). The same goes for the design package (`DDGDsgn50.dpk`). A previous version of the package would be `DdgStd40.dpk`. By using such a convention, you will prevent any confusion for your package users as to which version of the package they have and as to which version of the Delphi compiler applies to them. Note that our package name starts with a three-character author/company identifier, followed by `Std` to indicate a runtime package and `Dsgn` to signify a design package. You can follow whatever naming convention you like. Just be consistent and use the recommended inclusion of the Delphi version into your package name.

Add-In Packages

Add-in packages allow you to partition your applications into pieces or modules and to distribute those modules separately from the main application. This scheme is especially attractive because it allows you to extend the functionality of your application without having to recompile/redesign the entire application. This requires careful architectural design planning, however. It is beyond the scope of this book to go into such design issues. For a more detailed discussion of add-in packages and how they relate to application frameworks and design patterns, you will find articles at <http://www.xapware.com>.

Our example is a simple illustration of this technique. We will show how to add a form to an application without having to rewrite the application entirely. You can obtain a more elaborate example from the URL mentioned in the preceding paragraph.

Generating Add-In Forms

In Chapter 4, “Application Frameworks and Design Concepts,” you learned about application frameworks. We developed an application whose forms were descendants of a base class (TChildForm). We’ll use this same application to illustrate how you can create a shell application that knows only of the TChildForm class but can work with any descendent of that class. The descendants will be provided in thorough add-in packages.

NOTE

If you installed the forms used in the application framework demo from Chapter 4 to your Object Repository, you will have to remove them from the Repository before loading the project from this application.

The application is partitioned into three logical pieces: the main application (ChildTest.exe), the TChildForm package (AChildForm50.bpl), and the concrete TChildForm descendant classes, each residing in its own package.

The main application is basically the same as that from Chapter 4 with some modification. The package AChildForm50.bpl contains the *abstract* TChildForm class. The other packages contain descendant TChildForm classes or *concrete* TChildForms. We will refer to these packages as the *abstract package* and *concrete packages*, respectively.

The main application uses the abstract package (AChildForm50.bpl). Each concrete package also uses the abstract package. For this to work properly, the main application must be compiled with runtime packages, including the AChildForm50.dcp package. Likewise, each concrete package must require the AChildForm50.dcp package. We will not list the TChildForm

source or the concrete descendants to `TChildForm`, because they are not much different from those shown in Chapter 4. The only difference is that each `TChildForm` descendant unit must include initialization and finalization blocks that look like this:

```
initialization
  RegisterClass(TCF2Form);
finalization
  UnRegisterClass(TCF2Form);
```

The call to `RegisterClass()` is necessary to make the `TChildForm` descendant class available to the main application's streaming system when the main application loads its package. This is similar to how `RegisterComponents()` makes components available to the Delphi IDE. When the package is unloaded, the call to `UnRegisterClass()` is required to remove the registered class. Note that `RegisterClass()` only makes the class available to the main application, however. The main application still does not know of the class name. So how does the main application create an instance of a class whose class name is unknown? Isn't the intent of this exercise to make these forms available to the main application without having to hard code their class names into the main application's source? Listing 21.18 shows the source code to the main application's main form where we will highlight how we accomplish add-in forms with add-in packages.

LISTING 21.18 The Main Form of the Main Application Using Add-In Packages

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ExtCtrls, ChildFrm, Menus;

const
  { Child form registration location in the Windows Registry. }
  cCFRegLocation = 'Software\Delphi 5 Developer's Guide';
  cCFRegSection = 'ChildForms'; // Module initialization data section

  FMainCaption = 'Delphi 5 Developer's Guide Child Form Demo';

type

  TChildFormClass = class of TChildForm;

  TMainForm = class(TForm)
    pnlMain: TPanel;
```

continues

LISTING 21.18 Continued

```
Splitter1: TSplitter;
pnlParent: TPanel;
mmMain: TMainMenu;
mmiFile: TMenuItem;
mmiExit: TMenuItem;
mmiHelp: TMenuItem;
mmiForms: TMenuItem;
procedure mmiExitClick(Sender: TObject);
procedure FormCreate(Sender: TObject);
procedure FormDestroy(Sender: TObject);
private
  // reference to the child form.
  FChildForm: TChildForm;
  // a list of available child forms used to build a menu.
  FChildFormList: TStringList;
  // Index to the Close Form menu which shifts position.
  FCloseFormIndex: Integer;
  // Handle to the currently loaded package.
  FCurrentModuleHandle: HModule;
  // method to create menus for available child forms.
  procedure CreateChildFormMenus;
  // Handler to load a child form and its package.
  procedure LoadChildFormOnClick(Sender: TObject);
  // Handler to unload a child form and its package.
  procedure CloseFormOnClick(Sender: TObject);
  // Method to retrieve the classname for a TChildForm descendant
  function GetChildFormClassName(const AModuleName: String): String;
public
  { Public declarations }
end;

var
  MainForm: TMainForm;

implementation
uses Registry;

{$R *.DFM}

function RemoveExt(const AFileName: String): String;
{ Helper function to remove the extension from a filename. }
begin
  if Pos('.', AFileName) <> 0 then
    Result := Copy(AFileName, 1, Pos('.', AFileName)-1)
```

```
    else
      Result := AFileName;
end;

procedure TMainForm.mmiExitClick(Sender: TObject);
begin
  Close;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
  FChildFormList := TStringList.Create;
  CreateChildFormMenus;
end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
  FChildFormList.Free;
  // Unload any loaded child forms.
  if FCurrentModuleHandle <> 0 then
    CloseFormOnClick(nil);
end;

procedure TMainForm.CreateChildFormMenus;
{ All available child forms are registered in the Windows Registry.
  Here, we use this information to create menu items for loading each of the
  child forms. }
var
  IniFile: TRegIniFile;
  MenuItem: TMenuItem;
  i: integer;
begin
  inherited;

  { Retrieve a list of all child forms and build a menu based on the
    entries in the registry. }
  IniFile := TRegIniFile.Create(cCFRegLocation);
  try
    IniFile.ReadSectionValues(cCFRegSection, FChildFormList);
  finally
    IniFile.Free;
  end;

  { Add Menu items for each module. NOTE THE mmMain.AutoHotKeys property must
    be set to maAutomatic }
```

continues

LISTING 21.18 Continued

```
for i := 0 to FChildFormList.Count - 1 do
begin
  MenuItem := TMenuItem.Create(mmMain);
  MenuItem.Caption := FChildFormList.Names[i];
  MenuItem.OnClick := LoadChildFormOnClick;
  mmiForms.Add(MenuItem);
end;

// Create Separator
MenuItem := TMenuItem.Create(mmMain);
MenuItem.Caption := '-';
mmiForms.Add(MenuItem);

// Create Close Module menu item
MenuItem := TMenuItem.Create(mmMain);
MenuItem.Caption := '&Close Form';
MenuItem.OnClick := CloseFormOnClick;
MenuItem.Enabled := False;
mmiForms.Add(MenuItem);

{ Save a reference to the index of the menu item required to
  close a child form. This will be referred to in another method. }
FCloseFormIndex := MenuItem.MenuIndex;
end;

procedure TMainForm.LoadChildFormOnClick(Sender: TObject);
var
  ChildFormClassName: String;
  ChildFormClass: TChildFormClass;
  ChildFormName: String;
  ChildFormPackage: String;
begin
  // The menu caption represents the module name.
  ChildFormName := (Sender as TMenuItem).Caption;
  // Get the actual Package filename.
  ChildFormPackage := FChildFormList.Values[ChildFormName];

  // Unload any previously loaded packages.
  if FCurrentModuleHandle <> 0 then
    CloseFormOnClick(nil);

  try
    // Load the specified package
```

```
FCurrentModuleHandle := LoadPackage(ChildFormPackage);

// Return the classname that needs to be created
ChildFormClassName := GetChildFormClassName(ChildFormPackage);

{ Create an instance of the class using the FindClass() procedure. Note,
  this requires that the class already be registered with the streaming
  system using RegisterClass(). This is done in the child form
  initialization section for each child form package. }
ChildFormClass := TChildFormClass(FindClass(ChildFormClassName));
FChildForm := ChildFormClass.Create(self, pnlParent);
Caption := FChildForm.GetCaption;
FChildForm.Show;

mmiForms[FCloseFormIndex].Enabled := True;
except
  on E: Exception do
  begin
    CloseFormOnClick(nil);
    raise;
  end;
end;
end;

function TMainForm.GetChildFormClassName(const AModuleName: String): String;
{ The Actual class name of the TChildForm implementation resides in the
  registry. This method retrieves that class name. }
var
  IniFile: TRegIniFile;
begin
  IniFile := TRegIniFile.Create(cCFRegLocation);
  try
    Result := IniFile.ReadString(RemoveExt(AModuleName), 'ClassName',
      EmptyStr);
  finally
    IniFile.Free;
  end;
end;

procedure TMainForm.CloseFormOnClick(Sender: TObject);
begin
  if FCurrentModuleHandle <> 0 then
  begin
    if FChildForm <> nil then
    begin
      FChildForm.Free;
    end;
  end;
end;
```

continues

LISTING 21.18 Continued

```
FChildForm := nil;
end;

// Unregister any classes provided by the module
UnRegisterModuleClasses(FCurrentModuleHandle);
// Unload the child form package
UnloadPackage(FCurrentModuleHandle);

FCurrentModuleHandle := 0;
mmiForms[FCloseFormIndex].Enabled := False;
Caption := FMainCaption;
end;
end;

end.
```

The application's logic is actually very simple. It uses the system registry to determine which packages are available, the menu captions to use when building menus for loading each package, and the class name of the form contained in each package.

NOTE

We've included a file called D5DG.Reg on which you can double-click in Windows Explorer. This imports the registry settings in order for the add-in package demo to run properly.

The `LoadChildFormOnClick()` event handler is where most of the work is performed. After determining the package filename, the method loads the package using the `LoadPackage()` function. The `LoadPackage()` function is basically the same thing as `LoadLibrary()` for DLLs. The method then determines the class name for the form contained in the loaded package.

To create a class, you need a class reference such as `TButton` or `TForm1`. However, this main application does not have the hard-coded class name of the concrete `TChildForms`. This is why we retrieve the class name from the system registry. The main application can pass this class name to the `FindClass()` function to return a class reference for the specified class that already has been registered with the streaming system. Remember that we did this in the initialization section of the concrete form's unit, which is called when the package is loaded. We then create the class with these lines:

```
ChildFormClass := TChildFormClass(FindClass(ChildFormClassName));
FChildForm := ChildFormClass.Create(self, pnlParent);
```

The variable `ChildFormClass` is a predeclared class reference to `TChildForm` and can refer to a class reference for a `TChildForm` descendant.

The `CloseFormOnClick()` event handler simply closes the child form and unloads its package. The rest of the code basically is set up to create the package menus and to read the information from the system registry.

Further study on this technique will enable you to create very extensible and loosely coupled application frameworks.

Summary

Knowing how components work is fundamental to understanding Delphi, and you will work with many more custom components later in the book. Now that you can see what happens behind the scenes, components will no longer be such a mystery. The next chapter goes beyond component creation into more advanced component-building techniques.

Advanced Component Design Techniques

CHAPTER

22

IN THIS CHAPTER

- **Pseudo-Visual Components 1008**
- **Animated Components 1012**
- **Writing Property Editors 1029**
- **Component Editors 1040**
- **Streaming Nonpublished
Component Data 1046**
- **Property Categories 1058**
- **Lists of Components: TCollection and
TCollectionItem 1064**
- **Summary 1088**

The last chapter broke into writing Delphi custom components, and it gave you a solid introduction to the basics. In this chapter, you'll learn how to take component writing to the next level by incorporating advanced design techniques into your Delphi custom components. This chapter provides examples of advanced techniques such as pseudo-visual components, detailed property editors, component editors, and collections.

Pseudo-Visual Components

You've learned about visual components such as `TButton` and `TEdit`, and you've learned about nonvisual components such as `TTable` and `TTimer`. In this section, you'll also learn about a type of component that kind of falls in between visual and nonvisual components—we'll call these components *pseudo-visual components*.

Extending Hints

Specifically, the pseudo-visual component shown in this section is an extension of a Delphi pop-up hint window. We call this a *pseudo-visual* component because it's not a component that's used visually from the Component Palette at design time, but it does represent itself visually at runtime in the body of pop-up hints.

Replacing the default style hint window in a Delphi application requires that you complete the following four steps:

1. Create a descendant of `THintWindow`.
2. Destroy the old hint window class.
3. Assign the new hint window class.
4. Create the new hint window class.

Creating a `THintWindow` Descendant

Before you write the code for a `THintWindow` descendant, you must first decide how you want your new hint window class to behave differently than the default one. In this case, you'll create an elliptical hint window rather than the default square one. This actually demonstrates another cool technique: creating nonrectangular windows! Listing 22.1 shows the `RndHint.pas` unit, which contains the `THintWindow` descendant `TDDGHintWindow`.

LISTING 22.1 `RndHint.pas`—Illustrates an Elliptical Hint

```
unit RndHint;  
  
interface  
  
uses Windows, Classes, Controls, Forms, Messages, Graphics;
```

```

type
  TDDGHintWindow = class(THintWindow)
  private
    FRegion: THandle;
    procedure FreeCurrentRegion;
  public
    destructor Destroy; override;
    procedure ActivateHint(Rect: TRect; const AHint: string); override;
    procedure Paint; override;
    procedure CreateParams(var Params: TCreateParams); override;
  end;

implementation

destructor TDDGHintWindow.Destroy;
begin
  FreeCurrentRegion;
  inherited Destroy;
end;

procedure TDDGHintWindow.FreeCurrentRegion;
{ Regions, like other API objects, should be freed when you are }
{ through using them. Note, however, that you cannot delete a }
{ region which is currently set in a window, so this method sets }
{ the window region to 0 before deleting the region object. }
begin
  if FRegion <> 0 then begin           // if Region is alive...
    SetWindowRgn(Handle, 0, True);    // set win region to 0
    DeleteObject(FRegion);           // kill the region
    FRegion := 0;                    // zero out field
  end;
end;

procedure TDDGHintWindow.ActivateHint(Rect: TRect; const AHint: string);
{ Called when the hint is activated by putting the mouse pointer }
{ above a control. }
begin
  with Rect do
    Right := Right + Canvas.TextWidth('WWWW'); // add some slop
  BoundsRect := Rect;
  FreeCurrentRegion;
  with BoundsRect do

```

LISTING 22.1 Continued

```
    { Create a round rectangular region to display the hint window }
    FRegion := CreateRoundRectRgn(0, 0, Width, Height, Width, Height);
    if FRegion <> 0 then
        SetWindowRgn(Handle, FRegion, True);           // set win region
        inherited ActivateHint(Rect, AHint);          // call inherited
    end;

procedure TDDGHintWindow.CreateParams(var Params: TCreateParams);
{ We need to remove the border created on the Windows API-level }
{ when the window is created. }
begin
    inherited CreateParams(Params);
    Params.Style := Params.Style and not ws_Border; // remove border
end;

procedure TDDGHintWindow.Paint;
{ This method gets called by the WM_PAINT handler. It is }
{ responsible for painting the hint window. }
var
    R: TRect;
begin
    R := ClientRect;           // get bounding rectangle
    Inc(R.Left, 1);           // move left side slightly
    Canvas.Font.Color := clInfoText; // set to proper color
    { paint string in the center of the round rect }
    DrawText(Canvas.Handle, PChar(Caption), Length(Caption), R,
              DT_NOPREFIX or DT_WORDBREAK or DT_CENTER or DT_VCENTER);
end;

initialization
    Application.ShowHint := False; // destroy old hint window
    HintWindowClass := TDDGHintWindow; // assign new hint window
    Application.ShowHint := True; // create new hint window
end.
```

The overridden `CreateParams()` and `Paint()` methods are fairly straightforward. `CreateParams()` provides an opportunity to adjust the structure of the window styles before the hint window is created on an API level. In this method, the `WS_BORDER` style is removed from the window class in order to prevent a rectangular border from being drawn around the window. The `Paint()` method is responsible for rendering the window. In this case, the method must paint the hint's `Caption` property into the center of the caption window. The color of the text is set to `clInfoText`, which is the system-defined color of hint text.

An Elliptical Window

The `ActivateHint()` method contains the magic for creating the nonrectangular hint window. Well, it's not really magic. Actually, two API calls make it happen: `CreateRoundRectRgn()` and `SetWindowRgn()`.

`CreateRoundRectRgn()` defines a rounded rectangular region within a particular window. A *region* is a special API object that allows you to perform special painting, hit testing, filling, and clipping in one area. In addition to `CreateRoundRectRgn()`, a number of other Win32 API functions create different types of regions, including the following:

- `CreateEllipticRgn()`
- `CreateEllipticRgnIndirect()`
- `CreatePolygonRgn()`
- `CreatePolyPolygonRgn()`
- `CreateRectRgn()`
- `CreateRectRgnIndirect()`
- `CreateRoundRectRgn()`
- `ExtCreateRegion()`

Additionally, the `CombineRgn()` function can be used to combine multiple regions into one complex region. All these functions are described in detail in the Win32 API online help.

`SetWindowRgn()` is then called, passing the recently created region handle as a parameter. This function causes the operating system to take ownership of the region, and all subsequent drawing in the specified window will occur only within the region. Therefore, if the region defined is a rounded rectangle, painting will occur only within that rounded rectangular region.

CAUTION

You need to be aware of two side effects when using `SetWindowRgn()`. First, because only the portion of the window within the region is painted, your window probably won't have a frame or title bar. You must be prepared to provide the user with an alternative way to move, size, and close the window without the aid of a frame or title bar. Second, because the operating system takes ownership of the region specified in `SetWindowRgn()`, you must be careful not to manipulate or delete the region while it's in use. The `TDDGHintWindow` component handles this by calling its `FreeCurrentRegion()` method before the window is destroyed or a new window is created.

Enabling the THintWindow Descendant

The initialization code for the `RndHint` unit does the work of making the `TDDGHintWindow` component the application-wide active hint window. Setting `Application.ShowHint` to `False` causes the old hint window to be destroyed. At that point, you must assign your `THintWindow` descendant class to the `HintWindowClass` global variable. Then, setting `Application.ShowHint` back to `True` causes a new hint window to be created—this time it will be an instance of your descendant class.

Figure 22.1 shows the `TDDGHintWindow` component in action.

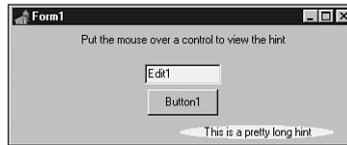


FIGURE 22.1

Looking at a `TDDGHintWindow` hint.

Deploying TDDGHintWindow

Deploying this pseudo-visual component is different from normal visual and nonvisual components. Because all the work for instantiating the component is performed in the initialization part of its unit, the unit should not be added to a design package for use on the Component Palette but merely added to the uses clause of one of the source files in your project.

Animated Components

Once upon a time while writing a Delphi application, we thought to ourselves, “This is a really cool application, but our About dialog is kind of boring. We need something to spice it up a little.” Suddenly, a light bulb came on and an idea for a new component was born: We would create a scrolling credits marquee window to incorporate into our About dialogs.

The Marquee Component

Let’s take a moment to analyze how the marquee component works. The marquee control is able to take a bunch of strings and scroll them across the component on command, like a real-life marquee. You’ll use `TCustomPanel` as the base class for this `TddgMarquee` component because it already has the basic built-in functionality you need, including a pretty 3D beveled border.

`TddgMarquee` paints some text strings to a bitmap residing in memory and then copies portions of the memory bitmap to its own canvas to simulate a scrolling effect. It does this using the

`BitBlt()` API function to copy a component-sized portion of the memory canvas to the component, starting at the top. Then, it moves down a couple pixels on the memory canvas and copies that image to the control. It moves down again, copies again, and repeats the process over and over so that the entire contents of the memory canvas appear to scroll through the component.

Now is the time to identify any additional classes you might need to integrate into the `TddgMarquee` component in order to bring it to life. There are really only two such classes. First, you need the `TStringList` class to hold all the strings you want to scroll. Second, you must have a memory bitmap on which you can render all the text strings. VCL's own `TBitmap` component will work nicely for this purpose.

Writing the Component

As with the previous components in this chapter, the code for `TddgMarquee` should be approached with a logical plan of attack. In this case, we break up the code work into reasonable parts. The `TddgMarquee` component can be divided into five major parts:

- The mechanism that renders the text onto the memory canvas
- The mechanism that copies the text from the memory canvas to the marquee window
- The timer that keeps track of when and how to scroll the window to perform the animation
- The class constructor, destructor, and associated methods
- The finishing touches, such as various helper properties and methods

Drawing on an Offscreen Bitmap

When creating an instance of `TBitmap`, you need to know how big it must be to hold the entire list of strings in memory. You do this by first figuring out how high each line of text will be and then multiplying by the number of lines. To find the height and spacing of a line of text in a particular font, use the `GetTextMetrics()` API function by passing it the canvas's handle. A `TTextMetric` record to be filled in by the function:

```
var
  Metrics: TTextMetric;
begin
  GetTextMetrics(Canvas.Handle, Metrics);
```

NOTE

The `GetTextMetrics()` API function modifies a `TTextMetric` record that contains a great deal of quantitative information about a device context's currently selected

continues

font. This function gives you information not only on font height and width but also on whether the font is boldfaced, italicized, struck out, or even what the character set name is.

The `TextHeight()` method of `TCanvas` won't work here. That method only determines the height of a specific line of text rather than the spacing for the font in general.

The height of a character cell in the canvas's current font is given by the `tmHeight` field of the `Metrics` record. If you add to that value the `tmInternalLeading` field—to allow for some space between lines—you get the height for each line of text to be drawn on the memory canvas:

```
LineHi := Metrics.tmHeight + Metrics.tmInternalLeading;
```

The height necessary for the memory canvas then can be determined by multiplying `LineHi` by the number of lines of text and adding that value to two times the height of the `TddgMarquee` control (to create the blank space at the beginning and end of the marquee). Suppose that the `TStringList` in which all the strings live is called `FItems`; now place the memory canvas dimensions in a `TRect` structure:

```
var
  VRect: TRect;
begin
  { VRect rectangle represents entire memory bitmap }
  VRect := Rect(0, 0, Width, LineHi * FItems.Count + Height * 2);
end;
```

After being instantiated and sized, the memory bitmap is initialized further by setting the font to match the `Font` property of `TddgMarquee`, filling the background with a color determined by the `Color` property of `TddgMarquee`, and setting the `Style` property of `Brush` to `bsClear`.

TIP

When you render text on `TCanvas`, the text background is filled with the current color of `TCanvas.Brush`. To cause the text background to be invisible, set `TCanvas.Brush.Style` to `bsClear`.

Most of the preliminary work is now in place, so it's time to render the text on the memory bitmap. As discussed in Chapter 8, "Graphics Programming with GDI and Fonts," there are a couple of ways to output text onto a canvas. The most straightforward way is to use the `TextOut()` method of `TCanvas`; however, you have more control over the formatting of the text

when you use the more complex `DrawText()` API function. Because it requires control over justification, `TddgMarquee` will use the `DrawText()` function. An enumerated type is ideal to represent the text justification:

```
type
  TJustification = (tjCenter, tjLeft, tjRight);
```

The following code shows the `PaintLine()` method for `TddgMarquee`, which makes use of `DrawText()` to render text onto the memory bitmap. In this method, `FJust` represents an instance variable of type `TJustification`. Here's the code:

```
procedure TddgMarquee.PaintLine(R: TRect; LineNum: Integer);
{ this method is called to paint each line of text onto MemBitmap }
const
  Flags: array[TJustification] of DWORD = (DT_CENTER, DT_LEFT, DT_RIGHT);
var
  S: string;
begin
  { Copy next line to local variable for clarity }
  S := FItems.Strings[LineNum];
  { Draw line of text onto memory bitmap }
  DrawText(MemBitmap.Canvas.Handle, PChar(S), Length(S), R,
    Flags[FJust] or DT_SINGLELINE or DT_TOP);
end;
```

Painting the Component

Now that you know how to create the memory bitmap and paint text onto it, the next step is learning how to copy that text to the `TddgMarquee` canvas.

The `Paint()` method of a component is invoked in response to a Windows `WM_PAINT` message. The `Paint()` method is what gives your component life; you use the `Paint()` method to paint, draw, and fill to determine the graphical appearance of your components.

The job of `TddgMarquee.Paint()` is to copy the strings from the memory canvas to the canvas of `TddgMarquee`. This feat is accomplished by the `BitBlt()` API function, which copies the bits from one device context to another.

To determine whether `TddgMarquee` is currently running, the component will maintain a Boolean instance variable called `FActive` that reveals whether the marquee's scrolling capability has been activated. Therefore, the `Paint()` method paints differently depending on whether the component is active:

```
procedure TddgMarquee.Paint;
{ this virtual method is called in response to a }
{ Windows paint message }
```

```
begin
  if FActive then
    { Copy from memory bitmap to screen }
    BitBlt(Canvas.Handle, 0, 0, InsideRect.Right, InsideRect.Bottom,
           MemBitmap.Canvas.Handle, 0, CurrLine, srcCopy)
  else
    inherited Paint;
end;
```

If the marquee is active, the component uses the `BitBlt()` function to paint a portion of the memory canvas onto the `TddgMarquee` canvas. Notice the `CurrLine` variable, which is passed as the next-to-last parameter to `BitBlt()`. The value of this parameter determines which portion of the memory canvas to transfer onto the screen. By continuously incrementing or decrementing the value of `CurrLine`, you can give `TddgMarquee` the appearance that the text is scrolling up or down.

Animating the Marquee

The visual aspects of the `TddgMarquee` component are now in place. The rest of the work involved in getting the component working is just hooking up the plumbing, so to speak. At this point, `TddgMarquee` requires some mechanism to change the value of `CurrLine` every so often and to repaint the component. This trick can be accomplished fairly easily using Delphi's `TTimer` component.

Before you can use `TTimer`, of course, you must create and initialize the class instance. `TddgMarquee` will have a `TTimer` instance called `FTimer`, and you'll initialize it in a procedure called `DoTimer`:

```
procedure DoTimer;
{ procedure sets up TddgMarquee's timer }
begin
  FTimer := TTimer.Create(Self);
  with FTimer do
  begin
    Enabled := False;
    Interval := TimerInterval;
    OnTimer := DoTimerOnTimer;
  end;
end;
```

In this procedure, `FTimer` is created, and it's disabled initially. Its `Interval` property then is assigned to the value of a constant called `TimerInterval`. Finally, the `OnTimer` event for `FTimer` is assigned to a method of `TddgMarquee` called `DoTimerOnTimer`. This is the method that will be called when an `OnTimer` event occurs.

NOTE

When assigning values to events in your code, you need to follow two rules:

- The procedure you assign to the event must be a method of some object instance. It can't be a standalone procedure or function.
- The method you assign to the event must accept the same parameter list as the event type. For example, the `OnTimer` event for `TTimer` is of type `TNotifyEvent`. Because `TNotifyEvent` accepts one parameter, `Sender`, of type `TObject`, any method you assign to `OnTimer` must also take one parameter of type `TObject`.

The `DoTimerOnTimer()` method is defined as follows:

```
procedure TddgMarquee.DoTimerOnTimer(Sender: TObject);
{ This method is executed in response to a timer event }
begin
  IncLine;
  { only repaint within borders }
  InvalidateRect(Handle, @InsideRect, False);
end;
```

In this method, a procedure named `IncLine()` is called; this procedure increments or decrements the value of `CurrLine` as necessary. Then the `InvalidateRect()` API function is called to “invalidate” (or *repaint*) the interior portion of the component. We chose to use `InvalidateRect()` rather than the `Invalidate()` method of `TCanvas` because `Invalidate()` causes the entire canvas to be repainted rather than just the portion within a defined rectangle, as is the case with `InvalidateRect()`. This method, because it doesn't continuously repaint the entire component, eliminates much of the flicker that would otherwise occur. Remember: Flicker is bad.

The `IncLine()` method, which updates the value of `CurrLine` and detects whether scrolling has completed, is defined as follows:

```
procedure TddgMarquee.IncLine;
{ this method is called to increment a line }
begin
  if not FScrollDown then      // if Marquee is scrolling upward
  begin
    { Check to see if marquee has scrolled to end yet }
    if FItems.Count * LineHi + ClientRect.Bottom -
      ScrollPixels >= CurrLine then
    { not at end, so increment current line }
      Inc(CurrLine, ScrollPixels)
```

```

        else SetActive(False);
    end
    else begin
        // if Marquee is scrolling downward
        { Check to see if marquee has scrolled to end yet }
        if CurrLine >= ScrollPixels then
            { not at end, so decrement current line }
            Dec(CurrLine, ScrollPixels)
        else SetActive(False);
        end;
    end;
end;

```

The constructor for `TddgMarquee` is actually quite simple. It calls the inherited `Create()` method, creates a `TStringList` instance, sets up `FTimer`, and then sets all the default values for the instance variables. Once again, you must remember to call the inherited `Create()` method in your components. Failure to do so means your components will miss out on important and useful functionality, such as handle and canvas creation, streaming, and Windows message response. The following code shows the `TddgMarquee` constructor, `Create()`:

```

constructor TddgMarquee.Create(AOwner: TComponent);
{ constructor for TddgMarquee class }

    procedure DoTimer;
    { procedure sets up TddgMarquee's timer }
    begin
        FTimer := TTimer.Create(Self);
        with FTimer do
            begin
                Enabled := False;
                Interval := TimerInterval;
                OnTimer := DoTimerOnTimer;
            end;
        end;
    end;

begin
    inherited Create(AOwner);
    FItems := TStringList.Create; { instantiate string list }
    DoTimer; { set up timer }
    { set instance variable default values }
    Width := 100;
    Height := 75;
    FActive := False;
    FScrollDown := False;
    FJust := tjCenter;

```

```
    BevelWidth := 3;
end;
```

The `TddgMarquee` destructor is even simpler: The method deactivates the component by passing `False` to the `SetActive()` method, frees the timer and the string list, and then calls the inherited `Destroy()` method:

```
destructor TddgMarquee.Destroy;
{ destructor for TddgMarquee class }
begin
    SetActive(False);
    FTimer.Free;           // free allocated objects
    FItems.Free;
    inherited Destroy;
end;
```

TIP

As a rule of thumb, when you override constructors, you usually call `inherited` first, and when you override destructors, you usually call `inherited` last. This ensures that the class has been set up before you modify it and that all dependent resources have been cleaned up before you dispose of the class.

Exceptions to this rule exist; however, you should generally stick to it unless you have good reason not to.

The `SetActive()` method, which is called by both the `Incline()` method and the destructor (in addition to serving as the writer for the `Active` property), serves as a vehicle that starts and stops the marquee scrolling up the canvas:

```
procedure TddgMarquee.SetActive(Value: Boolean);
{ called to activate/deactivate the marquee }
begin
    if Value and (not FActive) and (FItems.Count > 0) then
    begin
        FActive := True;           // set active flag
        MemBitmap := TBitmap.Create;
        FillBitmap;                // Paint Image on bitmap
        FTimer.Enabled := True;    // start timer
    end
    else if (not Value) and FActive then
    begin
        FTimer.Enabled := False;  // disable timer,
```

```
    if Assigned(FOnDone)      // fire OnDone event,
    then FOnDone(Self);
    FActive := False;        // set FActive to False
    MemBitmap.Free;         // free memory bitmap
    Invalidate;             // clear control window
end;
end;
```

An important feature of `TddgMarquee` that's lacking thus far is an event that tells the user when scrolling is complete. Never fear—this feature is very straightforward to add by way of an event: `FOnDone`. The first step to adding an event to your component is to declare an instance variable of some event type in the private portion of the class definition. You'll use the `TNotifyEvent` type for the `FOnDone` event:

```
FOnDone: TNotifyEvent;
```

The event should then be declared in the published part of the class as a property:

```
property OnDone: TNotifyEvent read FOnDone write FOnDone;
```

Recall that the `read` and `write` directives specify from which function or variable a given property should get or set its value.

Taking just these two small steps will cause an entry for `OnDone` to be displayed in the Events page of the Object Inspector at design time. The only other thing that needs to be done is to call the user's handler for `OnDone` (if a method is assigned to `OnDone`), as demonstrated by `TddgMarquee` with this line of code in the `Deactivate()` method:

```
if Assigned(FOnDone) then FOnDone(Self); // fire OnDone event
```

This line basically reads, "If the component user has assigned a method to the `OnDone` event, call that method and pass the `TddgMarquee` class instance (`Self`) as a parameter."

Listing 22.2 shows the completed source code for the Marquee unit. Notice that because the component descends from a `TCustomXXX` class, you need to publish many of the properties provided by `TCustomPanel`.

LISTING 22.2 Marquee.pas—Illustrates the `TddgMarquee` Component

```
unit Marquee;

interface

uses
  SysUtils, Windows, Classes, Forms, Controls, Graphics,
  Messages, ExtCtrls, Dialogs;

const
```

```

ScrollPixels = 3;    // num of pixels for each scroll
TimerInterval = 50; // time between scrolls in ms

type
  TJustification = (tjCenter, tjLeft, tjRight);

  EMarqueeError = class(Exception);

  TddgMarquee = class(TCustomPanel)
  private
    MemBitmap: TBitmap;
    InsideRect: TRect;
    FItems: TStringList;
    FJust: TJustification;
    FScrollDown: Boolean;
    LineHi : Integer;
    CurrLine : Integer;
    VRect: TRect;
    FTimer: TTimer;
    FActive: Boolean;
    FOnDone: TNotifyEvent;
    procedure SetItems(Value: TStringList);
    procedure DoTimerOnTimer(Sender: TObject);
    procedure PaintLine(R: TRect; LineNum: Integer);
    procedure SetLineHeight;
    procedure SetStartLine;
    procedure IncLine;
    procedure SetActive(Value: Boolean);
  protected
    procedure Paint; override;
    procedure FillBitmap; virtual;
  public
    property Active: Boolean read FActive write SetActive;
    constructor Create(AOwner: TComponent); override;
    destructor Destroy; override;
  published
    property ScrollDown: Boolean read FScrollDown write FScrollDown;
    property Justify: TJustification read FJust write FJust default tjCenter;
    property Items: TStringList read FItems write SetItems;
    property OnDone: TNotifyEvent read FOnDone write FOnDone;
    { Publish inherited properties: }
    property Align;
    property Alignment;
    property BevelInner;
    property BevelOuter;
    property BevelWidth;

```

LISTING 22.2 Continued

```
    property BorderWidth;
    property BorderStyle;
    property Color;
    property Ctl3D;
    property Font;
    property Locked;
    property ParentColor;
    property ParentCtl3D;
    property ParentFont;
    property Visible;
    property OnClick;
    property OnDblClick;
    property OnMouseDown;
    property OnMouseMove;
    property OnMouseUp;
    property OnResize;
end;

implementation

constructor TddgMarquee.Create(AOwner: TComponent);
{ constructor for TddgMarquee class }

procedure DoTimer;
{ procedure sets up TddgMarquee's timer }
begin
    FTimer := TTimer.Create(Self);
    with FTimer do
    begin
        Enabled := False;
        Interval := TimerInterval;
        OnTimer := DoTimerOnTimer;
    end;
end;

begin
    inherited Create(AOwner);
    FItems := TStringList.Create; { instantiate string list }
    DoTimer; { set up timer }
    { set instance variable default values }
    Width := 100;
    Height := 75;
    FActive := False;
    FScrollDown := False;
```

```
FJust := tjCenter;
BevelWidth := 3;
end;

destructor TddgMarquee.Destroy;
{ destructor for TddgMarquee class }
begin
  SetActive(False);
  FTimer.Free;           // free allocated objects
  FItems.Free;
  inherited Destroy;
end;

procedure TddgMarquee.DoTimerOnTimer(Sender: TObject);
{ This method is executed in response to a timer event }
begin
  IncLine;
  { only repaint within borders }
  InvalidateRect(Handle, @InsideRect, False);
end;

procedure TddgMarquee.IncLine;
{ this method is called to increment a line }
begin
  if not FScrollDown then      // if Marquee is scrolling upward
  begin
    { Check to see if marquee has scrolled to end yet }
    if FItems.Count * LineHi + ClientRect.Bottom -
      ScrollPixels >= CurrLine then
      { not at end, so increment current line }
      Inc(CurrLine, ScrollPixels)
    else SetActive(False);
  end
  else begin                    // if Marquee is scrolling downward
    { Check to see if marquee has scrolled to end yet }
    if CurrLine >= ScrollPixels then
      { not at end, so decrement current line }
      Dec(CurrLine, ScrollPixels)
    else SetActive(False);
  end;
end;

procedure TddgMarquee.SetItems(Value: TStringList);
begin
  if FItems <> Value then
    FItems.Assign(Value);
```

LISTING 22.2 Continued

```
end;

procedure TddgMarquee.SetLineHeight;
{ this virtual method sets the LineHi instance variable }
var
  Metrics : TTextMetric;
begin
  { get metric info for font }
  GetTextMetrics(Canvas.Handle, Metrics);
  { adjust line height }
  LineHi := Metrics.tmHeight + Metrics.tmInternalLeading;
end;

procedure TddgMarquee.SetStartLine;
{ this virtual method initializes the CurrLine instance variable }
begin
  // initialize current line to top if scrolling up, or...
  if not FScrollDown then CurrLine := 0
  // bottom if scrolling down
  else CurrLine := VRect.Bottom - Height;
end;

procedure TddgMarquee.PaintLine(R: TRect; LineNum: Integer);
{ this method is called to paint each line of text onto MemBitmap }
const
  Flags: array[TJustification] of DWORD = (DT_CENTER, DT_LEFT, DT_RIGHT);
var
  S: string;
begin
  { Copy next line to local variable for clarity }
  S := FItems.Strings[LineNum];
  { Draw line of text onto memory bitmap }
  DrawText(MemBitmap.Canvas.Handle, PChar(S), Length(S), R,
    Flags[FJust] or DT_SINGLELINE or DT_TOP);
end;

procedure TddgMarquee.FillBitmap;
var
  y, i : Integer;
  R: TRect;
begin
  SetLineHeight; // set height of each line
  { VRect rectangle represents entire memory bitmap }
  VRect := Rect(0, 0, Width, LineHi * FItems.Count + Height * 2);
```

```

{ InsideRect rectangle represents interior of beveled border }
InsideRect := Rect(BevelWidth, BevelWidth, Width - (2 * BevelWidth),
  Height - (2 * BevelWidth));
R := Rect(InsideRect.Left, 0, InsideRect.Right, VRect.Bottom);
SetStartLine;
MemBitmap.Width := Width;      // initialize memory bitmap
with MemBitmap do
begin
  Height := VRect.Bottom;
  with Canvas do
  begin
    Font := Self.Font;
    Brush.Color := Color;
    FillRect(VRect);
    Brush.Style := bsClear;
  end;
end;
y := Height;
i := 0;
repeat
  R.Top := y;
  PaintLine(R, i);
  { increment y by the height (in pixels) of a line }
  inc(y, LineHi);
  inc(i);
until i >= FItems.Count;      // repeat for all lines
end;

procedure TddgMarquee.Paint;
{ this virtual method is called in response to a }
{ Windows paint message }
begin
  if FActive then
    { Copy from memory bitmap to screen }
    BitBlt(Canvas.Handle, 0, 0, InsideRect.Right, InsideRect.Bottom,
      MemBitmap.Canvas.Handle, 0, CurrLine, srcCopy)
  else
    inherited Paint;
end;

procedure TddgMarquee.SetActive(Value: Boolean);
{ called to activate/deactivate the marquee }
begin
  if Value and (not FActive) and (FItems.Count > 0) then
  begin
    FActive := True;          // set active flag

```

LISTING 22.2 Continued

```
    MemBitmap := TBitmap.Create;
    FillBitmap;           // Paint Image on bitmap
    FTimer.Enabled := True; // start timer
end
else if (not Value) and FActive then
begin
    FTimer.Enabled := False; // disable timer,
    if Assigned(FOnDone) // fire OnDone event,
        then FOnDone(Self);
    FActive := False; // set FActive to False
    MemBitmap.Free; // free memory bitmap
    Invalidate; // clear control window
end;
end;

end.
```

TIP

Notice the default directive and value used with the `Justify` property of `TddgMarquee`. This use of default optimizes streaming of the component, which improves the component's design-time performance. You can give default values to properties of any ordinal type (`Integer`, `Word`, `Longint`, as well as enumerated types, for example), but you can't give them to nonordinal property types such as strings, floating-point numbers, arrays, records, and classes.

You also need to initialize the default values for the properties in your constructor. Failure to do so will cause streaming problems.

Testing TddgMarquee

Although it's very exciting to finally have this component written and in the testing stages, don't get carried away by trying to add it to the Component Palette just yet. It has to be debugged first. You should do all preliminary testing with the component by creating a project that creates and uses a dynamic instance of the component. Listing 22.3 depicts the main unit for a project called `TestMarq`, which is used to test the `TddgMarquee` component. This simple project consists of a form that contains two buttons.

LISTING 22.3 TestU.pas—Tests the TddgMarquee Component

```
unit Testu;

interface
```

```
uses
  SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, Marquee, StdCtrls, ExtCtrls;

type
  TForm1 = class(TForm)
    Button1: TButton;
    Button2: TButton;
    procedure FormCreate(Sender: TObject);
    procedure Button1Click(Sender: TObject);
    procedure Button2Click(Sender: TObject);
  private
    Marquee1: TddgMarquee;
    procedure MDone(Sender: TObject);
  public
    { Public declarations }
  end;

var
  Form1: TForm1;

implementation

{$R *.DFM}

procedure TForm1.MDone(Sender: TObject);
begin
  Beep;
end;

procedure TForm1.FormCreate(Sender: TObject);
begin
  Marquee1 := TddgMarquee.Create(Self);
  with Marquee1 do
  begin
    Parent := Self;
    Top := 10;
    Left := 10;
    Height := 200;
    Width := 150;
    OnDone := MDone;
    Show;
  end;
end;
```

LISTING 22.3 Continued

```
with Items do
begin
  Add('Greg');
  Add('Peter');
  Add('Bobby');
  Add('Marsha');
  Add('Jan');
  Add('Cindy');
end;
end;
end;

procedure TForm1.Button1Click(Sender: TObject);
begin
  Marquee1.Active := True;
end;

procedure TForm1.Button2Click(Sender: TObject);
begin
  Marquee1.Active := False;
end;

end.
```

TIP

Always create a test project for your new components. Never try to do initial testing on a component by adding it to the Component Palette. By trying to debug a component that resides on the palette, not only will you waste time with a lot of gratuitous package rebuilding, but it's possible to crash the IDE as a result of a bug in your component.

Figure 22.2 shows the TestMarq project in action.

After you squash all the bugs you find in this program, it's time to add it to the Component Palette. As you may recall, doing so is easy: Simply choose Component, Install Component from the main menu and then fill in the unit filename and package name in the Install Component dialog. Choose OK and Delphi will rebuild the package to which the component was added and update the Component Palette. Of course, your component will need to expose

a `Register()` procedure in order to be placed on the Component Palette. The `TddgMarquee` component is registered in the `DDGReg.pas` unit of the `DDGDsgn` package on the CD-ROM accompanying this book.

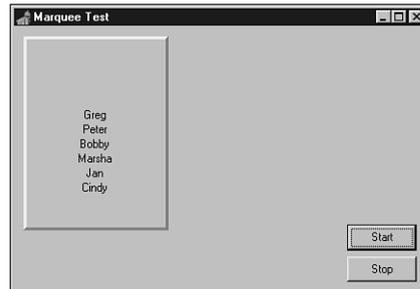


FIGURE 22.2

Testing the `TddgMarquee` component.

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Writing Property Editors

Chapter 21, “Writing Delphi Custom Components,” shows how properties are edited in the Object Inspector for most of the common property types. The means by which a property is edited is determined by its *property editor*. Several predefined property editors are used for the existing properties. However, there may be a situation in which none of the predefined editors meet your needs, such as when you’ve created a custom property. Given this situation, you’ll need to create your own editor for that property.

You can edit properties in the Object Inspector in two ways. One is to allow the user to edit the value as a text string. The other is to use a dialog that performs the editing of the property. In some cases, you’ll want to allow both editing capabilities for a single property.

Here are the steps required for writing a property editor:

1. Create a descendant property editor object.
2. Edit the property as text.
3. Edit the property as a whole with a dialog (optional).
4. Specify the property editor’s attributes.
5. Register the property editor.

The following sections cover each of these steps.

Creating a Descendant Property Editor Object

Delphi defines several property editors in the unit `DsgnIntf.pas`, all of which descend from the base class `TPropertyEditor`. When you create a property editor, your property editor must descend from `TPropertyEditor` or one of its descendants. Table 22.1 shows the `TPropertyEditor` descendants that are used with the existing properties.

TABLE 22.1 Property Editors Defined in `DsgnIntf.pas`

<i>Property Editor</i>	<i>Description</i>
<code>TOrdinalProperty</code>	The base class for all ordinal property editors, such as <code>TIntegerProperty</code> , <code>TEnumProperty</code> , <code>TCharProperty</code> , and so on.
<code>TIntegerProperty</code>	The default property editor for integer properties of all sizes.
<code>TCharProperty</code>	The property editor for properties that are a <code>char</code> type and a subrange of <code>char</code> ; that is, 'A'.. 'Z'.
<code>TEnumProperty</code>	The default property for all user-defined enumerated types.
<code>TFloatProperty</code>	The default property editor for floating-point numeric properties.
<code>TStringProperty</code>	The default property editor for string type properties.
<code>TSetElementProperty</code>	The default property editor for individual <code>set</code> elements. Each element in the <code>set</code> is displayed as an individual Boolean option.
<code>TSetProperty</code>	The default property editor for <code>set</code> properties. The <code>set</code> expands into separate <code>set</code> elements for each element in the <code>set</code> .
<code>TClassProperty</code>	The default property editor for properties that are, themselves, objects.
<code>TMethodProperty</code>	The default property editor for properties that are method pointers—that is, <i>events</i> .
<code>TComponentProperty</code>	The default property editor for properties that refer to a component. This isn't the same as the <code>TClassProperty</code> editor. Instead, this editor allows the user to specify a component to which the property refers—that is, <code>ActiveControl</code> .
<code>TColorProperty</code>	The default property editor for properties of the type <code>TColor</code> .
<code>TFontNameProperty</code>	The default property editor for font names. This editor displays a drop-down list of fonts available on the system.
<code>TFontProperty</code>	The default property editor for properties of type <code>TFont</code> , which allows the editing of subproperties. <code>TFontProperty</code> allows the editing of subproperties because it derives from <code>TClassProperty</code> .

The property editor from which your property editor must descend depends on how the property is going to behave when it's edited. In some cases, for example, your property might require the same functionality as `TIntegerProperty`, but it might also require additional logic

in the editing process. Therefore, it would be logical that your property editor descend from `TIntegerProperty`.

TIP

Bear in mind that there are cases when you don't need to create a property editor that depends on your property type. For example, subrange types are checked automatically (for example, `1..10` is checked for by `TIntegerProperty`), enumerated types get drop-down lists automatically, and so on. You should try to use type definitions instead of custom property editors because they're enforced by the language at compile time as well as by the default property editors.

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Editing the Property as Text

The property editor has two basic purposes: One is to provide a means for the user to edit the property; this is obvious. The other not-so-obvious purpose is to provide the string representation of the property value to the Object Inspector so that it can be displayed accordingly.

When you create a descendant property editor class, you must override the `GetValue()` and `SetValue()` methods. `GetValue()` returns the string representation of the property value for the Object Inspector to display. `SetValue()` sets the value based on its string representation as it's entered in the Object Inspector.

As an example, examine the definition of the `TIntegerProperty` class type as it's defined in `DSGNINTF.PAS`:

```
TIntegerProperty = class(TOrdinalProperty)
public
  function GetValue: string; override;
  procedure SetValue(const Value: string); override;
end;
```

Here, you see that the `GetValue()` and `SetValue()` methods have been overridden. The `GetValue()` implementation is as follows:

```
function TIntegerProperty.GetValue: string;
begin
  Result := IntToStr(GetOrdValue);
end;
```

Here's the `SetValue()` implementation:

```
procedure TIntegerProperty.SetValue(const Value: String);
var
```

```

    L: Longint;
begin
    L := StrToInt(Value);
    with GetTypeData(GetPropType)^ do
        if (L < MinValue) or (L > MaxValue) then
            raise EPropertyError.CreateResFmt(SOutOfRange, [MinValue, MaxValue]);
        SetOrdValue(L);
end;

```

GetValue() returns the string representation of an integer property. The Object Inspector uses this value to display the property's value. GetOrdValue() is a method defined by TPropertyEditor and is used to retrieve the value of the property referenced by the property editor.

SetValue() takes the string value entered by the user and assigns it to the property in the correct format. SetValue() also performs some error checking to ensure that the value is within a specified range of values. This illustrates how you might perform error checking with your descendant property editors. The SetOrdValue() method assigns the value to the property referenced by the property editor.

TPropertyEditor defines several methods similar to GetOrdValue() for getting the string representation of various types. Additionally, TPropertyEditor contains the equivalent "set" methods for setting the values in their respective format. TPropertyEditor descendants inherit these methods. These methods are used for getting and setting the values of the properties that the property editor references. Table 22.2 shows these methods.

TABLE 22.2 Read/Write Property Methods for TPropertyEditor

<i>Property Type</i>	<i>"Get" Method</i>	<i>"Set" Method</i>
Floating point	GetFloatValue()	SetFloatValue()
Event	GetMethodValue()	SetMethodValue()
Ordinal	GetOrdValue()	SetOrdValue()
String	GetStrValue()	SetStrValue()
Variant	GetVarValue()	SetVarValue(), SetVarValueAt()

To illustrate creating a new property editor, we'll have some more fun with the solar system example introduced in the last chapter. This time, we've created a simple component, TPlanet, to represent a single planet. TPlanet contains the property PlanetName. Internal storage for PlanetName is going to be of type integer and will hold the planet's position in the solar system. However, it will be displayed in the Object Inspector as the name of the planet.

So far this sounds easy, but here's the catch: We want to enable the user to type two values to represent the planet. The user should be able to type the planet name as a string, such as Venus,

VENUS, or VeNuS. He or she should also be able to type the position of the planet in the solar system. Therefore, for the planet Venus, the user would type the numeric value 2.

The component TPlanet is as follows:

```
type
  TPlanetName = type Integer;

  TPlanet = class(TComponent)
  private
    FPlanetName: TPlanetName;
  published
    property PlanetName: TPlanetName read FPlanetName write FPlanetName;
  end;
```

As you can see, there's not much to this component. It has only one property: PlanetName of the type TPlanetName. Here, the special definition of TPlanetName is used so that it's given its own runtime type information, yet it's still treated like an integer type.

This functionality doesn't come from the TPlanet component; rather, it comes from the property editor for the TPlanetName property type. This property editor is shown in Listing 22.4.

LISTING 22.4 PlanetPE.PAS—The Source Code for TPlanetNameProperty

```
unit PlanetPE;

interface

uses
  Windows, SysUtils, DsgnIntF;

type
  TPlanetNameProperty = class(TIntegerProperty)
  public
    function GetValue: string; override;
    procedure SetValue(const Value: string); override;
  end;

implementation

const
  { Declare a constant array containing planet names }
  PlanetNames: array[1..9] of String[7] =
    ('Mercury', 'Venus', 'Earth', 'Mars', 'Jupiter', 'Saturn',
```

continues

LISTING 22.4 Continued

```
    'Uranus', 'Neptune', 'Pluto');

function TPlanetNameProperty.GetValue: string;
begin
    Result := PlanetNames[GetOrdValue];
end;

procedure TPlanetNameProperty.SetValue(const Value: String);
var
    PName: string[7];
    i, ValErr: Integer;
begin
    PName := UpperCase(Value);
    i := 1;
    { Compare the Value with each of the planet names in the PlanetNames
      array. If a match is found, the variable i will be less than 10 }
    while (PName <> UpperCase(PlanetNames[i])) and (i < 10) do
        inc(i);
    { If i is less than 10, a valid planet name was entered. Set the value
      and exit this procedure. }
    if i < 10 then // A valid planet name was entered.
    begin
        SetOrdValue(i);
        Exit;
    end
    { If i was greater than 10, the user might have typed in a planet number, or
      an invalid planet name. Use the Val function to test if the user typed in
      a number, if an ValErr is non-zero, an invalid name was entered,
      otherwise, test the range of the number entered for (0 < i < 10). }
    else begin
        Val(Value, i, ValErr);
        if ValErr <> 0 then
            raise Exception.Create(Format('Sorry, Never heard of the planet %s.',
                [Value]));
        if (i <= 0) or (i >= 10) then
            raise Exception.Create('Sorry, that planet is not in OUR solar
system. ');
        SetOrdValue(i);
    end;
end;

end.
```

First, we create our property editor, `TPlanetNameProperty`, which descends from `TIntegerProperty`. By the way, it's necessary to include the `DsgnIntf` unit in the `uses` clause of this unit.

We've defined an array of string constants to represent the planets in the solar system by their position from the sun. These strings will be used to display the string representation of the planet in the Object Inspector.

As stated earlier, we have to override the `GetValue()` and `SetValue()` methods. In the `GetValue()` method, we just return the string from the `PlanetNames` array, which is indexed by the property value. Of course, this value must be within the range of 1–9. We handle this by not allowing the user to enter a number out of that range in the `SetValue()` method.

`SetValue()` gets a string as it's entered from the Object Inspector. This string can either be a planet name or a number representing a planet's position. If a valid planet name or planet number is entered, as determined by the code logic, the value assigned to the property is specified by the `SetOrdValue()` method. If the user enters an invalid planet name or planet position, the code raises the appropriate exception.

That's all there is to defining a property editor. Well, not quite; it must still be registered before it becomes known to the property to which you want to attach it.

Registering the New Property Editor

You register a property editor by using the appropriately named procedure `RegisterPropertyEditor()`. This method is declared as follows:

```
procedure RegisterPropertyEditor(PropertyType: PTypeInfo;  
    ComponentClass: TClass; const PropertyName: string;  
    EditorClass: TPropertyEditorClass);
```

The first parameter, `PropertyType`, is a pointer to the Runtime Type Information of the property being edited. This information is obtained by using the `TypeInfo()` function. `ComponentClass` is used to specify to which class this property editor will apply. `PropertyName` specifies the property name on the component, and the `EditorClass` parameter specifies the type of property editor to use. For the `TPlanet.PlanetName` property, the function looks like this:

```
RegisterPropertyEditor(TypeInfo(TPlanetName), TPlanet, 'PlanetName',  
    TPlanetNameProperty);
```

TIP

Although, for the purpose of illustration, this particular property editor is registered for use only with the `TPlanet` component and `'PlanetName'` property name, you

continues

might choose to be less restrictive in registering your custom property editors. By setting the `ComponentClass` parameter to `nil` and the `PropertyName` parameter to `''`, your property editor will work for any component's property of type `TPlanetName`.

You can register the property editor along with the registration of the component in the component's unit, as shown in Listing 22.5.

LISTING 22.5 Planet.pas: The TPlanet Component

```
unit Planet;

interface

uses
  Classes, SysUtils;

type
  TPlanetName = type Integer;

  TddgPlanet = class(TComponent)
  private
    FPlanetName: TPlanetName;
  published
    property PlanetName: TPlanetName read FPlanetName write FPlanetName;
  end;

implementation

end.
```

TIP

Placing the property editor registration in the `Register()` procedure of the component's unit will force all the property editor code to be linked in with your component when it's put into a package. For complex components, the design-time tools may take up more code space than the components themselves. Although code size isn't much of an issue for a small component such as this, keep in mind that everything that's listed in the `interface` section of your component's unit (such as the `Register()` procedure) as well as everything it touches (such as the property editor

class type) will tag along with your component when it's compiled into a package. For this reason, you might want to perform registration of your property editor in a separate unit. Furthermore, some component writers choose to create both design-time and runtime packages for their components, whereas the property editors and other design-time tools reside only in the design-time package. You'll note that the packages containing this book's code do this using the `DdgStd5` runtime package and the `DdgDsgn5` design package.

Editing the Property as a Whole with a Dialog

Sometimes it's necessary to provide more editing capability than the in-place editing of the Object Inspector. This is when it becomes necessary to use a dialog as a property editor. An example of this would be the `Font` property for most Delphi components. Certainly, the makers of Delphi could have forced the user to type the font name and other font-related information. However, it would be unreasonable to expect the user to know this information. It's far easier to provide the user with a dialog where he or she can set these various attributes related to the font and see an example before selecting it.

To illustrate using a dialog to edit a property, we're going to extend the functionality of the `TddgRunButton` component created in Chapter 21, "Writing Delphi Custom Components." Now the user will be able to click an ellipsis button in the Object Inspector for the `CommandLine` property, which will invoke an Open File dialog from which the user can select a file for `TddgRunButton` to represent.

Sample Dialog Property Editor: Extending `TddgRunButton`

The `TddgRunButton` component is shown in Listing 21.13 in Chapter 21, "Writing Delphi Custom Components." We won't show it again here, but there are a few things we want to point out. The `TddgRunButton.CommandLine` property is of type `TCommandLine`, which is defined as follows:

```
TCommandLine = type string;
```

Again, this is a special declaration that attaches unique Runtime Type Information to this special type. This allows you to define a property editor specific to the `TCommandLine` type. Additionally, because `TCommandLine` is treated as a string, the property editor for editing string properties still applies to the `TCommandLine` type as well.

Also, as we illustrate the property editor for the `TCommandLine` type, keep in mind that `TddgRunButton` already has included the necessary error checking of property assignments in the properties' access methods. Therefore, it isn't necessary to repeat this error checking in the property editor's logic.

Listing 22.6 shows the definition of the `TCommandLineProperty` property editor.

LISTING 22.6 RunBtnPE.pas: The Unit Containing TCommandLineProperty

```
unit runbtnpe;

interface
uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, Buttons, DsgnIntF, TypInfo;

type
  { Descend from the TStringProperty class so that this editor
    inherits the string property editing capabilities }
  TCommandLineProperty = class(TStringProperty)
    function GetAttributes: TPropertyAttributes; override;
    procedure Edit; override;
  end;

implementation

function TCommandLineProperty.GetAttributes: TPropertyAttributes;
begin
  Result := [paDialog]; // Display a dialog in the Edit method
end;

procedure TCommandLineProperty.Edit;
{ The Edit method displays a TOpenDialog from which the user obtains
  an executable file name that gets assigned to the property }
var
  OpenDialog: TOpenDialog;
begin
  { Create the TOpenDialog }
  OpenDialog := TOpenDialog.Create(Application);
  try
    { Show only executable files }
    OpenDialog.Filter := 'Executable Files|*.EXE';
    { If the user selects a file, then assign it to the property. }
    if OpenDialog.Execute then
      SetStrValue(OpenDialog.FileName);
  finally
    OpenDialog.Free // Free the TOpenDialog instance.
  end;
end;
```

```
end;
```

```
end.
```

Examination of `TCommandLineProperty` shows that the property editor, itself, is very simple. First, notice that it descends from `TStringProperty` so that the string-editing capabilities are maintained. Therefore, in the Object Inspector, it isn't necessary to invoke the dialog. The user can just type the command line directly. Also, we didn't override the `SetValue()` and `GetValue()` methods, because `TStringProperty` already handles this correctly. However, it was necessary to override the `GetAttributes()` method in order for the Object Inspector to know that this property is capable of being edited with a dialog. `GetAttributes()` merits further discussion.

Specifying the Property Editor's Attributes

Every property editor must tell the Object Inspector how a property is to be edited and what special attributes (if any) must be used when editing a property. Most of the time, the inherited attributes from a descendant property editor will suffice. In certain circumstances, however, you must override the `GetAttributes()` method of `TPropertyEditor`, which returns a set of property attribute flags (`TPropertyAttribute` flags) that indicate special property-editing attributes. The various `TPropertyAttribute` flags are shown in Table 22.3.

TABLE 22.3 `TPropertyAttribute` Flags

<i>Attribute</i>	<i>How the Property Editor Works with the Object Inspector</i>
<code>paValueList</code>	Returns an enumerated list of values for the property. The <code>GetValues()</code> method populates the list. A drop-down arrow button appears to the right of the property value. This applies to enumerated properties such as <code>TForm.BorderStyle</code> and integer <code>const</code> groups such as <code>TColor</code> and <code>TCharSet</code> .
<code>paSubProperties</code>	Subproperties are displayed indented below the current property in outline format. <code>paValueList</code> must also be set. This applies to set properties and class properties such as <code>TOpenDialog.Options</code> and <code>TForm.Font</code> .
<code>paDialog</code>	An ellipsis button is displayed to the right of the property in the Object Inspector, which, when pressed, causes the property editor's <code>Edit()</code> method to invoke a dialog. This applies to properties such as <code>TForm.Font</code> .
<code>paMultiSelect</code>	Properties are displayed when more than one component is selected on the Form Designer, allowing the user to change the property values for multiple components at once. Some properties aren't appropriate for this capability, such as the Name property.

continues

TABLE 22.3 Continued

<code>paAutoUpdate</code>	<code>SetValue()</code> is called on each change made to the property. If this flag isn't set, <code>SetValue()</code> is called when the user presses Enter or moves off the property in the Object Inspector. This applies to properties such as <code>TForm.Caption</code> .
<code>paFullWidthName</code>	Tells the Object Inspector that the value doesn't need to be rendered, and as such, the name should be rendered the full width of the inspector.
<code>paSortList</code>	The Object Inspector sorts the list returned by <code>GetValues()</code> .
<code>paReadOnly</code>	The property value can't be changed.
<code>paRevertable</code>	The property can be reverted to its original value. Some properties, such as nested properties, shouldn't be reverted. <code>TFont</code> is an example of this.

NOTE

You should take a look at `DsgnIntf.pas` and examine which `TPropertyAttribute` flags are set for various property editors.

Setting the paDialog Attribute for TCommandLineProperty

Because `TCommandLineProperty` is to display a dialog, you must tell the Object Inspector to use this capability by setting the `paDialog` attribute in the `TCommandLineProperty.GetAttributes()` method. This will place an ellipsis button to the right of the `CommandLine` property value in the Object Inspector. When the user presses this button, the `TCommandLineProperty.Edit()` method will be called.

Registering the TCommandLineProperty

The final step required for implementing the `TCommandLineProperty` property editor is to register it using the `RegisterPropertyEditor()` procedure discussed earlier in this chapter. This procedure was added to the `Register()` procedure in `DDGReg.pas` in the `DDGDsgn` package:

```
RegisterComponents('DDG', [TddgRunButton]);
RegisterPropertyEditor(TypeInfo(TCommandLine), TddgRunButton,
    '', TCommandLineProperty);
```

Also, note that the units `DsgnIntf` and `RunBtnPE` had to be added to the `uses` clause.

Component Editors

Component editors extend the design-time behavior of your components by allowing you to add items to the local menu associated with a particular component and by allowing you to change the default action when a component is double-clicked in the Form Designer. You might already be familiar with component editors without knowing it if you've ever used the fields editor provided with the `TTable`, `TQuery`, and `TStoredProc` components.

TComponentEditor

You might not be aware of this, but a different component editor is created for each component that's selected in the Form Designer. The type of component editor created depends on the component's type, although all component editors descend from TComponentEditor. This class is defined in the DsgnIntf unit as follows:

```
type
  TComponentEditor = class(TInterfacedObject, IComponentEditor)
  private
    FComponent: TComponent;
    FDesigner: IFormDesigner;
  public
    constructor Create(AComponent: TComponent; ADesigner: IFormDesigner);
    virtual;
    procedure Edit; virtual;
    procedure ExecuteVerb(Index: Integer); virtual;
    function GetComponent: IComponent;
    function GetDesigner: IFormDesigner;
    function GetVerb(Index: Integer): string; virtual;
    function GetVerbCount: Integer; virtual;
    procedure Copy; virtual;
    property Component: TComponent read FComponent;
    property Designer: IFormDesigner read GetDesigner;
  end;
```

Properties

The Component property of TComponentEditor is the instance of the component you're in the process of editing. Because this property is of the generic TComponent type, you must typecast the property in order to access fields introduced by descendant classes.

The Designer property is the instance of TFormDesigner that's currently hosting the application at design time. You'll find the complete definition for this class in the DsgnIntf.pas unit.

Methods

The Edit() method is called when the user double-clicks the component at design time. Often, this method will invoke some sort of design dialog. The default behavior for this method is to call ExecuteVerb(0) if GetVerbCount() returns a value of 1 or greater. You must call Designer.Modified() if you modify the component from this (or any) method.

The GetVerbCount() method is called to retrieve the number of items that are to be added to the local menu.

GetVerb() accepts an integer, Index, and returns a string containing the text that should appear on the local menu in the position corresponding to Index.

When an item is chosen from the local menu, the `ExecuteVerb()` method is called. This method receives the zero-based index of the item selected from the local menu in the `Index` parameter. You should respond by performing whatever action is necessary based on the verb the user selected from the local menu.

The `Paste()` method is called whenever the component is pasted to the Clipboard. Delphi places the component's filed stream image on the Clipboard, but you can use this method to paste data on the Clipboard in a different type of format.

TDefaultEditor

If a custom component editor isn't registered for a particular component, that component will use the default component editor, `TDefaultEditor`. `TDefaultEditor` overrides the behavior of the `Edit()` method so that it searches the properties of the component and generates (or navigates to) the `OnCreate`, `OnChanged`, or `OnClick` event (whichever it finds first).

A Simple Component

Consider the following simple custom component:

```
type
  TComponentEditorSample = class(TComponent)
  protected
    procedure SayHello; virtual;
    procedure SayGoodbye; virtual;
  end;

procedure TComponentEditorSample.SayHello;
begin
  MessageDlg('Hello, there!', mtInformation, [mbOk], 0);
end;

procedure TComponentEditorSample.SayGoodbye;
begin
  MessageDlg('See ya!', mtInformation, [mbOk], 0);
end;
```

As you can see, this little guy doesn't do much: It's a nonvisual component that descends directly from `TComponent`, and it contains two methods, `SayHello()` and `SayGoodbye()`, that simply display message dialogs.

A Simple Component Editor

To make the component a bit more exiting, you'll create a component editor that calls into the component and executes its methods at design time. The minimum `TComponentEditor` methods

that must be overridden are `ExecuteVerb()`, `GetVerb()`, and `GetVerbCount()`. The code for this component editor is as follows:

```
type
  TSampleEditor = class(TComponentEditor)
  private
    procedure ExecuteVerb(Index: Integer); override;
    function GetVerb(Index: Integer): string; override;
    function GetVerbCount: Integer; override;
  end;

procedure TSampleEditor.ExecuteVerb(Index: Integer);
begin
  case Index of
    0: TComponentEditorSample(Component).SayHello;    // call function
    1: TComponentEditorSample(Component).SayGoodbye; // call function
  end;
end;

function TSampleEditor.GetVerb(Index: Integer): string;
begin
  case Index of
    0: Result := 'Hello';           // return hello string
    1: Result := 'Goodbye';        // return goodbye string
  end;
end;

function TSampleEditor.GetVerbCount: Integer;
begin
  Result := 2;           // two possible verbs
end;
```

The `GetVerbCount()` method returns 2, indicating that there are two different verbs the component editor is prepared to execute. `GetVerb()` returns a string for each of these verbs to appear on the local menu. The `ExecuteVerb()` method calls the appropriate method inside the component, based on the verb index it receives as a parameter.

Registering a Component Editor

Like components and property editors, component editors must also be registered with the IDE within a unit's `Register()` method. To register a component editor, call the aptly named `RegisterComponentEditor()` procedure, which is defined as follows:

```
procedure RegisterComponentEditor(ComponentClass: TComponentClass;
  ComponentEditor: TComponentEditorClass);
```

The first parameter to this function is the component type for which you want to register a component editor, and the second parameter is the component editor itself.

Listing 22.7 shows the `CompEdit.pas` unit, which includes the component, component editor, and registration calls. Figure 22.3 shows the local menu associated with the `TComponentEditorSample` component, and Figure 22.4 displays the result of selecting one of the verbs from the local menu.

LISTING 22.7 `CompEdit.pas`—Illustrates a Component Editor

```
unit CompEdit;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls, Forms, Dialogs,
  DsgnIntf;

type
  TComponentEditorSample = class(TComponent)
  protected
    procedure SayHello; virtual;
    procedure SayGoodbye; virtual;
  end;

  TSampleEditor = class(TComponentEditor)
  private
    procedure ExecuteVerb(Index: Integer); override;
    function GetVerb(Index: Integer): string; override;
    function GetVerbCount: Integer; override;
  end;

implementation

{ TComponentEditorSample }

procedure TComponentEditorSample.SayHello;
begin
  MessageDlg('Hello, there!', mtInformation, [mbOk], 0);
```

```
end;

procedure TComponentEditorSample.SayGoodbye;
begin
  MessageDlg('See ya!', mtInformation, [mbOk], 0);
end;

{ TSampleEditor }

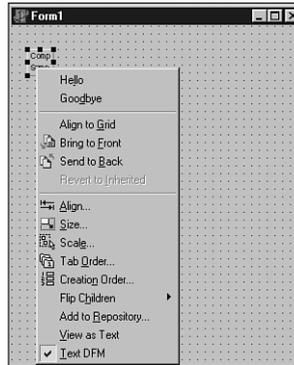
const
  vHello = 'Hello';
  vGoodbye = 'Goodbye';

procedure TSampleEditor.ExecuteVerb(Index: Integer);
begin
  case Index of
    0: TComponentEditorSample(Component).SayHello;    // call function
    1: TComponentEditorSample(Component).SayGoodbye; // call function
  end;
end;

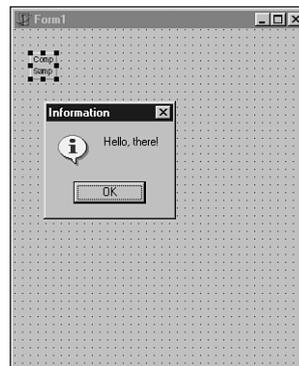
function TSampleEditor.GetVerb(Index: Integer): string;
begin
  case Index of
    0: Result := vHello;           // return hello string
    1: Result := vGoodbye;        // return goodbye string
  end;
end;

function TSampleEditor.GetVerbCount: Integer;
begin
  Result := 2;           // two possible verbs
end;

end.
```

**FIGURE 22.3**

The local menu of TComponentEditorSample.

**FIGURE 22.4**

The result of selecting a verb.

Streaming Nonpublished Component Data

Chapter 21 indicates that the Delphi IDE automatically knows how to stream the published properties of a component to and from a DFM file. What happens, however, when you have nonpublished data that you want to be persistent by keeping it in the DFM file? Fortunately, Delphi components provide a mechanism for writing and reading programmer-defined data to and from the DFM file.

Defining Properties

The first step in defining persistent nonpublished “properties” is to override a component’s `DefineProperties()` method. This method is inherited from `TPersistent`, and it’s defined as follows:

```
procedure DefineProperties(Filer: TFiler); virtual;
```

By default, this method handles reading and writing published properties to and from the DFM file. You can override this method, and, after calling `inherited`, you can call the `TFiler` method `DefineProperty()` or `DefineBinaryProperty()` once for each piece of data you want to become part of the DFM file. These methods are defined, respectively, as follows:

```
procedure DefineProperty(const Name: string; ReadData: TReaderProc;  
    WriteData: TWriterProc; HasData: Boolean); virtual;
```

```
procedure DefineBinaryProperty(const Name: string; ReadData,  
    WriteData: TStreamProc; HasData: Boolean); virtual;
```

`DefineProperty()` is used to make persistent standard data types such as strings, integers, Booleans, chars, floats, and enumerated types. `DefineBinaryProperty()` is used to provide access to raw binary data, such as a graphic or sound, written to the DFM file.

For both of these functions, the `Name` parameter identifies the property name that should be written to the DFM file. This doesn’t have to be the same as the internal name of the data field you’re accessing. The `ReadData` and `WriteData` parameters differ in type between `DefineProperty()` and `DefineBinaryProperty()`, but they serve the same purpose: These methods are called in order to write or read data to or from the DFM file. (We’ll discuss these in more detail in just a moment.) The `HasData` parameter indicates whether the “property” has data that it needs to store.

The `ReadData` and `WriteData` parameters of `DefineProperty()` are of type `TReaderProc` and `TWriterProc`, respectively. These types are defined as follows:

```
type  
    TReaderProc = procedure(Reader: TReader) of object;  
    TWriterProc = procedure(Writer: TWriter) of object;
```

`TReader` and `TWriter` are specialized descendants of `TFiler` that have additional methods for reading and writing native types. Methods of these types provide the conduit between published component data and the DFM file.

The `ReadData` and `WriteData` parameters of `DefineBinaryProperty()` are of type `TStreamProc`, which is defined as follows:

```
type  
    TStreamProc = procedure(Stream: TStream) of object;
```

Because TStreamProc-type methods receive only TStream as a parameter, this allows you to read and write binary data very easily to and from the stream. Like the other method types described earlier, methods of this type provide the conduit between nonstandard data and the DFM file.

An Example of DefineProperty()

In order to bring all this rather technical information together, Listing 22.8 shows the DefProp.pas unit. This unit illustrates the use of DefineProperty() by providing storage for two private data fields: a string and an integer.

LISTING 22.8 DefProp.pas—Illustrates Using the DefineProperty() Function

```
unit DefProp;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs;

type
  TDefinePropTest = class(TComponent)
  private
    FString: String;
    FInteger: Integer;
    procedure ReadStrData(Reader: TReader);
    procedure WriteStrData(Writer: TWriter);
    procedure ReadIntData(Reader: TReader);
    procedure WriteIntData(Writer: TWriter);
  protected
    procedure DefineProperties(Filer: TFile); override;
  public
    constructor Create(AOwner: TComponent); override;
  end;

implementation

constructor TDefinePropTest.Create(AOwner: TComponent);
begin
  inherited Create(AOwner);
  { Put data in private fields }
  FString := 'The following number is the answer...';
  FInteger := 42;
end;
```

```
procedure TDefinePropTest.DefineProperties(Filer: TFile);
begin
  inherited DefineProperties(Filer);
  { Define new properties and reader/writer methods }
  Filer.DefineProperty('StringProp', ReadStrData, WriteStrData,
    FString <> '');
  Filer.DefineProperty('IntProp', ReadIntData, WriteIntData, True);
end;

procedure TDefinePropTest.ReadStrData(Reader: TReader);
begin
  FString := Reader.ReadString;
end;

procedure TDefinePropTest.WriteStrData(Writer: TWriter);
begin
  Writer.WriteString(FString);
end;

procedure TDefinePropTest.ReadIntData(Reader: TReader);
begin
  FInteger := Reader.ReadInteger;
end;

procedure TDefinePropTest.WriteIntData(Writer: TWriter);
begin
  Writer.WriteInteger(FInteger);
end;

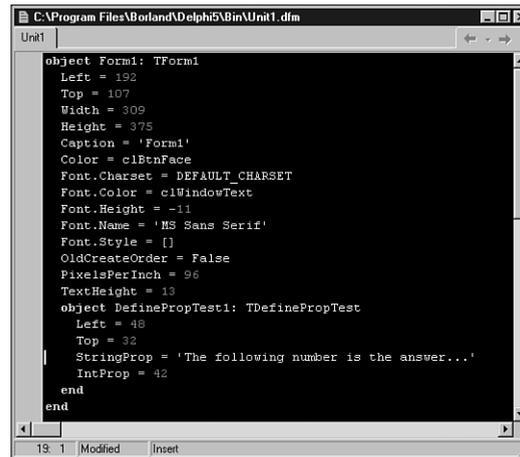
end.
```

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Always use the `ReadString()` and `WriteString()` methods of `TReader` and `TWriter` to read and write string data. Never use the similar-looking `ReadStr()` and `WriteStr()` methods because they'll corrupt your DFM file.

To demonstrate that the proof is in the pudding, Figure 22.5 shows a form containing a `TDefinePropTest` component, as text, in the Delphi Code Editor. Notice that the new properties have been written to the file.

**FIGURE 22.5**

Viewing a form as text to see the properties.

TddgWaveFile: An Example of DefineBinaryProperty()

We mentioned earlier that a good time to use `DefineBinaryProperty()` is when you need to store graphic or sound information along with a component. In fact, VCL uses this technique for storing images associated with components—the `Glyph` of a `TBitBtn`, for example, or the `Icon` of a `TForm`. In this section, you'll learn how to use this technique when storing the sound associated with the `TddgWaveFile` component.

NOTE

`TddgWaveFile` is quite a full-featured component, complete with a custom property, property editor, and component editor to allow you to play sounds at design time. You'll be able to pick through the code for all this a little later in the chapter, but for now we're going to focus the discussion on the mechanism for storing the binary property.

The `DefineProperties()` method for `TddgWaveFile` is as follows:

```
procedure TddgWaveFile.DefineProperties(Filer: TFiler);
{ Defines binary property called "Data" for FData field. }
{ This allows FData to be read from and written to DFM file. }

function DoWrite: Boolean;
begin
```

```

    if Filer.Ancestor <> nil then
        Result := not (Filer.Ancestor is TddgWaveFile) or
            not Equal(TddgWaveFile(Filer.Ancestor))
    else
        Result := not Empty;
    end;

begin
    inherited DefineProperties(Filer);
    Filer.DefineBinaryProperty('Data', ReadData, WriteData, DoWrite);
end;

```

This method defines a binary property called `Data`, which is read and written using the component's `ReadData()` and `WriteData()` methods. Additionally, data is written only if the return value of `DoWrite()` is `True`. (You'll learn more about `DoWrite()` in just moment.)

The `ReadData()` and `WriteData()` methods are defined as follows:

```

procedure TddgWaveFile.ReadData(Stream: TStream);
{ Reads WAV data from DFM stream. }
begin
    LoadFromStream(Stream);
end;

procedure TddgWaveFile.WriteData(Stream: TStream);
{ Writes WAV data to DFM stream }
begin
    SaveToStream(Stream);
end;

```

As you can see, there isn't much to these methods; they simply call the `LoadFromStream()` and `SaveToStream()` methods, which are also defined by the `TddgWaveFile` component. The `LoadFromStream()` method is as follows:

```

procedure TddgWaveFile.LoadFromStream(S: TStream);
{ Loads WAV data from stream S. This procedure will free }
{ any memory previously allocated for FData. }
begin
    if not Empty then
        FreeMem(FData, FDataSize);
    FDataSize := 0;
    FData := AllocMem(S.Size);
    FDataSize := S.Size;
    S.Read(FData^, FDataSize);
end;

```

This method first checks to see whether memory has been previously allocated by testing the value of the `FDataSize` field. If it's greater than zero, the memory pointed to by the `FData` field is freed. At that point, a new block of memory is allocated for `FData`, and `FDataSize` is set to the size of the incoming data stream. The contents of the stream are then read into the `FData` pointer.

The `SaveToStream()` method is much simpler; it's defined as follows:

```
procedure TddgWaveFile.SaveToStream(S: TStream);
{ Saves WAV data to stream S. }
begin
  if FDataSize > 0 then
    S.Write(FData^, FDataSize);
end;
```

This method writes the data pointed to by pointer `FData` to `TStream S`.

The local `DoWrite()` function inside the `DefineProperties()` method determines whether the `Data` property needs to be streamed. Of course, if `FData` is empty, there's no need to stream data. Additionally, you must take extra measures to ensure that your component works correctly with form inheritance: You must check to see whether the `Ancestor` property for `Filer` is non-`nil`. If it is and it points to an ancestor version of the current component, you must check to see whether the data you're about to write is different than the ancestor. If you don't perform these additional tests, a copy of the data (the wave file, in this case) will be written in each of the descendant forms, and changes to the ancestor's wave file won't be copied to the descendant forms.

CAUTION

For the reasons just explained, `DefineProperties()` is one area where you'll find a distinct difference between 16- and 32-bit Delphi. For the most part, Borland tried to make form inheritance transparent to the component writer. This is one place where it couldn't be hidden. Although Delphi 1.0 components will function in 32-bit Delphi, they won't be able to propagate updates in form inheritance without modification.

Figure 22.6 shows a view of the Delphi Code Editor displaying, as text, a form containing `TddgWaveFile`.

Listing 22.9 shows `Wavez.pas`, which includes the complete source code for the component.

```

C:\Program Files\Borland\Delphi5\Bin\Unit1.dfm
Unit1
Font.Height = -11
Font.Name = 'MS Sans Serif'
Font.Style = []
OldCreateOrder = False
PixelsPerInch = 96
TextHeight = 13
object ddgWaveFile1: TddgWaveFile
  WaveLoop = wlNoLoop
  WaveName = 'Chimes.wav'
  WavePause = wpAsync
  Left = 24
  Top = 24
  Data = {
    52494646D8D9000057415645666D74201000000010002002256000
    040010006461746184D90000020003000900600070002000500000
    01000200FFFF0300040001000500010005000200050000000400040
    0800020002000400000000200020000001000000020002000300020
    0600050007000200070001000900010007000200020003000200020
    0500050000000200060000000600010006000400010001000000010
    0800040008000100060000000400020007000500000003000900050
    0700020001000000FFFF00000400010004000200030004000900050
    0200000004000100030000000200010002000200FFFF03000100020
  }
  }
  22. 1 Modified Insert

```

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FIGURE 22.6

Viewing the Data property in the Code Editor.

LISTING 22.9 Wavez.pas—Illustrates a Component Encapsulating a Wave File

```

unit Wavez;

interface

uses
  SysUtils, Classes;

type
  { Special string "descendant" used to make a property editor. }
  TWaveFileString = type string;

  EWaveError = class(Exception);

  TWavePause = (wpAsync, wpsSync);
  TWaveLoop = (wlNoLoop, wlLoop);

  TddgWaveFile = class(TComponent)
  private
    FData: Pointer;
    FDataSize: Integer;
    FWaveName: TWaveFileString;

```

continues

LISTING 22.9 Continued

```
    FWavePause: TWavePause;
    FWaveLoop: TWaveLoop;
    FOnPlay: TNotifyEvent;
    FOnStop: TNotifyEvent;
    procedure SetWaveName(const Value: TWaveFileString);
    procedure WriteData(Stream: TStream);
    procedure ReadData(Stream: TStream);
protected
    procedure DefineProperties(Filer: TFile); override;
public
    destructor Destroy; override;
    function Empty: Boolean;
    function Equal(Wav: TddgWaveFile): Boolean;
    procedure LoadFromFile(const FileName: String);
    procedure LoadFromStream(S: TStream);
    procedure Play;
    procedure SaveToFile(const FileName: String);
    procedure SaveToStream(S: TStream);
    procedure Stop;
published
    property WaveLoop: TWaveLoop read FWaveLoop write FWaveLoop;
    property WaveName: TWaveFileString read FWaveName write SetWaveName;
    property WavePause: TWavePause read FWavePause write FWavePause;
    property OnPlay: TNotifyEvent read FOnPlay write FOnPlay;
    property OnStop: TNotifyEvent read FOnStop write FOnStop;
end;

implementation

uses MMSystem, Windows;

{ TddgWaveFile }

destructor TddgWaveFile.Destroy;
{ Ensures that any allocated memory is freed }
begin
    if not Empty then
        FreeMem(FData, FDataSize);
    inherited Destroy;
end;
```

```
function StreamsEqual(S1, S2: TMemoryStream): Boolean;
begin
  Result := (S1.Size = S2.Size) and CompareMem(S1.Memory, S2.Memory, S1.Size);
end;

procedure TddgWaveFile.DefineProperties(Filer: TFiler);
{ Defines binary property called "Data" for FData field. }
{ This allows FData to be read from and written to DFM file. }

function DoWrite: Boolean;
begin
  if Filer.Ancestor <> nil then
    Result := not (Filer.Ancestor is TddgWaveFile) or
      not Equal(TddgWaveFile(Filer.Ancestor))
  else
    Result := not Empty;
end;

begin
  inherited DefineProperties(Filer);
  Filer.DefineBinaryProperty('Data', ReadData, WriteData, DoWrite);
end;

function TddgWaveFile.Empty: Boolean;
begin
  Result := FDataSize = 0;
end;

function TddgWaveFile.Equal(Wav: TddgWaveFile): Boolean;
var
  MyImage, WavImage: TMemoryStream;
begin
  Result := (Wav <> nil) and (ClassType = Wav.ClassType);
  if Empty or Wav.Empty then
    begin
      Result := Empty and Wav.Empty;
      Exit;
    end;
  if Result then
    begin
      MyImage := TMemoryStream.Create;
      try
```

LISTING 22.9 Continued

```
        SaveToStream(MyImage);
        WavImage := TMemoryStream.Create;
        try
            Wav.SaveToStream(WavImage);
            Result := StreamsEqual(MyImage, WavImage);
        finally
            WavImage.Free;
        end;
    finally
        MyImage.Free;
    end;
end;

end;

procedure TddgWaveFile.LoadFromFile(const FileName: String);
{ Loads WAV data from FileName. Note that this procedure does }
{ not set the WaveName property. }
var
    F: TFileStream;
begin
    F := TFileStream.Create(FileName, fmOpenRead);
    try
        LoadFromStream(F);
    finally
        F.Free;
    end;
end;

procedure TddgWaveFile.LoadFromStream(S: TStream);
{ Loads WAV data from stream S. This procedure will free }
{ any memory previously allocated for FData. }
begin
    if not Empty then
        FreeMem(FData, FDataSize);
    FDataSize := 0;
    FData := AllocMem(S.Size);
    FDataSize := S.Size;
    S.Read(FData^, FDataSize);
end;

procedure TddgWaveFile.Play;
```

```
{ Plays the WAV sound in FData using the parameters found in }
{ FWaveLoop and FWavePause. }
const
  LoopArray: array[TWaveLoop] of DWORD = (0, SND_LOOP);
  PauseArray: array[TWavePause] of DWORD = (SND_ASYNC, SND_SYNC);
begin
  { Make sure component contains data }
  if Empty then
    raise EWaveError.Create('No wave data');
  if Assigned(FOnPlay) then FOnPlay(Self);    // fire event
  { attempt to play wave sound }
  if not PlaySound(FData, 0, SND_MEMORY or PauseArray[FWavePause] or
    LoopArray[FWaveLoop]) then
    raise EWaveError.Create('Error playing sound');
end;

procedure TddgWaveFile.ReadData(Stream: TStream);
{ Reads WAV data from DFM stream. }
begin
  LoadFromStream(Stream);
end;

procedure TddgWaveFile.SaveToFile(const FileName: String);
{ Saves WAV data to file FileName. }
var
  F: TFileStream;
begin
  F := TFileStream.Create(FileName, fmCreate);
  try
    SaveToStream(F);
  finally
    F.Free;
  end;
end;

procedure TddgWaveFile.SaveToStream(S: TStream);
{ Saves WAV data to stream S. }
begin
  if not Empty then
    S.Write(FData^, FDataSize);
end;
```

LISTING 22.9 Continued

```
procedure TddgWaveFile.SetWaveName(const Value: TWaveFileString);
{ Write method for WaveName property. This method is in charge of }
{ setting WaveName property and loading WAV data from file Value. }
begin
  if Value <> '' then begin
    FWaveName := ExtractFileName(Value);
    { don't load from file when loading from DFM stream }
    { because DFM stream will already contain data. }
    if (not (csLoading in ComponentState)) and FileExists(Value) then
      LoadFromFile(Value);
  end
  else begin
    { if Value is an empty string, that is the signal to free }
    { memory allocated for WAV data. }
    FWaveName := '';
    if not Empty then
      FreeMem(FData, FDataSize);
    FDataSize := 0;
  end;
end;

procedure TddgWaveFile.Stop;
{ Stops currently playing WAV sound }
begin
  if Assigned(FOnStop) then FOnStop(Self); // fire event
  PlaySound(nil, 0, SND_PURGE);
end;

procedure TddgWaveFile.WriteData(Stream: TStream);
{ Writes WAV data to DFM stream }
begin
  SaveToStream(Stream);
end;

end.
```

Property Categories

As you learned back in Chapter 1, “Windows Programming in Delphi 5,” a feature new to Delphi 5 is *property categories*. This feature provides a means for the properties of VCL components to be specified as belonging to particular categories and for the Object Inspector to be

sorted by these categories. Properties can be registered as belonging to a particular category using the `RegisterPropertyInCategory()` and `RegisterPropertiesInCategory()` functions declared in the `DsgnIntf` unit. The former enables you to register a single property for a category, whereas the latter allows you to register multiple properties with one call.

`RegisterPropertyInCategory()` is overloaded in order to provide four different versions of this function to suit your exact needs. All the versions of this function take a `TPropertyCategoryClass` as the first parameter, describing the category. From there, each of these versions takes a different combination of property name, property type, and component class to enable you to choose the best method for registering your properties. The various versions of `RegisterPropertyInCategory()` are shown here:

```
function RegisterPropertyInCategory(ACategoryClass: TPropertyCategoryClass;
  const APropertyName: string): TPropertyFilter; overload;
function RegisterPropertyInCategory(ACategoryClass: TPropertyCategoryClass;
  AComponentClass: TClass; const APropertyName: string): TPropertyFilter
  overload;
function RegisterPropertyInCategory(ACategoryClass: TPropertyCategoryClass;
  APropertyType: PTypeInfo; const APropertyName: string): TPropertyFilter;
  overload;
function RegisterPropertyInCategory(ACategoryClass: TPropertyCategoryClass;
  APropertyType: PTypeInfo): TPropertyFilter; overload;
```

These functions are also smart enough to understand wildcard symbols, so you can, for example, add all properties that match `'Data*'` to a particular category. Refer to the online help for the `TMask` class for a complete list of supported wildcard characters and their behavior.

`RegisterPropertiesInCategory()` comes in three overloaded variations:

```
function RegisterPropertiesInCategory(ACategoryClass: TPropertyCategoryClass;
  const AFilters: array of const): TPropertyCategory; overload;
function RegisterPropertiesInCategory(ACategoryClass: TPropertyCategoryClass;
  AComponentClass: TClass; const AFilters: array of string): TPropertyCategory;
  overload;
function RegisterPropertiesInCategory(ACategoryClass: TPropertyCategoryClass;
  APropertyType: PTypeInfo; const AFilters: array of string):
TPropertyCategory;
  overload;
```

Category Classes

The `TPropertyCategoryClass` type is a class reference for a `TPropertyCategory`. `TPropertyCategory` is the base class for all standard property categories in VCL. There are 12 standard property categories, and these classes are described in Table 22.4.

TABLE 22.4 Standard Property Category Classes

<i>Class Name</i>	<i>Description</i>
TActionCategory	Properties related to runtime actions. The Enabled and Hint properties of TControl are in this category.
TDatabaseCategory	Properties related to database operations. The DatabaseName and SQL properties of TQuery are in this category.
TDragNDropCategory	Properties related to drag-and-drop and docking operations. The DragCursor and DragKind properties of TControl are in this category.
THelpCategory	Properties related to using online help and hints. The HelpContext and Hint properties of TWinControl are in this category.
TLayoutCategory	Properties related to the visual display of a control at design time. The Top and Left properties of TControl are in this category.
TLegacyCategory	Properties related to obsolete operations. The Ct13D and ParentCt13D properties of TWinControl are in this category.
TLinkageCategory	Properties related to associating or linking one component to another. The DataSet property of TDataSource is in this category.
TLocaleCategory	Properties related to international locales. The BiDiMode and ParentBiDiMode properties of TControl are in this category.
TLocalizableCategory	Properties related to database operations. The DatabaseName and SQL properties of TQuery are in this category.
TMiscellaneousCategory	Properties that either do not fit a category, do not need to be categorized, or are not explicitly registered to a specific category. The AllowAllUp and Name properties of TSpeedButton are in this category.
TVisualCategory	Properties related to the visual display of a control at runtime; the Align and Visible properties of TControl are in this category.
TInputCategory	Properties related to the input of data (they need not be related to database operations). The Enabled and ReadOnly properties of TEdit are in this category.

As an example, let's say you've written a component called TNeato with a property called Keen, and you wish to register the Keen property as a member of the Action category represented by TActionCategory. You could do this by adding a call to RegisterPropertyInCategory() to the Register() procedure for your control, as shown here:

```
RegisterPropertyInCategory(TActionCategory, TNeato, 'Keen');
```

Custom Categories

As you've already learned, a property category is represented in code as a class that descends from `TPropertyCategory`. How difficult is it, then, to create your own property categories in this way? Quite easy, actually. In most cases, all you need to do is override the `Name()` and `Description()` virtual class functions of `TPropertyCategory` to return information specific to your category.

As an illustration, we'll create a new `Sound` category that will be used to categorize some of the properties of the `TddgWaveFile` component, which you learned about earlier in this chapter. This new category class, called `TSoundCategory`, is shown in Listing 22.10. This listing contains `WavezEd.pas`, which is a file that contains the component's category, property editor, and component editor.

LISTING 22.10 `WavezEd.pas`—Illustrates a Property Editor for the Wave File Component

```
unit WavezEd;

interface

uses DsgnIntf;

type
  { Category for some of TddgWaveFile's properties }
  TSoundCategory = class(TPropertyCategory)
  public
    class function Name: string; override;
    class function Description: string; override;
  end;

  { Property editor for TddgWaveFile's WaveName property }
  TWaveFileStringProperty = class(TStringProperty)
  public
    procedure Edit; override;
    function GetAttributes: TPropertyAttributes; override;
  end;

  { Component editor for TddgWaveFile. Allows user to play and stop }
  { WAV sounds from local menu in IDE. }
  TWaveEditor = class(TComponentEditor)
  private
    procedure EditProp(PropertyEditor: TPropertyEditor);
  public
    procedure Edit; override;
    procedure ExecuteVerb(Index: Integer); override;
    function GetVerb(Index: Integer): string; override;
```

22

 ADVANCED
 COMPONENT
 DESIGN

continues

LISTING 22.10 Continued

```
    function GetVerbCount: Integer; override;
    end;

implementation

uses TypInfo, Wavez, Classes, Controls, Dialogs;

{ TSoundCategory }

class function TSoundCategory.Name: string;
begin
    Result := 'Sound';
end;

class function TSoundCategory.Description: string;
begin
    Result := 'Properties dealing with the playing of sounds'
end;

{ TWaveFileStringProperty }

procedure TWaveFileStringProperty.Edit;
{ Executed when user clicks the ellipses button on the WavName  }
{ property in the Object Inspector. This method allows the user }
{ to pick a file from an OpenFileDialog and sets the property value. }
begin
    with TOpenDialog.Create(nil) do
        try
            { Set up properties for dialog }
            Filter := 'Wav files|*.wav|All files|*.*';
            DefaultExt := '*.wav';
            { Put current value in the FileName property of dialog }
            FileName := GetStrValue;
            { Execute dialog and set property value if dialog is OK }
            if Execute then
                SetStrValue(FileName);
        finally
            Free;
        end;
    end;
end;

function TWaveFileStringProperty.GetAttributes: TPropertyAttributes;
{ Indicates the property editor will invoke a dialog. }
begin
    Result := [paDialog];
end;
```

```

{ TWaveEditor }

const
  VerbCount = 2;
  VerbArray: array[0..VerbCount - 1] of string[7] = ('Play', 'Stop');

procedure TWaveEditor.Edit;
{ Called when user double-clicks on the component at design time. }
{ This method calls the GetComponentProperties method in order to }
{ invoke the Edit method of the WaveName property editor. }
var
  Components: TDesignerSelectionList;
begin
  Components := TDesignerSelectionList.Create;
  try
    Components.Add(Component);
    GetComponentProperties(Components, tkAny, Designer, EditProp);
  finally
    Components.Free;
  end;
end;

procedure TWaveEditor.EditProp(PropertyEditor: TPropertyEditor);
{ Called once per property in response to GetComponentProperties }
{ call. This method looks for the WaveName property editor and }
{ calls its Edit method. }
begin
  if PropertyEditor is TWaveFileStringProperty then begin
    TWaveFileStringProperty(PropertyEditor).Edit;
    Designer.Modified; // alert Designer to modification
  end;
end;

procedure TWaveEditor.ExecuteVerb(Index: Integer);
begin
  case Index of
    0: TddgWaveFile(Component).Play;
    1: TddgWaveFile(Component).Stop;
  end;
end;

function TWaveEditor.GetVerb(Index: Integer): string;
begin
  Result := VerbArray[Index];
end;

```

LISTING 22.10 Continued

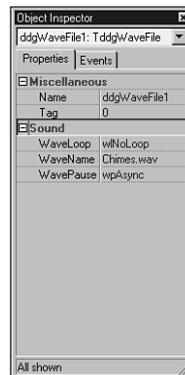
```
function TWaveEditor.GetVerbCount: Integer;
begin
    Result := VerbCount;
end;

end.
```

With the category class defined, all that needs to be done is register the properties for the category using one of the registration functions. This is done in the `Register()` procedure for `TddgWaveFile` using the following line of code:

```
RegisterPropertiesInCategory(TSoundCategory, TddgWaveFile,
    ['WaveLoop', 'WaveName', 'WavePause']);
```

Figure 22.7 shows the Object Inspector view of the categorized properties of a `TddgWaveFile` component.

**FIGURE 22.7**

Viewing the categorized properties of `TddgWaveFile`.

Lists of Components: `TCollection` and `TCollectionItem`

It's common for components to maintain or own a list of items such as data types, records, objects, or even other components. In some cases, it's suitable to encapsulate this list within its own object and then make this object a property of the owner component. An example of this arrangement is the `Lines` property of a `TMemo` component. `Lines` is a `TStrings` object type that encapsulates a list of strings. With this arrangement, the `TStrings` object is responsible for the streaming mechanism used to store its lines to the form file when the user saves the form.

What if you wanted to save a list of items such as components or objects that weren't already encapsulated by an existing class such as `TStrings`? Well, you could create a class that performs the streaming of the listed items and then make that a property of the owner component. Alternatively, you could override the default streaming mechanism of the owner component so that it knows how to stream its list of items. However, a better solution would be to take advantage of the `TCollection` and `TCollectionItem` classes.

The `TCollection` class is an object used to store a list of `TCollectionItem` objects. `TCollection`, itself, isn't a component but rather a descendant of `TPersistent`. Typically, `TCollection` is associated with an existing component.

To use `TCollection` to store a list of items, you would derive a descendant class from `TCollection`, which you could call `TNewCollection`. `TNewCollection` will serve as a property type for a component. Then, you must derive a class from the `TCollectionItem` class, which you could call `TNewCollectionItem`. `TNewCollection` will maintain a list of `TNewCollectionItem` objects. The beauty of this is that data belonging to `TNewCollectionItem` that needs to be streamed only needs to be published by `TNewCollectionItem`. Delphi already knows how to stream published properties.

An example of where `TCollection` is used is with the `TStatusBar` component. `TStatusBar` is a `TWinControl` descendant. One of its properties is `Panels`. `TStatusBar.Panels` is of type `TStatusPanels`, which is a `TCollection` descendant and defined as follows:

```
type
  TStatusPanels = class(TCollection)
  private
    FStatusBar: TStatusBar;
    function GetItem(Index: Integer): TStatusPanel;
    procedure SetItem(Index: Integer; Value: TStatusPanel);
  protected
    procedure Update(Item: TCollectionItem); override;
  public
    constructor Create(StatusBar: TStatusBar);
    function Add: TStatusPanel;
    property Items[Index: Integer]: TStatusPanel read GetItem write SetItem;
    default;
  end;
```

`TStatusPanels` stores a list of `TCollectionItem` descendants, `TStatusPanel`, as defined here:

```
type
  TStatusPanel = class(TCollectionItem)
  private
    FText: string;
    FWidth: Integer;
```

```
    FAlignment: TAlignment;
    FBevel: TStatusPanelBevel;
    FStyle: TStatusPanelStyle;
    procedure SetAlignment(Value: TAlignment);
    procedure SetBevel(Value: TStatusPanelBevel);
    procedure SetStyle(Value: TStatusPanelStyle);
    procedure SetText(const Value: string);
    procedure SetWidth(Value: Integer);
public
    constructor Create(Collection: TCollection); override;
    procedure Assign(Source: TPersistent); override;
published
    property Alignment: TAlignment read FAlignment
        write SetAlignment default taLeftJustify;
    property Bevel: TStatusPanelBevel read FBevel
        write SetBevel default pbLowered;
    property Style: TStatusPanelStyle read FStyle write SetStyle
        default psText;
    property Text: string read FText write SetText;
    property Width: Integer read FWidth write SetWidth;
end;
```

The `TStatusPanel` properties in the published section of the class declaration will automatically be streamed by Delphi. `TStatusPanel` takes a `TCollection` parameter in its `Create()` constructor, and it associates itself with that `TCollection`. Likewise, `TStatusPanel`s takes the `TStatusBar` component in its constructor to which it associates itself. The `TCollection` engine knows how to deal with the streaming of `TCollectionItem` components and also defines some methods and properties for manipulating the items maintained in `TCollection`. You can look these up in the online help.

To illustrate how you might use these two new classes, we've created the `TddgLaunchPad` component. `TddgLaunchPad` will enable the user to store a list of `TddgRunButton` components, which we created in Chapter 21.

`TddgLaunchPad` is a descendant of the `TScrollBox` component. One of the properties of `TddgLaunchPad` is `RunButtons`, a `TCollection` descendant. `RunButtons` maintains a list of `TRunBtnItem` components. `TRunBtnItem` is a `TCollectionItem` descendant whose properties are used to create a `TddgRunButton` component, which is placed on `TddgLaunchPad`. In the following sections, we'll discuss how we created this component.

Defining the `TCollectionItem` Class: `TRunBtnItem`

The first step is to define the item to be maintained in a list. For `TddgLaunchPad`, this would be a `TddgRunButton` component. Therefore, each `TRunBtnItem` instance must associate itself with

a `TddgRunButton` component. The following code shows a partial definition of the `TRunBtnItem` class:

```
type
  TRunBtnItem = class(TCollectionItem)
  private
    FCommandLine: String; // Store the command line
    FLeft: Integer; // Store the positional properties for the
    FTop: Integer; // TddgRunButton.
    FRunButton: TddgRunButton; // Reference to a TddgRunButton
    .
  public
    constructor Create(Collection: TCollection); override;
  published
    { The published properties will be streamed }
    property CommandLine: String read FCommandLine write SetCommandLine;
    property Left: Integer read FLeft write SetLeft;
    property Top: Integer read FTop write SetTop;
  end;
```

Notice that `TRunBtnItem` keeps a reference to a `TddgRunButton` component, yet it only streams the properties required to build a `TddgRunButton`. At first you might think that because `TRunBtnItem` associates itself with a `TddgRunButton`, it could just publish the component and let the streaming engine do the rest. Well, this poses some problems with the streaming engine and how it handles the streaming of `TComponent` classes differently from `TPersistent` classes. The fundamental rule here is that the streaming system is responsible for creating new instances for every `TComponent`-derived class name it finds in a stream, whereas it assumes `TPersistent` instances already exist does not attempt to instantiate new ones. Following this rule, we stream the information required of the `TddgRunButton` and then we create the `TddgRunButton` in the `TRunBtnItem` constructor, which we'll illustrate shortly.

Defining the `TCollection` Class: `TRunButtons`

The next step is to define the object that will maintain this list of `TRunBtnItem` components. We already said that this object must be a `TCollection` descendant. We call this class `TRunButtons`; its definition is as follows:

```
type
  TRunButtons = class(TCollection)
  private
    FLaunchPad: TddgLaunchPad; // Keep a reference to the TddgLaunchPad
    function GetItem(Index: Integer): TRunBtnItem;
    procedure SetItem(Index: Integer; Value: TRunBtnItem);
  protected
```

```

    procedure Update(Item: TCollectionItem); override;
public
    constructor Create(LaunchPad: TddgLaunchPad);
    function Add: TRunBtnItem;
    procedure UpdateRunButtons;
    property Items[Index: Integer]: TRunBtnItem read GetItem
        write SetItem; default;
end;

```

TRunButtons associates itself with a TddgLaunchPad component that we'll show a bit later. It does this in its Create() constructor, which, as you can see, takes a TddgLaunchPad component as its parameter. Notice the various properties and methods that have been added to allow the user to manipulate the individual TRunBtnItem classes. In particular, the Items property is an array to the TRunBtnItem list.

The use of the TRunBtnItem and TRunButtons classes will become clearer as we discuss the implementation of the TddgLaunchPad component.

Implementing the TddgLaunchPad, TRunBtnItem, and TRunButtons Objects

The TddgLaunchPad component has a property of the type TRunButtons. Its implementation, as well as the implementation of TRunBtnItem and TRunButtons, is shown in Listing 22.11.

LISTING 22.11 LnchPad.pas—Illustrates the TddgLaunchPad Implementation

```

unit LnchPad;

interface

uses
    Windows, Messages, SysUtils, Classes, Graphics, Controls,
    Forms, Dialogs, RunBtn, ExtCtrls;

type
    TddgLaunchPad = class;

    TRunBtnItem = class(TCollectionItem)
    private
        FCommandLine: string;    // Store the command line
        FLeft: Integer;         // Store the positional properties for the
        FTop: Integer;          // TddgRunButton.
        FRunButton: TddgRunButton; // Reference to a TddgRunButton
        FWidth: Integer;        // Keep track of the width and height
    end;

```

```

    FHeight: Integer;
    procedure SetCommandLine(const Value: string);
    procedure SetLeft(Value: Integer);
    procedure SetTop(Value: Integer);
public
    constructor Create(Collection: TCollection); override;
    destructor Destroy; override;
    procedure Assign(Source: TPersistent); override;
    property Width: Integer read FWidth;
    property Height: Integer read FHeight;
published
    { The published properties will be streamed }
    property CommandLine: String read FCommandLine
        write SetCommandLine;
    property Left: Integer read FLeft write SetLeft;
    property Top: Integer read FTop write SetTop;
end;

TRunButtons = class(TCollection)
private
    FLaunchPad: TddgLaunchPad; // Keep a reference to the TddgLaunchPad
    function GetItem(Index: Integer): TRunBtnItem;
    procedure SetItem(Index: Integer; Value: TRunBtnItem);
protected
    procedure Update(Item: TCollectionItem); override;
public
    constructor Create(LaunchPad: TddgLaunchPad);
    function Add: TRunBtnItem;
    procedure UpdateRunButtons;
    property Items[Index: Integer]: TRunBtnItem read
        GetItem write SetItem; default;
end;

TddgLaunchPad = class(TScrollBox)
private
    FRunButtons: TRunButtons;
    TopAlign: Integer;
    LeftAlign: Integer;
    procedure SetRunButtons(Value: TRunButtons);
    procedure UpdateRunButton(Index: Integer);
public
    constructor Create(AOwner: TComponent); override;

```

LISTING 22.11 Continued

```
    destructor Destroy; override;
    procedure GetChildren(Proc: TGetChildProc; Root: TComponent); override;
published
    property RunButtons: TRunButtons read FRunButtons write SetRunButtons;
end;

implementation

{ TRunBtnItem }

constructor TRunBtnItem.Create(Collection: TCollection);
{ This constructor gets the TCollection that owns this TRunBtnItem. }
begin
    inherited Create(Collection);
    { Create an FRunButton instance. Make the launch pad the owner
      and parent. Then initialize its various properties. }
    FRunButton := TddgRunButton.Create(TRunButtons(Collection).FLaunchPad);
    FRunButton.Parent := TRunButtons(Collection).FLaunchPad;
    FWidth := FRunButton.Width; // Keep track of the width and the
    FHeight := FRunButton.Height; // height.
end;

destructor TRunBtnItem.Destroy;
begin
    FRunButton.Free; // Destroy the TddgRunButton instance.
    inherited Destroy; // Call the inherited Destroy destructor.
end;

procedure TRunBtnItem.Assign(Source: TPersistent);
{ It is necessary to override the TCollectionItem.Assign method so that
  it knows how to copy from one TRunBtnItem to another. If this is done,
  then don't call the inherited Assign(). }
begin
    if Source is TRunBtnItem then
        begin
            { Instead of assigning the command line to the FCommandLine storage
              field, make the assignment to the property so that the accessor
              method will be called. The accessor method as some side-effects
              that we want to occur. }
            CommandLine := TRunBtnItem(Source).CommandLine;
            { Copy values to the remaining fields. Then exit the procedure. }
            FLeft := TRunBtnItem(Source).Left;
```

```
    FTop := TRunBtnItem(Source).Top;
    Exit;
end;
inherited Assign(Source);
end;

procedure TRunBtnItem.SetCommandLine(const Value: string);
{ This is the write accessor method for TRunBtnItem.CommandLine. It
  ensures that the private TddgRunButton instance, FRunButton, gets
  assigned the specified string from Value }
begin
    if FRunButton <> nil then
        begin
            FCommandLine := Value;
            FRunButton.CommandLine := FCommandLine;
            { This will cause the TRunButtons.Update method to be called
              for each TRunBtnItem }
            Changed(False);
        end;
end;

procedure TRunBtnItem.SetLeft(Value: Integer);
{ Access method for the TRunBtnItem.Left property. }
begin
    if FRunButton <> nil then
        begin
            FLeft := Value;
            FRunButton.Left := FLeft;
        end;
end;

procedure TRunBtnItem.SetTop(Value: Integer);
{ Access method for the TRunBtnItem.Top property }
begin
    if FRunButton <> nil then
        begin
            FTop := Value;
            FRunButton.Top := FTop;
        end;
end;

{ TRunButtons }
```

LISTING 22.11 Continued

```
constructor TRunButtons.Create(LaunchPad: TddgLaunchPad);
{ The constructor points FLaunchPad to the TddgLaunchPad parameter.
  LaunchPad is the owner of this collection. It is necessary to keep
  a reference to LaunchPad as it will be accessed internally. }
begin
  inherited Create(TRunBtnItem);
  FLaunchPad := LaunchPad;
end;

function TRunButtons.GetItem(Index: Integer): TRunBtnItem;
{ Access method for TRunButtons.Items which returns the TRunBtnItem
  instance. }
begin
  Result := TRunBtnItem(inherited GetItem(Index));
end;

procedure TRunButtons.SetItem(Index: Integer; Value: TRunBtnItem);
{ Access method for TddgRunButton.Items which makes the assignment to
  the specified indexed item. }
begin
  inherited SetItem(Index, Value)
end;

procedure TRunButtons.Update(Item: TCollectionItem);
{ TCollection.Update is called by TCollectionItems
  whenever a change is made to any of the collection items. This is
  initially an abstract method. It must be overridden to contain
  whatever logic is necessary when a TCollectionItem has changed.
  We use it to redraw the item by calling TddgLaunchPad.UpdateRunButton.}
begin
  if Item <> nil then
    FLaunchPad.UpdateRunButton(Item.Index);
end;

procedure TRunButtons.UpdateRunButtons;
{ UpdateRunButtons is a public procedure that we made available so that
  users of TRunButtons can force all run-buttons to be re-drawn. This
  method calls TddgLaunchPad.UpdateRunButton for each TRunBtnItem
  instance. }
var
  i: integer;
```

```
begin
  for i := 0 to Count - 1 do
    FLaunchPad.UpdateRunButton(i);
end;

function TRunButtons.Add: TRunBtnItem;
{ This method must be overridden to return the TRunBtnItem instance when
  the inherited Add method is called. This is done by typecasting the
  original result }
begin
  Result := TRunBtnItem(inherited Add);
end;

{ TddgLaunchPad }

constructor TddgLaunchPad.Create(AOwner: TComponent);
{ Initializes the TRunButtons instance and internal variables
  used for positioning of the TRunBtnItem as they are drawn }
begin
  inherited Create(AOwner);
  FRunButtons := TRunButtons.Create(Self);
  TopAlign := 0;
  LeftAlign := 0;
end;

destructor TddgLaunchPad.Destroy;
begin
  FRunButtons.Free; // Free the TRunButtons instance.
  inherited Destroy; // Call the inherited destroy method.
end;

procedure TddgLaunchPad.GetChildren(Proc: TGetChildProc; Root: TComponent);
{ Override GetChildren to cause TddgLaunchPad to ignore any TRunButtons
  that it owns since they do not need to be streamed in the context
  TddgLaunchPad. The information necessary for creating the TddgRunButton
  instances is already streamed as published properties of the
  TCollectionItem descendant, TRunBtnItem. This method prevents the
  TddgRunButton's from being streamed twice. }
var
  I: Integer;
begin
  for I := 0 to ControlCount - 1 do
```

continues

LISTING 22.11 Continued

```
    { Ignore the run buttons and the scrollbar }
    if not (Controls[i] is TddgRunButton) then
        Proc(TComponent(Controls[I]));
end;

procedure TddgLaunchPad.SetRunButtons(Value: TRunButtons);
{ Access method for the RunButtons property }
begin
    FRunButtons.Assign(Value);
end;

procedure TddgLaunchPad.UpdateRunButton(Index: Integer);
{ This method is responsible for drawing the TRunBtnItem instances.
  It ensures that the TRunBtnItem's do not extend beyond the width
  of the TddgLaunchPad. If so, it creates rows. This is only in effect
  as the user is adding/removing TRunBtnItems. The user can still
  resize the TddgLaunchPad so that it is smaller than the width of a
  TRunBtnItem }
begin
    { If the first item being drawn, set both positions to zero. }
    if Index = 0 then
        begin
            TopAlign := 0;
            LeftAlign := 0;
        end;
    { If the width of the current row of TRunBtnItems is more than
      the width of the TddgLaunchPad, then start a new row of TRunBtnItems. }
    if (LeftAlign + FRunButtons[Index].Width) > Width then
        begin
            TopAlign := TopAlign + FRunButtons[Index].Height;
            LeftAlign := 0;
        end;
    FRunButtons[Index].Left := LeftAlign;
    FRunButtons[Index].Top := TopAlign;
    LeftAlign := LeftAlign + FRunButtons[Index].Width;
end;

end.
```

Implementing TRunBtnItem

The `TRunBtnItem.Create()` constructor creates an instance of `TddgRunButton`. Each `TRunBtnItem` in the collection will maintain its own `TddgRunButton` instance. The following two lines in `TRunBtnItem.Create()` require further explanation:

```
FRunButton := TddgRunButton.Create(TRunButtons(Collection).FLaunchPad);  
FRunButton.Parent := TRunButtons(Collection).FLaunchPad;
```

The first line creates a `TddgRunButton` instance, `FRunButton`. The owner of `FRunButton` is `FLaunchPad`, which is a `TddgLaunchPad` component and a field of the `TCollection` object passed in as a parameter. It's necessary to use the `FLaunchPad` as the owner of `FRunButton` because neither a `TRunBtnItem` instance nor a `TRunButtons` object can be owners because they descend from `TPersistent`. Remember, an owner must be a `TComponent`.

We want to point out a problem that arises by making `FLaunchPad` the owner of `FRunButton`. By doing this, we effectively make `FLaunchPad` the owner of `FRunButton` at design time. The normal behavior of the streaming engine will cause Delphi to stream `FRunButton` as a component owned by the `FLaunchPad` instance when the user saves the form. This is not a desired behavior because `FRunButton` is already being created in the constructor of `TRunBtnItem`, based on the information that's also streamed in the context of `TRunBtnItem`. This is a vital tid-bit of information. Later, you'll see how we prevent `TddgRunButton` components from being streamed by `TddgLaunchPad` in order to remedy this undesired behavior.

The second line assigns `FLaunchPad` as the parent to `FRunButton` so that `FLaunchPad` can take care of drawing `FRunButton`.

The `TRunBtnItem.Destroy()` destructor frees `FRunButton` before calling its inherited destructor.

Under certain circumstances, it becomes necessary to override the `TRunBtnItem.Assign()` method that's called. One such instance is when the application is first run and the form is read from the stream. It's in the `Assign()` method that we tell the `TRunBtnItem` instance to assign the streamed values of its properties to the properties of the component (in this case `TddgRunButton`) that it encompasses.

The other methods are simply access methods for the various properties of `TRunBtnItem`; they are explained in the code's comments.

Implementing TRunButtons

`TRunButtons.Create()` simply points `FLaunchPad` to the `TddgLaunchPad` parameter passed to it so that `LaunchPad` can be referred to later.

`TRunButtons.Update()` is a method that's invoked whenever a change has been made to any of the `TRunBtnItem` instances. This method contains logic that should occur due to that change. We use it to call the method of `TddgLaunchPad` that redraws the `TRunBtnItem` instances. We've also added a public method, `UpdateRunButtons()`, to allow the user to force a redraw.

The remaining methods of `TRunButtons` are property access methods, which are explained in the code's comments in Listing 22.11.

Implementing TddgLaunchPad

The constructor and destructor for `TddgLaunchPad` are simple. `TddgLaunchPad.Create()` creates an instance of the `TRunButtons` object and passes itself as a parameter.

`TddgLaunchPad.Destroy()` frees the `TRunButtons` instance.

The overriding of the `TddgLaunchPad.GetChildren()` method is important to note here. This is where we prevent the `TddgRunButton` instances stored by the collection from being streamed as owned components of `TddgLaunchPad`. Remember that this is necessary because they shouldn't be created in the context of the `TddgLaunchPad` object but rather in the context of the `TRunBtnItem` instances. Because no `TddgRunButton` components are passed to the `Proc` procedure, they won't be streamed or read from a stream.

The `TddgLaunchPad.UpdateRunButton()` method is where the `TddgRunButton` instances maintained by the collection are drawn. The logic in this code ensures that they never extend beyond the width of `TddgLaunchPad`. Because `TddgLaunchPad` is a descendant of `TScrollBox`, scrolling will occur vertically.

The other methods are simply property-access methods and are commented in the code in Listing 22.11.

Finally, we register the property editor for the `TRunButtons` collection class in this unit's `Register()` procedure. The next section discusses this property editor and illustrates how to edit a list of components from a dialog property editor.

Editing the List of TCollectionItem Components with a Dialog Property Editor

Now that we've defined the `TddgLaunchPad` component, the `TRunButtons` collection class, and the `TRunBtnItem` collection class, we must provide a way for the user to add `TddgRunButton` components to the `TRunButtons` collection. The best way to do this is through a property editor that manipulates the list maintained by the `TRunButtons` collection.

The property editor that we'll use is a dialog, as shown in Figure 22.8.



FIGURE 22.8

The TddgLaunchPad - RunButtons editor.

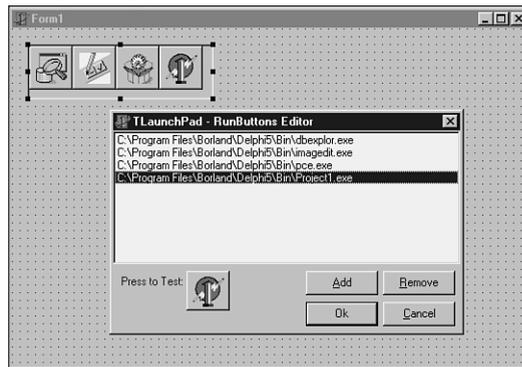
This dialog directly manipulates the `TRunBtnItem` components maintained by the `RunButtons` collection of `TddgLaunchPad`. The various `CommandLine` strings for each `TddgRunButton` enclosed in `TRunBtnItem` are displayed in `PathListBox`. A `TddgRunButton` component reflects the currently selected item in the list box to allow the user to test the selection. The dialog also contains buttons to allow the user to add or remove an item, accept the changes, and cancel the operation. As the user makes changes in the dialog, the changes are reflected on the `TddgLaunchPad`.

TIP

A convention for property editors is to include an `Apply` button to invoke changes on the form. We didn't show this here, but you might consider adding such a button to the `RunButtons` property editor as an exercise. To see how an `Apply` button works, take a look at the property editor for the `Panel1` property of the `TStatusBar` component from the `Win32` page of the `Component Palette`.

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Figure 22.9 illustrates the `TddgLaunchPad - RunButtons` property editor with some items. It also shows the form's `TddgLaunchPad` component with the `TddgRunButton` components listed in the property editor.

**FIGURE 22.9**

The `TddgLaunchPad - RunButtons` property editor with `TRunBtnItem` components.

Listing 22.12 shows the source code for the `TddgLaunchPad - RunButtons` property editor and its dialog.

LISTING 22.12 LPadPE.pas: the TRunButtons Property Editor

```
unit LPadPE;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, Buttons, RunBtn, StdCtrls, LnchPad, DsgnIntF, TypInfo, ExtCtrls;

type

  { First declare the editor dialog }
  TLaunchPadEditor = class(TForm)
    PathListBox: TListBox;
    AddBtn: TButton;
    RemoveBtn: TButton;
    CancelBtn: TButton;
    OkBtn: TButton;
    Label1: TLabel;
    pnlRBtn: TPanel;
    procedure PathListBoxClick(Sender: TObject);
    procedure AddBtnClick(Sender: TObject);
    procedure RemoveBtnClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
    procedure CancelBtnClick(Sender: TObject);
  private
    TestRunBtn: TddgRunButton;
    FLaunchPad: TddgLaunchPad; // To be used as a backup
    FRunButtons: TRunButtons; // Will refer to the actual TRunButtons
    Modified: Boolean;
    procedure UpdatePathListBox;
  end;

  { Now declare the TPropertyEditor descendant and override the
    required methods }
  TRunButtonsProperty = class(TPropertyEditor)
    function GetAttributes: TPropertyAttributes; override;
    function GetValue: string; override;
    procedure Edit; override;
  end;
```

```

{ This function will be called by the property editor. }
function EditRunButtons(RunButtons: TRunButtons): Boolean;

implementation

{$R *.DFM}

function EditRunButtons(RunButtons: TRunButtons): Boolean;
{ Instantiates the TLaunchPadEditor dialog which directly modifies
  the TRunButtons collection. }
begin
  with TLaunchPadEditor.Create(Application) do
    try
      FRunButtons := RunButtons; // Point to the actual TRunButtons
      { Copy the TRunBtnItems to the backup FLaunchPad which will be
        used as a backup in case the user cancels the operation }
      FLaunchPad.RunButtons.Assign(RunButtons);
      { Draw the listbox with the list of TRunBtnItems. }
      UpdatePathListBox;
      ShowModal; // Display the form.
      Result := Modified;
    finally
      Free;
    end;
end;

{ TLaunchPadEditor }

procedure TLaunchPadEditor.FormCreate(Sender: TObject);
begin
  { Created the backup instances of TLaunchPad to be used if the user
    cancels editing the TRunBtnItems }
  FLaunchPad := TddgLaunchPad.Create(Self);

  // Create the TddgRunButton instance and align it to the
  // enclosing panel.
  TestRunBtn := TddgRunButton.Create(Self);
  TestRunBtn.Parent := pnlRBtn;

  TestRunBtn.Width := pnlRBtn.Width;
  TestRunBtn.Height := pnlRBtn.Height;
end;

```

LISTING 22.12 Continued

```
procedure TLaunchPadEditor.FormDestroy(Sender: TObject);
begin
    TestRunBtn.Free;
    FLaunchPad.Free; // Free the TLaunchPad instance.
end;

procedure TLaunchPadEditor.PathListBoxClick(Sender: TObject);
{ When the user clicks on an item in the list of TRunBtnItems, make
  the test TRunButton reflect the currently selected item }
begin
    if PathListBox.ItemIndex > -1 then
        TestRunBtn.CommandLine := PathListBox.Items[PathListBox.ItemIndex];
end;

procedure TLaunchPadEditor.UpdatePathListBox;
{ Re-initializes the PathListBox so that it reflects the list of
  TRunBtnItems }
var
    i: integer;
begin
    PathListBox.Clear; // First clear the list box.
    for i := 0 to FRunButtons.Count - 1 do
        PathListBox.Items.Add(FRunButtons[i].CommandLine);
end;

procedure TLaunchPadEditor.AddBtnClick(Sender: TObject);
{ When the add button is clicked, launch a TOpenDialog to retrieve
  an executable filename and path. Then add this file to the
  PathListBox. Also, add a new FRunBtnItem. }
var
    OpenDialog: TOpenDialog;
begin
    OpenDialog := TOpenDialog.Create(Application);
    try
        OpenDialog.Filter := 'Executable Files|*.EXE';
        if OpenDialog.Execute then
            begin
                { add to the PathListBox. }
                PathListBox.Items.Add(OpenDialog.FileName);
                FRunButtons.Add; // Create a new TRunBtnItem instance.
                { Set focus to the new item in PathListBox }
            end;
    except
    end;
end;
```

```

    PathListBox.ItemIndex := FRunButtons.Count - 1;
    { Set the command line for the new TRunBtnItem to that of the
      file name gotten as specified by PathListBox.ItemIndex }
    FRunButtons[PathListBox.ItemIndex].CommandLine :=
      PathListBox.Items[PathListBox.ItemIndex];
    { Invoke the PathListBoxClick event handler so that the test
      TRunButton will reflect the newly added item }
    PathListBoxClick(nil);
    Modified := True;
  end;
finally
  OpenFileDialog.Free
end;
end;

procedure TLaunchPadEditor.RemoveBtnClick(Sender: TObject);
{ Remove the selected path/filename from PathListBox as well as the
  corresponding TRunBtnItem from FRunButtons }
var
  i: integer;
begin
  i := PathListBox.ItemIndex;
  if i >= 0 then
  begin
    PathListBox.Items.Delete(i); // Remove the item from the listbox
    FRunButtons[i].Free;        // Remove the item from the collection
    TestRunBtn.CommandLine := ''; // Erase the test run button
    Modified := True;
  end;
end;

procedure TLaunchPadEditor.CancelBtnClick(Sender: TObject);
{ When the user cancels the operation, copy the backup LaunchPad
  TRunBtnItems back to the original TLaunchPad instance. Then,
  close the form by setting ModalResult to mrCancel. }
begin
  FRunButtons.Assign(FLaunchPad.RunButtons);
  Modified := False;
  ModalResult := mrCancel;
end;

{ TRunButtonsProperty }

```

LISTING 22.12 Continued

```
function TRunButtonsProperty.GetAttributes: TPropertyAttributes;
{ Tell the Object Inspector that the property editor will use a
  dialog. This will cause the Edit method to be invoked when the user
  clicks the ellipsis button in the Object Inspector. }
begin
  Result := [paDialog];
end;

procedure TRunButtonsProperty.Edit;
{ Invoke the EditRunButton() method and pass in the reference to the
  TRunButton's instance being edited. This reference can be obtained by
  using the GetOrdValue method. Then redraw the LaunchDialog by calling
  the TRunButtons.UpdateRunButtons method. }
begin
  if EditRunButtons(TRunButtons(GetOrdValue)) then
    Modified;
  TRunButtons(GetOrdValue).UpdateRunButtons;
end;

function TRunButtonsProperty.GetValue: string;
{ Override the GetValue method so that the class type of the property
  being edited is displayed in the Object Inspector. }
begin
  Result := Format('%s', [GetPropType^.Name]);
end;

end.

TddgLaunchPadEditor = class(TForm)
  PathListBox: TListBox;
  AddBtn: TButton;
  RemoveBtn: TButton;
  TestRunBtn: TddgRunButton;
  CancelBtn: TButton;
  OkBtn: TButton;
  Label1: TLabel;
  procedure PathListBoxClick(Sender: TObject);
  procedure AddBtnClick(Sender: TObject);
  procedure RemoveBtnClick(Sender: TObject);
  procedure FormCreate(Sender: TObject);
  procedure FormDestroy(Sender: TObject);
  procedure CancelBtnClick(Sender: TObject);
```

```

private
  FLaunchPad: TddgLaunchPad; // To be used as a backup
  FRunButtons: TRunButtons; // Will refer to the actual TRunButtons
  Modified: Boolean;
  procedure UpdatePathListBox;
end;

{ Now declare the TPropertyEditor descendant and override the
  required methods }
TRunButtonsProperty = class(TPropertyEditor)
  function GetAttributes: TPropertyAttributes; override;
  function GetValue: string; override;
  procedure Edit; override;
end;

{ This function will be called by the property editor. }
function EdiTRunButtons(RunButtons: TRunButtons): Boolean;

implementation

{$R *.DFM}

function EdiTRunButtons(RunButtons: TRunButtons): Boolean;
{ Instantiates the TddgLaunchPadEditor dialog which directly modifies
  the TRunButtons collection. }
begin
  with TddgLaunchPadEditor.Create(Application) do
    try
      FRunButtons := RunButtons; // Point to the actual TRunButtons
      { Copy the TRunBtnItems to the backup FLaunchPad which will be
        used as a backup in case the user cancels the operation }
      FLaunchPad.RunButtons.Assign(RunButtons);
      { Draw the listbox with the list of TRunBtnItems. }
      UpdatePathListBox;
      ShowModal; // Display the form.
      Result := Modified;
    finally
      Free;
    end;
  end;
end;

{ TddgLaunchPadEditor }

```

LISTING 22.12 Continued

```
procedure TddgLaunchPadEditor.FormCreate(Sender: TObject);
begin
    { Created the backup instances of TddgLaunchPad to be used if the user
      cancels editing the TRunBtnItems }
    FLaunchPad := TddgLaunchPad.Create(Self);
    // Create the TddgRunButton instance and align it to the
    // enclosing panel.
    TestRunBtn := TddgRunButton.Create(Self);
    TestRunBtn.Parent := pnlRBtn;

    TestRunBtn.Width := pnlRBtn.Width;
    TestRunBtn.Height := pnlRBtn.Height;
end;

procedure TddgLaunchPadEditor.FormDestroy(Sender: TObject);
begin
    TestRunBtn.Free;
    FLaunchPad.Free; // Free the TddgLaunchPad instance.
end;

procedure TddgLaunchPadEditor.PathListBoxClick(Sender: TObject);
{ When the user clicks on an item in the list of TRunBtnItems, make
  the test TddgRunButton reflect the currently selected item }
begin
    if PathListBox.ItemIndex > -1 then
        TestRunBtn.CommandLine := PathListBox.Items[PathListBox.ItemIndex];
end;

procedure TddgLaunchPadEditor.UpdatePathListBox;
{ Re-initializes the PathListBox so that it reflects the list of
  TRunBtnItems }
var
    i: integer;
begin
    PathListBox.Clear; // First clear the list box.
    for i := 0 to FRunButtons.Count - 1 do
        PathListBox.Items.Add(FRunButtons[i].CommandLine);
end;

procedure TddgLaunchPadEditor.AddBtnClick(Sender: TObject);
{ When the add button is clicked, launch a TOpenDialog to retrieve
  an executable filename and path. Then add this file to the
```

```

    PathListBox. Also, add a new FRunBtnItem. }
var
  OpenFileDialog: TOpenDialog;
begin
  OpenFileDialog := TOpenDialog.Create(Application);
  try
    OpenFileDialog.Filter := 'Executable Files|*.EXE';
    if OpenFileDialog.Execute then
      begin
        { add to the PathListBox. }
        PathListBox.Items.Add(OpenDialog.FileName);
        FRunButtons.Add; // Create a new TRunBtnItem instance.
        { Set focus to the new item in PathListBox }
        PathListBox.ItemIndex := FRunButtons.Count - 1;
        { Set the command line for the new TRunBtnItem to that of the
          filename gotten as specified by PathListBox.ItemIndex }
        FRunButtons[PathListBox.ItemIndex].CommandLine :=
          PathListBox.Items[PathListBox.ItemIndex];
        { Invoke the PathListBoxClick event handler so that the test
          TddgRunButton will reflect the newly added item }
        PathListBoxClick(nil);
        Modified := True;
      end;
  finally
    OpenFileDialog.Free
  end;
end;

procedure TddgLaunchPadEditor.RemoveBtnClick(Sender: TObject);
{ Remove the selected path/filename from PathListBox as well as the
  corresponding TRunBtnItem from FRunButtons }
var
  i: integer;
begin
  i := PathListBox.ItemIndex;
  if i >= 0 then
    begin
      PathListBox.Items.Delete(i); // Remove the item from the listbox
      FRunButtons[i].Free;        // Remove the item from the collection
      TestRunBtn.CommandLine := ''; // Erase the test run button
      Modified := True;
    end;
end;

```

LISTING 22.12 Continued

```
end;

procedure TddgLaunchPadEditor.CancelBtnClick(Sender: TObject);
{ When the user cancels the operation, copy the backup LaunchPad
  TRunBtnItems back to the original TddgLaunchPad instance. Then,
  close the form by setting ModalResult to mrCancel. }
begin
  FRunButtons.Assign(FLaunchPad.RunButtons);
  Modified := False;
  ModalResult := mrCancel;
end;

{ TRunButtonsProperty }

function TRunButtonsProperty.GetAttributes: TPropertyAttributes;
{ Tell the Object Inspector that the property editor will use a
  dialog. This will cause the Edit method to be invoked when the user
  clicks the ellipsis button in the Object Inspector. }
begin
  Result := [paDialog];
end;

procedure TRunButtonsProperty.Edit;
{ Invoke the EdiTddgRunButton() method and pass in the reference to the
  TddgRunButton's instance being edited. This reference can be obtained by
  using the GetOrdValue method. Then redraw the LaunchDialog by calling
  the TRunButtons.UpdateRunButtons method. }
begin
  if EdiTRunButtons(TRunButtons(GetOrdValue)) then
    Modified;
  TRunButtons(GetOrdValue).UpdateRunButtons;
end;

function TRunButtonsProperty.GetValue: string;
{ Override the GetValue method so that the class type of the property
  being edited is displayed in the Object Inspector. }
begin
  Result := Format('%s', [GetPropType^.Name]);
end;

end.
```

This unit first defines the `TddgLaunchPadEditor` dialog and then the `TRunButtonsProperty` property editor. We're going to discuss the property editor first because it's the property editor that invokes the dialog.

The `TRunButtonsProperty` property editor is not much different than the dialog property editor we showed earlier. Here, we override the `GetAttributes()`, `Edit()`, and `GetValue()` methods.

`GetAttributes()` simply sets the `TPropertyAttributes` return value to specify that this editor invokes a dialog. Again, this will place an ellipsis button on the Object Inspector.

The `GetValue()` method uses the `GetPropType()` function to return a pointer to the Runtime Type Information for the property being edited. It returns the name field of this information that represents the property's type string. The string is displayed in the Object Inspector inside parentheses, which is a convention used by Delphi.

Finally, the `Edit()` method calls a function defined in this unit, `EditRunButtons()`. As a parameter, it passes the reference to the `TRunButtons` property by using the `GetOrdValue` function. When the function returns, the method `UpdateRunButton()` is invoked to cause `RunButtons` to be redrawn to reflect any changes.

The `EditRunButtons()` function creates the `TddgLaunchPadEditor` instance and points its `FRunButtons` field to the `TRunButtons` parameter passed to it. It uses this reference internally to make changes to the `TRunButtons` collection. The function then copies the `TRunButtons` collection of the property to an internal `TddgLaunchPad` component, `FLaunchPad`. It uses this instance as a backup in case the user cancels the edit operation.

Earlier we talked about the possibility of adding an Apply button to this dialog. To do so, you can edit the `FLaunchPad` component's `RunButtons` collection instance instead of directly modifying the actual collection. This way, if the user cancels the operation, nothing happens; if the user presses Apply or OK, the changes are invoked.

The form's `Create()` constructor creates the internal `TddgLaunchPad` instance. The `Destroy()` destructor ensures that it's freed when the form is destroyed.

`PathListBoxClick()` is the `OnClick` event handler for `PathListBox`. This method makes `TestRunBtn` (the test `TddgRunButton`) reflect the currently selected item in `PathListBox`, which displays a path to the executable file. The user can press this `TddgRunButton` instance to launch the application.

`UpdatePathListBox()` initializes `PathListBox` with the items in the collection.

`AddButtonClick()` is the `OnClick` event handler for the Add button. This event handler invokes a File Open dialog to retrieve an executable filename from the user and adds the path of this filename to `PathListBox`. It also creates a `TRunBtnItem` instance in the collection and assigns the path to its `CommandLine` property, which in turn does the same for the `TddgRunButton` component it encloses.

`RemoveBtnClick()` is the `OnClick` event handler for the Remove button. It removes the selected item from `PathListBox` as well as the `TRunBtnItem` instance from the collection.

`CancelBtnClick()` is the `OnClick` event handler for the Cancel button. It copies the backup collection from `FLaunchPad` to the actual `TRunButtons` collection and closes the form.

The `TCollection` and `TCollectionItems` objects are extremely useful and offer themselves to being used for a variety of purposes. Get to know them well, and next time you need to store a list of components, you'll already have a solution.

Summary

This chapter let you in on some of the more advanced tricks and techniques for Delphi component design. Among other things, you learned about extending hints and animating components as well as component editors, property editors, and component collections. Armed with this information, as well as the more conventional information you learned in the preceding chapter, you should be able to write a component to suit just about any of your programming needs. In the next chapter, "COM and ActiveX," we'll go even deeper into the world of component-based development.

IN THIS CHAPTER

- **COM Basics 1090**
- **COM Meets Object Pascal 1094**
- **COM Objects and Class Factories 1102**
- **Aggregation 1108**
- **Distributed COM 1108**
- **Automation 1109**
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- **Summary 1215**

Robust support for COM-based technologies is one of the marquee features of Delphi. The term *COM-based technologies* refers to a number of sundry technologies that rely on COM as their foundation. These technologies include COM servers and clients, ActiveX controls, Object Linking and Embedding (OLE), Automation, and Microsoft Transaction Server (MTS). However, all this new technology at your fingertips can be a bit perplexing, if not daunting. This chapter is designed to give you a complete overview of the technologies that make up COM, ActiveX, and OLE and help you leverage these technologies in your own applications. In earlier days, this topic referred primarily to OLE, which provides a method for sharing data among different applications, dealing primarily with linking or embedding data associated with one type of application to data associated with another application (such as embedding a spreadsheet into a word processor document). However, there is a lot more to COM than just OLE-based word processor tricks!

In this chapter, you will first get a solid background in the basics of COM-based technologies in general and extensions to Object Pascal and VCL added to support COM. You will learn how to apply this knowledge in order to control Automation servers from your Delphi applications and write Automation servers of your own. You will also learn about more sophisticated COM topics, such as advanced Automation techniques and MTS. Finally, this chapter covers VCL's `TOLEContainer` class, which encapsulates ActiveX containers. This chapter does not teach you everything there is to know about OLE and ActiveX—that could take volumes—but it does cover all the important features of OLE and ActiveX, particularly as they apply to Delphi.

COM Basics

First things first. Before we jump into the topic at hand, it is important that you understand the basic concepts and terminology associated with the technology. This section introduces you to basic ideas and terms behind the COM-based technologies.

COM: The Component Object Model

The *Component Object Model* (COM) forms the foundation upon which OLE and ActiveX technology is built. COM defines an API and a binary standard for communication between objects that is independent of any particular programming language or (in theory) platform. COM objects are similar to the VCL objects you are familiar with—except they have only methods and properties associated with them, not data fields.

A COM object consists of one or more *interfaces* (described in detail later in this chapter), which are essentially tables of functions associated with that object. You can call an interface's methods just like the methods of a Delphi object.

The component objects you use can be implemented from any EXE or DLL, although the implementation is transparent to you as a user of the object because of a service provided by

COM called *marshaling*. The COM marshaling mechanism handles all the intricacies of calling functions across process—and even machine—boundaries, which makes it possible to use a 32-bit object from a 16-bit application or access an object located on machine A from an application running on machine B. This intermachine communication is known as Distributed COM (DCOM) and is described in greater detail later in this chapter.

COM Versus ActiveX Versus OLE

“So, what’s the difference between COM, OLE, and ActiveX, anyway?” That’s one of the most common (and reasonable) questions developers ask as they get into this technology. It’s a reasonable question because it seems that the purveyor of this technology, Microsoft, does little to clarify the matter. You’ve already learned that COM is the API and binary standard that forms the building blocks of the other technologies. In the old days (like 1995), *OLE* was the blanket term used to describe the entire suite of technologies built on the COM architecture. These days, *OLE* refers only to those technologies associated specifically with linking and embedding, such as containers, servers, in-place activation, drag-and-drop, and menu merging. In 1996, Microsoft embarked on an aggressive marketing campaign in an attempt to create brand recognition for the term *ActiveX*, which became the blanket term used to describe non-OLE technologies built on top of COM. ActiveX technologies include Automation (formerly called *OLE Automation*) controls, documents, containers, scripting, and several Internet technologies. Because of the confusion created by using the term *ActiveX* to describe everything short of the family pet, Microsoft has backed off a bit and now sometimes refers to non-OLE COM technologies simply as *COM-based technologies*.

Those with a more cynical view of the industry might say that the term *OLE* became associated with adjectives such as “slow” and “bloated,” and marketing-savvy Microsoft needed a new term for those APIs on which it planned to base its future operating system and Internet technologies. Also amusing is the fact that Microsoft now claims *OLE* no longer stands for *Object Linking and Embedding*—it’s just a word that is pronounced *Oh-lay*.

Terminology

COM technologies bring with them a great deal of new terminology, so some terms are presented here before going any deeper into the guts of ActiveX and OLE.

Although an instance of a COM object is usually referred to simply as an *object*, the type that identifies that object is usually referred to as a *component class* or *coclass*. Therefore, to create an instance of a COM *object*, you must pass the CLSID of the COM *class* you want to create.

The chunk of data that is shared between applications is referred to as an *OLE object*. Applications that have the capability to contain OLE objects are referred to as *OLE containers*. Applications that have the capability to have their data contained within an OLE container are called *OLE servers*.

A document that contains one or more OLE objects is usually referred to as a *compound document*. Although OLE objects can be contained within a particular document, full-scale applications that can be hosted within the context of another document are known as *ActiveX documents*.

As the name implies, an OLE object can be *linked* or *embedded* into a compound document. Linked objects are stored in a file on disk. With object linking, multiple containers—or even the server application—can link to the same OLE object on disk. When one application modifies the linked object, the modification is reflected in all the other applications maintaining a link to that object. Embedded objects are stored by the OLE container application. Only the container application is able to edit the OLE object. Embedding prevents other applications from accessing (and therefore modifying or corrupting) your data, but it does put the burden of managing the data on the container.

Another facet of ActiveX that you'll learn more about in this chapter is *Automation*, which is a means to allow applications (called *Automation controllers*) to manipulate objects associated with other applications or libraries (called an *Automation server*). Automation enables you to manipulate objects in another application and, conversely, to expose elements of your application to other developers.

What's So Great About ActiveX?

The coolest thing about ActiveX is that it enables you to easily build the capability to manipulate many types of data into your applications. You might snicker at the word *easily*, but it's true. It is much easier, for example, to give your application the capability to contain ActiveX objects than it is to build word processing, spreadsheet, or graphics-manipulation capabilities into your application.

ActiveX fits very well with Delphi's tradition of maximum code reuse. You don't have to write code to manipulate a particular kind of data if you already have an OLE server application that does the job. As complicated as OLE can be, it often makes more sense than the alternatives.

It also is no secret that Microsoft has a large investment in ActiveX technology, and serious developers for Windows 95, NT, and other upcoming operating systems will have to become familiar with using ActiveX in their applications. So, like it or not, COM is here for a while, and it behooves you, as a developer, to become comfortable with it.

OLE 1 Versus OLE 2

One of the primary differences between OLE objects associated with 16-bit OLE version 1 servers and those associated with OLE version 2 servers is in how they activate themselves. When you activate an object created with an OLE 1 server, the server application starts up and receives focus, and then the OLE object appears in the server application, ready for editing.

When you activate an OLE 2 object, the OLE 2 server application becomes active “inside” your container application. This is known as *in-place activation* or *visual editing*.

When an OLE 2 object is activated, the menus and toolbars of the server application replace or merge with those of the client application, and a portion of the client application’s window essentially becomes the window of the server application. This process is demonstrated in the sample application shown later in this chapter.

Structured Storage

OLE 2 defines a system for storing information on disk known as *structured storage*. This system basically does on a file level what DOS does on a disk level. A storage object is one physical file on a disk, but it equates with the DOS concept of a directory, and it is made up of multiple storages and streams. A storage equates to a subdirectory, and a stream equates to a DOS file. You will often hear this implementation referred to as *compound files*.

Uniform Data Transfer

OLE 2 also has the concept of a *data object*, which is the basic object used to exchange data under the rules of uniform data transfer. *Uniform data transfer* (UDT) governs data transfers through the Clipboard, drag-and-drop, DDE, and OLE. Data objects allow for a greater degree of description about the kind of data they contain than previously was practical given the limitations of those transfer media. In fact, UDT is destined to replace DDE. A data object can be aware of its important properties, such as size, color, and even what device it is designed to be rendered on. Try doing that on the Windows Clipboard!

Threading Models

Every COM object operates in a particular threading model that dictates how an object can be manipulated in a multithreaded environment. When a COM server is registered, each of the COM objects contained in that server should register the threading model they support. For COM objects written in Delphi, the threading model chosen in the Automation, ActiveX control, or COM object wizards dictates how a control is registered. The COM threading models include the following:

- *Single*. The entire COM server runs on a single thread.
- *Apartment*. Also known as *single-threaded apartment* (STA). Each COM object executes within the context of its own thread, and multiple instances of the same type of COM object can execute within separate threads. Because of this, any data that is shared between object instances (such as global variables) must be protected by thread synchronization objects when appropriate.

- *Free*. Also known as multithreaded apartment (MTA). A client can call a method of an object on any thread at any time. This means that the COM object must protect even its own instance data from simultaneous access by multiple threads.
- *Both*. Both the apartment and free threading models are supported.

Keep in mind that merely selecting the desired threading model in the wizard doesn't guarantee that your COM object will be safe for that threading model. You must write the code to ensure that your COM servers operate correctly for the threading model you wish to support. This most often includes using thread synchronization objects to protect access to global or instance data in your COM objects. For more information on multithreaded development in Delphi, see Chapter 11, "Writing Multithreaded Applications."

COM+

As a part of the Windows 2000 release, Microsoft has provided the most significant update to COM in recent memory with the release of a new iteration called *COM+*. The goal of *COM+* is the simplification of the COM development process through the integration of several satellite technologies, most notably MTS (described later in this chapter) and Microsoft Message Queue (MSMQ). The integration of these technologies into the standard *COM+* runtime means that all *COM+* developers will be able to take advantage of features such as transaction control, security, administration, queued components, and publish and subscribe event services. Because *COM+* consists mostly of off-the-shelf parts, this means complete backward compatibility, such that all existing COM and MTS applications automatically become *COM+* applications.

COM Meets Object Pascal

Now that you understand the basic concepts and terms behind COM, ActiveX, and OLE, it's time to discuss how the concepts are implemented in Delphi. This section goes into more detail on COM and gives you a look at how it fits into the Object Pascal language and VCL.

Interfaces

COM defines a standard map for how an object's functions are laid out in memory. Functions are arranged in virtual tables (called *vtables*)—tables of function addresses identical to Delphi class *virtual method tables* (VMTs). The programming language description of each *vtable* is referred to as an *interface*.

Think of an interface as a facet of a particular class. Each facet represents a specific set of functions or procedures that you can use to manipulate the class. For example, a COM object that represents a bitmap image might support two interfaces: one containing methods that

enable the bitmap to render itself to the screen or printer and another interface to manage storing and retrieving the bitmap to and from a file on disk.

An interface really has two parts: The first part is the interface definition, which consists of a collection of one or more function declarations in a specific order. The interface definition is shared between the object and the user of the object. The second part is the interface implementation, which is the actual implementation of the functions described in the interface declaration. The interface definition is like a contract between the COM object and a client of that object—a guarantee to the client that the object will implement specific methods in a specific order.

Introduced in Delphi 3, the `interface` keyword in Object Pascal enables you to easily define COM interfaces. An interface declaration is semantically similar to a class declaration, with a few exceptions. Interfaces can consist only of properties and methods—no data. Because interfaces cannot contain data, their properties must write and read to and from methods. Most important, interfaces have no implementation because they only define a contract.

IUnknown

Just as all Object Pascal classes implicitly descend from `TObject`, all COM interfaces (and therefore all Object Pascal interfaces) implicitly derive from `IUnknown`, which is defined in the `System` unit as follows:

```
type
  IUnknown = interface
    ['{00000000-0000-0000-C000-000000000046}']
    function QueryInterface(const IID: TGUID; out Obj): Integer; stdcall;
    function _AddRef: Integer; stdcall;
    function _Release: Integer; stdcall;
  end;
```

Aside from the use of the `interface` keyword, another obvious difference between an interface and class declaration that you will notice from the preceding code is the presence of a *globally unique identifier* (GUID).

Globally Unique Identifiers (GUIDs)

A GUID (pronounced *goo-id*) is a 128-bit integer used in COM to uniquely identify an interface, coclass, or other entity. Because of their large size and the hairy algorithm used to generate these numbers, GUIDs are almost guaranteed to be globally unique (hence the name). GUIDs are generated using the `CoCreateGUID()` API function, and the algorithm employed by this function to generate new GUIDs combines information such as the current date and time, CPU clock sequence, network card number,

continues

and the balance of Bill Gates's bank accounts (okay, so we made up the last one). If you have a network card installed on a particular machine, a GUID generated on that machine is guaranteed to be unique because every network card has an internal ID that is globally unique. If you don't have a network card, it will synthesize a close approximation using other hardware information.

Because there is no language type that holds something as large as 128 bits in size, GUIDs are represented by the TGUID record, which is defined as follows in the System unit:

```
type
  PGUID = ^TGUID;
  TGUID = record
    D1: LongWord;
    D2: Word;
    D3: Word;
    D4: array[0..7] of Byte;
  end;
```

Because it can be a pain to assign GUID values to variables and constants in this record format, Object Pascal also allows a TGUID to be represented as a string with the following format:

```
'{xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx}'
```

Thanks to this, the following declarations are equivalent as far as the Delphi compiler is concerned:

```
MyGuid: TGUID = (
  D1:$12345678;D2:$1234;D3:$1234;D4:($01,$02,$03,$04,$05,$06,$07,$08));
```

```
MyGuid: TGUID = '{12345678-1234-1234-12345678}';
```

In COM, every interface or class has an accompanying GUID that uniquely defines that interface. In this way, two interfaces or classes having the same name defined by two different people will never conflict because their respective GUIDs will be different.

When used to represent an interface, a GUID is normally referred to as an *interface ID* (IID). When used to represent a class, a GUID is referred to as a *class ID* (CLSID).

TIP

You can generate a new GUID in the Delphi IDE using the Ctrl+Shift+G keystroke in the Code Editor.

In addition to its IID, `IUnknown` declares three methods: `QueryInterface()`, `_AddRef()`, and `_Release()`. Because `IUnknown` is the base interface for COM, all interfaces must implement `IUnknown` and its methods. The `_AddRef()` method should be called when a client obtains and wants to use a pointer to a given interface, and a call to `_AddRef()` must have an accompanying call to `_Release()` when the client is finished using the interface. In this way, the object that implements the interfaces can maintain a count of clients that are keeping a reference to the object, or *reference count*. When the reference count reaches zero, the object should free itself from memory. The `QueryInterface()` function is used to query whether an object supports a given interface and, if so, to return a pointer to that interface. For example, suppose that object `o` supports two interfaces, `I1` and `I2`, and you have a pointer to `o`'s `I1` interface. To obtain a pointer to `o`'s `I2` interface, you would call `I1.QueryInterface()`.

NOTE

If you're an experienced COM developer, you may have noticed that the underscore in front of the `_AddRef()` and `_Release()` methods is not consistent with other COM programming languages or even with Microsoft's COM documentation. Because Object Pascal is "IUnknown aware," you won't normally call these methods directly (more on this in a moment), so the underscores exist primarily to make you think before calling these methods.

Because every interface in Delphi implicitly descends from `IUnknown`, every Delphi class that implements interfaces must also implement the three `IUnknown` methods. You can do this yourself manually, or you can let VCL do the dirty work for you by descending your class from `TInterfacedObject`, which implements `IUnknown` for you.

Using Interfaces

Chapter 2, "The Object Pascal Language," and Delphi's own "Object Pascal Language Guide" documentation cover the semantics of using interface instances, so we won't rehash that material here. Instead, we'll discuss how `IUnknown` is seamlessly integrated into the rules of Object Pascal.

When an interface variable is assigned a value, the compiler automatically generates a call to the interface's `_AddRef()` method so that the reference count of the object is incremented. When an interface variable falls out of scope or is assigned the value `nil`, the compiler automatically generates a call to the interface's `_Release()` method. Consider the following piece of code:

```
var
  I: ISomeInterface;
begin
```

```
    I := FunctionThatReturnsAnInterface;  
    I.SomeMethod;  
end;
```

Now take a look at the following code snippet, which shows the code you would type (in bold) and an approximate Pascal version of the code the compiler generates (in normal font):

```
var  
    I: ISomeInterface;  
begin  
    // interface is automatically initialized to nil  
    I := nil;  
    try  
        // your code goes here  
        I := FunctionThatReturnsAnInterface;  
        // _AddRef() is called implicitly when I is assigned  
        I._AddRef;  
        I.SomeMethod;  
    finally  
        // implicit finally block ensures that the reference to the  
        // interface is released  
        if I <> nil I._Release;  
    end;  
end;
```

The Delphi compiler is also smart enough to know when to call `_AddRef()` and `_Release()` as interfaces are reassigned to other interface instances or assigned the value `nil`. For example, consider the following code block:

```
var  
    I: ISomeInteface;  
begin  
    // assign I  
    I := FunctionThatReturnsAnInterface;  
    I.SomeMethod;  
    // reassign I  
    I := OtherFunctionThatReturnsAnInterface;  
    I.OtherMethod;  
    // set I to nil  
    I := nil;  
end;
```

Again, here is a composite of the user-written (bold) code and the approximate compiler-generated (normal) code:

```
var  
    I: ISomeInterface;  
begin  
    // interface is automatically initialized to nil
```

```

I := nil;
try
  // your code goes here
  // assign I
  I := FunctionThatReturnsAnInterface;
  // _AddRef() is called implicitly when I is assigned
  I._AddRef;
  I.SomeMethod;
  // reassign I
  I._Release;
  I := OtherFunctionThatReturnsAnInterface;
  I._AddRef;
  I.OtherMethod;
  // set I to nil
  I._Release;
  I := nil;
finally
  // implicit finally block ensures that the reference to the
  // interface is released
  if I <> nil I._Release;
end;
end;

```

The preceding code example also helps to illustrate why Delphi prepends the underscore to the `_AddRef()` and `_Release()` methods. Forgetting to increment or decrement the reference of an interface was one of the classic COM programming bugs in the pre-interface days. Delphi's interface support is designed to alleviate these problems by handling the housekeeping details for you, so there's rarely ever a reason to call these methods directly.

Because the compiler knows how to generate calls to `_AddRef()` and `_Release()`, wouldn't it make sense if the compiler had some inherent knowledge of the third `IUnknown` method, `QueryInterface()`? It would, and it does. Given an interface pointer for an object, you can use the `as` operator to "typecast" the interface to another interface supported by the COM object. We say *typecast* because this application of the `as` operator isn't really a typecast in the strict sense but rather an internal call to the `QueryInterface()` method. The following sample code demonstrates this:

```

var
  I1: ISomeInterface;
  I2: ISomeOtherInterface;
begin
  // assign to I1
  I1 := FunctionThatReturnsAnInterface;
  // QueryInterface I1 for an I2 interface
  I2 := I1 as ISomeOtherInterface;
end;

```

In the preceding example, if the object referenced by `I1` doesn't support the `ISomeOtherInterface` interface, an exception will be raised by the `as` operator.

One additional language rule pertaining to interfaces is that an interface variable is assignment compatible with an Object Pascal class that implements that interface. For example, consider the following interface and class declarations:

```
type
  IFoo = interface
    // definition of IFoo
  end;

  IBar = interface(IFoo)
    // definition of IBar
  end;

  TBarClass = class(TObject, IBar)
    // definition of TBarClass
  end;
```

Given the preceding declarations, the following code is correct:

```
var
  IB: IBar;
  TB: TBarClass;
begin
  TB := TBarClass.Create;
  try
    // obtain TB's IBar interface pointer:
    IB := TB;
    // use TB and IB
  finally
    IB := nil; // explicitly release IB
    TB.Free;
  end;
end;
```

Although this feature seems to violate traditional Pascal assignment-compatibility rules, it does make interfaces feel more natural and easier to work with.

An important but nonobvious corollary to this rule is that interfaces are only assignment compatible with classes that explicitly support the interface. For example, the `TBarClass` class defined earlier declares explicit support for the `IBar` interface. Because `IBar` descends from `IFoo`, conventional wisdom might indicate that `TBarClass` also directly supports `IFoo`. This is not the case, however, as the following sample code illustrates:

```
var
  IF: IFoo;
```

```
TB: TBarClass;
begin
  TB := TBarClass.Create;
  try
    // compiler error raised on the next line because TBarClass
    // doesn't explicitly support IFoo.
    IF := TB;
    // use TB and IF
  finally
    IF := nil; // explicitly release IF
    TB.Free;
  end;
end;
```

Interfaces and IIDs

Because the interface IID is declared as a part of an interface declaration, the Object Pascal compiler knows how to obtain the IID from an interface. Therefore, you can pass an interface type to a procedure or function that requires a TIID or TGUID as a parameter. For example, suppose you have a function like this:

```
procedure TakesIID(const IID: TIID);
```

The following code is syntactically correct:

```
TakesIID(IUnknown);
```

This capability obviates the need for `IID_InterfaceType` constants defined for each interface type that you might be familiar with if you've done COM development in C++.

Method Aliasing

A problem that occasionally arises when you implement multiple interfaces in a single class is that there can be a collision of method names in two or more interfaces. For example, consider the following interfaces:

```
type
  IIntf1 = interface
    procedure AProc;
  end;

  IIntf2 = interface
    procedure AProc;
  end;
```

Given that each of the interfaces contains a method called `AProc()`, how can you declare a class that implements both interfaces? The answer is *method aliasing*. Method aliasing enables you to map a particular interface method to a method of a different name in a class. The following code example demonstrates how to declare a class that implements `IIntf1` and `IIntf2`:

```
type
  TNewClass = class(TInterfacedObject, IIntf1, IIntf2)
  protected
    procedure IIntf2.AProc = AProc2;
    procedure AProc; // binds to IIntf1.AProc
    procedure AProc2; // binds to IIntf2.AProc
  end;
```

In this declaration, the `AProc()` method of `IIntf2` is mapped to a method with the name `AProc()`. Creating aliases in this way enables you to implement any interface on any class without fear of method name collisions.

The HRESULT Return Type

You might notice that the `QueryInterface()` method of `IUnknown` returns a result of type `HRESULT`. `HRESULT` is a very common return type for many ActiveX and OLE interface methods and COM API functions. `HRESULT` is defined in the `System` unit as a type `LongWord`. Possible `HRESULT` values are listed in the `Windows` unit (if you have the VCL source code, you can find them under the heading { `HRESULT` value definitions }). An `HRESULT` value of `S_OK` or `NOERROR` (0) indicates success, whereas if the high bit of the `HRESULT` value is set, it indicates failure or some type of error condition. Two functions in the `Windows` unit, `Succeeded()` and `Failed()`, take an `HRESULT` as a parameter and return a `BOOL`, indicating success or failure. Here's the syntax for calling these methods:

```
if Succeeded(FunctionThatReturnsHRESULT) then
  \\ continue as normal

if Failed(FunctionThatReturnsHRESULT) then
  \\ error condition code
```

Of course, checking the return value of every single function call can become tedious. Also, dealing with errors returned by functions undermines Delphi's exception-handling methods for error detection and recovery. For these reasons, the `ComObj` unit defines a procedure called `OLECheck()` that converts `HRESULT` errors to exceptions. The syntax for calling this method is `OLECheck(FunctionThatReturnsHRESULT);`

This procedure can be quite handy, and it will clean up your ActiveX code considerably.

COM Objects and Class Factories

In addition to supporting one or more interfaces that descend from `IUnknown` and implementing reference counting for lifetime management, COM objects also have another special feature: They are created through special objects called *class factories*. Each COM class has an associated class factory responsible for creating instances of that COM class. Class factories are

special COM objects that support the `IClassFactory` interface. This interface is defined in the ActiveX unit as follows:

```
type
  IClassFactory = interface(IUnknown)
    ['{00000001-0000-0000-C000-000000000046}']
    function CreateInstance(const unkOuter: IUnknown; const iid: TIID;
      out obj): HRESULT; stdcall;
    function LockServer(fLock: BOOL): HRESULT; stdcall;
  end;
```

The `CreateInstance()` method is called to create an instance of the class factory's associated COM object. The `unkOuter` parameter of this method references the controlling `IUnknown` if the object is being created as a part of an aggregate (aggregation is explained a bit later). The `iid` parameter contains the IID of the interface by which you want to manipulate the object. Upon return, the `obj` parameter will hold a pointer to the interface indicated by `iid`.

The `LockServer()` method is called to keep a COM server in memory, even though no clients may be referencing the server. The `fLock` parameter, when `True`, should increment the server's lock count. When `False`, `fLock` should decrement the server's lock count. When the server's lock count is 0 and there are no clients referencing the server, COM will unload the server.

TComObject and TComObjectFactory

Delphi provides two classes that encapsulate COM objects and class factories: `TComObject` and `TComObjectFactory`, respectively. `TComObject` contains the necessary infrastructure for supporting `IUnknown` and creation via `TComObjectFactory`. Likewise, `TComObjectFactory` supports `IClassFactory` and has the capability to create `TComObject` objects. You can easily generate a COM object using the COM Object Wizard found on the ActiveX page of the New Items dialog. Listing 23.1 shows pseudocode for the unit generated by this wizard, which illustrates the relationship between these classes.

LISTING 23.1 COM Server Unit Pseudocode

```
unit ComDemo;

interface

uses ComObj;

type
  TSomeComObject = class(TComObject, interfaces supported)
    class and interface methods declared here
  end;
```

continues

LISTING 23.1 Continued

```
implementation

uses ComServ;

TSomeComObject implementation here

initialization
  TComObjectFactory.Create(ComServer, TSomeComObject,
    CLSID_TSomeComObject, 'ClassName', 'Description');
end;
```

The TComServer descendant is declared and implemented like most VCL classes. What binds it to its corresponding TComObjectFactory object is the parameters passed to TComObjectFactory's constructor Create(). The first constructor parameter is a TComServer object. You almost always will pass the global ComServer object declared in the ComServ unit in this parameter. The second parameter is the TComObject class you want to bind to the class factory. The third parameter is the CLSID of the TComObject's COM class. The fourth and fifth parameters are the class name and description strings used to describe the COM class in the System Registry.

The TComObjectFactory instance is created in the initialization of the unit in order to ensure that the class factory will be available to create instances of the COM object as soon as the COM server is loaded. Exactly how the COM server is loaded depends on whether the COM server is an in-process server (a DLL) or an out-of-process server (an application).

In-Process COM Servers

In-process (or *in-proc*, for short) COM servers are DLLs that can create COM objects for use by the host application. This type of COM server is called *in process* because, as a DLL, it resides in the same process as the calling application. An in-proc server must export four standard entry-point functions:

```
function DllRegisterServer: HRESULT; stdcall;
function DllUnregisterServer: HRESULT; stdcall;
function DllGetClassObject (const CLSID, IID: TGUID; var Obj): HRESULT;
  stdcall;
function DllCanUnloadNow: HRESULT; stdcall;
```

Each of these functions is already implemented by the ComServ unit, so the only work to be done for your Delphi COM servers is to ensure that these functions are added to an exports clause in your project.

NOTE

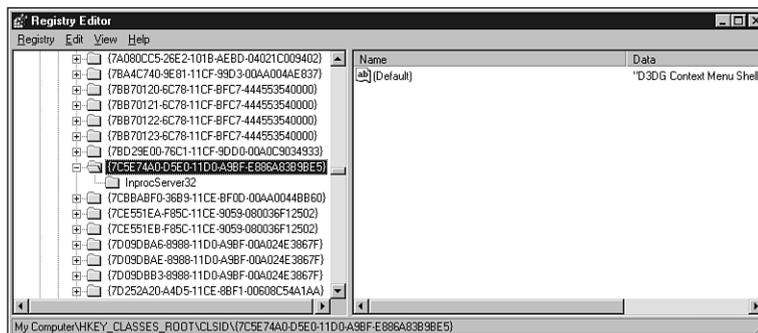
A good example of a real-world application of in-process COM servers can be found in Chapter 24, “Extending the Windows Shell,” which demonstrates how to create shell extensions.

DllRegisterServer()

The `DllRegisterServer()` function is called to register a COM server DLL with the System Registry. If you simply export this method from your Delphi application, as described earlier, VCL will iterate over all the COM objects in your application and register them with the System Registry. When a COM server is registered, it will make a key entry in the System Registry under

```
HKEY_CLASSES_ROOT\CLSID\{XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXX}
```

for each COM class, where the X's denote the CLSID of the COM class. For in-proc servers, an additional entry is created as a subkey of the preceding key called `InProcServer32`. The default value for this key is the full path to the in-proc server DLL. Figure 23.1 shows a COM server registered with the System Registry.

**FIGURE 23.1**

A COM server as shown in the Registry Editor.

DllUnregisterServer()

The `DllUnregisterServer()` function's job is simply to undo what is done by the `DllRegisterServer()` function. When called, it should remove all the entries in the System Registry made by `DllRegisterServer()`.

DllGetClassObject()

`DllGetClassObject()` is called by the COM engine in order to retrieve a class factory for a particular COM class. The `CLSID` parameter of this method is the `CLSID` of the type of COM class you want to create. The `IID` parameter holds the `IID` of the interface instance pointer you want to obtain for the class factory object (usually, `IClassFactory`'s interface `ID` is passed here). Upon successful return, the `Obj` parameter contains a pointer to the class factory interface denoted by `IID` that is capable of creating COM objects of the class type denoted by `CLSID`.

DllCanUnloadNow()

`DllCanUnloadNow()` is called by the COM engine to determine whether the COM server DLL is capable of being unloaded from memory. If there are references to any COM object within the DLL, this function should return `S_FALSE`, indicating that the DLL should not be unloaded. If none of the DLL's COM objects are in use, this method should return `S_TRUE`.

TIP

Even after all references to an in-proc server's COM objects have been freed, COM may not necessarily call `DllCanUnloadNow()` to begin the process of releasing the in-proc server DLL from memory. If you want to ensure that all unused COM server DLLs have been released from memory, call the `CoFreeUnusedLibraries()` API function, which is defined in the ActiveX units as follows:

```
procedure CoFreeUnusedLibraries; stdcall;
```

Creating an Instance of an In-Proc COM Server

To create an instance of a COM server in Delphi, use the `CreateComObject()` function, which is defined in the `ComObj` unit as follows:

```
function CreateComObject(const ClassID: TGUID): IUnknown;
```

The `ClassID` parameter holds the `CLSID`, which identifies the type of COM object you want to create. The return value of this function is the `IUnknown` interface of the requested COM object, or the function raises an exception if the COM object cannot be created.

`CreateComObject()` is a wrapper around the `CoCreateInstance()` COM API function. Internally, `CoCreateInstance()` calls the `CoGetClassObject()` API function to obtain an `IClassFactory` for the specified COM object. `CoCreateInstance()` does this by looking in the Registry for the COM class's `InProcServer32` entry in order to find the path to the in-proc server DLL, calling `LoadLibrary()` on the in-proc server DLL, and then calling the DLL's `DllGetClassObject()` function. After obtaining the `IClassFactory` interface pointer, `CoCreateInstance()` calls `IClassFactory.CreateInstance()` to create an instance of the specified COM class.

TIP

`CreateComObject()` can be inefficient if you need to create multiple objects from a class factory because it disposes of the `IClassFactory` interface pointer obtained by `CoGetObject()` after creating the requested COM object. In cases where you need to create multiple instances of the same COM object, you should call `CoGetObject()` directly and use `IClassFactory.CreateInstance()` to create multiple instances of the COM object.

NOTE

Before you can use any COM or OLE API functions, you must initialize the COM library using the `CoInitialize()` function. The single parameter to this function must be `nil`. To properly shut down the COM library, you should call the `CoUninitialize()` function as the last call to the OLE library. Calls are cumulative, so each call to `CoInitialize()` in your application must have a corresponding call to `CoUninitialize()`.

For applications, `CoInitialize()` is called automatically from `Application.Initialize()`, and `CoUninitialize()` is called automatically from the finalization of `ComObj`.

It's not necessary to call these functions from in-process libraries because their client applications are required to perform the initialization and uninitialization for the process.

Out-of-Process COM Servers

Out-of-process servers are executables that can create COM objects for use by other applications. The name comes from the fact that they do not execute from within the same process of the client but instead are executables that operate within the context of their own processes.

Registration

Like their in-proc cousins, out-of-process servers must also be registered with the System Registry. Out-of-process servers must make an entry under

```
HKEY_CLASSES_ROOT\CLSID\{XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXX}
```

called `LocalServer32`, which identifies the full pathname of the out-of-process server executable.

Delphi applications' COM servers are registered in the `Application.Initialize()` method, which is usually the first line of code in an application's project file. If the `/regserver` command-line switch is passed to your application, `Application.Initialize()` will register

the COM classes with the System Registry and immediately terminate the application. Likewise, if the `/unregserver` command-line switch is passed, `Application.Initialize()` will unregister the COM classes with the System Registry and immediately terminate the application. If neither of these switches are passed, `Application.Initialize()` will register the COM classes with the System Registry and continue to run the application normally.

Creating an Instance of an Out-of-Process COM Server

On the surface, the method for creating instances of COM objects from out-of-process servers is the same as for in-proc servers: Just call `ComObj`'s `CreateComObject()` function. Behind the scenes, however, the process is quite different. In this case, `CoGetClassObject()` looks for the `LocalServer32` entry in the System Registry and invokes the associated application using the `CreateProcess()` API function. When the out-of-proc server application is invoked, the server must register its class factories using the `CoRegisterClassObject()` COM API function. This function adds an `IClassFactory` pointer to COM's internal table of active registered class objects. `CoGetClassObject()` can then obtain the requested COM class's `IClassFactory` pointer from this table to create an instance of the COM object.

Aggregation

You know now that interfaces are the basic building blocks of COM as well as that inheritance is possible with interfaces, but interfaces are entities without implementation. What happens, then, when you want to recycle the implementation of one COM object within another? COM's answer to this question is a concept called *aggregation*. Aggregation means that the containing (outer) object creates the contained (inner) object as part of its creation process, and the interfaces of the inner object are exposed by the outer. An object has to allow itself to operate as an aggregate by providing a means to forward all calls to its `IUnknown` methods to the containing object. For an example of aggregation within the context of VCL COM objects, you should take a look at the `TAggregatedObject` class in the `AxCtrls` unit.

Distributed COM

Introduced with Windows NT 4, Distributed COM (or *DCOM*) provides a means for accessing COM objects located on other machines on a network. In addition to remote object creation, DCOM also provides security facilities that allow servers to specify which clients have rights to create instances of which servers and what operations they may perform. Windows NT 4 and Windows 98 have built-in DCOM capability, but Windows 95 requires an add-on available on Microsoft's Web site (<http://www.microsoft.com>) to serve as a DCOM client.

You can create remote COM objects using the `CreateRemoteComObject()` function, which is declared in the `ComObj` unit as follows:

```
function CreateRemoteComObject(const MachineName: WideString;  
    const ClassID: TGUID): IUnknown;
```

The first parameter, *MachineName*, to this function is a string representing the network name of the machine containing the COM class. The *ClassID* parameter specifies the CLSID of the COM class to be created. The return value for this function is the *IUnknown* interface pointer for the COM object specified in CLSID. An exception will be raised if the object cannot be created.

`CreateRemoteComObject()` is a wrapper around the `CoCreateInstanceEx()` COM API function, which is an extended version of `CoCreateInstance()` that knows how to create objects remotely.

Automation

Automation (formerly known as *OLE Automation*) provides a means for applications or DLLs to expose programmable objects for use by other applications. Applications or DLLs that expose programmable objects are referred to as *Automation servers*. Applications that access and manipulate the programmable objects contained within Automation servers are known as *Automation controllers*. Automation controllers are able to program the Automation server using a macro-like language exposed by the server.

Among the chief advantages to using Automation in your applications is its language-independent nature. An Automation controller is able to manipulate a server regardless of the programming language used to develop either component. Additionally, because Automation is supported at the operating system level, the theory is that you'll be able to leverage future advancements in this technology by using Automation today. If these things sound good to you, then read on. What follows is information on creating Automation servers and controllers in Delphi.

CAUTION

If you have an Automation project from Delphi 2 that you want to migrate to the current version of Delphi, you should be forewarned that the techniques for Automation changed drastically starting with Delphi 3. In general, you shouldn't mix Delphi 2's Automation unit, `OLEAuto`, with the newer `ComObj` or `ComServ` units. If you want to compile a Delphi 2 Automation project in Delphi 5, the `OLEAuto` unit remains in the `\Delphi5\lib\Delphi2` subdirectory for backward compatibility.

IDispatch

Automation objects are essentially COM objects that implement the IDispatch interface.

IDispatch is defined in the System unit as shown here:

```
type
  IDispatch = interface(IUnknown)
    ['{00020400-0000-0000-C000-000000000046}']
    function GetTypeInfoCount(out Count: Integer): Integer; stdcall;
    function GetTypeInfo(Index, LocaleID: Integer; out TypeInfo):
      Integer; stdcall;
    function GetIDsOfNames(const IID: TGUID; Names: Pointer;
      NameCount, LocaleID: Integer; DispIDs: Pointer): Integer; stdcall;
    function Invoke(DispID: Integer; const IID: TGUID; LocaleID: Integer;
      Flags: Word; var Params; VarResult, ExcepInfo, ArgErr: Pointer): Integer;
  end;
```

The first thing you should know is that you don't have to understand the ins and outs of the IDispatch interface to take advantage of Automation in Delphi, so don't let this complicated interface alarm you. You generally don't have to interact with this interface directly because Delphi provides an elegant encapsulation of Automation, but the description of IDispatch in this section should provide you with a good foundation for understanding Automation.

Central to the function of IDispatch is the `Invoke()` method, so we'll start there. When a client obtains an IDispatch pointer for an Automation server, it can call the `Invoke()` method to execute a particular method on the server. The `DispID` parameter of this method holds a number, called a *dispatch ID*, that indicates which method on the server should be invoked. The `IID` parameter is unused. The `LocaleID` parameter contains language information. The `Flags` parameter describes what kind of method is to be invoked and whether it's a normal method or a put or get method for a property. The `Params` property contains a pointer to an array of `TDispParams`, which holds the parameters passed to the method. The `VarResult` parameter is a pointer to an `OleVariant`, which will hold the return value of the method that is invoked. `ExcepInfo` is a pointer to a `TExcepInfo` record that will contain error information if `Invoke()` returns `DISP_E_EXCEPTION`. Finally, if `Invoke()` returns `DISP_E_TYPERISMATCH` or `DISP_E_PARAMNOTFOUND`, the `ArgError` parameter is a pointer to an integer that will contain the index of the offending parameter in the `Params` array.

The `GetIDsOfName()` method of IDispatch is called to obtain the dispatch ID of one or more method names given strings identifying those methods. The `IID` parameter of this method is unused. The `Names` parameter points to an array of `PWideChar` method names. The `NameCount` parameter holds the number of strings in the `Names` array. `LocaleID` contains language information. The last parameter, `DispIDs`, is a pointer to an array of `NameCount` integers, which `GetIDsOfName()` will fill in with the dispatch IDs for the methods listed in the `Names` parameter.

`GetTypeInfo()` retrieves the type information (type information is described next) for the Automation object. The `Index` parameter represents the type of information to obtain and should normally be 0. The `LCID` parameter holds language information. Upon successful return, the `TypeInfo` parameter will hold an `ITypeInfo` pointer for the Automation object's type information.

The `GetTypeInfoCount()` method retrieves the number of type information interfaces supported by the Automation object in the `Count` parameter. Currently, `Count` will only contain two possible values: 0, meaning the Automation object doesn't support type information, and 1, meaning the Automation object does support type information.

Type Information

After you have spent a great deal of time carefully crafting an Automation server, it would be a shame if potential users of your server couldn't exploit its capabilities to the fullest because of lack of documentation on the methods and properties provided. Fortunately, Automation provides a means for helping avoid this problem by allowing developers to associate type information with Automation objects. This type information is stored in something called a *type library*, and an Automation server's type library can be linked to the server application or library as a resource or stored in an external file. Type libraries contain information about classes, interfaces, types, and other entities in a server. This information provides clients of the Automation server with the information needed to create instances of each of its classes and properly call methods on each interface.

Delphi generates type libraries for you when you add Automation objects to applications and libraries. Additionally, Delphi knows how to translate type library information into Object Pascal so that you can easily control Automation servers from your Delphi applications.

Late Versus Early Binding

The elements of Automation that you've learned about so far in this chapter deal with what's called *late binding*. Late binding is a fancy way to say that a method is called through `IDispatch`'s `Invoke()` method. It's called *late binding* because the method call isn't resolved until runtime. At compile time, an Automation method call resolves into a call to `IDispatch.Invoke()` with the proper parameters, and at runtime, `Invoke()` executes the Automation method. When you call an Automation method via a Delphi `Variant` or `OleVariant` type, you're using late binding because Delphi must call `IDispatch.GetIDsOfNames()` to convert the method name into a `DispID`, and then it can invoke the method by calling `IDispatch.Invoke()` with the `DispID`.

A common optimization of early binding is to resolve the `DispIDs` of methods at compile time and therefore avoid the runtime calls to `GetIDsOfNames()` in order to invoke a method. This

optimization is often referred to as *ID binding*, and it is the convention used when you invoke methods via a Delphi `dispinterface` type.

Early binding occurs when the Automation object exposes methods by means of a custom interface descending from `IDispatch`. This way, controllers can call Automation objects directly through the vtable without going through `IDispatch.Invoke()`. Because the call is direct, a call to such as method will generally occur faster than a call through late binding. Early binding is used you when call a method using a Delphi interface type.

An Automation object that allows methods to be called both from `Invoke()` and directly from an `IDispatch` descendant interface is said to support a *dual interface*. Delphi-generated Automation objects always support a dual interface, and Delphi controllers allow methods to be called both through `Invoke()` and directly through an interface.

Registration

Automation objects must make all the same Registry entries as regular COM objects, but Automation servers typically also make an additional entry under

```
HKEY_CLASSES_ROOT\CLSID\{xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxx}
```

called `ProgID`, which provides a string identifier for the Automation class. Yet another Registry entry under `HKEY_CLASSES_ROOT\(ProgID string)` is made, which contains the CLSID of the Automation class in order to cross-reference back to the first Registry entry under `CLSID`.

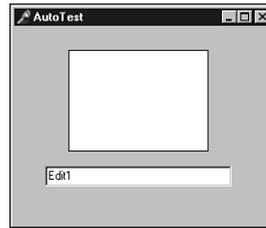
Creating Automation Servers

Delphi makes it a fairly simple chore to create both out-of-process and in-process Automation servers. The process for creating an Automation server can be boiled down into four steps:

1. Create the application or DLL you want to automate. You can even use one of your existing applications as a starting point in order to spice it up with some automation. This is the only step where you'll see a real difference between creating in-process and out-of-process servers.
2. Create the Automation object and add it to your project. Delphi provides an Automation Object Expert to help this step go smoothly.
3. Add properties and methods to the Automation object by means of the type library. These are the properties and methods that will be exposed to Automation controllers.
4. Implement the methods generated by Delphi from your type library in your source code.

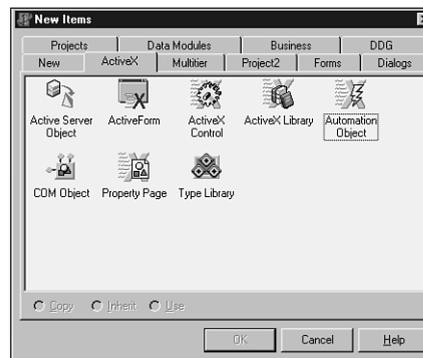
Creating an Out-of-Process Automation Server

This section walks you through the creation of a simple out-of-process Automation server. Start by creating a new project and placing a `TShape` and a `TEdit` component on the main form, as shown in Figure 23.2. Save this project as `Srv.dpr`.

**FIGURE 23.2**

The main form of the Srv project.

Now add an Automation object to the project by selecting File, New from the main menu and choosing Automation Object from the ActiveX page of the New Items dialog, as shown in Figure 23.3. This will invoke the Automation Object Wizard shown in Figure 23.4.

**FIGURE 23.3**

Adding a new Automation object.

**FIGURE 23.4**

The Automation Object Wizard.

In the Class Name field of the Automation Object Wizard dialog, you should enter the name you want to give the COM class for this Automation object. The wizard will automatically prepend a *T* to the class name when creating the Object Pascal class for the Automation object and an *I* to the class name when creating the primary interface for the Automation object. The Instancing combo box in the wizard can hold any one of these three values:

<i>Value</i>	<i>Description</i>
Internal	This OLE object will be used internal to the application only, and it will not be registered with the System Registry. External processes cannot access internal instanced Automation servers.
Single Instance	Each instance of the server can export only one instance of the OLE object. If a controller application requests another instance of the OLE object, Windows will start a new instance of the server application.
Multiple Instance	Each server instance can create and export multiple instances of the OLE object. In-process servers are always multiple instance.

When you complete the wizard's dialog, Delphi will create a new type library for your project (if one doesn't already exist) and add an interface and a coclass to the type library. Additionally, the wizard will generate a new unit in your project that contains the implementation of the Automation interface added to the type library. Figure 23.5 shows the type library editor immediately after the wizard's dialog is dismissed, and Listing 23.2 shows the implementation unit for the Automation object.

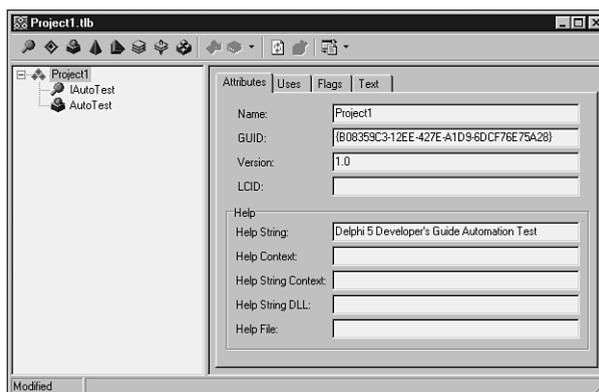


FIGURE 23.5

A new Automation project as shown in the type library editor.

LISTING 23.2 Automation Object Implementation Unit

```
unit TestImpl;

interface

uses
  ComObj, ActiveX, Srv_TLB;

type
  TAutoTest = class(TAutoObject, IAutoTest)
  protected
    { Protected declarations }
  end;

implementation

uses ComServ;

initialization
  TAutoObjectFactory.Create(ComServer, TAutoTest, Class_AutoTest,
    ciMultiInstance, tmApartment);
end.
```

The Automation object, `TAutoTest`, is a class that descends from `TAutoObject`. `TAutoObject` is the base class for all Automation servers. As you add methods to your interface by using the type library editor, new method skeletons will be generated in this unit that you will implement, thus forming the innards of your Automation object.

CAUTION

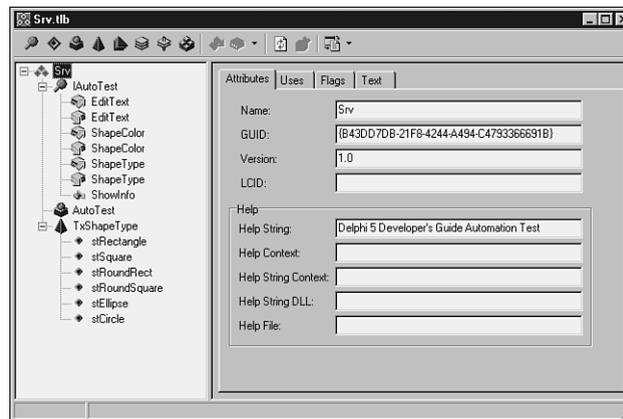
Again, be careful not to confuse Delphi 2's `TAutoObject` (from the `01eAuto` unit) with Delphi 5's `TAutoObject` (from the `ComObj` unit). The two are not compatible.

Similarly, the automated visibility specifier introduced in Delphi 2 is now mostly obsolete.

When the Automation object has been added to the project, you must add one or more properties or methods to the primary interface using the type library editor. For this project, the type library will contain properties to get and set the shape, color, and type as well as the edit control's text. For good measure, you'll also add a method that displays the current status of these properties in a dialog. Figure 23.6 shows the completed type library for the `Srv` project. Note especially the enumeration added to the type library (whose values are shown in the right pane) to support the `ShapeType` property.

NOTE

As you add properties and methods to Automation objects in the type library, keep in mind that the parameters and return values used for these properties and methods must be of Automation-compatible types. Types compatible with Automation include Byte, SmallInt, Integer, Single, Double, Currency, TDateTime, WideString, WordBool, PSafeArray, TDecimal, OleVariant, IUnknown, and IDispatch.

**FIGURE 23.6**

The completed type library.

When the type library has been completed, all that is left to do is fill in the implementation for each of the method stubs created by the type library editor. This unit is shown in Listing 23.3.

LISTING 23.3 The Completed Implementation Unit

```
unit TestImpl;

interface

uses
  ComObj, ActiveX, Srv_TLB;

type
  TAutoTest = class(TAutoObject, IAutoTest)
  protected
    function Get_EditText: WideString; safecall;
```

```
function Get_ShapeColor: OLE_COLOR; safecall;  
procedure Set_EditText(const Value: WideString); safecall;  
procedure Set_ShapeColor(Value: OLE_COLOR); safecall;  
function Get_ShapeType: TxShapeType; safecall;  
procedure Set_ShapeType(Value: TxShapeType); safecall;  
procedure ShowInfo; safecall;  
end;
```

implementation

```
uses ComServ, SrvMain, TypInfo, ExtCtrls, Dialogs, SysUtils, Graphics;
```

```
function TAutoTest.Get_EditText: WideString;  
begin  
  Result := FrmAutoTest.Edit.Text;  
end;
```

```
function TAutoTest.Get_ShapeColor: OLE_COLOR;  
begin  
  Result := ColorToRGB(FrmAutoTest.Shape.Brush.Color);  
end;
```

```
procedure TAutoTest.Set_EditText(const Value: WideString);  
begin  
  FrmAutoTest.Edit.Text := Value;  
end;
```

```
procedure TAutoTest.Set_ShapeColor(Value: OLE_COLOR);  
begin  
  FrmAutoTest.Shape.Brush.Color := Value;  
end;
```

```
function TAutoTest.Get_ShapeType: TxShapeType;  
begin  
  Result := TxShapeType(FrmAutoTest.Shape.Shape);  
end;
```

```
procedure TAutoTest.Set_ShapeType(Value: TxShapeType);  
begin  
  FrmAutoTest.Shape.Shape := TShapeType(Value);  
end;
```

```
procedure TAutoTest.ShowInfo;  
const  
  SInfoStr = 'The Shape's color is %s, and it's shape is %s.'#13#10 +  
    'The Edit's text is "%s."';
```

LISTING 23.3 Continued

```
begin
  with FrmAutoTest do
    ShowMessage(Format(SInfoStr, [ColorToString(Shape.Brush.Color),
      GetEnumName(TypeInfo(TShapeType), Ord(Shape.Shape)), Edit.Text]));
  end;

  initialization
    TAutoObjectFactory.Create(ComServer, TAutoTest, Class_AutoTest,
      ciMultiInstance, tmApartment);
  end.
```

The uses clause for this unit contains a unit called Srv_TLB. This unit is the Object Pascal translation of the project type library, and it is shown in Listing 23.4.

LISTING 23.4 Srv_TLB: The Type Library File

```
unit Srv_TLB;

// ***** //
// WARNING
// -----
// The types declared in this file were generated from data read from a
// Type Library. If this type library is explicitly or indirectly (via
// another type library referring to this type library) re-imported, or
// the 'Refresh' command of the Type Library Editor activated while
// editing the Type Library, the contents of this file will be regenerated
// and all manual modifications will be lost.
// ***** //

// PASTLWTR : $Revision: 1.88 $
// File generated on 10/28/99 1:55:17 PM from Type Library described below

// ***** //
// NOTE:
// Items guarded by $IFDEF LIVE_SERVER_AT_DESIGN_TIME are used by
// properties which return objects that may need to be explicitly created
// via a function call prior to any access via the property. These items
// have been disabled in order to prevent accidental use from within the
// object inspector. You may enable them by defining
// LIVE_SERVER_AT_DESIGN_TIME or by selectively removing them from the
// $IFDEF blocks. However, such items must still be programmatically
// created via a method of the appropriate CoClass before they can be used
// ***** //
// Type Lib: C:\work\d5dg\code\Ch23\Automate\Srv.tlb (1)
```

```

// IID\LCID: {B43DD7DB-21F8-4244-A494-C4793366691B}\0
// Helpfile:
// DepndLst:
// (1) v2.0 stdole, (C:\WINDOWS\SYSTEM\STDOLE2.TLB)
// (2) v4.0 StdVCL, (C:\WINDOWS\SYSTEM\STDVCL40.DLL)
// ***** //
{$TYPEDADDRESS OFF} // Unit must be compiled without type-checked pointers
interface

uses Windows, ActiveX, Classes, Graphics, OleServer, OleCtrls, StdVCL;

// *****//
// GUIDS declared in the TypeLibrary. Following prefixes are used:
// Type Libraries      : LIBID_xxxx
// CoClasses           : CLASS_xxxx
// DISPInterfaces      : DIID_xxxx
// Non-DISP interfaces: IID_xxxx
// *****//
const
  // TypeLibrary Major and minor versions
  SrvMajorVersion = 1;
  SrvMinorVersion = 0;

  LIBID_Srv: TGUID = '{B43DD7DB-21F8-4244-A494-C4793366691B}';

  IID_IAutoTest: TGUID = '{C16B6A4C-842C-417F-8BF2-2F306F6C6B59}';
  CLASS_AutoTest: TGUID = '{64C576F0-C9A7-420A-9EAB-0BE98264BC9D}';

// *****//
// Declaration of Enumerations defined in Type Library
// *****//
// Constants for enum TxShapeType
type
  TxShapeType = ToleEnum;
const
  stRectangle = $00000000;
  stSquare = $00000001;
  stRoundRect = $00000002;
  stRoundSquare = $00000003;
  stEllipse = $00000004;
  stCircle = $00000005;

type

// *****//
// Forward declaration of types defined in TypeLibrary

```

continues

LISTING 23.4 Continued

```
// *****//
IAutoTest = interface;
IAutoTestDisp = dispinterface;

// *****//
// Declaration of CoClasses defined in Type Library
// (NOTE: Here we map each CoClass to its Default Interface)
// *****//
AutoTest = IAutoTest;

// *****//
// Interface: IAutoTest
// Flags:      (4416) Dual OleAutomation Dispatchable
// GUID:       {C16B6A4C-842C-417F-8BF2-2F306F6C6B59}
// *****//
IAutoTest = interface(IDispatch)
  ['{C16B6A4C-842C-417F-8BF2-2F306F6C6B59}']
  function Get_EditText: WideString; safecall;
  procedure Set_EditText(const Value: WideString); safecall;
  function Get_ShapeColor: OLE_COLOR; safecall;
  procedure Set_ShapeColor(Value: OLE_COLOR); safecall;
  function Get_ShapeType: TxShapeType; safecall;
  procedure Set_ShapeType(Value: TxShapeType); safecall;
  procedure ShowInfo; safecall;
  property EditText: WideString read Get_EditText write Set_EditText;
  property ShapeColor: OLE_COLOR read Get_ShapeColor write
    Set_ShapeColor;
  property ShapeType: TxShapeType read Get_ShapeType write
    Set_ShapeType;
end;

// *****//
// DispIntf: IAutoTestDisp
// Flags:      (4416) Dual OleAutomation Dispatchable
// GUID:       {C16B6A4C-842C-417F-8BF2-2F306F6C6B59}
// *****//
IAutoTestDisp = dispinterface
  ['{C16B6A4C-842C-417F-8BF2-2F306F6C6B59}']
  property EditText: WideString dispid 1;
  property ShapeColor: OLE_COLOR dispid 2;
  property ShapeType: TxShapeType dispid 3;
  procedure ShowInfo; dispid 4;
end;
```

```
// *****//
// The Class CoAutoTest provides a Create and CreateRemote method to
// create instances of the default interface IAutoTest exposed by
// the CoClass AutoTest. The functions are intended to be used by
// clients wishing to automate the CoClass objects exposed by the
// server of this typelibrary.
// *****//
CoAutoTest = class
  class function Create: IAutoTest;
  class function CreateRemote(const MachineName: string): IAutoTest;
end;

// *****//
// OLE Server Proxy class declaration
// Server Object      : TAutoTest
// Help String        : AutoTest Object
// Default Interface: IAutoTest
// Def. Intf. DISP?   : No
// Event Interface:
// TypeFlags          : (2) CanCreate
// *****//
{$IFDEF LIVE_SERVER_AT_DESIGN_TIME}
  TAutoTestProperties= class;
{$ENDIF}
  TAutoTest = class(TOLEServer)
  private
    FIntf:      IAutoTest;
{$IFDEF LIVE_SERVER_AT_DESIGN_TIME}
    FProps:    TAutoTestProperties;
    function   GetServerProperties: TAutoTestProperties;
{$ENDIF}
    function   GetDefaultInterface: IAutoTest;
  protected
    procedure InitServerData; override;
    function   Get_EditText: WideString;
    procedure Set_EditText(const Value: WideString);
    function   Get_ShapeColor: OLE_COLOR;
    procedure Set_ShapeColor(Value: OLE_COLOR);
    function   Get_ShapeType: TxShapeType;
    procedure Set_ShapeType(Value: TxShapeType);
  public
    constructor Create(AOwner: TComponent); override;
    destructor Destroy; override;
    procedure Connect; override;
    procedure ConnectTo(svrIntf: IAutoTest);
```

LISTING 23.4 Continued

```

    procedure Disconnect; override;
    procedure ShowInfo;
    property DefaultInterface: IAutoTest read GetDefaultInterface;
    property EditText: WideString read Get_EditText write Set_EditText;
    property ShapeColor: OLE_COLOR read Get_ShapeColor write
        Set_ShapeColor;
    property ShapeType: TxShapeType read Get_ShapeType write
        Set_ShapeType;
published
{$IFDEF LIVE_SERVER_AT_DESIGN_TIME}
    property Server: TAutoTestProperties read GetServerProperties;
{$ENDIF}
end;

{$IFDEF LIVE_SERVER_AT_DESIGN_TIME}
// *****
// OLE Server Properties Proxy Class
// Server Object      : TAutoTest
// (This object is used by the IDE's Property Inspector to allow editing
// of the properties of this server)
// *****
TAutoTestProperties = class(TPersistent)
private
    FServer:    TAutoTest;
    function   GetDefaultInterface: IAutoTest;
    constructor Create(AServer: TAutoTest);
protected
    function   Get_EditText: WideString;
    procedure Set_EditText(const Value: WideString);
    function   Get_ShapeColor: OLE_COLOR;
    procedure Set_ShapeColor(Value: OLE_COLOR);
    function   Get_ShapeType: TxShapeType;
    procedure Set_ShapeType(Value: TxShapeType);
public
    property DefaultInterface: IAutoTest read GetDefaultInterface;
published
    property EditText: WideString read Get_EditText write Set_EditText;
    property ShapeColor: OLE_COLOR read Get_ShapeColor write
        Set_ShapeColor;
    property ShapeType: TxShapeType read Get_ShapeType write
        Set_ShapeType;
end;
{$ENDIF}

procedure Register;

```

```
implementation

uses ComObj;

class function CoAutoTest.Create: IAutoTest;
begin
  Result := CreateComObject(CLASS_AutoTest) as IAutoTest;
end;

class function CoAutoTest.CreateRemote(const MachineName: string):
  IAutoTest;
begin
  Result := CreateRemoteComObject(MachineName, CLASS_AutoTest) as IAutoTest;
end;

procedure TAutoTest.InitServerData;
const
  CServerData: TServerData = (
    ClassID:   '{64C576F0-C9A7-420A-9EAB-0BE98264BC9D}';
    IntfIID:   '{C16B6A4C-842C-417F-8BF2-2F306F6C6B59}';
    EventIID:  '';
    LicenseKey: nil;
    Version: 500);
begin
  ServerData := @CServerData;
end;

procedure TAutoTest.Connect;
var
  punk: IUnknown;
begin
  if FIntf = nil then
    begin
      punk := GetServer;
      FIntf := punk as IAutoTest;
    end;
end;

procedure TAutoTest.ConnectTo(svrIntf: IAutoTest);
begin
  Disconnect;
  FIntf := svrIntf;
end;

procedure TAutoTest.DisConnect;
begin
```

LISTING 23.4 Continued

```
    if FIntf <> nil then
    begin
        FIntf := nil;
    end;
end;

function TAutoTest.GetDefaultInterface: IAutoTest;
const
    ErrStr = 'DefaultInterface is NULL. Component is not connected to ' +
            'Server. You must call ''Connect'' or ''ConnectTo'' before this ' +
            'operation';
begin
    if FIntf = nil then
        Connect;
    Assert(FIntf <> nil, ErrStr);
    Result := FIntf;
end;

constructor TAutoTest.Create(AOwner: TComponent);
begin
    inherited Create(AOwner);
    {$IFDEF LIVE_SERVER_AT_DESIGN_TIME}
        FProps := TAutoTestProperties.Create(Self);
    {$ENDIF}
end;

destructor TAutoTest.Destroy;
begin
    {$IFDEF LIVE_SERVER_AT_DESIGN_TIME}
        FProps.Free;
    {$ENDIF}
    inherited Destroy;
end;

{$IFDEF LIVE_SERVER_AT_DESIGN_TIME}
function TAutoTest.GetServerProperties: TAutoTestProperties;
begin
    Result := FProps;
end;
{$ENDIF}

function TAutoTest.Get_EditText: WideString;
begin
    Result := DefaultInterface.Get_EditText;
end;
```

```
procedure TAutoTest.Set_EditText(const Value: WideString);
begin
  DefaultInterface.Set_EditText(Value);
end;

function TAutoTest.Get_ShapeColor: OLE_COLOR;
begin
  Result := DefaultInterface.Get_ShapeColor;
end;

procedure TAutoTest.Set_ShapeColor(Value: OLE_COLOR);
begin
  DefaultInterface.Set_ShapeColor(Value);
end;

function TAutoTest.Get_ShapeType: TxShapeType;
begin
  Result := DefaultInterface.Get_ShapeType;
end;

procedure TAutoTest.Set_ShapeType(Value: TxShapeType);
begin
  DefaultInterface.Set_ShapeType(Value);
end;

procedure TAutoTest.ShowInfo;
begin
  DefaultInterface.ShowInfo;
end;

{$IFDEF LIVE_SERVER_AT_DESIGN_TIME}
constructor TAutoTestProperties.Create(AServer: TAutoTest);
begin
  inherited Create;
  FServer := AServer;
end;

function TAutoTestProperties.GetDefaultInterface: IAutoTest;
begin
  Result := FServer.DefaultInterface;
end;

function TAutoTestProperties.Get_EditText: WideString;
begin
  Result := DefaultInterface.Get_EditText;
end;
```

LISTING 23.4 Continued

```
procedure TAutoTestProperties.Set_EditText(const Value: WideString);
begin
    DefaultInterface.Set_EditText(Value);
end;

function TAutoTestProperties.Get_ShapeColor: OLE_COLOR;
begin
    Result := DefaultInterface.Get_ShapeColor;
end;

procedure TAutoTestProperties.Set_ShapeColor(Value: OLE_COLOR);
begin
    DefaultInterface.Set_ShapeColor(Value);
end;

function TAutoTestProperties.Get_ShapeType: TxShapeType;
begin
    Result := DefaultInterface.Get_ShapeType;
end;

procedure TAutoTestProperties.Set_ShapeType(Value: TxShapeType);
begin
    DefaultInterface.Set_ShapeType(Value);
end;

{$ENDIF}

procedure Register;
begin
    RegisterComponents('Servers',[TAutoTest]);
end;

end.
```

Looking at this unit from the top down, you will notice that the type library version is specified first and then the GUID for the type library, `LIBID_Srv`, is declared. This GUID will be used when the type library is registered with the System Registry. Next, the values for the `TxShapeType` enumeration are listed. What's interesting about the enumeration is that the values are declared as constants rather than as an Object Pascal enumerated type. This is because type library enums are like C/C++ enums (and unlike Object Pascal) in that they don't have to start at the ordinal value zero or be sequential in value.

Next, in the `Srv_TLB` unit the `IAutoTest` interface is declared. In this interface declaration you'll see the properties and methods you created in the type library editor. Additionally, you'll see the `Get_XXX` and `Set_XXX` methods generated as the read and write methods for each of the properties.

Safecall

`Safecall` is the default calling convention for methods entered into the type library editor, as you can see from the `IAutoTest` declaration earlier. `Safecall` is actually more than a calling convention because it implies two things: First, it means that the method will be called using the `safecall` calling convention. Second, it means that the method will be encapsulated so that it returns an `HResult` value to the caller. For example, suppose you have a method that looks like this in Object Pascal:

```
function Foo(W: WideString): Integer; safecall;
```

This method actually compiles to code that looks something like this:

```
function Foo(W: WideString; out RetVal: Integer): HRESULT; stdcall;
```

The advantage of `safecall` is that it catches all exceptions before they flow back into the caller. When an unhandled exception is raised in a `safecall` method, the exception is handled by the implicit wrapper and converted into an `HResult`, which is returned to the caller.

Next in `Srv_TLB` is the `dispinterface` declaration for the Automation object: `IAutoTestDisp`. A `dispinterface` signals to the caller that Automation methods may be executed by `Invoke()` but does not imply a custom interface through which methods can be executed. Although the `IAutoTest` interface can be used by development tools that support early-binding Automation, `IAutoTestDisp`'s `dispinterface` can be used by tools that support late binding.

The `Srv_TLB` unit then declares a class called `CoAutoTest`, which makes creation of the Automation object easy; just call `CoAutoTest.Create()` to create an instance of the Automation object.

Finally, `Srv_TLB` creates a class called `TAutoTest` that wraps the server into a component that can be placed on the palette. This feature, new to Delphi 5, is targeted more toward Automation servers that you import rather than new Automation servers that you create.

As mentioned earlier, you must run this application once to register it with the System Registry. Later in this chapter, you'll learn about the controller application used to manipulate this server.

Creating an In-Process Automation Server

Just as out-of-process servers start out as applications, in-process servers start out as DLLs. You can begin with an existing DLL or with a new DLL, which you can create by selecting DLL from the New Items dialog found under the File, New menu.

NOTE

If you're not familiar with DLLs, they are covered in depth in Chapter 9, "Dynamic Link Libraries." This chapter assumes that you have some knowledge of DLL programming.

As mentioned earlier, in order to serve as an in-process Automation server, a DLL must export four functions that are defined in the ComServ unit: `DllGetClassObject()`, `DllCanUnloadNow()`, `DllRegisterServer()`, and `DllUnregisterServer()`. Do this by adding these functions to the exports clause in your project file, as shown in the project file `IPS.dpr` in Listing 23.5.

LISTING 23.5 IPS.dpr—The Project File for an In-Process Server

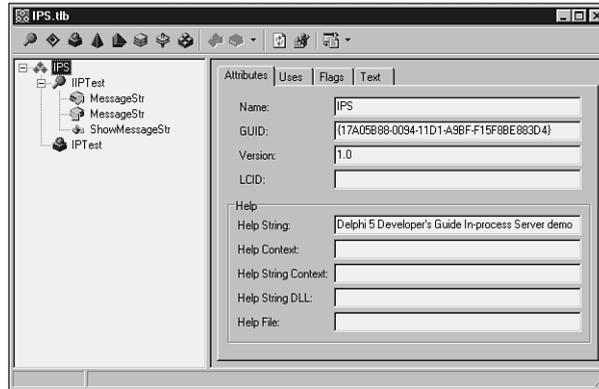
```
library IPS;

uses
  ComServ;

exports
  DllRegisterServer,
  DllUnregisterServer,
  DllGetClassObject,
  DllCanUnloadNow;

begin
end.
```

The Automation object is added to the DLL project in the same manner as an executable project: through the Automation Object Wizard. For this project, you will add only one property and one method, as shown in the type library editor in Figure 23.7. The Object Pascal version of the type library, `IPS_TLB`, is shown in Listing 23.6.

**FIGURE 23.7**

The IPS project in the type library editor.

LISTING 23.6 IPS_TLB.pas—The Type Library Import File for the In-Process Server Project

```
unit IPS_TLB;

// ***** //
// WARNING
// -----
// The types declared in this file were generated from data read from a
// Type Library. If this type library is explicitly or indirectly (via
// another type library referring to this type library) re-imported, or the
// 'Refresh' command of the Type Library Editor activated while editing the
// Type Library, the contents of this file will be regenerated and all
// manual modifications will be lost.
// ***** //

// PASTLWTR : $Revision: 1.79 $
// File generated on 8/14/99 11:37:16 PM from Type Library described below.

// ***** //
// Type Lib: C:\work\d5dg\code\Ch23\Automate\IPS.tlb (1)
// IID\LCID: {17A05B88-0094-11D1-A9BF-F15F8BE883D4}\0
// Helpfile:
// DepndLst:
// (1) v1.0 stdole, (C:\WINDOWS\SYSTEM\stdole32.tlb)
// (2) v2.0 StdType, (c:\WINDOWS\SYSTEM\OLEPRO32.DLL)
// (3) v1.0 StdVCL, (C:\WINDOWS\SYSTEM\STDVCL32.DLL)
// ***** //
interface
```

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continues

LISTING 23.6 Continued

```

uses Windows, ActiveX, Classes, Graphics, OleServer, OleCtrls, StdVCL;

// *****//
// GUIDS declared in the TypeLibrary. Following prefixes are used:
//   Type Libraries       : LIBID_xxxx
//   CoClasses           : CLASS_xxxx
//   DISPInterfaces      : DIID_xxxx
//   Non-DISP interfaces: IID_xxxx
// *****//
const
  // TypeLibrary Major and minor versions
  IPSMajorVersion = 1;
  IPSMinorVersion = 0;

  LIBID_IPS: TGUID = '{17A05B88-0094-11D1-A9BF-F15F8BE883D4}';

  IID_IIPTest: TGUID = '{17A05B89-0094-11D1-A9BF-F15F8BE883D4}';
  CLASS_IPTest: TGUID = '{17A05B8A-0094-11D1-A9BF-F15F8BE883D4}';
type

// *****//
// Forward declaration of types defined in TypeLibrary
// *****//
IIPTest = interface;
IIPTestDisp = dispinterface;

// *****//
// Declaration of CoClasses defined in Type Library
// (NOTE: Here we map each CoClass to its Default Interface)
// *****//
IPTest = IIPTest;

// *****//
// Interface: IIPTest
// Flags:      (4432) Hidden Dual OleAutomation Dispatchable
// GUID:      {17A05B89-0094-11D1-A9BF-F15F8BE883D4}
// *****//
IIPTest = interface(IDispatch)
  ['{17A05B89-0094-11D1-A9BF-F15F8BE883D4}']
  function Get_MessageStr: WideString; safecall;
  procedure Set_MessageStr(const Value: WideString); safecall;
  function ShowMessageStr: Integer; safecall;
  property MessageStr: WideString read Get_MessageStr write Set_MessageStr;

```

```

end;

// *****//
// DispIntf:  IIPTestDisp
// Flags:     (4432) Hidden Dual OleAutomation Dispatchable
// GUID:      {17A05B89-0094-11D1-A9BF-F15F8BE883D4}
// *****//
IIPTestDisp = dispinterface
  ['{17A05B89-0094-11D1-A9BF-F15F8BE883D4}']
  property MessageStr: WideString dispid 1;
  function ShowMessageStr: Integer; dispid 2;
end;

// *****//
// The Class CoIPTest provides a Create and CreateRemote method to
// create instances of the default interface IIPTest exposed by
// the CoClass IPTest. The functions are intended to be used by
// clients wishing to automate the CoClass objects exposed by the
// server of this typelibrary.
// *****//
CoIPTest = class
  class function Create: IIPTest;
  class function CreateRemote(const MachineName: string): IIPTest;
end;

implementation

uses ComObj;

class function CoIPTest.Create: IIPTest;
begin
  Result := CreateComObject(CLASS_IPTest) as IIPTest;
end;

class function CoIPTest.CreateRemote(const MachineName: string): IIPTest;
begin
  Result := CreateRemoteComObject(MachineName, CLASS_IPTest) as IIPTest;
end;

end.

```

Clearly, this is a pretty simple Automation server, but it serves to illustrate the point. The `MessageStr` property can be set to a value and then shown with the `ShowMessageStr()` function. The implementation of the `IIPTest` interface resides in the unit `IPSMain.pas`, which is shown in Listing 23.7.

LISTING 23.7 IPMain.pas—The Main Unit for the In-Process Server Project

```
unit IPMain;

interface

uses
  ComObj, IPS_TLB;

type
  TIPTest = class(TAutoObject, IIPTest)
  private
    MessageStr: string;
  protected
    function Get_MessageStr: WideString; safecall;
    procedure Set_MessageStr(const Value: WideString); safecall;
    function ShowMessageStr: Integer; safecall;
  end;

implementation

uses Windows, ComServ;

function TIPTest.Get_MessageStr: WideString;
begin
  Result := MessageStr;
end;

function TIPTest.ShowMessageStr: Integer;
begin
  MessageBox(0, PChar(MessageStr), 'Your string is...', MB_OK);
  Result := Length(MessageStr);
end;

procedure TIPTest.Set_MessageStr(const Value: WideString);
begin
  MessageStr := Value;
end;

initialization
  TAutoObjectFactory.Create(ComServer, TIPTest, Class_IPTest, ciMultiInstance,
    tmApartment);
end.
```

As you learned earlier in this chapter, in-process servers are registered differently than out-of-process servers; an in-process server's `DllRegisterServer()` function is called to register it

with the System Registry. The Delphi IDE makes this very easy: Select Run, Register ActiveX server from the main menu.

Creating Automation Controllers

Delphi makes it extremely easy to control Automation servers in your applications. Delphi also gives you a great amount of flexibility in how you want to control Automation servers, with options for early binding using interfaces or late binding using dispinterfaces or variants.

Controlling Out-of-Process Servers

The Control project is an Automation controller that demonstrates all three types of Automation (interfaces, dispinterface, and variants). Control is the controller for the Srv Automation server application from earlier in this chapter. The main form for this project is shown in Figure 23.8.

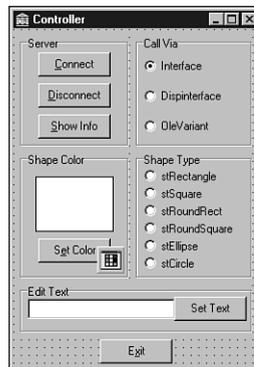


FIGURE 23.8

The main form for the Control project.

When the Connect button is clicked, the Control application connects to the server in several different ways with the following code:

```
FIntf := CoAutoTest.Create;  
FDispintf := CreateComObject(Class_AutoTest) as IAutoTestDisp;  
FVar := CreateOleObject('Srv.AutoTest');
```

This code shows interface, dispinterface, and OleVariant variables, each creating an instance of the Automation server in different ways. What's interesting about these different techniques is that they're almost totally interchangeable. For example, the following code is also correct:

```
FIntf := CreateComObject(Class_AutoTest) as IAutoTest;
FDispintf := CreateOleObject('Srv.AutoTest') as IAutoTestDisp;
FVar := CoAutoTest.Create;
```

Listing 23.8 shows the `Ctrl` unit, which contains the rest of the source code for the Automation controller. Notice that the application allows you to manipulate the server using either the interface, dispinterface, or `OleVariant`.

LISTING 23.8 `Ctrl.pas`—The Main Unit for the Controller Project for the Out-of-Process Server Project

```
unit Ctrl;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ColorGrd, ExtCtrls, Srv_TLB, Buttons;

type
  TControlForm = class(TForm)
    CallViaRG: TRadioGroup;
    ShapeTypeRG: TRadioGroup;
    GroupBox1: TGroupBox;
    GroupBox2: TGroupBox;
    Edit: TEdit;
    GroupBox3: TGroupBox;
    ConBtn: TButton;
    DisBtn: TButton;
    InfoBtn: TButton;
    ColorBtn: TButton;
    ColorDialog: TColorDialog;
    ColorShape: TShape;
    ExitBtn: TButton;
    TextBtn: TButton;
    procedure ConBtnClick(Sender: TObject);
    procedure DisBtnClick(Sender: TObject);
    procedure ColorBtnClick(Sender: TObject);
    procedure ExitBtnClick(Sender: TObject);
    procedure TextBtnClick(Sender: TObject);
    procedure InfoBtnClick(Sender: TObject);
    procedure ShapeTypeRGClick(Sender: TObject);
  private
    { Private declarations }
    FIntf: IAutoTest;
    FDispintf: IAutoTestDisp;
    FVar: OleVariant;
```

```
    procedure SetControls;
    procedure EnableControls(DoEnable: Boolean);
public
    { Public declarations }
end;

var
    ControlForm: TControlForm;

implementation

{$R *.DFM}

uses ComObj;

procedure TControlForm.SetControls;
// Initializes the controls to the current server values
begin
    case CallViaRG.ItemIndex of
        0:
            begin
                ColorShape.Brush.Color := FIntf.ShapeColor;
                ShapeTypeRG.ItemIndex := FIntf.ShapeType;
                Edit.Text := FIntf.EditText;
            end;
        1:
            begin
                ColorShape.Brush.Color := FDispintf.ShapeColor;
                ShapeTypeRG.ItemIndex := FDispintf.ShapeType;
                Edit.Text := FDispintf.EditText;
            end;
        2:
            begin
                ColorShape.Brush.Color := FVar.ShapeColor;
                ShapeTypeRG.ItemIndex := FVar.ShapeType;
                Edit.Text := FVar.EditText;
            end;
    end;
end;

procedure TControlForm.EnableControls(DoEnable: Boolean);
begin
    DisBtn.Enabled := DoEnable;
    InfoBtn.Enabled := DoEnable;
    ColorBtn.Enabled := DoEnable;
    ShapeTypeRG.Enabled := DoEnable;
```

continues

LISTING 23.8 Continued

```
    Edit.Enabled := DoEnable;
    TextBtn.Enabled := DoEnable;
end;

procedure TControlForm.ConBtnClick(Sender: TObject);
begin
    FIntf := CoAutoTest.Create;
    FDispintf := CreateComObject(Class_AutoTest) as IAutoTestDisp;
    FVar := CreateOleObject('Srv.AutoTest');
    EnableControls(True);
    SetControls;
end;

procedure TControlForm.DisBtnClick(Sender: TObject);
begin
    FIntf := nil;
    FDispintf := nil;
    FVar := Unassigned;
    EnableControls(False);
end;

procedure TControlForm.ColorBtnClick(Sender: TObject);
var
    NewColor: TColor;
begin
    if ColorDialog.Execute then
    begin
        NewColor := ColorDialog.Color;
        case CallViaRG.ItemIndex of
            0: FIntf.ShapeColor := NewColor;
            1: FDispintf.ShapeColor := NewColor;
            2: FVar.ShapeColor := NewColor;
        end;
        ColorShape.Brush.Color := NewColor;
    end;
end;

procedure TControlForm.ExitBtnClick(Sender: TObject);
begin
    Close;
end;

procedure TControlForm.TextBtnClick(Sender: TObject);
begin
    case CallViaRG.ItemIndex of
```

```
    0: FIntf.EditText := Edit.Text;
    1: FDispintf.EditText := Edit.Text;
    2: FVar.EditText := Edit.Text;
end;
end;

procedure TControlForm.InfoBtnClick(Sender: TObject);
begin
    case CallViaRG.ItemIndex of
        0: FIntf.ShowInfo;
        1: FDispintf.ShowInfo;
        2: FVar.ShowInfo;
    end;
end;

procedure TControlForm.ShapeTypeRGClick(Sender: TObject);
begin
    case CallViaRG.ItemIndex of
        0: FIntf.ShapeType := ShapeTypeRG.ItemIndex;
        1: FDispintf.ShapeType := ShapeTypeRG.ItemIndex;
        2: FVar.ShapeType := ShapeTypeRG.ItemIndex;
    end;
end;

end.
```

Another interesting thing this code illustrates is how easy it is to disconnect from an Automation server: Interfaces and dispinterfaces can be set to `nil`, and variants can be set to `Unassigned`. Of course, the Automation server will also be released when the `Control` application is closed, as a part of the normal finalization of these lifetime-managed types.

TIP

Interfaces will almost always perform better than dispinterfaces and variants, so you should always use interfaces to control Automation servers when available.

Variants rank last in terms of performance because, at runtime, an Automation call through a variant must call `GetIDsOfNames()` to convert a method name into a dispatch ID before it can execute the method with a call to `Invoke()`.

The performance of dispinterfaces is in between that of an interface and that of a variant. "But why," you might ask, "is the performance different if variants and dispinterfaces both use late binding?" The reason for this is that dispinterfaces take advantage of an optimization called *ID binding*, which means that the dispatch IDs of

continues

methods are known at compile time, so the compiler doesn't need to generate a run-time call to `GetIDsOfName()` prior to calling `Invoke()`. Another, perhaps more obvious, advantage of dispinterfaces over variants is that dispinterfaces allow for the use of CodeInsight for easier coding, whereas this is not possible using variants.

Figure 23.9 shows the Control application controlling the Srv server.

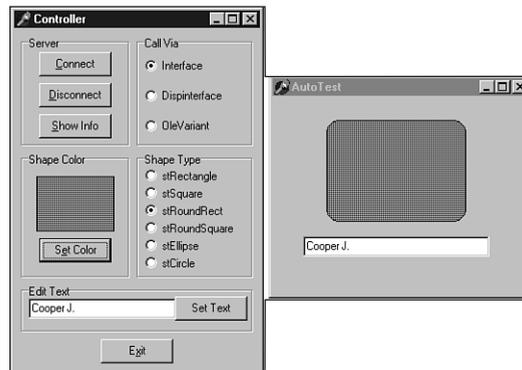


FIGURE 23.9

Automation controller and server.

Controlling In-Process Servers

The technique for controlling an in-process server is no different than that for controlling its out-of-process counterpart. Just keep in mind that the Automation controller is now executing within your own process space. This means performance will be a bit better than with out-of-process servers, but it also means that a crash in the Automation server can take down your application.

Now you'll look at a controller application for the in-process Automation server created earlier in this chapter. In this case, we'll use only the interface for controlling the server. This is a pretty simple application, and Figure 23.10 shows the main form for the IPCtrl project. The code in Listing 23.9 is `IPCMain.pas`, the main unit for the IPCtrl project.

**FIGURE 23.10**

The *IPCtrl* project's main form.

LISTING 23.9 IPCMain.pas—The Main Unit for the Controller Project for the In-Process Server Project

```

unit IPCMain;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ExtCtrls, IPS_TLB;

type
  TIPCForm = class(TForm)
    ExitBtn: TButton;
    Panel1: TPanel;
    ConBtn: TButton;
    DisBtn: TButton;
    Edit: TEdit;
    SetBtn: TButton;
    ShowBtn: TButton;
    procedure ConBtnClick(Sender: TObject);
    procedure DisBtnClick(Sender: TObject);
    procedure SetBtnClick(Sender: TObject);
    procedure ShowBtnClick(Sender: TObject);
    procedure ExitBtnClick(Sender: TObject);
  private
    { Private declarations }
    IPTest: IIPTest;
    procedure EnableControls(DoEnable: Boolean);
  public
    { Public declarations }
  end;

var
  IPCForm: TIPCForm;
  
```

LISTING 23.9 Continued

```
implementation

uses ComObj;

{$R *.DFM}

procedure TIPCFrm.EnableControls(DoEnable: Boolean);
begin
    DisBtn.Enabled := DoEnable;
    Edit.Enabled := DoEnable;
    SetBtn.Enabled := DoEnable;
    ShowBtn.Enabled := DoEnable;
end;

procedure TIPCFrm.ConBtnClick(Sender: TObject);
begin
    IPTest := CreateComObject(CLASS_IPTest) as IPTest;
    EnableControls(True);
end;

procedure TIPCFrm.DisBtnClick(Sender: TObject);
begin
    IPTest := nil;
    EnableControls(False);
end;

procedure TIPCFrm.SetBtnClick(Sender: TObject);
begin
    IPTest.MessageStr := Edit.Text;
end;

procedure TIPCFrm.ShowBtnClick(Sender: TObject);
begin
    IPTest.ShowMessageStr;
end;

procedure TIPCFrm.ExitBtnClick(Sender: TObject);
begin
    Close;
end;

end.
```

Remember to ensure that the server has been registered prior to attempting to run IPCtrl. You can do this in several ways: Using Run, Register ActiveX Server from the main menu while the

IPS project is loaded, using the Windows RegSvr32.exe utility, and using the TRegSvr.exe tool that comes with Delphi. Figure 23.11 shows this project in action controlling the IPS server.

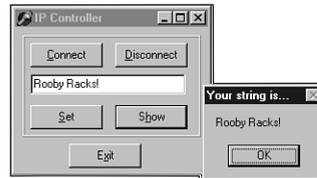


FIGURE 23.11

IPCtrl controlling the IPS server.

Advanced Automation Techniques

In this section, our goal is to get you up to speed on some of the more advanced features of Automation that the wizards never told you about. Topics such as Automation events, collections, type library gotchas, and low-level language support for COM are all covered. Rather than devote more time to talking about this stuff, let's jump right in and do it!

Automation Events

We Delphi programmers have long taken events for granted. You drop a button, you double-click `OnClick` in the Object Inspector, and you write some code. No big deal. Even from the control writer's point of view, events are a snap. You create a new method type, add a field and published property to your control, and you're good to go. For Delphi COM developers, however, events can be scary. Many Delphi COM developers avoid events altogether simply because they "don't have time to learn all that mumbo jumbo." If you fall into that group, you'll be happy to know that working with events is actually not very difficult thanks to some nice built-in support provided by Delphi. Although all the new terms associated with Automation events can add an air of complexity, in this section I hope to demystify events to the point where you think, "Oh, is that all they are?"

What Are Events?

Put simply, events provide a means for a server to call back into a client to provide some information. Under a traditional client/server model, the client calls the server to perform an action or obtain some data, the server executes the action or obtains the data, and control returns to the client. This model works fine for most things, but it breaks down when the event in which the client is interested is asynchronous in nature or is driven by a user interface entry. For example, if the client sends the server a request to download a file, the client probably doesn't want to sit around and wait for the thing to download before it can continue processing (especially

over a high-latency connection such as a modem). A better model would be for the client to issue the instruction to the server and continue to go about its business until the server notifies the client about the completion of the file download. Similarly, a user interface entry, such as a button click, is a good example of when the server needs to notify the client using an event mechanism. The client obviously can't call a method on the server that waits around until some button is clicked.

Generally speaking, the server is responsible for defining and firing events, whereas the client is normally responsible for connecting itself to and implementing events. Of course, given such a loose definition, there is room to haggle, and consequently Delphi and Automation provide two very different approaches to the idea of events. Drilling down into each of these models will help put things into perspective.

Events in Delphi

Delphi follows the KISS (keep it simple, stupid!) methodology when it comes to events. Events are implemented as method pointers—these pointers can be assigned to some method in the application and are executed when such a method is called via the method pointer. As an illustration, consider the everyday application-development scenario of an application that needs to handle an event on a component. If you look at the situation abstractly, the “server” in this case would be a component, which defines and fires the event. The “client” is the application that employs the component, because it connects to the event by assigning some specific method name to the event method pointer.

Although this simple event model is one of the things that make Delphi elegant and easy to use, it definitely sacrifices some power for the sake of usability. For example, there is no built-in way to allow multiple clients to listen for the same event (this is called *multicasting*). Also, there is no way to dynamically obtain a type description for an event without writing some RTTI code (which you probably shouldn't be using in an application anyway due to its version-specific nature).

Events in Automation

Whereas the Delphi event model is simple yet limited, the Automation event model is powerful but more complex. As a COM programmer, you may have guessed that events are implemented in Automation using interfaces. Rather than existing on a per-method basis, events exist only as part of an interface. This interface is often called an *events interface* or an *outgoing interface*. It's called *outgoing* because it is not implemented by the server like other interfaces but is instead implemented by clients of the server, and methods of the interface will be called outward from the server to the client. Like all interfaces, event interfaces have associated with them corresponding *interface identifications* (IIDs) that uniquely identify them. Also, the description of the events interface is found in the type library of an Automation object, tied to the Automation object's coclass like other interfaces.

Servers needing to surface event interfaces to clients must implement the `IConnectionPointContainer` interface. This interface is defined in the ActiveX unit as follows:

```
type
  IConnectionPointContainer = interface
    ['{B196B284-BAB4-101A-B69C-00AA00341D07}']
    function EnumConnectionPoints(out Enum: IEnumConnectionPoints):
      HRESULT; stdcall;
    function FindConnectionPoint(const iid: TIID;
      out cp: IConnectionPoint): HRESULT; stdcall;
  end;
```

In COM parlance, a *connection point* describes the entity that provides programmatic access to an outgoing interface. If a client needs to determine whether a server supports events, all it has to do is `QueryInterface` for the `IConnectionPointContainer` interface. If this interface is present, the server is capable of surfacing events. The `EnumConnectionPoints()` method of `IConnectionPointContainer` enables clients to iterate over all the outgoing interfaces supported by the server. Clients may use the `FindConnectionPoint()` method to obtain a specific outgoing interface.

You'll notice that `FindConnectionPoint()` provides an `IConnectionPoint` that represents an outbound interface. `IConnectionPoint` is also defined in the ActiveX unit, and it looks like this:

```
type
  IConnectionPoint = interface
    ['{B196B286-BAB4-101A-B69C-00AA00341D07}']
    function GetConnectionInterface(out iid: TIID): HRESULT; stdcall;
    function GetConnectionPointContainer(
      out cpc: IConnectionPointContainer): HRESULT; stdcall;
    function Advise(const unkSink: IUnknown; out dwCookie: Longint):
      HRESULT; stdcall;
    function Unadvise(dwCookie: Longint): HRESULT; stdcall;
    function EnumConnections(out Enum: IEnumConnections): HRESULT;
      stdcall;
  end;
```

The `GetConnectionInterface()` method of `IConnectionPoint` provides the IID of the outgoing interface supported by this connection point. The `GetConnectionPointContainer()` method provides the `IConnectionPointContainer` (described earlier), which manages this connection point. The `Advise` method is the interesting one. `Advise()` is the method that actually does the magic of hooking up the outgoing events on the server to the events interface implemented by the client. The first parameter to this method is the client's implementation of the events interface, and the second parameter will receive a cookie that identifies this particular connection. `Unadvise()` simply disconnects the client/server relationship established by

`Advise()`. `EnumConnections` enables the client to iterate over all currently active connections—that is, all connections that have called `Advise()`.

Because of the obvious confusion that can arise if we describe the participants in this relationship as simply *client* and *server*, Automation defines some different nomenclature that enables us to unambiguously describe who is who. The implementation of the outgoing interface contained within the client is called a *sink*, and the server object that fires events to the client is referred to as the *source*.

What is hopefully clear in all this is that Automation events have a couple of advantages over Delphi events. Namely, they can be multicast, because `IConnectionPoint.Advise()` can be called more than once. Also, Automation events are self-describing (via the type library and the enumeration methods), so they can be manipulated dynamically.

Automation Events in Delphi

Okay, all this technical stuff is well and good, but how do we actually make Automation events work in Delphi? Glad you asked. At this point, we will create an Automation server application that exposes an outgoing interface and a client that implements a sink for the interface. Bear in mind, too, that you don't need to be an expert in connection points, sinks, sources, and whatnot in order to get Delphi to do what you want. However, it does help you in the long run when you understand what goes on behind the wizard's curtain.

The Server

The first step in creating the server is to create a new application. For purposes of this demo, we will create a new application containing one form with a client-aligned `TMemo`, as shown in Figure 23.12.

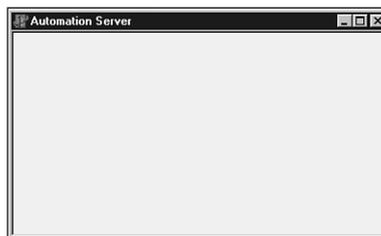


FIGURE 23.12

Automation Server with the Events main form.

Next, we will add an Automation object to this application by selecting `File, New, ActiveX, Automation Object` from the main menu. This invokes the Automation Object Wizard (refer to Figure 23.4).

Note the Generate Event Support Code option on the Automation Object Wizard. This box must be selected because it will generate the code necessary to expose an outgoing interface on the Automation object. It will also create the outgoing interface in the type library. After selecting OK in this dialog, we are presented with the Type Library Editor window. Both the Automation interface and the outgoing interface are already present in the type library (named `IServerWithEvents` and `IServerWithEventsEvents`, respectively). `AddText()` and `Clear()` methods have been added to the `IServerWithEvents` interface, and `OnTextChanged()` and `OnClear()` methods have been added to the `IServerWithEventsEvents` interface.

As you might guess, `Clear()` will clear the contents of the memo, and `AddText()` will add another line of text to the memo. The `OnTextChanged()` event will fire when the contents of the memo change, and the `OnClear()` event will fire when the memo is cleared. Notice also that `AddText()` and `OnTextChanged()` each have one parameter of type `WideString`.

The first thing to do is implement the `AddText()` and `Clear()` methods. The implementation for these methods is shown here:

```
procedure TServerWithEvents.AddText(const NewText: WideString);
begin
    MainForm.Memo.Lines.Add(NewText);
end;

procedure TServerWithEvents.Clear;
begin
    MainForm.Memo.Lines.Clear;
    if FEvents <> nil then FEvents.OnClear;
end;
```

You should be familiar with all this code except perhaps the last line of `Clear()`. This code ensures that there is a client sink advised on the event by checking for `nil`; then it first fires the event simply by calling `OnClear()`.

To set up the `OnTextChanged()` event, we first have to handle the `OnChange` event of the memo. We will do this by inserting a line of code into the `Initialized()` method of `TServerWithEvents` that points the event to the method in `TServerWithEvents`:

```
MainForm.Memo.OnChange := MemoChange;
```

The `MemoChange()` method is implemented as follows:

```
procedure TServerWithEvents.MemoChange(Sender: TObject);
begin
    if FEvents <> nil then FEvents.OnTextChanged((Sender as TMemo).Text);
end;
```

This code also checks to ensure a client is listening; then it fires the event, passing the memo's text as the parameter.

Believe it or not, that sums up the implementation of the server! Now on to the client.

The Client

The client is an application with one form that contains a TEdit, TMemo, and three TButton components, as shown in Figure 23.13.

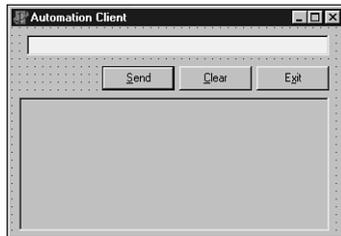


FIGURE 23.13

The Automation Client main form.

In the main unit for the client application, the `Server_TLB` unit has been added to the `uses` clause so that we have access to the types and methods contained within that unit. The main form object, `TMainForm`, of the client application will contain a field that references the server called `FServer` of type `IServerWithEvents`. We will create an instance of the server in `TMainForm`'s constructor using the helper class found in `Server_TLB`, like this:

```
FServer := CoServerWithEvents.Create;
```

The next step is to implement the event sink class. Because this class will be called by the server via Automation, it must implement `IDispatch` (and therefore `IUnknown`). The type declaration for this class is shown here:

```
type
  TEventSink = class(TObject, IUnknown, IDispatch)
  private
    FController: TMainForm;
    { IUnknown }
    function QueryInterface(const IID: TGUID; out Obj): HRESULT; stdcall;
    function _AddRef: Integer; stdcall;
    function _Release: Integer; stdcall;
    { IDispatch }
    function GetTypeInfoCount(out Count: Integer): HRESULT; stdcall;
    function GetTypeInfo(Index, LocaleID: Integer; out TypeInfo):
      HRESULT; stdcall;
  function GetIDsOfNames(const IID: TGUID; Names: Pointer;
    NameCount, LocaleID: Integer; DispIDs: Pointer): HRESULT; stdcall;
    function Invoke(DispID: Integer; const IID: TGUID; LocaleID: Integer;
      Flags: Word; var Params; VarResult, ExcepInfo, ArgErr: Pointer):
```

```

        HRESULT; stdcall;
public
    constructor Create(Controller: TMainForm);
end;

```

Most of the methods of IUnknown and IDispatch are not implemented, with the notable exceptions of IUnknown.QueryInterface() and IDispatch.Invoke(). These will be discussed in turn.

The QueryInterface() method for TEventSink is implemented as shown here:

```

function TEventSink.QueryInterface(const IID: TGUID; out Obj): HRESULT;
begin
    // First look for my own implementation of an interface
    // (I implement IUnknown and IDispatch).
    if GetInterface(IID, Obj) then
        Result := S_OK
    // Next, if they are looking for outgoing interface, recurse to return
    // our IDispatch pointer.
    else if IsEqualIID(IID, IServerWithEventsEvents) then
        Result := QueryInterface(IDispatch, Obj)
    // For everything else, return an error.
    else
        Result := E_NOINTERFACE;
end;

```

Essentially, this method returns an instance only when the requested interface is IUnknown, IDispatch, or IServerWithEventsEvents.

Here's the Invoke method for TEventSink:

```

function TEventSink.Invoke(DispID: Integer; const IID: TGUID;
    LocaleID: Integer; Flags: Word; var Params; VarResult, ExcepInfo,
    ArgErr: Pointer): HRESULT;
var
    V: OleVariant;
begin
    Result := S_OK;
    case DispID of
        1:
            begin
                // First parameter is new string
                V := OleVariant(TDispParams(Params).rgvarg^[0]);
                FController.OnServerMemoChanged(V);
            end;
        2: FController.OnClear;
    end;
end;

```

`TEventSink.Invoke()` is hard-coded for methods having `DispID 1` or `DispID 2`, which happen to be the `DispIDs` chosen for `OnTextChanged()` and `OnClear()`, respectively, in the server application. `OnClear()` has the most straightforward implementation: It simply calls the client main form's `OnClear()` method in response to the event. The `OnTextChanged()` event is a little trickier: This code pulls the parameter out of the `Params.rgvarg` array, which is passed in as a parameter to this method, and passes it through to the client main form's `OnServerMemoChanged()` method. Note that because the number and type of parameters are known, we are able to make simplifying assumptions in the source code. If you're clever, it is possible to implement `Invoke()` in a generic manner such that it figures out the number and types of parameters and pushes them onto the stack or into registers prior to calling the appropriate function. If you'd like to see an example of this, take a look at the `TOLEControl.InvokeEvent()` method in the `OLECtrls` unit. This method represents the event-sinking logic for the ActiveX control container.

The implementation for `OnClear()` and `OnServerMemoChanged()` manipulate the contents of the client's memo. They are shown here:

```
procedure TMainForm.OnServerMemoChanged(const NewText: string);
begin
    Memo.Text := NewText;
end;

procedure TMainForm.OnClear;
begin
    Memo.Clear;
end;
```

The final piece of the puzzle is to connect the event sink to the server's source interface. This is easily accomplished using the `InterfaceConnect()` function found in the `ComObj` unit, which we will call from the main form's constructor, like so:

```
InterfaceConnect(FServer, IServerWithEventsEvents, FEventSink, FCookie);
```

The first parameter to this function is a reference to the source object. The second parameter is the IID of the outgoing interface. The third parameter holds the event sink interface. The fourth and final parameter is the cookie, and it is a reference parameter that will be filled in by the callee.

To be a good citizen, you should also clean up properly by calling `InterfaceDisconnect()` when you are finished playing with events. This is done in the main form's destructor:

```
InterfaceDisconnect(FEventSink, IServerWithEventsEvents, FCookie);
```

The Demo

Now that the client and server are written, we can see them in action. Be sure to run and close the server once (or run it with the `/regserver` switch) to ensure it is registered before attempting to run the client. Figure 23.14 shows the interactions between client, server, source, and sink.

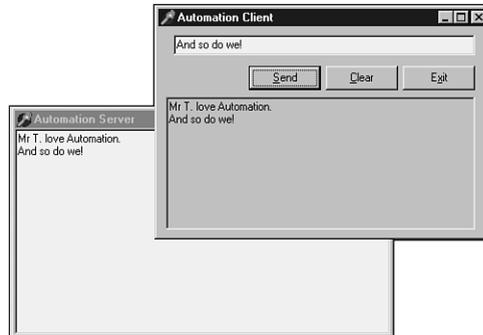


FIGURE 23.14

The Automation client manipulating the server and receiving events.

Events with Multiple Sinks

Although the technique just described works great for firing events back to a single client, it doesn't work so well when multiple clients are involved. You will often find yourself in situations where there are multiple clients connecting to your server, and you need to fire events back to all clients. Fortunately, you need just a little bit more code to add this type of functionality. In order to fire events back to multiple clients, you must write code that enumerates over each advised connection and calls the appropriate method on the sink. This can be done by making several modifications to the previous example.

First things first. In order to support multiple client connections on a connection point, we must pass `ckMulti` in the `Kind` parameter of `TConnectionPoints.CreateConnectionPoint()`. This method is called from the Automation object's `Initialize()` method, as shown here:

```
FConnectionPoints.CreateConnectionPoint(AutoFactory.EventIID, ckMulti,  
    EventConnect);
```

Before connections can be enumerated, we need to obtain a reference to `IConnectionPointContainer`. From `IConnectionPointContainer`, we can obtain the `IConnectionPoint` representing the outgoing interface, and using the

`IConnectionPoint.EnumConnections()` method, we can obtain an `IEnumConnections` interface that can be used to enumerate the connections. All this logic is encapsulated into the following method:

```
function TServerWithEvents.GetConnectionEnumerator: IEnumConnections;
var
  Container: IConnectionPointContainer;
  CP: IConnectionPoint;
begin
  Result := nil;
  OleCheck(QueryInterface(IConnectionPointContainer, Container));
  OleCheck(Container.FindConnectionPoint(AutoFactory.EventIID, CP));
  CP.EnumConnections(Result);
end;
```

After the enumerator interface has been obtained, calling the sink for each client is just a matter of iterating over each connection. This logic is demonstrated in the following code, which fires the `OnTextChanged()` event:

```
procedure TServerWithEvents.MemoChange(Sender: TObject);
var
  EC: IEnumConnections;
  ConnectData: TConnectData;
  Fetched: Cardinal;
begin
  EC := GetConnectionEnumerator;
  if EC <> nil then
  begin
    while EC.Next(1, ConnectData, @Fetched) = S_OK do
      if ConnectData.pUnk <> nil then
        (ConnectData.pUnk as IServerWithEventsEvents).OnTextChanged(
  ➤(Sender as TMemo).Text);
  end;
end;
```

Finally, in order to enable clients to connect to a single active instance of the Automation object, we must call the `RegisterActiveObject()` COM API function. This function accepts as parameters an `IUnknown` for the object, the `CLSID` of the object, a flag indicating whether the registration is strong (the server should be `AddRef`-ed) or weak (do not `AddRef` the server), and a handle that is returned by reference:

```
RegisterActiveObject(Self as IUnknown, Class_ServerWithEvents,
  ACTIVEOBJECT_WEAK, FObjRegHandle);
```

Listing 23.10 shows the complete source code for the `ServAuto` unit, which ties all these tidbits together.

LISTING 23.10 ServAuto.pas

```
unit ServAuto;

interface

uses
  ComObj, ActiveX, AxCtrls, Server_TLB;

type
  TServerWithEvents = class(TAutoObject, IConnectionPointContainer,
    IServerWithEvents)
private
  { Private declarations }
  FConnectionPoints: TConnectionPoints;
  FObjRegHandle: Integer;
  procedure MemoChange(Sender: TObject);
protected
  { Protected declarations }
  procedure AddText(const NewText: WideString); safecall;
  procedure Clear; safecall;
  function GetConnectionEnumerator: IEnumConnections;
  property ConnectionPoints: TConnectionPoints read FConnectionPoints
    implements IConnectionPointContainer;
public
  destructor Destroy; override;
  procedure Initialize; override;
end;

implementation

uses Windows, ComServ, ServMain, SysUtils, StdCtrls;

destructor TServerWithEvents.Destroy;
begin
  inherited Destroy;
  RevokeActiveObject(FObjRegHandle, nil); // Make sure I'm removed from ROT
end;

procedure TServerWithEvents.Initialize;
begin
  inherited Initialize;
  FConnectionPoints := TConnectionPoints.Create(Self);
  if AutoFactory.EventTypeInfo <> nil then
    FConnectionPoints.CreateConnectionPoint(AutoFactory.EventIID, ckMulti,
      EventConnect);
```

continues

LISTING 23.10 Continued

```
// Route main form memo's OnChange event to MemoChange method:
MainForm.Memo.OnChange := MemoChange;
// Register this object with COM's Running Object Table (ROT) so other
// clients can connect to this instance.
RegisterActiveObject(Self as IUnknown, Class_ServerWithEvents,
    ACTIVEOBJECT_WEAK, FObjRegHandle);
end;

procedure TServerWithEvents.Clear;
var
    EC: IEnumConnections;
    ConnectData: TConnectData;
    Fetched: Cardinal;
begin
    MainForm.Memo.Lines.Clear;
    EC := GetConnectionEnumerator;
    if EC <> nil then
    begin
        while EC.Next(1, ConnectData, @Fetched) = S_OK do
            if ConnectData.pUnk <> nil then
                (ConnectData.pUnk as IServerWithEventsEvents).OnClear;
        end;
    end;
end;

procedure TServerWithEvents.AddText(const NewText: WideString);
begin
    MainForm.Memo.Lines.Add(NewText);
end;

procedure TServerWithEvents.MemoChange(Sender: TObject);
var
    EC: IEnumConnections;
    ConnectData: TConnectData;
    Fetched: Cardinal;
begin
    EC := GetConnectionEnumerator;
    if EC <> nil then
    begin
        while EC.Next(1, ConnectData, @Fetched) = S_OK do
            if ConnectData.pUnk <> nil then
                (ConnectData.pUnk as IServerWithEventsEvents).OnTextChanged(
                    (Sender as TMemo).Text);
        end;
    end;
end;
```

```
function TServerWithEvents.GetConnectionEnumerator: IEnumConnections;
var
  Container: IConnectionPointContainer;
  CP: IConnectionPoint;
begin
  Result := nil;
  OleCheck(QueryInterface(IConnectionPointContainer, Container));
  OleCheck(Container.FindConnectionPoint(AutoFactory.EventIID, CP));
  CP.EnumConnections(Result);
end;

initialization
  TAutoObjectFactory.Create(ComServer, TServerWithEvents,
    Class_ServerWithEvents, ciMultiInstance, tmApartment);
end.
```

On the client side, a small adjustment needs to be made in order enable clients to connect to an active instance if it is already running. This is accomplished using the `GetActiveObject` COM API function, as shown here:

```
procedure TMainForm.FormCreate(Sender: TObject);
var
  ActiveObj: IUnknown;
begin
  // Get active object if it's available, or create anew if not
  GetActiveObject(Class_ServerWithEvents, nil, ActiveObj);
  if ActiveObj <> nil then FServer := ActiveObj as IServerWithEvents
  else FServer := CoServerWithEvents.Create;
  FEventSink := TEventSink.Create(Self);
  InterfaceConnect(FServer, IServerWithEventsEvents, FEventSink, FCookie);
end;
```

Figure 23.15 shows several clients receiving events from a single server.

Automation Collections

Let's face it: We programmers are obsessed with bits of software code that serve as containers for other bits of software code. Think about it—whether it's an array, a `TList`, a `TCollection`, a template container class for you C++ folks, or a Java vector, it seems that we're always in search of the proverbial better mousetrap for software objects that hold other software objects. If you consider the time invested over the years in this pursuit for the perfect container class, it is clear that this is an important problem in the minds of developers. And why not? This logical separation of container and contained entities helps us better organize our algorithms and maps to the real world rather nicely (a basket can contain eggs, a pocket can contain coins, a parking lot can contain autos, and so on). Whenever you learn a new language or development model,

you have to learn “their way” of managing groups of entities. This leads to my point: Like any other software development model, COM also has its ways for managing these kinds of groups of entities, and to be an effective COM developer, we must learn how to master these things.

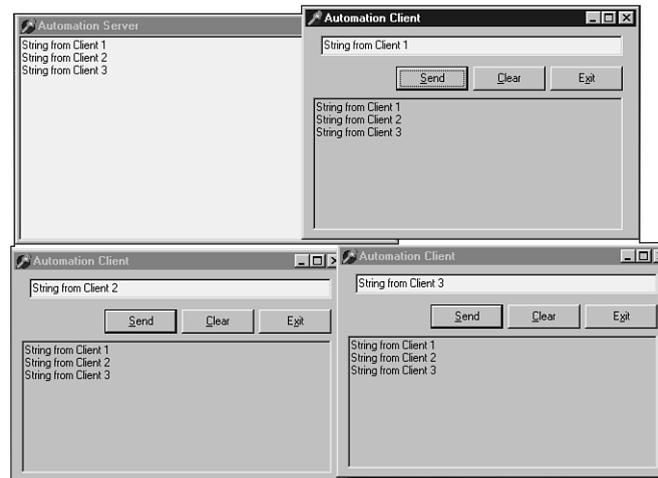


FIGURE 23.15

Several clients manipulating the same server and receiving events.

When we work with the `IDispatch` interface, COM specifies two primary methods by which we represent the notion of containership: arrays and collections. If you’ve done a bit of Automation or ActiveX control work in Delphi, you will probably already be familiar with arrays. You can easily create automation arrays in Delphi by adding an array property to your `IDispatch` descendant interface or `dispinterface`, as shown in the following example:

```
type
  IMyDisp = interface(IDispatch)
    function GetProp(Index: Integer): Integer; safecall;
    procedure SetProp(Index, Value: Integer); safecall;
    property Prop[Index: Integer]: Integer read GetProp write SetProp;
  end;
```

Arrays are useful in many circumstances, but they pose some limitations. For example, arrays make sense when you have data that can be accessed in a logical, fixed-index manner, such as the strings in an `IStrings`. However, if the nature of the data is such that individual items are frequently deleted, added, or moved, an array is a poor container solution. The classic example is a group of active windows. Because windows are constantly being created, destroyed, and changing z-order, there is no solid criteria for determining the order in which the windows should appear in the array.

Collections are designed to solve this problem by allowing you to manipulate a series of elements in a manner that doesn't imply any particular order or number of items. Collections are unusual because there isn't really a *collection* object or interface, but a collection is instead represented as a custom `IDispatch` that follows a number of rules and guidelines. The following rules must be adhered to in order for an `IDispatch` to qualify as a collection:

- Collections must contain a `_NewEnum` property that returns the `IUnknown` for an object that supports the `IEnumVARIANT` interface, which will be used to enumerate the items in the collection. Note that the name of this property must be preceded with an underscore, and this property must be marked as *restricted* in the type library. The `DispID` for the `_NewEnum` property must be `DISPID_NEWENUM (-4)`, and it will be defined as follows in the Delphi type library editor:

```
function _NewEnum: IUnknown [propget, dispid $FFFFFFFC, restricted];  
safecall;
```

- Languages such as Visual Basic that support the `For Each` construct will use this method to obtain the `IEnumVARIANT` interface needed to enumerate collection items. More on this later.
- Collections must contain an `Item()` method that returns an element from the collection based on the index. The `DispID` for this method must be `0`, and it should be marked with the *default collection element* flag. If we were to implement a collection of `IFoo` interface pointers, the definition for this method in the type library editor might look something like this:

```
function Item(Index: Integer): IFoo [propget, dispid $00000000,  
    defaultcollelem]; safecall;
```

Note that it is also acceptable for the `Index` parameter to be an `OleVariant` so that an `Integer`, `WideString`, or some other type of value can index the item in question.

- Collections must contain a `Count` property that returns the number of items in the collection. This method would typically be defined in the type library editor as this:

```
function Count: Integer [propget, dispid $00000001]; safecall;
```

In addition to the aforementioned rules, you should also follow these guidelines when creating your own collection objects:

- The property or method that returns a collection should be named with the plural of the name of the items in the collection. For example, if you had a property that returned a collection of listview items, the property name would probably be `Items`, whereas the name of the item in the collection would be `Item`. Likewise, an item called `Foot` would be contained in a collection property called `Feet`. In the rare case that the plural and singular of a word are the same (a collection of fish or deer, for example), the collection property name should be the name of the item with "Collection" tacked on the end (`FishCollection` or `DeerCollection`).

- Collections that support adding of items should do so using a method called `Add()`. The parameters for this method vary depending on the implementation, but you may want to pass parameters that indicate the initial position of the new item within the collection. The `Add()` method normally returns a reference to the item added to the collection.
- Collections that support deleting of items should do so using a method called `Remove()`. This method should take one parameter that identifies the index of the item being deleted, and this index should behave semantically in the same manner as the `Item()` method.

A Delphi Implementation

If you've ever created ActiveX controls in Delphi, you may have noticed that there are fewer controls listed in the combo box in the ActiveX Control Wizard than there are on the IDE's component palette. This is because Inprise prevents some controls showing in the list using the `RegisterNonActiveX()` function. One such control that is available on the palette but not in the wizard is the `TListView` control found on the Win32 page of the palette. The reason the `TListView` control isn't shown in the wizard is because the wizard doesn't know what to do with its `Items` property, which is of type `TListItems`. Because the wizard doesn't know how to wrap this property type in an ActiveX control, the control is simply excluded from the wizard's list rather than allowing the user to create an utterly useless ActiveX control wrapper of a control.

However, in the case of `TListView`, `RegisterNonActiveX()` is called with the `axrComponentOnly` flag, which means that a descendent of `TListView` will show up in the ActiveX Control Wizard's list. By taking the minor detour of creating a do-nothing descendent of `TListView` called `TListView2` and adding it to the palette, we can then create an ActiveX control that encapsulates the listview control. Of course, then we are faced with the same problem of the wizard not generating wrappers for the `Items` property and having a useless ActiveX control. Fortunately, ActiveX control writing doesn't have to stop at the wizard-generated code, and we are free to wrap the `Items` property ourselves at this point in order to make the control useful. As you might be beginning to suspect, a collection is the perfect way to encapsulate the `Items` property of the `TListView`.

In order to implement this collection of listview items, we must create new objects representing the item and the collection and add a new property to the ActiveX control default interface that returns a collection. We will begin by defining the object representing an item, which we will call `ListItem`. The first step to creating the `ListItem` object is to create a new Automation object using the icon found on the ActiveX page of the New Items dialog. After creating the object, we can fill out the properties and methods for this object in the type library editor. For the purposes of this demonstration, we will add properties for the `Caption`, `Index`, `Checked`, and `SubItems` properties of a listview item. Similarly, we will create yet another new Automation object for the collection itself. This Automation object is called `ListItems`, and it is provided with the `_NewEnum`, `Item()`, `Count()`, `Add()`, and `Remove()` methods mentioned

earlier. Finally, we will add a new property to the default interface of the ActiveX control called `Items` that returns a collection.

After the interfaces for `IListItem` and `IListItems` are completely defined in the type library editor, a little manual tweaking should be done in the implementation files generated for these objects. Specifically, the default parent class for a new automation object is `TAutoObject`; however, these objects will only be created internally (that is, not from a factory), so we will manually change the ancestor to `TAutoIntfObject`, which is more appropriate for internally created automation objects. Also, because these objects won't be created from a factory, we will remove from the units the initialization code that creates the factories because it is not needed.

Now that the entire infrastructure is properly set up, it is time to implement the `ListItem` and `ListItems` objects. The `Listitem` object is the most straightforward because it is a pretty simple wrapper around a listview item. The code for the unit containing this object is shown in Listing 23.11.

LISTING 23.11 The Listview Item Wrapper

```
unit LVItem;

interface

uses
  ComObj, ActiveX, ComCtrls, LVCtrl_TLB, StdVcl, AxCtrls;

type
  TListItem = class(TAutoIntfObject, IListItem)
  private
    FListItem: ComCtrls.TListItem;
  protected
    function Get_Caption: WideString; safecall;
    function Get_Index: Integer; safecall;
    function Get_SubItems: IStrings; safecall;
    procedure Set_Caption(const Value: WideString); safecall;
    procedure Set_SubItems(const Value: IStrings); safecall;
    function Get_Checked: WordBool; safecall;
    procedure Set_Checked(Value: WordBool); safecall;
  public
    constructor Create(AOwner: ComCtrls.TListItem);
  end;

implementation

uses ComServ;
```

continues

LISTING 23.11 Continued

```
constructor TListItem.Create(AOwner: ComCtrls.TListItem);
begin
    inherited Create(ComServer.TypeLib, IListItem);
    FListItem := AOwner;
end;

function TListItem.Get_Caption: WideString;
begin
    Result := FListItem.Caption;
end;

function TListItem.Get_Index: Integer;
begin
    Result := FListItem.Index;
end;

function TListItem.Get_SubItems: IStrings;
begin
    GetOleStrings(FListItem.SubItems, Result);
end;

procedure TListItem.Set_Caption(const Value: WideString);
begin
    FListItem.Caption := Value;
end;

procedure TListItem.Set_SubItems(const Value: IStrings);
begin
    SetOleStrings(FListItem.SubItems, Value);
end;

function TListItem.Get_Checked: WordBool;
begin
    Result := FListItem.Checked;
end;

procedure TListItem.Set_Checked(Value: WordBool);
begin
    FListItem.Checked := Value;
end;

end.
```

Note that `ComCtrls.TListItem()` is being passed into the constructor to serve as the listview item to be manipulated by this Automation object.

The implementation for the `ListItems` collection object is just a bit more complex. First, because the object must be able to provide an object supporting `IEnumVARIANT` in order to implement the `_NewEnum` property, `IEnumVARIANT` is supported directly in this object. Therefore, the `TListItems` class supports both `IListItems` and `IEnumVARIANT`. `IEnumVARIANT` contains four methods, which are described in Table 23.1.

TABLE 23.1 IEnumVARIANT Methods

<i>Method</i>	<i>Purpose</i>
<code>Next</code>	Retrieves the next <i>n</i> number of items in the collection
<code>Skip</code>	Skips over <i>n</i> items in the collection
<code>Reset</code>	Resets current item back to the first item in the collection.
<code>Clone</code>	Creates a copy of this <code>IEnumVARIANT</code>

The source code for the unit containing the `ListItems` object is shown in Listing 23.12.

LISTING 23.12 The Listview Items Wrapper

```
unit LVItems;

interface

uses
  ComObj, Windows, ActiveX, ComCtrls, LVCtrl_TLB;

type
  TListItems = class(TAutoIntfObject, IListItems, IEnumVARIANT)
  private
    FListItems: ComCtrls.TListItems;
    FEnumPos: Integer;
  protected
    { IListItems methods }
    function Add: IListItem; safecall;
    function Get_Count: Integer; safecall;
    function Get_Item(Index: Integer): IListItem; safecall;
    procedure Remove(Index: Integer); safecall;
    function Get__NewEnum: IUnknown; safecall;
    { IEnumVariant methods }
    function Next(celt: Longint; out elt; pceltFetched: PLongint): HRESULT;
      stdcall;
    function Skip(celt: Longint): HRESULT; stdcall;
    function Reset: HRESULT; stdcall;
    function Clone(out Enum: IEnumVariant): HRESULT; stdcall;
```

LISTING 23.12 Continued

```
public
  constructor Create(AOwner: ComCtrls.TListItems);
end;

implementation

uses ComServ, LVItem;

{ TListItems }

constructor TListItems.Create(AOwner: ComCtrls.TListItems);
begin
  inherited Create(ComServer.TypeLib, IListItems);
  FListItems := AOwner;
end;

{ TListItems.IListItems }

function TListItems.Add: IListItem;
begin
  Result := LVItem.TListItem.Create(FListItems.Add);
end;

function TListItems.Get__NewEnum: IUnknown;
begin
  Result := Self;
end;

function TListItems.Get_Count: Integer;
begin
  Result := FListItems.Count;
end;

function TListItems.Get_Item(Index: Integer): IListItem;
begin
  Result := LVItem.TListItem.Create(FListItems[Index]);
end;

procedure TListItems.Remove(Index: Integer);
begin
  FListItems.Delete(Index);
end;

{ TListItems.IEnumVariant }
```

```

function TListItems.Clone(out Enum: IEnumVariant): HRESULT;
begin
  Enum := nil;
  Result := S_OK;
  try
    Enum := TListItems.Create(FListItems);
  except
    Result := E_OUTOFMEMORY;
  end;
end;

function TListItems.Next(celt: Integer; out elt; pceltFetched: PLongint):
  HRESULT;
var
  V: OleVariant;
  I: Integer;
begin
  Result := S_FALSE;
  try
    if pceltFetched <> nil then pceltFetched^ := 0;
    for I := 0 to celt - 1 do
      begin
        if FEnumPos >= FListItems.Count then Exit;
        V := Get_Item(FEnumPos);
        TVariantArgList(elt)[I] := TVariantArg(V);
        // trick to prevent variant from being garbage collected, since it needs
        // to stay alive because it is party of the elt array
        TVarData(V).VType := varEmpty;
        TVarData(V).VInteger := 0;
        Inc(FEnumPos);
        if pceltFetched <> nil then Inc(pceltFetched^);
      end;
    except
      end;
    if (pceltFetched = nil) or ((pceltFetched <> nil) and
      (pceltFetched^ = celt)) then
      Result := S_OK;
    end;

function TListItems.Reset: HRESULT;
begin
  FEnumPos := 0;
  Result := S_OK;
end;

function TListItems.Skip(celt: Integer): HRESULT;

```

LISTING 23.12 Continued

```
begin
  Inc(FEnumPos, celt);
  Result := S_OK;
end;

end.
```

The only method in this unit with a nontrivial implementation is the `Next()` method. The `celt` parameter of the `Next()` method indicates how many items should be retrieved. The `elt` parameter contains an array of `TVarArgs` with at least `elt` elements. Upon return, `pceltFetched` (if not `nil`) should hold the actual number of items fetched. This method returns `S_OK` when the number of items returned is the same as the number requested; it returns `S_FALSE` otherwise. The logic for this method iterates over the array in `elt` and assigns a `TVarArg` representing a collection item to an element of the array. Note the little trick we are performing to clear out the `OleVariant` after assigning it to the array. This ensures that the array will not be garbage collected. Were we not to do this, the contents of `elt` could potentially become stale if the objects referenced by `V` are freed when the `OleVariant` is finalized.

Similar to `TListItem`, the constructor for `TListItems` takes `ComCtrls.TListItems` as a parameter and manipulates that object in the implementation of its methods.

Finally, we complete the implementation of the ActiveX control by adding the logic to manage the `Items` property. First, we must add a field to the object to hold the collection:

```
type
  TListViewX = class(TActiveXControl, IListViewX)
  private
    ...
    FItems: IListItems;
    ...
  end;
```

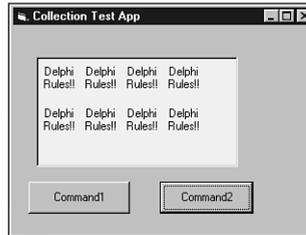
Next, we assign `FItems` to a new `TListItems` instance in the `InitializeControl()` method:

```
FItems := LVItems.TListItems.Create(FDelphiControl.Items);
```

Lastly, the `Get_Items()` method can be implemented to simply return `FItems`:

```
function TListViewX.Get_Items: IListItems;
begin
  Result := FItems;
end;
```

The real test to see whether this collection works is to load the control in Visual Basic 6 and try to use the `For Each` construct with the collection. Figure 23.16 shows a simple VB test application running.

**FIGURE 23.16**

A Visual Basic application to test our collection.

Of the two command buttons you see in Figure 23.16, Command1 adds items to the listview, whereas Command2 iterates over all the items in the listview using `For Each` and adds exclamation points to each caption. The code for these methods is shown here:

```
Private Sub Command1_Click()  
    ListViewX1.Items.Add.Caption = "Delphi"  
End Sub  
  
Private Sub Command2_Click()  
    Dim Item As ListItem  
    Set Items = ListViewX1.Items  
    For Each Item In Items  
        Item.Caption = Item.Caption + " Rules!!"  
    Next  
End Sub
```

Despite the feelings some of the Delphi faithful have toward VB, we must remember that VB is the primary consumer of ActiveX controls, and it's very important to ensure that our controls function properly in that environment.

Collections provide powerful functionality that can enable your controls and Automation servers to function more smoothly in the world of COM. Because collections are terribly difficult to implement, it's worth your while to get in the habit of using them when appropriate. Unfortunately, once you become comfortable with collections, it's very likely that someone will soon come along and create yet a newer and better container object for COM.

New Interface Types in the Type Library

As every well-behaved Delphi developer should, we have used the type library editor to define new interfaces for our Automation objects. However, it is not unusual to occasionally run into a situation where one of the methods for a new interface includes a parameter of a COM interface type that isn't supported by default in the type library editor. Because the type library editor does not let you work with types that it doesn't know about, how do you complete such a method definition?

Before this is explained, it's important that you understand why the type library editor behaves the way it does. If you create a new method in the type library editor and take a look at the types available in the Type column of the Parameters page, you will see a number of interfaces, including `IDataBroker`, `IDispatch`, `IEnumVARIANT`, `IFont`, `IPicture`, `IProvider`, `IStrings`, and `IUnknown`. Why are these the only interfaces available? What makes them so special? They're not special, really—they just happen to be types that are defined in type libraries that are used by this type library. By default, a Delphi type library automatically uses the Borland Standard VCL type library and the OLE Automation type library. You can configure which type libraries are used by your type library by selecting the root node in the tree view in the left pane of the type library editor and choosing the Uses tab in the page control in the right pane. The types contained in the type libraries used by your type library will automatically become available in the drop-down list shown in the type library editor.

Armed with this knowledge, you've probably already figured out that if the interface you want to use as the method parameter in question is defined in a type library, you can simply use that type library, and the problem is solved. But what if the interface isn't defined in a type library? There are certainly quite a few COM interfaces that are defined only by SDK in header or IDL files and are not found in type libraries. If this is the case, the best course is to define the method parameter as being of type `IUnknown`. This `IUnknown` can be `QueryInterface`d in your method implementation for the specific interface type you want to work with. You should also be sure to document this method parameter as an `IUnknown` that must support the appropriate interface. The following code shows an example of how such a method could be implemented:

```
procedure TSomeClass.SomeMethod(SomeParam: IUnknown);
var
    Intf: ISomeComInterface;
begin
    Intf := SomeParam as ISomeComInterface;
    // remainder of method implementation
end;
```

You should also be aware of the fact that the interface to which you cast the `IUnknown` must be an interface that COM knows how to marshal. This means that it must either be defined in a type library somewhere, must be a type compatible with the standard Automation marshaler, or the COM server in question must provide a proxy/stub DLL capable of marshalling the interface.

Exchanging Binary Data

Occasionally you may want to exchange a block of binary data between an Automation client and server. Because COM doesn't support the exchange of raw pointers, you can't simply pass pointers around. However, the solution isn't much more difficult than that. The easiest way to exchange binary data between Automation clients and servers is to use safearrays of bytes.

Delphi encapsulates safearrays nicely in `OleVariants`. The admittedly contrived example shown in Listings 23.13 and 23.14 depict client and server units that use memo text to demonstrate how to transfer binary data using safearrays of bytes.

LISTING 23.13 The Server Unit

```
unit ServObj;

interface

uses
  ComObj, ActiveX, Server_TLB;

type
  TBinaryData = class(TAutoObject, IBinaryData)
  protected
    function Get_Data: OleVariant; safecall;
    procedure Set_Data(Value: OleVariant); safecall;
  end;

implementation

uses ComServ, ServMain;

function TBinaryData.Get_Data: OleVariant;
var
  P: Pointer;
  L: Integer;
begin
  // Move data from memo into array
  L := Length(MainForm.Memo.Text);
  Result := VarArrayCreate([0, L - 1], varByte);
  P := VarArrayLock(Result);
  try
    Move(MainForm.Memo.Text[1], P^, L);
  finally
    VarArrayUnlock(Result);
  end;
end;

procedure TBinaryData.Set_Data(Value: OleVariant);
var
  P: Pointer;
  L: Integer;
  S: string;
```

continues

LISTING 23.13 Continued

```
begin
  // Move data from array into memo
  L := VarArrayHighBound(Value, 1) - VarArrayLowBound(Value, 1) + 1;
  SetLength(S, L);
  P := VarArrayLock(Value);
  try
    Move(P^, S[1], L);
  finally
    VarArrayUnlock(Value);
  end;
  MainForm.Memo.Text := S;
end;

initialization
  TAutoObjectFactory.Create(ComServer, TBinaryData, Class_BinaryData,
    ciSingleInstance, tmApartment);
end.
```

LISTING 23.14 The Client Unit

```
unit CliMain;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ExtCtrls, Server_TLB;

type
  TMainForm = class(TForm)
    Memo: TMemo;
    Panel1: TPanel;
    SetButton: TButton;
    GetButton: TButton;
    OpenButton: TButton;
    OpenDialog: TOpenDialog;
    procedure OpenButtonClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure SetButtonClick(Sender: TObject);
    procedure GetButtonClick(Sender: TObject);
  private
    FServer: IBinaryData;
  end;
```

```
var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.FormCreate(Sender: TObject);
begin
  FServer := CoBinaryData.Create;
end;

procedure TMainForm.OpenButtonClick(Sender: TObject);
begin
  if OpenDialog.Execute then
    Memo.Lines.LoadFromFile(OpenDialog.FileName);
end;

procedure TMainForm.SetButtonClick(Sender: TObject);
var
  P: Pointer;
  L: Integer;
  V: OleVariant;
begin
  // Send memo data to server
  L := Length(Memo.Text);
  V := VarArrayCreate([0, L - 1], varByte);
  P := VarArrayLock(V);
  try
    Move(Memo.Text[1], P^, L);
  finally
    VarArrayUnlock(V);
  end;
  FServer.Data := V;
end;

procedure TMainForm.GetButtonClick(Sender: TObject);
var
  P: Pointer;
  L: Integer;
  S: string;
  V: OleVariant;
begin
  // Get server's memo data
  V := FServer.Data;
  L := VarArrayHighBound(V, 1) - VarArrayLowBound(V, 1) + 1;
```

LISTING 23.14 Continued

```
SetLength(S, L);
P := VarArrayLock(V);
try
  Move(P^, S[1], L);
finally
  VarArrayUnlock(V);
end;
Memo.Text := S;
end;

end.
```

Behind the Scenes: Language Support for COM

One thing often heard when folks talk about COM development in Delphi is what great language support Object Pascal provides for COM. (You won't get any static from us on that point.) With features such as interfaces, variants, and wide strings built right into the language, it's hardly a point to be argued. However, what does it mean to have these things built into the language? How do these features work, and what is the nature of their dependence on the COM APIs? In this section, we will take a low-level look at how all the pieces fit together to form Object Pascal's COM support and dig into some of the implementation details of the language features.

As I mentioned, Object Pascal's COM language features can basically be summed up into three categories:

- `Variant` and `OLEVariant`, which encapsulate COM's variant record, safearrays, and late-bound Automation.
- `WideString`, which encapsulates COM's BSTR.
- `Interface` and `dispinterface`, which encapsulate COM interfaces and early- and ID-bound Automation.

You crusty old OLE developers from the Delphi 2 days might have noticed that the automated reserved word, through which late-bound Automation servers could be created, is conveniently ignored. Because this feature was superceded by the "real" Automation support first introduced in Delphi 3 and remains only for backward compatibility, it is not discussed here.

Variants

Variants are the oldest form of COM support in Delphi, dating back to Delphi 2. As you likely already know, a `Variant` is really just a big record that is used to pass around some bit of data that can be any one of a number of types. If you're interested in what this record looks like, it's defined in the `System` unit as `TVarData`:

```
type
  PVarData = ^TVarData;
  TVarData = record
    VType: Word;
    Reserved1, Reserved2, Reserved3: Word;
    case Integer of
      varSmallint: (VSmallint: Smallint);
      varInteger: (VInteger: Integer);
      varSingle: (VSingle: Single);
      varDouble: (VDouble: Double);
      varCurrency: (VCurrency: Currency);
      varDate: (VDate: Double);
      varOleStr: (VOleStr: PWideChar);
      varDispatch: (VDispatch: Pointer);
      varError: (VError: LongWord);
      varBoolean: (VBoolean: WordBool);
      varUnknown: (VUnknown: Pointer);
      varByte: (VByte: Byte);
      varString: (VString: Pointer);
      varAny: (VAny: Pointer);
      varArray: (VArray: PVarArray);
      varByRef: (VPointer: Pointer);
    end;
end;
```

The value of the `VType` field of this record indicates the type of data contained in the `Variant`, and it can be any of the variant type codes found at the top of the `System` unit and listed in the variant portion of this record (within the case statement). The only difference between `Variant` and `OleVariant` is that `Variant` supports all the type codes, whereas `OleVariant` only supports those types compatible in Automation. For example, an attempt to assign a Pascal string (`varString`) to a `Variant` is an acceptable practice, but assigning the same string to an `OleVariant` will cause it to be converted to an Automation-compatible `WideString` (`varOleStr`).

When you work with the `Variant` and `OleVariant` types, what the compiler is really manipulating and passing around is instances of this `TVarData` record. In fact, you can safely typecast a `Variant` or `OleVariant` to a `TVarData` if you for some reason need to manipulate the innards of the record (although we don't recommend this practice unless you really know what you're doing).

In the harsh world of COM programming in C and C++ (without a class framework), variants are represented with the `VARIANT` struct defined in `oaid1.h`. When working with variants in this environment, you have to manually initialize and manage them using `VariantXXX()` API functions found in `oleaut32.dll`, such as `VariantInit()`, `VariantCopy()`, `VariantClear()`, and so on. This makes working with variants in straight C and C++ a high-maintenance task.

With support for variants built into Object Pascal, the compiler generates the necessary calls to the API's variant-support routines automatically as you use instances of the `Variant` and `OleVariant` types. This nicety in the language does saddle you with one bit of baggage you should know about, however. If you inspect the import table of a "do-nothing" Delphi EXE using a tool such as Borland's `TDUMP.EXE` or Microsoft's `DUMPBIN.EXE`, you will notice a few suspicious imports from `oleaut32.dll`: `VariantChangeTypeEx()`, `VariantCopyInd()`, and `VariantClear()`. What this means is that even in an application in which you do not explicitly employ `Variant` or `OleVariant` types, your Delphi EXE still has a dependence on these COM API functions in `oleaut32.dll`.

Variant Arrays

Variant arrays in Delphi are designed to encapsulate COM safearrays, which are a type of record used to encapsulate an array of data in Automation. They are called *safe* because they are self-describing; in addition to array data, the record contains information regarding the number of dimensions, the size of an element, and the number of elements in the array. Variant arrays are created and managed in Delphi using the `VarArrayXXX()` functions and procedures found in the `System` unit and documented in the online help. These functions and procedures are essentially wrappers around the API's `SafeArrayXXX()` functions. Once a `Variant` contains a variant array, standard array subscript syntax is used to access array elements. Once again, comparing this to manually coding safearrays as you would in C and C++, Object Pascal's language encapsulation is clean and much less cumbersome and error prone.

Late-Binding Automation

As you learned earlier in this chapter, `Variant` and `OleVariant` types enable to write late-binding Automation clients (*late-binding* means that functions are called at runtime using the `Invoke` method of the `IDispatch` interface). That's all pretty easy to take at face value, but the question is "Where is the magic connection between calling a method of an Automation server from a `Variant` and `IDispatch.Invoke()` somehow getting called with the right parameters?" The answer is more low-tech than you might expect.

When a method call is made on a `Variant` or `OleVariant` containing an `IDispatch`, the compiler simply generates a call to the `_DispInvoke` helper function declared in the `System` unit, which jumps to a function pointer called `VarDispProc`. By default, the `VarDispProc` pointer is assigned to a method that simply returns an error when it is called. However, if you include the `ComObj` unit in your `uses` clause, the initialization section for the `ComObj` unit redirects `VarDispProc` to another method with a line of code that looks like this:

```
VarDispProc := @VarDispInvoke;
```

`VarDispInvoke` is a procedure in the `ComObj` unit with the following declaration:

```
procedure VarDispInvoke(Result: PVariant; const Instance: Variant;  
    CallDesc: PCallDesc; Params: Pointer); cdecl;
```

The implementation of the procedure handles the complexity of calling `IDispatch.GetIDsOfNames()` to obtain a `DispID` from the method name, setting up the parameters correctly, and making the call to `IDispatch.Invoke()`. What's interesting about this is that the compiler in this instance doesn't have any inherent knowledge of `IDispatch` or how the `Invoke()` call is made; it simply passes a bunch of stuff through a function pointer. Also interesting is the fact that because of this architecture, you could reroute this function pointer to your own procedure if you wanted to handle all Automation calls through `Variant` and `OleVariant` types yourself. You would only have to ensure that your function declaration matched that of `VarDispInvoke`. Certainly, this would be a task reserved for experts, but it's interesting to know that the flexibility is there when you need it.

WideString

The `WideString` data type was added in Delphi 3 to serve the dual purpose of providing a native double-byte, Unicode character string and a character string compatible with the COM BSTR string. The `WideString` type differs from its cousin `AnsiString` in a few key respects:

- The characters comprising a `WideString` string are all two bytes in size.
- `WideString` types are always allocated using `SysAllocStringLen()` and therefore are fully compatible with BSTRs.
- `WideString` types are never reference counted and therefore are always copied on assignment.

Like variants, BSTRs can be cumbersome to work with using standard API functions, so the native Object Pascal support via `WideString` is certainly a welcome language addition. However, because they consume twice the memory and are not reference counted, they are much more inefficient than `AnsiStrings`, and you should therefore be judicious about their use.

Like the Pascal Variant, `WideString` causes a number of functions to be imported from `oleaut32.dll`, even if you don't employ this type yourself. Inspecting the import table of a "do-nothing" Delphi application reveals that `SysStringLen()`, `SysFreeString()`, `SysReAllocStringLen()`, and `SysAllocStringLen()` are all pulled in by the Delphi RTL in order to provide `WideString` support.

Interfaces

Perhaps the most important big-ticket COM feature in the Object Pascal language is the native support for interfaces. Somewhat ironically, although arguably smaller features such as Variants and `WideStrings` pull in functions from the COM API for implementation, Object Pascal's implementation of interfaces doesn't require COM at all. That is, Object Pascal provides a completely self-contained implementation of interfaces that adheres to the COM specification, but it doesn't necessarily require any COM API functions.

As a part of adhering to the COM spec, all interfaces in Delphi implicitly descend from `IUnknown`. As you may know, `IUnknown` provides the identity and reference counting support that is the root of COM. This means that knowledge of `IUnknown` is built into the compiler, and `IUnknown` is defined in the `System` unit. By making `IUnknown` a first-class citizen in the language, Delphi is able to provide the automatic reference counting by having the compiler generate the calls to `IUnknown.AddRef()` and `IUnknown.Release()` at the appropriate times. Additionally, the `as` operator can be used as a shortcut for interface identity normally obtained via `QueryInterface()`. The root support for `IUnknown`, however, is almost incidental when you consider the low-level support that the language and compiler provide for interfaces in general.

Figure 23.17 shows a simplified diagram of how classes internally support interfaces. A Delphi object is really a reference that points to the physical instance. The first four bytes of an object instance are a pointer to the object's virtual method table (VMT). At a positive offset from the VMT are all the object's virtual methods. At a negative offset are pointers to methods and data that are important to the internal function of the object. In particular, offset `-72` from the VMT contains a pointer to the object's interface table. The interface table is a list of `PInterfaceEntry` records (defined in the `System` unit) that essentially contain the IID and information on where to find the vtable pointer for that IID.

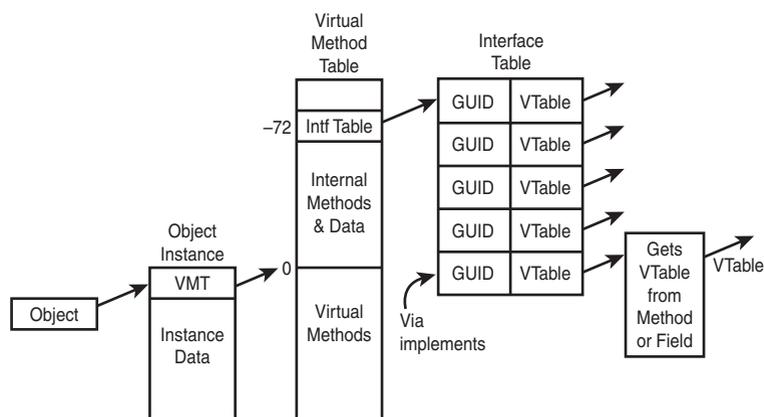


FIGURE 23.17

How interfaces are supported internally in Object Pascal.

After you have a moment to reflect on the diagram in Figure 23.17 and understand how things are put together, the details surrounding the implementation of interfaces just kind of fall into place. For example, `QueryInterface()` is normally implemented on Object Pascal objects by calling `TObject.GetInterface()`. `GetInterface()` walks the interface table looking for the IID in question and returns the vtable pointer for that interface. This also illustrates why new interface types must be defined with a GUID; otherwise, there would be no way for

`GetInterface()` to walk the interface table, and therefore there would be no identity via `QueryInterface()`. Typcasting of interfaces using the `as` operator simply generates a call to `QueryInterface()`, so the same rules apply there.

The last entry in the interface table in Figure 23.17 illustrates how an interface is implemented internally using the `implements` directive. Rather than providing a direct pointer for the vtable, the interface table entry provides the address of a little compiler-generated getter function that gets the interface vtable from the property upon which the `implements` directive was used.

Dispinterfaces

A dispinterface provides an encapsulation of a non-dual `IDispatch`. That is, an `IDispatch` in which methods can be called via `Invoke()` but not via a vtable. In this respect, a dispinterface is similar to Automation with variants. However, dispinterfaces are slightly more efficient than variants because `dispinterface` declarations contain the `DispID` for each of the properties or methods supported. This means that `IDispatch.Invoke()` can be called directly without first calling `IDispatch.GetIDsOfNames()`, as must be done with a variant. The mechanism behind dispinterfaces is similar to that of variants: When you call a method via a dispinterface, the compiler generates a call to `_IntfDispCall` in the `System` unit. This method jumps through the `DispCallByIDProc` pointer, which by default only returns an error. However, when the `ComObj` unit is included, `DispCallByIDProc` is routed to the `DispCallByID()` procedure, which is declared in `ComObj` as follows:

```
procedure DispCallByID(Result: Pointer; const Dispatch: IDispatch;  
    DispDesc: PDispDesc; Params: Pointer); cdecl;
```

Microsoft Transaction Server (MTS)

The COM development community has been making a lot of noise of late about Microsoft Transaction Server (MTS), and not without good reason. MTS represents a new paradigm for COM developers. COM developers have long enjoyed the advantages of language-independent interfaces, location transparency, and automatic activation and deactivation. However, thanks to MTS, COM developers can now take advantage of powerful runtime services, such as lifetime management, security, resource pooling, and transaction management. Although MTS brings a lot of useful features to the table, it also requires some changes in system design that in some cases contradict ideas COM has pounded into our skulls over the years. In this section, we will discuss MTS technology, and in the following section, we will talk more specifically about MTS and Delphi, Delphi's MTS framework and IDE support, and walk through some sample MTS components and applications.

Before we leap into the technical details, you should know up front that transaction handling is only a small part of the MTS big picture, and the fact that *transaction* appears in the name of this technology is quite unfortunate. It's sort of like calling your new home entertainment

system a soap opera viewer. Yeah, it does that, but it's so much more. To their credit, when we've spoken with folks at Microsoft close to the technology, they generally hate the name. Fortunately, the name *MTS* won't be with us much longer; as mentioned earlier in this chapter, MTS will be folded into the operating system as a part of the upcoming enhancements to COM known as COM+.

Why MTS?

The magic word of system design these days is *scalability*. With the hypergrowth of the Internet and intranets, the consolidation of corporate data into centrally located data stores, and the need for everyone and their cousin to get at the data, it's absolutely crucial that a system be able to scale to ever-larger numbers of concurrent users. It's definitely a challenge, especially considering the rather unforgiving limitations we must deal with, such as finite database connections, network bandwidth, server load, and so on. In the good old days of the early 90s, client/server computing was all the rage and considered The Way to write scalable applications. However, as databases were bogged down with triggers and stored procedures and clients were complicated with various bits of code here and there in an effort to implement business rules, it shortly became obvious that such systems would never scale to a large number of users. The multitier architecture soon became popular as a way to scale a system to a greater number of users. By placing application logic and sharing database connections in the middle tier, database and client logic could be simplified and resource usage optimized for an overall higher-bandwidth system.

As a side note, it is interesting that the added infrastructure introduced in a multitier environment tends to increase latency as it increases bandwidth. In other words, you may very well need to sacrifice the performance of the system in order to improve scalability.

Microsoft extended to COM developers the ability to build applications that are distributed across multiple machines with the introduction of DCOM several years ago. DCOM was a step in the right direction. It provided the means by which things COM may communicate with one another over the wire, but it did not make many significant steps toward solving the real-world problems encountered by developers of distributed applications. Issues such as lifetime optimization, thread management, flexible security, and transaction support were still left to individual developers. Enter MTS.

What Is MTS?

MTS is a COM-based programming model and collection of runtime services for developing scalable or transactional COM-based applications. The programming model part of MTS isn't much different than what you are familiar with already as a COM developer. There are a few wrinkles that you will learn about shortly, but for the most part, any in-process (DLL) COM object with a type library can be an MTS object. However, it's not recommended that you run

non-MTS-aware COM components within MTS. MTS runtime services mean that MTS serves as the caregiver for your COM components. MTS can host them, manage their lifetime, provide security for them, and so on. This means that rather than running within the context of your application, MTS COM objects run within the context of the MTS runtime. All this adds up to a bunch of new features that you can take advantage of with little or no coding changes in your client or COM object code.

It's interesting to note that because MTS objects do not run directly within the context of a client like other COM objects, clients never really obtain interface pointers directly to an object instance. Instead, MTS inserts a proxy between the client and the MTS object such that the proxy is identical to the object from the client's point of view. However, because MTS has complete control over the proxy, it can control access to interface methods of the object for purposes such as lifetime management and security, as you will soon learn.

Stateful Versus Stateless

The number one topic of conversation among folks looking at, playing with, and working on MTS technology seems to be the discussion of stateful versus stateless objects. Although COM itself doesn't give a whit as to the state of an object, in practice most traditional COM objects are stateful. That is, they continuously maintain state information from the time they're created, while they're being used, and up until the time they're destroyed. The problem with stateful objects is that they aren't particularly scalable, because state information would have to be maintained for every object being accessed by every client. A *stateless object* is one that generally does not maintain state information between method calls. Stateless objects are preferred because they enable MTS to play some optimization tricks. If an object doesn't maintain any state between method calls, MTS can theoretically make the object go away between calls without causing any harm. Furthermore, because the client maintains pointers only to MTS's internal proxy for the object, MTS could do so without the client being any the wiser. It's more than a theory; this is actually how MTS works. MTS will destroy the instances of the object between calls in order to free up resources associated with the object. When the client makes another call to that object, the MTS proxy will intercept it and a new instance of the object will be created automatically. This helps the system scale to a larger number of users, because there will likely be comparatively few active instances of a class at any given time.

Writing interfaces to behave in a stateless manner will probably require a slight departure from your usual way of thinking for interface design. For example, consider the following classic COM-style interface:

```
ICheckbook = interface
['{2CCF0409-EE29-11D2-AF31-0000861EF0BB}']
    procedure SetAccount(AccountNum: WideString); safecall;
    procedure AddActivity(Amount: Integer); safecall;
end;
```

As you might imagine, you would use this interface in a manner something like this:

```
var
  CB: ICheckbook;
begin
  CB := SomehowGetInstance;
  CB.SetAccount('12345ABCDE'); // open my checking account
  CB.AddActivity(-100);          // add a debit for $100
  ...
end;
```

The problem with this style is that the object is not stateless between method calls because state information regarding the account number must be maintained across the call. A better approach to this interface for use in MTS would be to pass all the necessary information to the `AddActivity()` method so that the object could behave in a stateless manner, as shown here:

```
procedure AddActivity(AccountNum: WideString; Amount: Integer); safecall;
```

The particular state of an active object is also referred to as a *context*. MTS maintains a context for each active object that tracks things such as security and transaction information for the object. An object can at any time call `GetObjectContext()` to obtain an `IObjectContext` interface pointer for the object's context. `IObjectContext` is defined in the `Mtx` unit as follows:

```
IObjectContext = interface(IUnknown)
  [{51372AE0-CAE7-11CF-BE81-00AA00A2FA25}]
  function CreateInstance(const cid, rid: TGUID; out pv): HRESULT; stdcall;
  procedure SetComplete; safecall;
  procedure SetAbort; safecall;
  procedure EnableCommit; safecall;
  procedure DisableCommit; safecall;
  function IsInTransaction: Bool; stdcall;
  function IsSecurityEnabled: Bool; stdcall;
  function IsCallerInRole(const bstrRole: WideString): Bool; safecall;
end;
```

The two most important methods in this interface are `SetComplete()` and `SetAbort()`. If either of these methods are called, the object is telling MTS that it no longer has any state to maintain. MTS will therefore destroy the object (unbeknownst to the client, of course), thereby freeing up resources for other instances. If the object is participating in a transaction, `SetComplete()` and `SetAbort()` also have the effect of a commit and rollback for the transaction, respectively.

Lifetime Management

From the time we were itty-bitty COM programmers, we were taught to hold onto interface pointers only for as long as necessary and to release them as soon as they were unneeded. In traditional COM, this makes a lot of sense because we don't want to occupy the system with

maintaining resources that aren't being used. However, because MTS will automatically free up stateless objects after they call `SetComplete()` or `SetAbort()`, there is no expense associated with holding a reference to such an object indefinitely. Furthermore, because the client never knows that the object instance may have been deleted under the sheets, clients do not have to be rewritten to take advantage of this feature.

Packages

The word *package* is already overloaded enough—Delphi packages, C++Builder packages, and Oracle packages are all examples of the overuse of this word. MTS also has a notion of *packages* that no doubt differs from those other varieties. An MTS package is more logical than physical, because it represents a programmer-defined collection of MTS objects with like activation, security, and transaction attributes. The physical part of a package is a file that contains references to the COM server DLLs and MTS objects within those servers that make up the package. The package file also contains information on the attributes of the MTS objects within.

MTS will run all components within a package in the same process. This enables you to configure your well-behaved and error-free packages so that they are insulated from the potential problems that could be caused by faults or errors in other packages. It is also interesting to note that the physical location of components has no bearing on eligibility for package inclusion: A single COM server can contain several COM objects, each in a separate package.

Packages are created and manipulated using either the Run, Install MTS Objects menu in Delphi or the Transaction Server Explorer that is installed with MTS and shown in Figure 23.18.

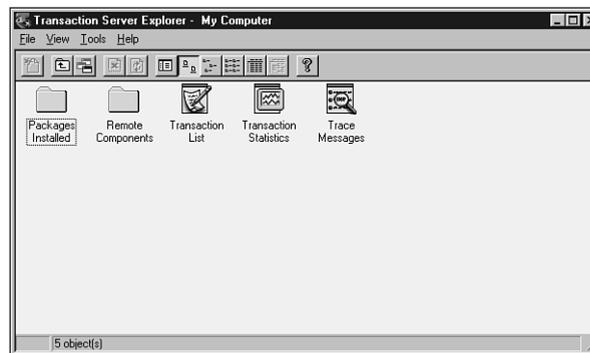


FIGURE 23.18

The Windows 98 Transaction Server Explorer.

Security

MTS provides a roll-based security system that is much more flexible than the standard Windows NT security normally used with DCOM. A *roll* is a category of user (for example, in

a banking system typical rolls might be teller, supervisor, and manager). MTS allows you to specify the degree to which any particular roll can manipulate an object on a per-interface basis. For example, you can specify that the manager roll has access to the `ICreateHomeLoan` interface, but the teller roll does not. If you need to get more granular than access to entire interfaces, you can determine the roll of the user in the current context by calling the `IsCallerInRole()` method of `IObjectContext`. Using this, for example, you could enforce a business rule that stipulates that tellers can approve normal account closures, but only supervisors can approve an account closure when the account balance is over \$100,000. Security rolls can be configured in the Transaction Server Explorer.

Oh, It Also Does Transactions

Of course, as the name implies, MTS also does transactions. You might be thinking to yourself, “Big deal, my database server already supports transactions. Why do I need my components to support them as well?” This is a fair question, and luckily there’s a good answer. Transaction support in MTS can enable you to perform transactions across multiple databases or can even make a single atomic action out of some set of operations having nothing to do with databases. In order to support transactions on your MTS objects, you must set the correct transaction flag on your object’s coclass in the type library either during development (this is what the Delphi MTS Wizard does) or after deployment in the Transaction Server Explorer.

When should you use transactions in your objects? That’s easy: You should use transactions whenever you have a process involving multiple steps that you want to make into a single, atomic transaction. In doing so, the entire process can be either committed or rolled back, but you will never leave your logic or data in an incorrect or indeterminate state somewhere in between. For example, if you are writing software for a bank and you want to handle the case where a client bounces a check, there would likely be several steps involved in handling that, including debiting account for the amount of the check, debiting the account for the bounced check service charge, and sending a letter to the client.

In order to properly process the bounced check, each of these things must happen. Therefore, wrapping them in a single transaction would ensure that all will occur (if no errors are encountered) or all will roll back to their original pretransaction state if an error occurs.

Resources

With objects being created and destroyed all the time and transactions happening everywhere, it’s important for MTS to provide a means for sharing certain finite or expensive resources (such as database connections) across multiple objects. MTS does this using resource managers and resource dispensers. A *resource manager* is a service that manages some type of durable data, such as account balances or inventory. Microsoft provides a resource manager in MS SQL Server. A *resource dispenser* manages nondurable resources, such as database connections. Microsoft provides a resource dispenser for ODBC database connections, and Borland provides a resource dispenser for BDE database connections.

When a transaction makes use of some type of resource, it *enlists* the resource to become a part of the transaction so that all changes made to the resource during the transaction will participate in the commit or rollback operation of the transaction.

MTS in Delphi

Now that you've got the "what" and "why" down, it's time to talk about the "how." In particular, we will focus on Delphi's support of MTS and how to build MTS solutions in Delphi. Before we jump right in, however, you should first know that MTS support is built only into the Enterprise version of Delphi. Although it's technically possible to create MTS components using the facilities available in the Standard and Professional versions, it is not the most productive use of your time. Therefore, this section will help you leverage the features of Delphi Enterprise.

MTS Wizards

Delphi provides two wizards for building MTS components that are both found on the Multitier tab of the New Items dialog: the MTS Remote Data Module Wizard and the MTS Object Wizard. The MTS Remote Data Module Wizard enables you to build MIDAS servers that operate in the MTS environment. The MTS Object Wizard will serve as the starting point for your MTS objects, and it will be the focus of this discussion. Upon invoking this wizard, you will be presented with the dialog shown in Figure 23.19.

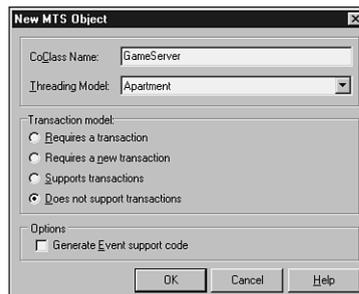


FIGURE 23.19

The New MTS Object Wizard.

The dialog in Figure 23.19 is similar to the Automation Object Wizard discussed earlier in this chapter. The obvious difference is the facility provided by this wizard to select the transaction model supported by your MTS component. The available transaction models are as follows:

- *Requires a transaction.* The component will always be created within the context of a transaction. It will inherit the transaction of its creator if one exists; otherwise, it will create a new one.

- *Requires a new transaction.* A new transaction will always be created for the component to execute within.
- *Supports transactions.* The component will inherit the transaction of its creator if one exists; otherwise, it will execute without a transaction.
- *Does not support transactions.* The component will never be created within a transaction.

The transaction model information is stored as an attribute along with the component's coclass in the type library.

After you click OK to dismiss the dialog, the wizard will generate an empty definition for a class that descends from `TMtsAutoObject`, and it will leave you off in the Type Library Editor in order to define your MTS components by adding properties, methods, interfaces, and so on. This should be familiar territory because the workflow is identical at this point to developing Automation objects in Delphi. It's interesting to note that although the Delphi wizard-created MTS objects are Automation objects (that is, COM objects that implement `IDispatch`), MTS doesn't technically require this. However, because COM inherently knows how to marshal `IDispatch` interfaces accompanied by type libraries, employing this type of object in MTS enables you to concentrate more on your components' functionality and less on how they integrate with MTS. You should also be aware that MTS components must reside in in-process COM servers (DLLs); MTS components are not supported in out-of-process servers (EXEs).

MTS Framework

The aforementioned `TMtsAutoObject` class, which is the base class for all Delphi wizard-created MTS objects, is defined in the `MtsObj` unit. `TMtsAutoObject` is a relatively straightforward class that is defined as follows:

```
type
  TMtsAutoObject = class(TAutoObject, IObjectControl)
  private
    FObjectContext: IObjectContext;
  protected
    { IObjectControl }
    procedure Activate; safecall;
    procedure Deactivate; stdcall;
    function CanBePooled: Bool; stdcall;

    procedure OnActivate; virtual;
    procedure OnDeactivate; virtual;
    property ObjectContext: IObjectContext read FObjectContext;
  public
    procedure SetComplete;
    procedure SetAbort;
    procedure EnableCommit;
    procedure DisableCommit;
```

```

function IsInTransaction: Bool;
function IsSecurityEnabled: Bool;
function IsCallerInRole(const Role: WideString): Bool;
end;

```

TMtsAutoObject is essentially a TAutoObject that adds two important bits of functionality:

- TMtsAutoObject implements the IObjectControl interface, which manages initialization and cleanup of MTS components. Here are the methods of this interface:

<i>Method Name</i>	<i>Description</i>
Activate	Allows an object to perform context-specific initialization when activated. This method will be called by MTS prior to any custom methods on your MTS component.
Deactivate	Enables you to perform context-specific cleanup when an object is deactivated.
CanBePooled	This method is currently unused because MTS does not yet support object pooling.

TMtsAutoObject provides virtual OnActivate() and OnDeactivate() methods, which are fired from the private Activate() and Deactivate() methods. Simply override these to create special context-specific activation or deactivation logic.

- TMtsAutoObject also maintains a pointer to MTS's IObjectContext interface in the form of the ObjectContext property. As previously explained, IObjectContext is the interface provided by MTS that provides a component the ability to manipulate its current context. As a shortcut for users of this class, TMtsAutoObject also surfaces each of IObjectContext's methods, which are implemented to simply call into ObjectContext. For example, the implementation of the TMtsAutoObject.SetComplete() method simply checks FObjectContext for nil and then calls FObjectContext.SetComplete(). Here's a list of IObjectContext's methods and a brief explanation of each:

<i>Method Name</i>	<i>Description</i>
CreateInstance	Creates an instance of another MTS object. You can think of this method as performing the same task for MTS objects as IClassFactory.CreateInstance does for normal COM objects.
SetComplete	Signals to MTS that the component has completed whatever work it needs to do and no longer has any internal state to maintain. If the component is transactional, it also indicates that the current transactions can be committed. After the method calling this function returns, MTS may deactivate the object, thereby freeing up resources for greater scalability.

<i>Method Name</i>	<i>Description</i>
<code>SetAbort</code>	Similar to <code>SetComplete()</code> , this method signals to MTS that the component has completed work and no longer has state information to maintain. However, calling this method also means that the component is in an error or indeterminate state and any pending transactions must be aborted.
<code>EnableCommit</code>	Indicates that the component is in a “committable” state, such that transactions can be committed when the component calls <code>SetComplete</code> . This is the default state of a component.
<code>DisableCommit</code>	Indicates that the component is in an inconsistent state, and further method invocations are necessary before the component will be prepared to commit transactions.
<code>IsInTransaction</code>	Enables the component to determine whether it is executing within the context of a transaction.
<code>IsSecurityEnabled</code>	Allows a component to determine whether MTS security is enabled. This method always returns <code>True</code> unless the component is executing in the client’s process space.
<code>IsCallerInRole</code>	Provides a means by which a component can determine whether the user serving as the client for the component is a member of a specific MTS role. This method is the heart of MTS’s easy-to-use, role-based security system. (More on roles later in this chapter.)

The `Mtx` unit contains the core MTS support. It is the Pascal translation of the `mtx.h` header file, and it contains the types (such as `IObjectContext` and `IObjectContext`) and functions that make up the MTS API.

Tic-Tac-Toe: A Sample Application

Enough theory. Now it’s time to write some code and see how all this MTS stuff performs on the open road. MTS ships with a sample tic-tac-toe application that’s a bit on the ugly side, so it inspired us to implement the classic game from the ground up in Delphi. To start, we use the MTS Object Wizard to create a new object called `GameServer`. Using the Type Library Editor, we add to the default interface for this object, `IGameServer`, three methods: `NewGame()`, `ComputerMove()`, and `PlayerMove()`. Additionally, we add two new enums, `SkillLevels` and `GameResults`, which are used by these methods. Figure 23.20 shows all of these items displayed in the type library editor.

The logic behind the three methods of this interface is simple, and these methods make up the requirements to support a game of human versus computer tic-tac-toe. `NewGame()` initializes a new game for the client. `ComputerMove()` analyzes the available moves and makes a move for the computer. `PlayerMove()` enables the client to let the computer know how he or she has chosen to move. Earlier in this chapter we mentioned that MTS component development

requires a different frame of mind than development of standard COM components. This component offers a nice opportunity to illustrate this fact.

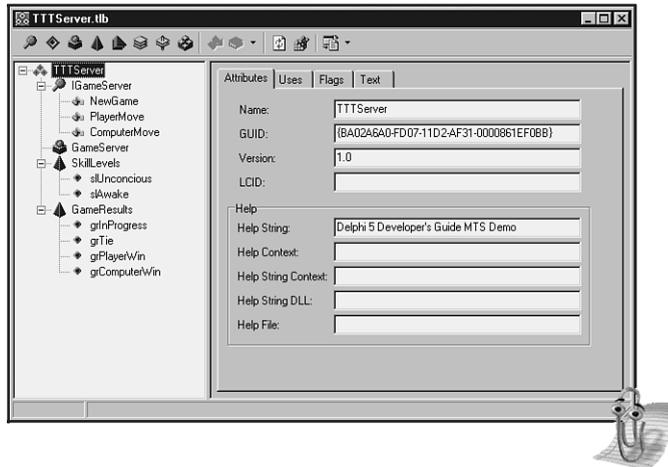


FIGURE 23.20

The tic-tac-toe server, as shown in the type library editor.

If this were your average, everyday, run-of-the-mill COM component, you might approach design of the object by initializing some data structure to maintain game state in the `NewGame()` method. That data structure would probably be an instance field of the object, which the other methods would access and manipulate throughout the life of the object.

What's the problem with this approach for an MTS component? One word: state. As you learned earlier, objects must be stateless in order to realize the full benefit of MTS. However, a component architecture that depends on instance data to be maintained across method calls is far from stateless. A better design for MTS would be to return a "handle" identifying a game from the `NewGame()` method and using that handle to maintain per-game data structures in some type of shared resource facility. This shared resource facility would need to be maintained outside the context of a specific object instance, because MTS may activate and deactivate object instances with each method call. Each of the other methods of the component could accept this handle as a parameter, enabling it to retrieve game data from the shared resource facility. This is a stateless design because it doesn't require the object to remain activated between method calls, because each method is a self-contained operation that gets all the data it needs from parameters and a shared data facility.

This shared data facility that we are speaking abstractly about is known as a *resource dispenser* in MTS. Specifically, the Shared Property Manager is the MTS resource dispenser that is used to maintain component-defined, process-wide shared data. The Shared Property Manager is

represented by the `ISharedPropertyGroupManager` interface. The Shared Property Manager is the top level of a hierarchical storage system, maintaining any number of shared property groups, which are represented by the `ISharedPropertyGroup` interface. In turn, each shared property group may contain any number of shared properties, represented by the `ISharedProperty` interface. Shared properties are convenient because they exist within MTS, outside the context of any specific object instance, and access to them is controlled by locks and semaphores managed by the Shared Property Manager.

With all that in mind, the implementation of the `NewGame()` method is shown in the following code:

```
procedure TGameServer.NewGame(out GameID: Integer);
var
    SPG: ISharedPropertyGroup;
    SProp: ISharedProperty;
    Exists: WordBool;
    GameData: OleVariant;
begin
    // Use caller's role to validate security
    CheckCallerSecurity;
    // Get shared property group for this object
    SPG := GetSharedPropertyGroup;
    // Create or retrieve NextGameID shared property
    SProp := SPG.CreateProperty('NextGameID', Exists);
    if Exists then GameID := SProp.Value
    else GameID := 0;
    // Increment and store NextGameID shared property
    SProp.Value := GameID + 1;
    // Create game data array
    GameData := VarArrayCreate([1, 3, 1, 3], varByte);
    SProp := SPG.CreateProperty(Format(GameDataStr, [GameID]), Exists);
    SProp.Value := GameData;
    SetComplete;
end;
```

This method first checks to ensure the caller is in the proper role to invoke this method (more on this in a moment). It then uses a shared property to obtain an ID number for the next game. Next, this method creates a variant array into which to store game data and saves that data as a shared property. Finally, this method calls `SetComplete()` so that MTS knows it's okay to deactivate this instance after the method returns.

This leads to the number one rule of MTS development: Call `SetComplete()` or `SetAbort()` as often as possible. Ideally, you will call `SetComplete()` or `SetAbort()` in every method so that MTS can reclaim resources previously consumed by your component instance after the method returns. A corollary to this rule is that object activation and deactivation should not be expensive, because that code is likely to be called quite frequently.

The implementation of the `CheckCallerSecurity()` method illustrates how easy it is to take advantage of role-based security in MTS:

```
procedure TGameServer.CheckCallerSecurity;
begin
  // Just for fun, only allow those in the "TTT" role to play the game.
  if IsSecurityEnabled and not IsCallerInRole('TTT') then
    raise Exception.Create('Only those in the TTT role can play tic-tac-toe');
end;
```

This code begs the obvious question, “How does one establish the TTT role and determine what users belong to that role?” Although it’s possible to define roles programmatically, the most straightforward way to add and configure roles is using the Windows NT Transaction Server Explorer. After the component is installed (you’ll learn how to install the component shortly), you can set up roles using the “Roles” node found under each package node in the Explorer. It’s important to note that roles-based security is supported only for components running on Windows NT. For components running on Windows 9x, `IsCallerInRole()` will always return `True`.

The `ComputerMove()` and `PlayerMove()` methods are shown in the following code:

```
procedure TGameServer.ComputerMove(GameID: Integer;
  SkillLevel: SkillLevels; out X, Y: Integer; out GameRez: GameResults);
var
  Exists: WordBool;
  PropVal: OleVariant;
  GameData: PGameData;
  SProp: ISharedProperty;
begin
  // Get game data shared property
  SProp := GetSharedPropertyGroup.CreateProperty(Format(GameDataStr, [GameID]),
    Exists);
  // Get game data array and lock it for more efficient access
  PropVal := SProp.Value;
  GameData := PGameData(VarArrayLock(PropVal));
  try
    // If game isn't over, then let computer make a move
    GameRez := CalcGameStatus(GameData);
    if GameRez = grInProgress then
      begin
        CalcComputerMove(GameData, SkillLevel, X, Y);
        // Save away new game data array
        SProp.Value := PropVal;
        // Check for end of game
        GameRez := CalcGameStatus(GameData);
      end;
  end;
```

```
        finally
            VarArrayUnlock(PropVal);
        end;
        SetComplete;
    end;

procedure TGameServer.PlayerMove(GameID, X, Y: Integer;
    out GameRez: GameResults);
var
    Exists: WordBool;
    PropVal: OleVariant;
    GameData: PGameData;
    SProp: ISharedProperty;
begin
    // Get game data shared property
    SProp := GetSharedPropertyGroup.CreateProperty(Format(GameDataStr, [GameID]),
        Exists);
    // Get game data array and lock it for more efficient access
    PropVal := SProp.Value;
    GameData := PGameData(VarArrayLock(PropVal));
    try
        // Make sure game isn't over
        GameRez := CalcGameStatus(GameData);
        if GameRez = grInProgress then
            begin
                // If spot isn't empty, raise exception
                if GameData[X, Y] <> EmptySpot then
                    raise Exception.Create('Spot is occupied!');
                // Allow move
                GameData[X, Y] := PlayerSpot;
                // Save away new game data array
                SProp.Value := PropVal;
                // Check for end of game
                GameRez := CalcGameStatus(GameData);
            end;
        finally
            VarArrayUnlock(PropVal);
        end;
        SetComplete;
    end;
end;
```

These methods are similar in that they both obtain the game data from the shared property based on the GameID parameter, manipulate the data to reflect the current move, save the data away again, and check to see whether the game is over. The ComputerMove() method also calls CalcComputerMove() to analyze the game and make a move. If you're interested in seeing this and the other logic of this MTS component, take a look at Listing 23.15, which contains the entire source code for the ServMain unit.

LISTING 23.15 ServMain.pas: Containing TGameServer

```
unit ServMain;

interface

uses
  ActiveX, MtsObj, Mtx, ComObj, TTTServer_TLB;

type
  PGameData = ^TGameData;
  TGameData = array[1..3, 1..3] of Byte;

  TGameServer = class(TMtsAutoObject, IGameServer)
  private
    procedure CalcComputerMove(GameData: PGameData; Skill: SkillLevels;
      var X, Y: Integer);
    function CalcGameStatus(GameData: PGameData): GameResults;
    function GetSharedPropertyGroup: ISharedPropertyGroup;
    procedure CheckCallerSecurity;
  protected
    procedure NewGame(out GameID: Integer); safecall;
    procedure ComputerMove(GameID: Integer; SkillLevel: SkillLevels; out X,
      Y: Integer; out GameRez: GameResults); safecall;
    procedure PlayerMove(GameID, X, Y: Integer; out GameRez: GameResults);
      safecall;
  end;

implementation

uses ComServ, Windows, SysUtils;

const
  GameDataStr = 'TTTGameData%d';
  EmptySpot = 0;
  PlayerSpot = $1;
  ComputerSpot = $2;

function TGameServer.GetSharedPropertyGroup: ISharedPropertyGroup;
var
  SPGMgr: ISharedPropertyGroupManager;
  LockMode, RelMode: Integer;
  Exists: WordBool;
begin
  if ObjectContext = nil then
    raise Exception.Create('Failed to obtain object context');
```

continues

LISTING 23.15 Continued

```
// Create shared property group for this object
OleCheck(ObjectContext.CreateInstance(CLASS_SharedPropertyGroupManager,
  ISharedPropertyGroupManager, SPGMgr));
LockMode := LockSetGet;
RelMode := Process;
Result := SPGMgr.CreatePropertyGroup('DelphiTTT', LockMode, RelMode, Exists);
if Result = nil then
  raise Exception.Create('Failed to obtain property group');
end;

procedure TGameServer.NewGame(out GameID: Integer);
var
  SPG: ISharedPropertyGroup;
  SProp: ISharedProperty;
  Exists: WordBool;
  GameData: OleVariant;
begin
  // Use caller's role to validate security
  CheckCallerSecurity;
  // Get shared property group for this object
  SPG := GetSharedPropertyGroup;
  // Create or retrieve NextGameID shared property
  SProp := SPG.CreateProperty('NextGameID', Exists);
  if Exists then GameID := SProp.Value
  else GameID := 0;
  // Increment and store NextGameID shared property
  SProp.Value := GameID + 1;
  // Create game data array
  GameData := VarArrayCreate([1, 3, 1, 3], varByte);
  SProp := SPG.CreateProperty(Format(GameDataStr, [GameID]), Exists);
  SProp.Value := GameData;
  SetComplete;
end;

procedure TGameServer.ComputerMove(GameID: Integer;
  SkillLevel: SkillLevels; out X, Y: Integer; out GameRez: GameResults);
var
  Exists: WordBool;
  PropVal: OleVariant;
  GameData: PGameData;
  SProp: ISharedProperty;
begin
  // Get game data shared property
  SProp := GetSharedPropertyGroup.CreateProperty(Format(GameDataStr, [GameID]),
    Exists);
```

```

// Get game data array and lock it for more efficient access
PropVal := SProp.Value;
GameData := PGameData(VarArrayLock(PropVal));
try
  // If game isn't over, then let computer make a move
  GameRez := CalcGameStatus(GameData);
  if GameRez = grInProgress then
    begin
      CalcComputerMove(GameData, SkillLevel, X, Y);
      // Save away new game data array
      SProp.Value := PropVal;
      // Check for end of game
      GameRez := CalcGameStatus(GameData);
    end;
finally
  VarArrayUnlock(PropVal);
end;
SetComplete;
end;

procedure TGameServer.PlayerMove(GameID, X, Y: Integer;
  out GameRez: GameResults);
var
  Exists: WordBool;
  PropVal: OleVariant;
  GameData: PGameData;
  SProp: ISharedProperty;
begin
  // Get game data shared property
  SProp := GetSharedPropertyGroup.CreateProperty(Format(GameDataStr, [GameID]),
    Exists);
  // Get game data array and lock it for more efficient access
  PropVal := SProp.Value;
  GameData := PGameData(VarArrayLock(PropVal));
  try
    // Make sure game isn't over
    GameRez := CalcGameStatus(GameData);
    if GameRez = grInProgress then
      begin
        // If spot isn't empty, raise exception
        if GameData[X, Y] <> EmptySpot then
          raise Exception.Create('Spot is occupied!');
        // Allow move
        GameData[X, Y] := PlayerSpot;
        // Save away new game data array
        SProp.Value := PropVal;

```

LISTING 23.15 Continued

```
        // Check for end of game
        GameRez := CalcGameStatus(GameData);
    end;
finally
    VarArrayUnlock(PropVal);
end;
SetComplete;
end;

function TGameServer.CalcGameStatus(GameData: PGameData): GameResults;
var
    I, J: Integer;
begin
    // First check for a winner
    if GameData[1, 1] <> EmptySpot then
    begin
        // Check top row, left column, and top left to bottom right diagonal for
        win
        if ((GameData[1, 1] = GameData[1, 2]) and (GameData[1, 1] = GameData[1,
            3])) or ((GameData[1, 1] = GameData[2, 1]) and (GameData[1, 1] = GameData[3,
            1])) or ((GameData[1, 1] = GameData[2, 2]) and (GameData[1, 1] =
            GameData[3, 3])) then
        begin
            Result := GameData[1, 1] + 1; // Game result is spot ID + 1
            Exit;
        end;
    end;
    if GameData[3, 3] <> EmptySpot then
    begin
        // Check bottom row and right column for win
        if ((GameData[3, 3] = GameData[3, 2]) and (GameData[3, 3] =
            GameData[3, 1])) or
            ((GameData[3, 3] = GameData[2, 3]) and (GameData[3, 3] =
            GameData[1, 3])) then
        begin
            Result := GameData[3, 3] + 1; // Game result is spot ID + 1
            Exit;
        end;
    end;
    if GameData[2, 2] <> EmptySpot then
    begin
        // Check middle row, middle column, and bottom left to top right diagonal
        for win
        if ((GameData[2, 2] = GameData[2, 1]) and (GameData[2, 2] =
            GameData[2, 3])) or
```

```

        ((GameData[2, 2] = GameData[1, 2]) and (GameData[2, 2] =
        GameData[3, 2])) or
        ((GameData[2, 2] = GameData[3, 1]) and (GameData[2, 2] =
        GameData[1, 3])) then
begin
    Result := GameData[2, 2] + 1; // Game result is spot ID + 1
    Exit;
end;
end;
// Finally, check for game still in progress
for I := 1 to 3 do
    for J := 1 to 3 do
        if GameData[I, J] = 0 then
            begin
                Result := grInProgress;
                Exit;
            end;
        // If we get here, then we've tied
        Result := grTie;
end;

procedure TGameServer.CalcComputerMove(GameData: PGameData;
    Skill: SkillLevels; var X, Y: Integer);
type
    // Used to scan for possible moves by either row, column, or diagonal line
    TCalcType = (ctRow, ctColumn, ctDiagonal);
    // mtWin = one move away from win, mtBlock = opponent is one move away from
    // win, mtOne = I occupy one other spot in this line, mtNew = I occupy no
    // spots on this line
    TMoveType = (mtWin, mtBlock, mtOne, mtNew);
var
    CurrentMoveType: TMoveType;

function DoCalcMove(CalcType: TCalcType; Position: Integer): Boolean;
var
    RowData, I, J, CheckTotal: Integer;
    PosVal, Mask: Byte;
begin
    Result := False;
    RowData := 0;
    X := 0;
    Y := 0;
    if CalcType = ctRow then
        begin
            I := Position;
            J := 1;

```

LISTING 23.15 Continued

```
end
else if CalcType = ctColumn then
begin
  I := 1;
  J := Position;
end
else begin
  I := 1;
  case Position of
    1: J := 1; // scanning from top left to bottom right
    2: J := 3; // scanning from top right to bottom left
  else
    Exit; // bail; only 2 diagonal scans
  end;
end;
// Mask masks off Player or Computer bit, depending on whether we're
// thinking
// offensively or defensively. Checktotal determines whether that is a row
// we need to move into.
case CurrentMoveType of
  mtWin:
  begin
    Mask := PlayerSpot;
    CheckTotal := 4;
  end;
  mtNew:
  begin
    Mask := PlayerSpot;
    CheckTotal := 0;
  end;
  mtBlock:
  begin
    Mask := ComputerSpot;
    CheckTotal := 2;
  end;
else
  begin
    Mask := 0;
    CheckTotal := 2;
  end;
end;
// loop through all lines in current CalcType
repeat
  // Get status of current spot (X, O, or empty)
  PosVal := GameData[I, J];
```

```

// Save away last empty spot in case we decide to move here
if PosVal = 0 then
begin
  X := I;
  Y := J;
end
else
  // If spot isn't empty, then add masked value to RowData
  Inc(RowData, (PosVal and not Mask));
if (CalcType = ctDiagonal) and (Position = 2) then
begin
  Inc(I);
  Dec(J);
end
else begin
  if CalcType in [ctRow, ctDiagonal] then Inc(J);
  if CalcType in [ctColumn, ctDiagonal] then Inc(I);
end;
until (I > 3) or (J > 3);
// If RowData adds up, then we must block or win, depending on
// whether we're thinking offensively or defensively.
Result := (X <> 0) and (RowData = CheckTotal);
if Result then
begin
  GameData[X, Y] := ComputerSpot;
  Exit;
end;
end;
end;

```

```

var
  A, B, C: Integer;
begin
  if Skill = slAwake then
  begin
    // First look to win the game, next look to block a win
    for A := Ord(mtWin) to Ord(mtBlock) do
    begin
      CurrentMoveType := TMoveType(A);
      for B := Ord(ctRow) to Ord(ctDiagonal) do
        for C := 1 to 3 do
          if DoCalcMove(TCalcType(B), C) then Exit;
        end;
      // Next look to take the center of the board
      if GameData[2, 2] = 0 then
      begin
        GameData[2, 2] := ComputerSpot;

```

LISTING 23.15 Continued

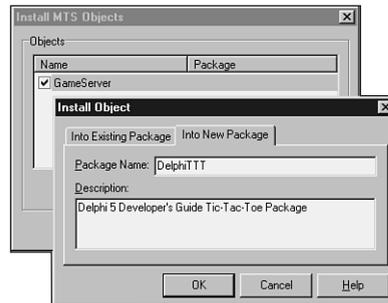
```
    X := 2;
    Y := 2;
    Exit;
end;
// Next look for the most advantageous position on a line
for A := Ord(mtOne) to Ord(mtNew) do
begin
    CurrentMoveType := TMoveType(A);
    for B := Ord(ctRow) to Ord(ctDiagonal) do
        for C := 1 to 3 do
            if DoCalcMove(TCalcType(B), C) then Exit;
        end;
    end;
end;
// Finally (or if skill level is unconscious), just find the first open place
for A := 1 to 3 do
    for B := 1 to 3 do
        if GameData[A, B] = 0 then
            begin
                GameData[A, B] := ComputerSpot;
                X := A;
                Y := B;
                Exit;
            end;
        end;
    end;
end;

procedure TGameServer.CheckCallerSecurity;
begin
    // Just for fun, only allow those in the "TTT" role to play the game.
    if IsSecurityEnabled and not IsCallerInRole('TTT') then
        raise Exception.Create('Only those in the TTT role can play tic-tac-toe');
end;

initialization
    TAutoObjectFactory.Create(ComServer, TGameServer, Class_GameServer,
        ciMultiInstance, tmApartment);
end.
```

Installing the Server

Once the server has been written and you're ready to install it into MTS, Delphi makes your life very easy. Simply select Run, Install MTS Objects from the main menu, and you will invoke the Install MTS Objects dialog. This dialog enables you to install your object(s) into a new or existing package, and it is shown in Figure 23.21.

**FIGURE 23.21**

Installing an MTS object via the Delphi IDE.

Select the component(s) to be installed, specify whether the package is new or existing, click OK, and that's it; the component is installed. Alternatively, you can also install MTS components via the Transaction Server Explorer application. Note that this installation procedure is markedly different than that of standard COM objects, which typically involves using the RegSvr32 tool from the command line to register a COM server. Transaction Server Explorer also makes it similarly easy to set up MTS components on remote machines, providing a welcome alternative to the configuration hell experienced by many of those trying to configure DCOM connectivity.

The Client Application

Listing 23.16 shows the source code for the client application for this MTS component. Its purpose is to essentially map the engine provided by the MTS component to a tic-tac-toe-looking user interface.

LISTING 23.16 UiMain.pas: The Main Unit for the Client Application

```
unit UiMain;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  Buttons, ExtCtrls, Menus, TTTServer_TLB, ComCtrls;

type
  TRecord = record
    Wins, Loses, Ties: Integer;
  end;
```

continues

LISTING 23.16 Continued

```
TFrmMain = class(TForm)
  SbTL: TSpeedButton;
  SbTM: TSpeedButton;
  SbTR: TSpeedButton;
  SbMM: TSpeedButton;
  SbBL: TSpeedButton;
  SbBR: TSpeedButton;
  SbMR: TSpeedButton;
  SbBM: TSpeedButton;
  SbML: TSpeedButton;
  Bevel1: TBevel;
  Bevel2: TBevel;
  Bevel3: TBevel;
  Bevel4: TBevel;
  MainMenu1: TMainMenu;
  FileItem: TMenuItem;
  HelpItem: TMenuItem;
  ExitItem: TMenuItem;
  AboutItem: TMenuItem;
  SkillItem: TMenuItem;
  UnconItem: TMenuItem;
  AwakeItem: TMenuItem;
  NewGameItem: TMenuItem;
  N1: TMenuItem;
  StatusBar: TStatusBar;
  procedure FormCreate(Sender: TObject);
  procedure ExitItemClick(Sender: TObject);
  procedure SkillItemClick(Sender: TObject);
  procedure AboutItemClick(Sender: TObject);
  procedure SBClick(Sender: TObject);
  procedure NewGameItemClick(Sender: TObject);
private
  FXImage: TBitmap;
  FOImage: TBitmap;
  FCurrentSkill: Integer;
  FGameID: Integer;
  FGameServer: IGameServer;
  FRec: TRecord;
  procedure TagToCoord(ATag: Integer; var Coords: TPoint);
  function CoordToCtl(const Coords: TPoint): TSpeedButton;
  procedure DoGameResult(GameRez: GameResults);
end;

var
  FrmMain: TFrmMain;
```

```
implementation

uses UiAbout;

{$R *.DFM}

{$R xo.res}

const
  RecStr = 'Wins: %d, Loses: %d, Ties: %d';

procedure TFrmMain.FormCreate(Sender: TObject);
begin
  // load "X" and "O" images from resource into TBitmaps
  FXImage := TBitmap.Create;
  FXImage.LoadFromResourceName(MainInstance, 'x_img');
  FOImage := TBitmap.Create;
  FOImage.LoadFromResourceName(MainInstance, 'o_img');
  // set default skill
  FCurrentSkill := slAwake;
  // init record UI
  with FRec do
    StatusBar.SimpleText := Format(RecStr, [Wins, Loses, Ties]);
  // Get server instance
  FGameServer := CoGameServer.Create;
  // Start a new game
  FGameServer.NewGame(FGameID);
end;

procedure TFrmMain.ExitItemClick(Sender: TObject);
begin
  Close;
end;

procedure TFrmMain.SkillItemClick(Sender: TObject);
begin
  with Sender as TMenuItem do
    begin
      Checked := True;
      FCurrentSkill := Tag;
    end;
end;

procedure TFrmMain.AboutItemClick(Sender: TObject);
begin
  // Show About box
```

LISTING 23.16 Continued

```
with TFrmAbout.Create(Application) do
  try
    ShowModal;
  finally
    Free;
  end;
end;

procedure TFrmMain.TagToCoord(ATag: Integer; var Coords: TPoint);
begin
  case ATag of
    0: Coords := Point(1, 1);
    1: Coords := Point(1, 2);
    2: Coords := Point(1, 3);
    3: Coords := Point(2, 1);
    4: Coords := Point(2, 2);
    5: Coords := Point(2, 3);
    6: Coords := Point(3, 1);
    7: Coords := Point(3, 2);
  else
    Coords := Point(3, 3);
  end;
end;

function TFrmMain.CoordToCtl(const Coords: TPoint): TSpeedButton;
begin
  Result := nil;
  with Coords do
    case X of
      1:
        case Y of
          1: Result := SbTL;
          2: Result := SbTM;
          3: Result := SbTR;
        end;
      2:
        case Y of
          1: Result := SbML;
          2: Result := SbMM;
          3: Result := SbMR;
        end;
      3:
        case Y of
          1: Result := SbBL;
          2: Result := SbBM;
        end;
    end;
end;
```

```

        3: Result := SbBR;
    end;
end;
end;

procedure TFrmMain.SBClick(Sender: TObject);
var
    Coords: TPoint;
    GameRez: GameResults;
    SB: TSpeedButton;
begin
    if Sender is TSpeedButton then
    begin
        SB := TSpeedButton(Sender);
        if SB.Glyph.Empty then
        begin
            with SB do
            begin
                TagToCoord(Tag, Coords);
                FGameServer.PlayerMove(FGameID, Coords.X, Coords.Y, GameRez);
                Glyph.Assign(FXImage);
            end;
            if GameRez = grInProgress then
            begin
                FGameServer.ComputerMove(FGameID, FCurrentSkill, Coords.X,
                    Coords.Y, GameRez);
                CoordToCtl(Coords).Glyph.Assign(FOImage);
            end;
            DoGameResult(GameRez);
        end;
    end;
end;

procedure TFrmMain.NewGameItemClick(Sender: TObject);
var
    I: Integer;
begin
    FGameServer.NewGame(FGameID);
    for I := 0 to ControlCount - 1 do
        if Controls[I] is TSpeedButton then
            TSpeedButton(Controls[I]).Glyph := nil;
    end;
end;

procedure TFrmMain.DoGameResult(GameRez: GameResults);
const
    EndMsg: array[grTie..grComputerWin] of string = (

```

LISTING 23.16 Continued

```
'Tie game', 'You win', 'Computer wins');  
begin  
  if GameRez <> grInProgress then  
  begin  
    case GameRez of  
      grComputerWin: Inc(FRec.Loses);  
      grPlayerWin: Inc(FRec.Wins);  
      grTie: Inc(FRec.Ties);  
    end;  
    with FRec do  
      StatusBar.SimpleText := Format(RecStr, [Wins, Loses, Ties]);  
      if MessageDlg(Format('%s! Play again?', [EndMsg[GameRez]]), mtConfirmation,  
        [mbYes, mbNo], 0) = mrYes then  
        NewGameItemClick(nil);  
    end;  
  end;  
end.  
end.
```

Figure 23.22 shows this application in action. The user is X, and the computer is O.

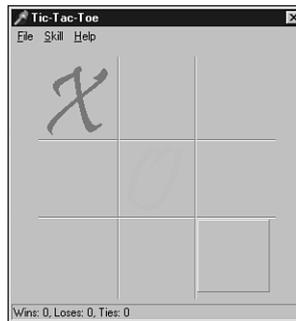


FIGURE 23.22

Playing tic-tac-toe.

Debugging MTS Applications

Because MTS components run within MTS's process space rather than the client's, you might think that they would be difficult to debug. However, MTS provides a side door for debugging purposes that makes debugging a snap. Just load the server project and use the Run Parameters dialog to specify `mtx.exe` as the host application. As a parameter to `mtx.exe`, you must pass

/p:{package guid}, where “package guid” is the GUID of the package as shown in the Transaction Server Explorer. This dialog is shown in Figure 23.23. Next, set your desired breakpoints and run the application. You won’t see anything happen initially because the client application is not yet running. Now you can run the client from Windows Explorer or a command prompt, and you will be off and debugging.

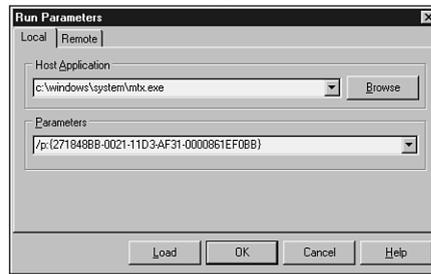


FIGURE 23.23

Using the Run Parameters dialog to set up an MTS debug session.

MTS is a powerful addition to the COM family of technologies. By adding services such as lifetime management, transaction support, security, and transactions to COM objects without requiring significant changes to existing source code, Microsoft has leveraged COM into a more scalable technology, suitable for large-scale distributed development. This section took you through a tour of the basics of MTS and on to the specifics of Delphi’s support for MTS and how to create MTS applications in Delphi. What’s more, you’ve hopefully caught a few tips and tricks along the way for developing optimized and well-behaved MTS components. MTS packs a wallop out of the box by providing services such as lifetime management, transaction support, and security, all in a familiar framework. MTS and Delphi combine to provide you with a great way to leverage your COM experience into creating scalable multitier applications. Just don’t forget those differences in design nuances between normal COM components and MTS components!

T0leContainer

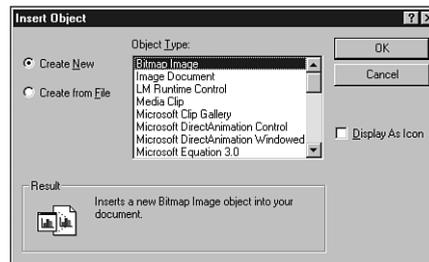
Now that you have some ActiveX OLE background under your belt, take a look at Delphi’s T0leContainer class. T0leContainer is located in the 0leCntrs unit, and it encapsulates the complexities of an OLE Document and ActiveX Document container into an easily digestible VCL component.

NOTE

If you were familiar with using Delphi 1.0's `TOLEContainer` component, you can pretty much throw that knowledge out the window. The 32-bit version of this component was redesigned from the ground up (as they say in the car commercials), so any knowledge you have of the 16-bit version of this component may not be applicable to the 32-bit version. Don't let that scare you, though; the 32-bit version of this component is of a much cleaner design, and you'll find that the code you must write to support the object is perhaps a quarter of what it used to be.

A Small Sample Application

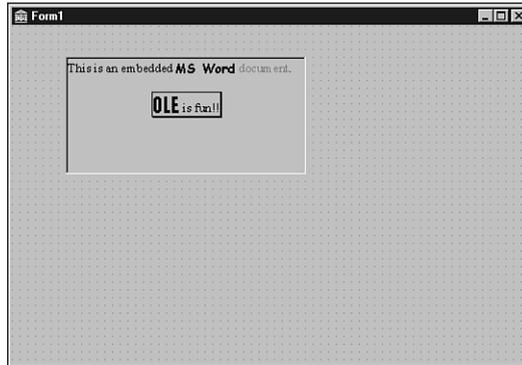
Now let's jump right in and create an OLE container application. Create a new project and drop a `TOLEContainer` object (found on the System page of the Component Palette) on the form. Right-click the object in the Form Designer and select `Insert Object` from the local menu. This invokes the `Insert Object` dialog, as shown in Figure 23.24.

**FIGURE 23.24**

The Insert Object dialog.

Embedding a New OLE Object

By default, the `Insert Object` dialog contains the names of OLE server applications registered with Windows. To embed a new OLE object, you can select a server application from the `Object Type` list box. This causes the OLE server to execute in order to create a new OLE object to be inserted into `TOLEContainer`. When you close the server application, the `TOLEContainer` object is updated with the embedded object. For this example, we will create a new MS Word 2000 document, as shown in Figure 23.25.

**FIGURE 23.25**

An embedded MS Word 2000 document.

NOTE

An OLE object will not activate in place at design time. You will only be able to take advantage of the in-place activation capability of `TOLEContainer` at runtime.

If you want to invoke the Insert Object dialog at runtime, you can call the `InsertObjectDialog()` method of `TOLEContainer`, which is defined as follows:

```
function InsertObjectDialog: Boolean;
```

This function returns `True` if a new type of OLE object was successfully chosen from the dialog.

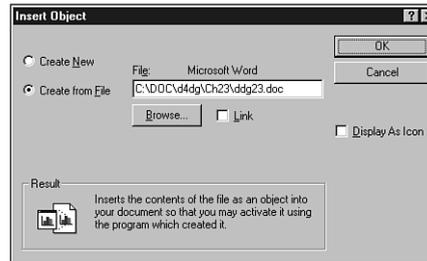
Embedding or Linking an Existing OLE File

To embed an existing OLE file into the `TOLEContainer`, select the Create From File radio button on the Insert Object dialog. This enables you to pick an existing file, as shown in Figure 23.26. After you choose the file, it behaves much the same as a new OLE object.

To embed a file at runtime, call the `CreateObjectFromFile()` method of `TOLEContainer`, which is defined as follows:

```
procedure CreateObjectFromFile(const FileName: string; Iconic: Boolean);
```

To link (rather than embed) the OLE object, simply check the Link check box in the Insert Object dialog shown in Figure 23.26. As described earlier, this creates a link from your application to the OLE file so that you can edit and view the same linked object from multiple applications.

**FIGURE 23.26**

Inserting an object from a file.

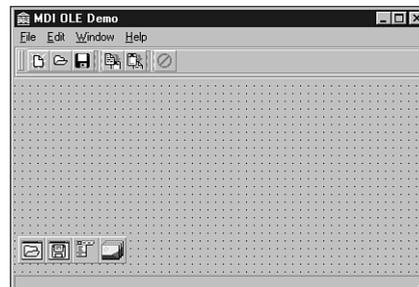
To link to a file at runtime, call the `CreateLinkToFile()` method of `TOLEContainer`, which is defined as follows:

```
procedure CreateLinkToFile(const FileName: string; Iconic: Boolean);
```

A Bigger Sample Application

Now that you have the basics of OLE and the `TOLEContainer` class behind you, we will create a more sizable application that truly reflects the usage of OLE in realistic applications.

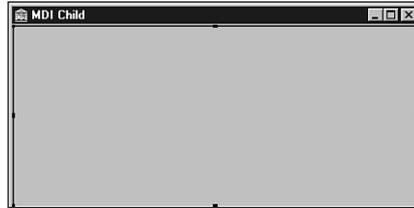
Start by creating a new project based on the MDI application template. The main form makes only a few modifications to the standard MDI template, and it is shown in Figure 23.27.

**FIGURE 23.27**

The MDI OLE Demo main window.

The MDI child form is shown in Figure 23.28. It is simply an `fsmDIChild`-style form with a `TOLEContainer` component aligned to `alClient`.

Listing 23.17 shows `ChildWin.pas`, the source code unit for the MDI child form. Note that this unit is fairly standard except for the addition of the `OLEFileName` property and the associated method and `private` instance variable. This property stores the path and filename of the OLE file, and the property accessor sets the child form's caption to the filename.

**FIGURE 23.28**

The MDI OLE Demo child window.

LISTING 23.17 The Source Code for ChildWin.pas

```
unit Childwin;

interface

uses WinTypes, WinProcs, Classes, Graphics, Forms, Controls, OleCtnrs;

type
  TMDIChild = class(TForm)
    OleContainer: TOleContainer;
    procedure FormClose(Sender: TObject; var Action: TCloseAction);
  private
    FOLEFileName: String;
    procedure SetOLEFileName(const Value: String);
  public
    property OLEFileName: String read FOLEFileName write SetOLEFileName;
  end;

implementation

{$R *.DFM}

uses Main, SysUtils;

procedure TMDIChild.SetOLEFileName(const Value: String);
begin
  if Value <> FOLEFileName then begin
    FOLEFileName := Value;
    Caption := ExtractFileName(FOLEFileName);
  end;
end;

procedure TMDIChild.FormClose(Sender: TObject; var Action: TCloseAction);
```

continues

LISTING 23.17 Continued

```
begin
  Action := caFree;
end;

end.
```

Creating a Child Form

When a new MDI child form is created from the File, New menu of the MDI OLE Demo application, the Insert Object dialog is invoked using the `InsertObjectDialog()` method mentioned earlier. Additionally, a caption is assigned to the MDI child form using a global variable called `NumChildren` to provide a unique number. The following code shows the main form's `CreateMDIChild()` method:

```
procedure TMainForm.FileNewItemClick(Sender: TObject);
begin
  inc(NumChildren);
  { create a new MDI child window }
  with TMDIChild.Create(Application) do
  begin
    Caption := 'Untitled' + IntToStr(NumChildren);
    { bring up insert OLE object dialog and insert into child }
    OleContainer.InsertObjectDialog;
  end;
end;
```

Saving to and Reading from Files

As discussed earlier in this chapter, OLE objects lend themselves to the capability of being written to and read from streams and, therefore, files. The `TOleContainer` component has the methods `SaveToStream()`, `LoadFromStream()`, `SaveToFile()`, and `LoadFromFile()`, which make saving an OLE object out to a file or stream very easy.

The MDIOLE application's main form contains methods for saving and opening OLE object files. The following code shows the `FileOpenItemClick()` method, which is called in response to choosing File, Open from the main form. In addition to loading a saved OLE object from a file specified by `OpenDialog`, this method also assigns the `OleFileName` field of the `TMDIChild` instance to the filename provided by `OpenDialog`. If an error occurs loading the file, the form instance is freed. Here's the code:

```
procedure TMainForm.FileOpenItemClick(Sender: TObject);
begin
  if OpenDialog.Execute then
  with TMDIChild.Create(Application) do
  begin
```

```

    try
      OleFileName := OpenDialog.FileName;
      OleContainer.LoadFromFile(OleFileName);
      Show;
    except
      Release; // free form on error
      raise; // reraise exception
    end;
  end;
end;

```

The following code handles the File, Save As and File, Save menu items. Note that the `FileSaveItemClick()` method invokes `FileSaveAsItemClick()` when the active MDI child does not have a name specified. Here's the code:

```

procedure TMainForm.FileSaveAsItemClick(Sender: TObject);
begin
  if (ActiveMDIChild <> Nil) and (SaveDialog.Execute) then
    with TMDIChild(ActiveMDIChild) do
      begin
        OleFileName := SaveDialog.FileName;
        OleContainer.SaveToFile(OleFileName);
      end;
    end;
end;

```

```

procedure TMainForm.FileSaveItemClick(Sender: TObject);
begin
  if ActiveMDIChild <> Nil then
    { if no name is assigned, then do a "save as" }
    if TMDIChild(ActiveMDIChild).OLEFileName = '' then
      FileSaveAsItemClick(Sender)
    else
      { otherwise save under current name }
      with TMDIChild(ActiveMDIChild) do
        OleContainer.SaveToFile(OLEFileName);
      end;
  end;
end;

```

Using the Clipboard to Copy and Paste

Thanks to the universal data-transfer mechanism described earlier, it also is possible to use the Windows Clipboard to transfer OLE objects. Again, the `TOLEContainer` component automates these tasks to a great degree.

Copying an OLE object from a `TOLEContainer` to the Clipboard, in particular, is a trivial task. Simply call the `Copy()` method:

```

procedure TMainForm.CopyItemClick(Sender: TObject);
begin
  if ActiveMDIChild <> Nil then

```

```
TMDIChild(ActiveMDIChild).OleContainer.Copy;  
end;
```

After you think you have an OLE object on the Clipboard, only one additional step is required to properly read it out into a `TOLEContainer` component. Prior to attempting to paste the contents of the Clipboard into a `TOLEContainer`, you should first check the value of the `CanPaste` property to ensure that the data on the Clipboard is a suitable OLE object. After that, you can invoke the Paste Special dialog to paste the object into the `TOLEContainer` by calling its `PasteSpecialDialog()` method, as shown in the following code (the Paste Special dialog is shown in Figure 23.29):

```
procedure TMainForm.PasteItemClick(Sender: TObject);  
begin  
  if ActiveMDIChild <> nil then  
    with TMDIChild(ActiveMDIChild).OleContainer do  
      { Before invoking dialog, check to be sure that there }  
      { are valid OLE objects on the clipboard. }  
      if CanPaste then PasteSpecialDialog;  
    end;  
end;
```

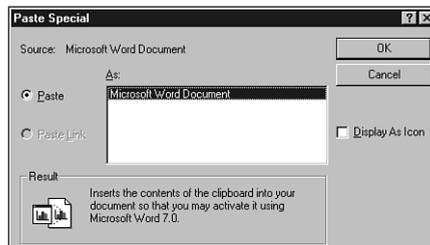
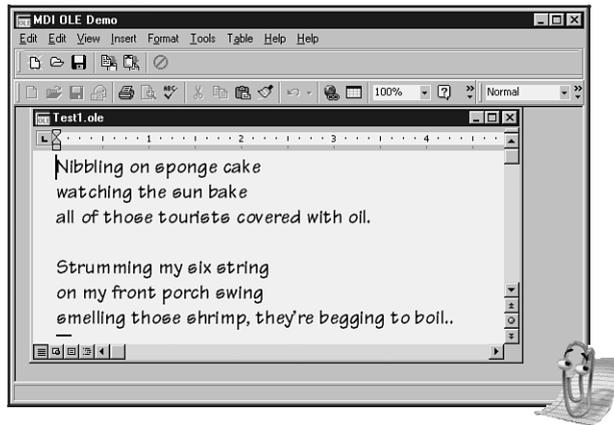


FIGURE 23.29

The Paste Special dialog box.

When the application is run, the server controlling the OLE object in the active MDI child merges with or takes control of the application's menu and toolbar. Figures 23.30 and 23.31 show OLE's in-place activation feature—the MDI OLE application is controlled by two different OLE servers.

**FIGURE 23.30**

Editing an embedded Word 2000 document.

**FIGURE 23.31**

Editing an embedded Paint graphic.

The complete listing for `Main.pas`, the MDI OLE application's main unit, is shown in Listing 23.18.

LISTING 23.18 The source code for Main.pas

```
unit Main;

interface

uses WinTypes, WinProcs, SysUtils, Classes, Graphics, Forms, Controls, Menus,
    StdCtrls, Dialogs, Buttons, Messages, ExtCtrls, ChildWin, ComCtrls,
    ToolWin;

type
    TMainForm = class(TForm)
        MainMenu1: TMainMenu;
        File1: TMenuItem;
        FileNewItem: TMenuItem;
        FileOpenItem: TMenuItem;
        FileCloseItem: TMenuItem;
        Window1: TMenuItem;
        Help1: TMenuItem;
        N1: TMenuItem;
        FileExitItem: TMenuItem;
        WindowCascadeItem: TMenuItem;
        WindowTileItem: TMenuItem;
        WindowArrangeItem: TMenuItem;
        HelpAboutItem: TMenuItem;
        OpenDialog: TOpenDialog;
        FileSaveItem: TMenuItem;
        FileSaveAsItem: TMenuItem;
        Edit1: TMenuItem;
        PasteItem: TMenuItem;
        WindowMinimizeItem: TMenuItem;
        SaveDialog: TSaveDialog;
        CopyItem: TMenuItem;
        CloseAll1: TMenuItem;
        StatusBar: TStatusBar;
        CoolBar1: TCoolBar;
        ToolBar1: TToolBar;
        OpenBtn: TToolButton;
        SaveBtn: TToolButton;
        ToolButton3: TToolButton;
        CopyBtn: TToolButton;
        PasteBtn: TToolButton;
        ToolButton6: TToolButton;
        ExitBtn: TToolButton;
        ImageList1: TImageList;
        procedure FormCreate(Sender: TObject);
        procedure FileNewItemClick(Sender: TObject);
    end;
end;
```

```
    procedure WindowCascadeItemClick(Sender: TObject);
    procedure UpdateMenuItems(Sender: TObject);
    procedure WindowTileItemClick(Sender: TObject);
    procedure WindowArrangeItemClick(Sender: TObject);
    procedure FileCloseItemClick(Sender: TObject);
    procedure FileOpenItemClick(Sender: TObject);
    procedure FileExitItemClick(Sender: TObject);
    procedure FileSaveItemClick(Sender: TObject);
    procedure FileSaveAsItemClick(Sender: TObject);
    procedure PasteItemClick(Sender: TObject);
    procedure WindowMinimizeItemClick(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
    procedure HelpAboutItemClick(Sender: TObject);
    procedure CopyItemClick(Sender: TObject);
    procedure CloseAll1Click(Sender: TObject);
private
    procedure ShowHint(Sender: TObject);
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

uses About;

var
    NumChildren: Cardinal = 0;

procedure TMainForm.FormCreate(Sender: TObject);
begin
    Application.OnHint := ShowHint;
    Screen.OnActiveFormChange := UpdateMenuItems;
end;

procedure TMainForm.ShowHint(Sender: TObject);
begin
    { Show hints on status bar }
    StatusBar.Panels[0].Text := Application.Hint;
end;

procedure TMainForm.FileNewItemClick(Sender: TObject);
begin
    inc(NumChildren);
```

continues

LISTING 23.18 Continued

```
{ create a new MDI child window }
with TMDIChild.Create(Application) do
begin
  Caption := 'Untitled' + IntToStr(NumChildren);
  { bring up insert OLE object dialog and insert into child }
  OleContainer.InsertObjectDialog;
end;
end;

procedure TMainForm.FileOpenItemClick(Sender: TObject);
begin
  if OpenFileDialog.Execute then
    with TMDIChild.Create(Application) do
      begin
        try
          OleFileName := OpenFileDialog.FileName;
          OleContainer.LoadFromFile(OleFileName);
          Show;
        except
          Release; // free form on error
          raise; // reraise exception
        end;
      end;
    end;
end;

procedure TMainForm.FileCloseItemClick(Sender: TObject);
begin
  if ActiveMDIChild <> nil then
    ActiveMDIChild.Close;
end;

procedure TMainForm.FileSaveAsItemClick(Sender: TObject);
begin
  if (ActiveMDIChild <> nil) and (SaveDialog.Execute) then
    with TMDIChild(ActiveMDIChild) do
      begin
        OleFileName := SaveDialog.FileName;
        OleContainer.SaveToFile(OleFileName);
      end;
    end;
end;

procedure TMainForm.FileSaveItemClick(Sender: TObject);
begin
  if ActiveMDIChild <> nil then
    { if no name is assigned, then do a "save as" }
```

```
    if TMDIChild(ActiveMDIChild).OLEFileName = '' then
        FileSaveAsItemClick(Sender)
    else
        { otherwise save under current name }
        with TMDIChild(ActiveMDIChild) do
            OleContainer.SaveToFile(OLEFileName);
end;

procedure TMainForm.FileExitItemClick(Sender: TObject);
begin
    Close;
end;

procedure TMainForm.PasteItemClick(Sender: TObject);
begin
    if ActiveMDIChild <> nil then
        with TMDIChild(ActiveMDIChild).OleContainer do
            { Before invoking dialog, check to be sure that there }
            { are valid OLE objects on the clipboard. }
            if CanPaste then PasteSpecialDialog;
end;

procedure TMainForm.WindowCascadeItemClick(Sender: TObject);
begin
    Cascade;
end;

procedure TMainForm.WindowTileItemClick(Sender: TObject);
begin
    Tile;
end;

procedure TMainForm.WindowArrangeItemClick(Sender: TObject);
begin
    ArrangeIcons;
end;

procedure TMainForm.WindowMinimizeItemClick(Sender: TObject);
var
    I: Integer;
begin
    { Must be done backwards through the MDIChildren array }
    for I := MDIChildCount - 1 downto 0 do
        MDIChildren[I].WindowState := wsMinimized;
end;
```

continues

LISTING 23.18 Continued

```
procedure TMainForm.UpdateMenuItems(Sender: TObject);
var
  DoIt: Boolean;
begin
  DoIt := MDIChildCount > 0;
  { only enable options if there are active children }
  FileCloseItem.Enabled := DoIt;
  FileSaveItem.Enabled := DoIt;
  CloseAll1.Enabled := DoIt;
  FileSaveAsItem.Enabled := DoIt;
  CopyItem.Enabled := DoIt;
  PasteItem.Enabled := DoIt;
  CopyBtn.Enabled := DoIt;
  SaveBtn.Enabled := DoIt;
  PasteBtn.Enabled := DoIt;
  WindowCascadeItem.Enabled := DoIt;
  WindowTileItem.Enabled := DoIt;
  WindowArrangeItem.Enabled := DoIt;
  WindowMinimizeItem.Enabled := DoIt;
end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
  Screen.OnActiveFormChange := nil;
end;

procedure TMainForm.HelpAboutItemClick(Sender: TObject);
begin
  with TAboutBox.Create(Self) do
  begin
    ShowModal;
    Free;
  end;
end;

procedure TMainForm.CopyItemClick(Sender: TObject);
begin
  if ActiveMDIChild <> nil then
    TMDIChild(ActiveMDIChild).OleContainer.Copy;
end;

procedure TMainForm.CloseAll1Click(Sender: TObject);
begin
  while ActiveMDIChild <> nil do
```

```
begin
  ActiveMDIChild.Release;           // use Release, not Free!
  Application.ProcessMessages;      // let Windows take care of business
end;

end;
```

Summary

That wraps up this chapter on COM, OLE, and ActiveX. This chapter covered an enormous amount of information! First, you received a solid foundation in COM-based technologies, which should help you understand what goes on behind the scenes. Next, you got some insight and information on various types of COM clients and servers. Following that, you were immersed in various advanced techniques for Automation in Delphi. With all that under your belt, the chapter led you through the theory and practice of MTS. In addition to in-depth coverage of COM, Automation, and MTS, you should be familiar with the workings of VCL's `TOLEContainer` component.

If you'd like to know more about COM, you'll find more information on the COM and ActiveX technologies in other areas of this book. Chapter 24, "Extending the Windows Shell," shows real-world examples of COM server creation, and Chapter 25, "Creating ActiveX Controls," discusses ActiveX control creation in Delphi.

IN THIS CHAPTER

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- **Application Desktop Toolbars 1234**
- **Shell Links 1248**
- **Shell Extensions 1268**
- **Summary 1295**

First introduced in Windows 95, the Windows shell is also supported on Windows NT 3.51 (and higher), Windows 98, and Windows 2000. A far cry from Program Manager, the Windows shell includes some great features for extending the shell to meet your needs. Problem is, many of these nifty extensible features are some of the most poorly documented subjects of Win32 development. This chapter is intended to give you the information and examples you need to tap into shell features such as tray-notification icons, application desktop toolbars, shell links, and shell extensions.

A Tray-Notification Icon Component

This section illustrates a technique for encapsulating the Windows shell tray-notification icon cleanly into a Delphi component—called `TTrayNotifyIcon`—you'll learn about the API requirements for creating a tray-notification icon as well as how to tackle some of the hairy problems you'll come across as you work to embed all the icon's functionality within the component. If you're unfamiliar with what a tray-notification icon is, it's one of those little icons that appear in the bottom-right corner of the Windows system taskbar (assuming your taskbar is aligned to the bottom of your screen), as shown in Figure 24.1.



Tray-notification icons

FIGURE 24.1

Tray-notification icons.

The API

Believe it or not, only one API call is involved in creating, modifying, and removing tray-notification icons from the notification tray. The function is called `Shell_NotifyIcon()`. This and other functions dealing with the Windows shell are contained in the `ShellAPI` unit.

`Shell_NotifyIcon()` is defined as follows:

```
function Shell_NotifyIcon(dwMessage: DWORD; lpData:
    PNotifyIconData): BOOL; stdcall;
```

The `dwMessage` parameter describes the action to be taken for the icon. This can be any one of the values shown in Table 24.1.

TABLE 24.1 Values for the dwMessage Parameter

<i>Constant</i>	<i>Value</i>	<i>Meaning</i>
NIM_ADD	0	Add an icon to the notification tray.
NIM_MODIFY	1	Modify the properties of an existing icon.
NIM_DELETE	2	Remove an icon from the notification tray.

The lpData parameter is a pointer to a TNotifyIconData record. This record is defined as follows:

```
type
  TNotifyIconData = record
    cbSize: DWORD;
    Wnd: HWND;
    uID: UINT;
    uFlags: UINT;
    uCallbackMessage: UINT;
    hIcon: HICON;
    szTip: array [0..63] of AnsiChar;
  end;
```

The cbSize field holds the size of the record, and it should be initialized to SizeOf(TNotifyIconData).

Wnd is the handle of the window to which tray-notification “callback” messages should be sent (*callback* is in quotes here because it’s not really a callback in the strict sense; however, the Win32 documentation uses this terminology for messages sent to a window on behalf of a tray-notification icon).

uID is a programmer-defined unique ID number. If you have an application with several icons, you’ll need to identify each one by a placing a different number in this field.

uFlags describes which of the fields of the TNotifyIconData record should be considered live by the Shell_NotifyIcon() function, and, therefore, which of the icon properties are to be affected by the action specified by the dwMessage parameter. This parameter can be any combination of the flags (using or to join them) shown in Table 24.2.

TABLE 24.2 Possible Flags to be Included in uFlags

<i>Constant</i>	<i>Value</i>	<i>Meaning</i>
NIF_MESSAGE	0	The uCallbackMessage field is live.
NIF_ICON	2	The hIcon field is live.
NIF_TIP	4	The szTip field is live.

`uCallbackMessage` contains the value of the Windows message to be sent to the window identified by the `Wnd` field. Generally, the value of this field is obtained by calling `RegisterWindowMessage()` or by using an offset from `WM_USER`. The `lParam` of this message will be the same value as the `uID` field, and the `wParam` will hold the mouse message generated over the notification icon.

`hIcon` identifies the handle to the icon that will be placed in the notification tray.

`szTip` holds a null-terminated string that will appear in the hint window displayed when the mouse pointer is held above the notification icon.

The `TTrayNotifyIcon` component encapsulates the `Shell_NotifyIcon()` into a method called `SendTrayMessage()`, which is shown here:

```
procedure TTrayNotifyIcon.SendTrayMessage(Msg: DWORD; Flags: UINT);
{ This method wraps up the call to the API's Shell_NotifyIcon }
begin
  { Fill up record with appropriate values }
  with Tnd do
  begin
    cbSize := SizeOf(Tnd);
    StrPLCopy(szTip, PChar(FHint), SizeOf(szTip));
    uFlags := Flags;
    uID := UINT(Self);
    Wnd := IconMgr.HWindow;
    uCallbackMessage := Tray_Callback;
    hIcon := ActiveIconHandle;
  end;
  Shell_NotifyIcon(Msg, @Tnd);
end;
```

In this method, `szTip` is copied from a private string field called `FHint`.

`uID` is used to hold a reference to `Self`. Because this data will be included in subsequent notification tray messages, correlating notification tray messages for multiple icons to individual components will be easy.

`Wnd` is assigned the value of `IconMgr.HWindow`. `IconMgr` is a global variable of type `TIconMgr`. You'll see the implementation of this object in a moment, but for now you only need know that it's through this component that all notification tray messages will be sent.

`uCallbackMessage` is assigned from `DDGM_TRAYICON`. `DDGM_TRAYICON` obtains its value from the `RegisterWindowMessage()` API function. This ensures that `DDGM_TRAYICON` is a system-wide unique message ID. The following code accomplishes this task:

```
const
  { String to identify registered window message }
  TrayMsgStr = 'DDG.TrayNotifyIconMsg';
```

```

initialization
  { Get a unique windows message ID for tray callback }
  DDGM_TRAYICON := RegisterWindowMessage(TrayMsgStr);

```

hIcon takes on the return value provided by the `ActiveIconHandle()` method. This method returns the handle for the icon currently selected in the component's `Icon` property.

Handling Messages

We mentioned earlier that all notification tray messages are sent to a window maintained by the global `IconMgr` object. This object is constructed and freed in the `initialization` and `finalization` sections of the component's unit, as shown here:

```

initialization
  { Get a unique windows message ID for tray callback }
  DDGM_TRAYICON := RegisterWindowMessage(TrayMsgStr);
  IconMgr := TIconManager.Create;
finalization
  IconMgr.Free;

```

This object is fairly small. Here's its definition:

```

type
  TIconManager = class
  private
    FHWND: HWND;
    procedure TrayWndProc(var Message: TMessage);
  public
    constructor Create;
    destructor Destroy; override;
    property HWND: HWND read FHWND write FHWND;
  end;

```

The window to which notification tray messages will be sent is created in the constructor for this object using the `AllocateHWND()` function:

```

constructor TIconManager.Create;
begin
  FHWND := AllocateHWND(TrayWndProc);
end;

```

The `TrayWndProc()` method serves as the window procedure for the window created in the constructor. More about this method in a moment.

Icons and Hints

The most straightforward way to surface icons and hints for the component's end user is through properties. Additionally, creating an `Icon` property of type `TIcon` means that it can automatically take advantage of Delphi's property editor for icons, which is a nice touch.

Because the tray icon is visible even at design time, you need to ensure that the icon and tip can change dynamically. Doing this really isn't a lot of extra work; it's just a matter of making sure the `SendTrayMessage()` method is called (using the `NIM_MODIFY` message) in the `write` method of the `Hint` and `Icon` properties.

Here are the `write` methods for those properties:

```
procedure TTrayNotifyIcon.SetIcon(Value: TIcon);
{ Write method for Icon property. }
begin
  FIcon.Assign(Value); // set new icon
  if FIconVisible then
    { Change icon on notification tray }
    SendTrayMessage(NIM_MODIFY, NIF_ICON);
end;

procedure TTrayNotifyIcon.SetHint(Value: String);
{ Set method for Hint property }
begin
  if FHint <> Value then
    begin
      FHint := Value;
      if FIconVisible then
        { Change hint on icon on notification tray }
        SendTrayMessage(NIM_MODIFY, NIF_TIP);
    end;
end;
```

Mouse Clicks

One of the most challenging parts of this component is ensuring that the mouse clicks are handled properly. You may have noticed that many tray-notification icons perform three different actions due to mouse clicks:

- Bring up a window on a single-click
- Bring up a different window (usually a properties sheet) on a double-click
- Invoke a local menu with a right-click

The challenge comes in creating an event that represents the double-click without also firing the single-click event.

In Windows message terms, when the user double-clicks the left mouse button, the window with focus will receive both the `WM_LBUTTONDOWN` message and the `WM_LBUTTONDBLCLK` message. In order to allow a double-click message to be processed independently of a single-click, some mechanism is required to delay the handling of the single-click message long enough to ensure that a double-click message isn't forthcoming.

The amount of time to wait before you can be sure that a `WM_LBUTTONDOWNBLCLK` message is not following a `WM_LBUTTONDOWN` message is actually pretty easy to determine. The API function `GetDoubleClickTime()`, which takes no parameters, returns the maximum amount of time (in milliseconds) that the Control Panel will allow between the two clicks of a double-click. The obvious choice for a mechanism to allow you to wait the number of milliseconds specified by `GetDoubleClickTime()` to ensure that a double-click is not following a click is the `TTimer` component. Therefore, a `TTimer` component is created and initialized in the `TTrayNotifyIcon` component's constructor with the following code:

```
FTimer := TTimer.Create(Self);
with FTimer do
begin
  Enabled := False;
  Interval := GetDoubleClickTime;
  OnTimer := OnButtonTimer;
end;
```

`OnButtonTimer()` is a method that will be called when the timer interval expires. We'll show you this method in just a moment.

Earlier, we mentioned that notification tray messages are filtered through the `TrayWndProc()` method of the `IconMgr`. Now it's time to spring this method on you, so here it is:

```
procedure TIconManager.TrayWndProc(var Message: TMessage);
{ This allows us to handle all tray callback messages }
{ from within the context of the component. }
var
  Pt: TPoint;
  TheIcon: TTrayNotifyIcon;
begin
  with Message do
  begin
    { if it's the tray callback message }
    if (Msg = DDGM_TRAYICON) then
    begin
      TheIcon := TTrayNotifyIcon(WParam);
      case lParam of
        { enable timer on first mouse down. }
        { OnClick will be fired by OnTimer method, provided }
        { double click has not occurred. }
        WM_LBUTTONDOWN: TheIcon.FTimer.Enabled := True;
        { Set no click flag on double click. This will suppress }
        { the single click. }
        WM_LBUTTONDOWNBLCLK:
          begin
            TheIcon.FNoShowClick := True;
```

```

        if Assigned(TheIcon.FOnDb1Click) then TheIcon.FOnDb1Click(Self);
    end;
WM_RBUTTONDOWN:
    begin
        if Assigned(TheIcon.FPopupMenu) then
            begin
                { Call to SetForegroundWindow is required by API }
                SetForegroundWindow(IconMgr.HWindow);
                { Popup local menu at the cursor position. }
                GetCursorPos(Pt);
                TheIcon.FPopupMenu.Popup(Pt.X, Pt.Y);
                { Message post required by API to force task switch }
                PostMessage(IconMgr.HWindow, WM_USER, 0, 0);
            end;
        end;
    end;
end;
else
    { If it isn't a tray callback message, then call DefWindowProc }
    Result := DefWindowProc(FHWindow, Msg, wParam, lParam);
end;
end;
end;

```

What makes this all work is that the single-click message merely enables the timer, whereas the double-click message sets a flag to indicate that the double-click has occurred before firing its `OnDb1Click` event. The right-click, incidentally, invokes the pop-up menu given by the component's `PopupMenu` property. Now take a look at the `OnButtonTimer()` method:

```

procedure TTrayNotifyIcon.OnButtonTimer(Sender: TObject);
begin
    { Disable timer because we only want it to fire once. }
    FTimer.Enabled := False;
    { if double click has not occurred, then fire single click. }
    if (not FNoShowClick) and Assigned(FOnClick) then
        FOnClick(Self);
    FNoShowClick := False; // reset flag
end;

```

This method first disables the timer to ensure that the event fires only once per mouse click. The method then checks the status of the `FNoShowClick` flag. Remember that this flag will be set by the double-click message in the `OwnerWndProc()` method. Therefore, the `OnClick` event will be fired only when `OnDb1Click` is not.

Hiding the Application

Another aspect of tray-notification applications is that they do not appear as buttons in the system taskbar. To provide this functionality, the `TTrayNotifyIcon` component surfaces a

HideTask property that allows the user to decide whether the application should be visible in the taskbar. The write method for this property is shown in the following code. The line of code that does the work is the call to the ShowWindow() API procedure, which passes the Handle property of Application and a constant to indicate whether the application is to be shown normally or hidden. Here's the code:

```
procedure TTrayNotifyIcon.SetHideTask(Value: Boolean);
{ Write method for HideTask property }
const
  { Flags to show application normally or hide it }
  ShowArray: array[Boolean] of integer = (sw_ShowNormal, sw_Hide);
begin
  if FHideTask <> Value then begin
    FHideTask := Value;
    { Don't do anything in design mode }
    if not (csDesigning in ComponentState) then
      ShowWindow(Application.Handle, ShowArray[FHideTask]);
  end;
end;
```

Listing 24.1 shows the TrayIcon.pas unit, which contains the complete source code for the TTrayNotifyIcon component.

LISTING 24.1 TrayIcon.pas: Source Code for the TTrayNotifyIcon Component

```
unit TrayIcon;

interface

uses Windows, SysUtils, Messages, ShellAPI, Classes, Graphics, Forms, Menus,
  StdCtrls, ExtCtrls;

type
  ENotifyIconError = class(Exception);

  TTrayNotifyIcon = class(TComponent)
  private
    FDefaultIcon: THandle;
    FIcon: TIcon;
    FHideTask: Boolean;
    FHint: string;
    FIconVisible: Boolean;
    FPopupMenu: TPopupMenu;
    FOnClick: TNotifyEvent;
    FOnDb1Click: TNotifyEvent;
    FNoShowClick: Boolean;
```

LISTING 24.1 Continued

```

    FTimer: TTimer;
    Tnd: TNotifyIconData;
    procedure SetIcon(Value: TIcon);
    procedure SetHideTask(Value: Boolean);
    procedure SetHint(Value: string);
    procedure SetIconVisible(Value: Boolean);
    procedure SetPopupMenu(Value: TPopupMenu);
    procedure SendTrayMessage(Msg: DWORD; Flags: UINT);
    function ActiveIconHandle: THandle;
    procedure OnButtonTimer(Sender: TObject);
protected
    procedure Loaded; override;
    procedure LoadDefaultIcon; virtual;
    procedure Notification(AComponent: TComponent;
        Operation: TOperation); override;
public
    constructor Create(AOwner: TComponent); override;
    destructor Destroy; override;
published
    property Icon: TIcon read FIcon write SetIcon;
    property HideTask: Boolean read FHideTask write SetHideTask default False;
    property Hint: String read FHint write SetHint;
    property IconVisible: Boolean read FIconVisible write SetIconVisible
        default False;
    property PopupMenu: TPopupMenu read FPopupMenu write SetPopupMenu;
    property OnClick: TNotifyEvent read FOnClick write FOnClick;
    property OnDbClick: TNotifyEvent read FOnDbClick write FOnDbClick;
end;

implementation

{ TIconManager }
{ This class creates a hidden window which handles and routes }
{ tray icon messages }
type
    TIconManager = class
    private
        FHWND: HWND;
        procedure TrayWndProc(var Message: TMessage);
    public
        constructor Create;
        destructor Destroy; override;
        property HWND: HWND read FHWND write FHWND;
    end;

var

```

```

    IconMgr: TIconManager;
    DDGM_TRAYICON: Integer;

constructor TIconManager.Create;
begin
    FHWindow := AllocateHWnd(TrayWndProc);
end;

destructor TIconManager.Destroy;
begin
    if FHWindow <> 0 then DeallocateHWnd(FHWindow);
    inherited Destroy;
end;

procedure TIconManager.TrayWndProc(var Message: TMessage);
{ This allows us to handle all tray callback messages }
{ from within the context of the component. }
var
    Pt: TPoint;
    TheIcon: TTrayNotifyIcon;
begin
    with Message do
    begin
        { if it's the tray callback message }
        if (Msg = DDGM_TRAYICON) then
        begin
            TheIcon := TTrayNotifyIcon(WParam);
            case lParam of
                { enable timer on first mouse down. }
                { OnClick will be fired by OnTimer method, provided }
                { double click has not occurred. }
                WM_LBUTTONDOWN: TheIcon.FTimer.Enabled := True;
                { Set no click flag on double click. This will suppress }
                { the single click. }
                WM_LBUTTONDBLCLK:
                    begin
                        TheIcon.FNoShowClick := True;
                        if Assigned(TheIcon.FOnDb1Click) then TheIcon.FOnDb1Click(Self);
                    end;
                WM_RBUTTONDOWN:
                    begin
                        if Assigned(TheIcon.FPopupMenu) then
                        begin
                            { Call to SetForegroundWindow is required by API }
                            SetForegroundWindow(IconMgr.HWindow);
                            { Popup local menu at the cursor position. }

```

LISTING 24.1 Continued

```
        GetCursorPos(Pt);
        TheIcon.FPopupMenu.Popup(Pt.X, Pt.Y);
        { Message post required by API to force task switch }
        PostMessage(IconMgr.HWindow, WM_USER, 0, 0);
    end;
end;
end;
else
    { If it isn't a tray callback message, then call DefWindowProc }
    Result := DefWindowProc(FHWindow, Msg, wParam, lParam);
end;
end;

{ TTrayNotifyIcon }

constructor TTrayNotifyIcon.Create(AOwner: TComponent);
begin
    inherited Create(AOwner);
    FIcon := TIcon.Create;
    FTimer := TTimer.Create(Self);
    with FTimer do
    begin
        Enabled := False;
        Interval := GetDoubleClickTime;
        OnTimer := OnButtonTimer;
    end;
    { Keep default windows icon handy... }
    LoadDefaultIcon;
end;

destructor TTrayNotifyIcon.Destroy;
begin
    if FIconVisible then SetIconVisible(False);    // destroy icon
    FIcon.Free;                                    // free stuff
    FTimer.Free;
    inherited Destroy;
end;

function TTrayNotifyIcon.ActiveIconHandle: THandle;
{ Returns handle of active icon }
begin
    { If no icon is loaded, then return default icon }
    if (FIcon.Handle <> 0) then
        Result := FIcon.Handle
```

```

    else
        Result := FDefaultIcon;
    end;

procedure TTrayNotifyIcon.LoadDefaultIcon;
{ Loads default window icon to keep it handy. }
{ This will allow the component to use the windows logo }
{ icon as the default when no icon is selected in the }
{ Icon property. }
begin
    FDefaultIcon := LoadIcon(0, IDI_WINLOGO);
end;

procedure TTrayNotifyIcon.Loaded;
{ Called after component is loaded from stream }
begin
    inherited Loaded;
    { if icon is supposed to be visible, create it. }
    if FIconVisible then
        SendTrayMessage(NIM_ADD, NIF_MESSAGE or NIF_ICON or NIF_TIP);
end;

procedure TTrayNotifyIcon.Notification(AComponent: TComponent;
    Operation: TOperation);
begin
    inherited Notification(AComponent, Operation);
    if (Operation = opRemove) and (AComponent = PopupMenu) then
        PopupMenu := nil;
end;

procedure TTrayNotifyIcon.OnButtonTimer(Sender: TObject);
{ Timer used to keep track of time between two clicks of a }
{ double click. This delays the first click long enough to }
{ ensure that a double click hasn't occurred. The whole }
{ point of these gymnastics is to allow the component to }
{ receive OnClicks and OnDblClicks independently. }
begin
    { Disable timer because we only want it to fire once. }
    FTimer.Enabled := False;
    { if double click has not occurred, then fire single click. }
    if (not FNoShowClick) and Assigned(FOnClick) then
        FOnClick(Self);
    FNoShowClick := False; // reset flag
end;

procedure TTrayNotifyIcon.SendTrayMessage(Msg: DWORD; Flags: UINT);

```

LISTING 24.1 Continued

```
{ This method wraps up the call to the API's Shell_NotifyIcon }
begin
  { Fill up record with appropriate values }
  with Tnd do
  begin
    cbSize := SizeOf(Tnd);
    StrPLCopy(szTip, PChar(FHint), SizeOf(szTip));
    uFlags := Flags;
    uID := UINT(Self);
    Wnd := IconMgr.HWindow;
    uCallbackMessage := DDGM_TRAYICON;
    hIcon := ActiveIconHandle;
  end;
  Shell_NotifyIcon(Msg, @Tnd);
end;

procedure TTrayNotifyIcon.SetHideTask(Value: Boolean);
{ Write method for HideTask property }
const
  { Flags to show application normally or hide it }
  ShowArray: array[Boolean] of integer = (sw_ShowNormal, sw_Hide);
begin
  if FHideTask <> Value then
  begin
    FHideTask := Value;
    { Don't do anything in design mode }
    if not (csDesigning in ComponentState) then
      ShowWindow(Application.Handle, ShowArray[FHideTask]);
  end;
end;

procedure TTrayNotifyIcon.SetHint(Value: string);
{ Set method for Hint property }
begin
  if FHint <> Value then
  begin
    FHint := Value;
    if FIconVisible then
      { Change hint on icon on notification tray }
      SendTrayMessage(NIM_MODIFY, NIF_TIP);
  end;
end;
```

```
procedure TTrayNotifyIcon.SetIcon(Value: TIcon);
{ Write method for Icon property. }
begin
  FIcon.Assign(Value); // set new icon
  { Change icon on notification tray }
  if FIconVisible then SendTrayMessage(NIM_MODIFY, NIF_ICON);
end;

procedure TTrayNotifyIcon.SetIconVisible(Value: Boolean);
{ Write method for IconVisible property }
const
  { Flags to add or delete a tray-notification icon }
  MsgArray: array[Boolean] of DWORD = (NIM_DELETE, NIM_ADD);
begin
  if FIconVisible <> Value then
  begin
    FIconVisible := Value;
    { Set icon as appropriate }
    SendTrayMessage(MsgArray[Value], NIF_MESSAGE or NIF_ICON or NIF_TIP);
  end;
end;

procedure TTrayNotifyIcon.SetPopupMenu(Value: TPopupMenu);
{ Write method for PopupMenu property }
begin
  FPopupMenu := Value;
  if Value <> nil then Value.FreeNotification(Self);
end;

const
  { String to identify registered window message }
  TrayMsgStr = 'DDG.TrayNotifyIconMsg';

initialization
  { Get a unique windows message ID for tray callback }
  DDGM_TRAYICON := RegisterWindowMessage(TrayMsgStr);
  IconMgr := TIconManager.Create;
finalization
  IconMgr.Free;
end.
```

Figure 24.2 shows a picture of the icon generated by TTrayNotifyIcon in the notification tray.

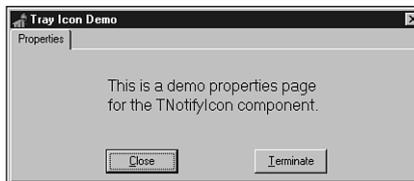
**FIGURE 24.2**

The TTrayNotifyIcon component in action.

By the way, because the tray icon is initialized inside the component's constructor and because constructors are executed at design time, this component displays the tray-notification icon even at design time!

Sample Tray Application

In order to provide you with a better overall feel for how the TTrayNotifyIcon component works within the context of an application, Figure 24.3 shows the main window of this application, and Listing 24.2 shows the fairly minimal code for the main unit for this application.

**FIGURE 24.3**

Notification icon application.

LISTING 24.2 Main.pas, the Main Unit for the Notification Icon Demo Application

```
unit main;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ShellAPI, TrayIcon, Menus, ComCtrls;

type
  TMainForm = class(TForm)
    pmiPopup: TPopupMenu;
    pgclPageCtl: TPageControl;
    TabSheet1: TTabSheet;
    btnClose: TButton;
    btnTerm: TButton;
    Terminate1: TMenuItem;
  end;
end;
```

```
Label1: TLabel;
N1: TMenuItem;
Propeties1: TMenuItem;
TrayNotifyIcon1: TTrayNotifyIcon;
procedure NotifyIcon1Click(Sender: TObject);
procedure NotifyIcon1Db1Click(Sender: TObject);
procedure FormClose(Sender: TObject; var Action: TCloseAction);
procedure btnTermClick(Sender: TObject);
procedure btnCloseClick(Sender: TObject);
procedure FormCreate(Sender: TObject);
end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

procedure TMainForm.NotifyIcon1Click(Sender: TObject);
begin
  ShowMessage('Single click');
end;

procedure TMainForm.NotifyIcon1Db1Click(Sender: TObject);
begin
  Show;
end;

procedure TMainForm.FormClose(Sender: TObject; var Action: TCloseAction);
begin
  Action := caNone;
  Hide;
end;

procedure TMainForm.btnTermClick(Sender: TObject);
begin
  Application.Terminate;
end;

procedure TMainForm.btnCloseClick(Sender: TObject);
begin
  Hide;
end;
```

LISTING 24.2 Continued

```
procedure TMainForm.FormCreate(Sender: TObject);
begin
    TrayNotifyIcon1.IconVisible := True;
end;

end.
```

Application Desktop Toolbars

Application desktop toolbars, also known as *AppBar*s, are windows that can dock to one of the edges of your screen. You're already familiar with AppBar's, even though you might not know it; the shell's taskbar, which you probably work with every day, is an example of an AppBar. As shown in Figure 24.4, the taskbar is really little more than an AppBar window containing a Start button, notification tray, and other controls.

**FIGURE 24.4**

The shell's taskbar.

Apart from docking to screen edges, AppBar's can, optionally, employ taskbar-like features, such as auto-hide and drag-and-drop functionality. What you might find surprising, however, is how small the API is (just one function). As its small size might imply, the API doesn't provide a whole lot. The role of the API is more advisory than functional. That is, rather than controlling the AppBar with "do this, do that" commands types, you interrogate the AppBar with "can I do this, can I do that?" commands types.

The API

Just like tray-notification icons, AppBar's have only one API function that you'll work with—`SHAppBarMessage()`, in this case. Here's how `SHAppBarMessage()` is defined in the `ShellAPI` unit:

```
function SHAppBarMessage(dwMessage: DWORD; var pData: TAppBarData): UINT;
    stdcall;
```

The first parameter to this function, `dwMessage`, can contain any one of the values described in Table 24.3.

TABLE 24.3 AppBar Messages

<i>Constant</i>	<i>Value</i>	<i>Meaning</i>
ABM_NEW	\$0	Registers a new AppBar and specifies a new callback message
ABM_REMOVE	\$1	Unregisters an existing AppBar
ABM_QUERYPOS	\$2	Requests a new position and size for an AppBar
ABM_SETPOS	\$3	Sets a new position and size of an AppBar
ABM_GETSTATE	\$4	Gets the auto-hide and always-on-top states of the shell taskbar
ABM_GETTASKBARPOS	\$5	Gets the position of the shell taskbar
ABM_ACTIVATE	\$6	Notifies the shell that a new AppBar has been created
ABM_GETAUTOHIDEBAR	\$7	Gets the handle of an auto-hide AppBar docked to a particular edge of the screen
ABM_SETAUTOHIDEBAR	\$8	Registers an auto-hide AppBar for a particular screen edge
ABM_WINDOWPOSCHANGED	\$9	Notifies the shell that the position of an AppBar has changed

The `pData` parameter of `SHAppBarMessage()` is a record of type `TAppBarData`, which is defined in `ShellAPI` as follows:

```
type
  PAppBarData = ^TAppBarData;
  TAppBarData = record
    cbSize: DWORD;
    hWnd: HWND;
    uCallbackMessage: UINT;
    uEdge: UINT;
    rc: TRect;
    lParam: LPARAM; { message specific }
  end;
```

In this record, the `cbSize` field holds the size of the record, the `hWnd` field holds the window handle of the specified AppBar, `uCallbackMessage` holds the message value that will be sent to the AppBar window along with notification messages, `rc` holds the bounding rectangle of the AppBar in question, and `lParam` holds some additional message-specific information.

TIP

You'll find more information on the `SHAppBarMessage()` API function and the `TAppBarData` type in the Win32 online help.

TAppBar: The AppBar Form

Given this fairly small API, it's not terribly difficult to encapsulate an AppBar in a VCL form. This section will explain the techniques used to wrap the AppBar API into a control descending from TCustomForm. Because TCustomForm is a form, you'll interact with the control as a top-level form in the Form Designer rather than as a component on a form.

Most of the work in an AppBar is done by sending a TAppBarData record to the shell using the SHAppBarMessage() API function. The TAppBar component maintains an internal TAppBarData record called FABD. FABD is set up for the call to SendAppBarMsg() in the constructor and the CreateWnd() methods in order to create the AppBar. In particular, the cbSize field is initialized, the uCallbackMessage field is set to a value obtained from the RegisterWindowMessage() API function, and the hWnd field is set to the current window handle of the form. SendAppBarMessage() is a simple wrapper for SHAppBarMessage() and is defined as follows:

```
function TAppBar.SendAppBarMsg(Msg: DWORD): UINT;
begin
    Result := SHAppBarMessage(Msg, FABD);
end;
```

If the AppBar is created successfully, the SetAppBarEdge() method is called to set the AppBar to its initial position. This method, in turn, calls the SetAppBarPos() method, passing the appropriate API-defined flag that indicates the requested screen edge. As you would expect, the ABE_TOP, ABE_BOTTOM, ABE_LEFT, and ABE_RIGHT flags represent each of the screen edges. This is shown in the following code snippet:

```
procedure TAppBar.SetAppBarPos(Edge: UINT);
begin
    if csDesigning in ComponentState then Exit;
    FABD.uEdge := Edge;           // set edge
    with FABD.rc do
    begin
        // set coordinates to full-screen
        Top := 0;
        Left := 0;
        Right := Screen.Width;
        Bottom := Screen.Height;
        // Send ABM_QUERYPOS to obtain proper rect on edge
        SendAppBarMsg(ABM_QUERYPOS);
        // re-adjust rect based on that modified by ABM_QUERYPOS
        case Edge of
            ABE_LEFT: Right := Left + FDockedWidth;
            ABE_RIGHT: Left := Right - FDockedWidth;
            ABE_TOP: Bottom := Top + FDockedHeight;
```

```

    ABE_BOTTOM: Top := Bottom - FDockedHeight;
end;
// Set the app bar position.
SendAppBarMsg(ABM_SETPOS);
end;
// Set the BoundsRect property so that it conforms to the
// bounding rectangle passed to the system.
BoundsRect := FABD.rc;
end;

```

This method first sets the `uEdge` field of `FABD` to the value passed via the `Edge` parameter. It then sets the `rc` field to the full-screen coordinates and sends the `ABM_QUERYPOS` message. This message resets the `rc` field so that it contains the correct bounding rectangle for the edge indicated by `uEdge`. Once the proper bounding rectangle has been obtained, `rc` is again adjusted so that it's a reasonable height or width. At this point, `rc` holds the final bounding rectangle for the `AppBar`. The `ABM_SETPOS` message is then sent to inform the shell of the new rectangle, and the rectangle is set using the control's `BoundsRect` property.

We mentioned earlier that `AppBar` notification messages will be sent to the window indicated by `FABD.hWnd` using the message identifier held in `FABD.uCallbackMessage`. These notification messages are handled in the `WndProc()` method shown here:

```

procedure TAppBar.WndProc(var M: TMessage);
var
    State: UINT;
    WndPos: HWND;
begin
    if M.Msg = AppBarMsg then
        begin
            case M.WParam of
                // Sent when always on top or auto-hide state has changed.
                ABN_STATECHANGE:
                    begin
                        // Check to see whether the access bar is still ABS_ALWAYSONTOP.
                        State := SendAppBarMsg(ABM_GETSTATE);
                        if ABS_ALWAYSONTOP and State = 0 then
                            SetTopMost(False)
                        else
                            SetTopMost(True);
                    end;
                // A full screen application has started, or the last
                // full-screen application has closed.
                ABN_FULLSCREENAPP:
                    begin
                        // Set the access bar's z-order appropriately.
                        State := SendAppBarMsg(ABM_GETSTATE);
                    end;
            end;
        end;
    end;

```

```

        if M.lParam <> 0 then begin
            if ABS_ALWAYSONTOP and State = 0 then
                SetTopMost(False)
            else
                SetTopMost(True);
        end
    else
        if State and ABS_ALWAYSONTOP <> 0 then
            SetTopMost(True);
        end;
    // Sent when something happened which may effect the AppBar position.
    ABN_POSCHANGED:
    begin
        // The taskbar or another access bar
        // has changed its size or position.
        SetAppBarPos(FABD.uEdge);
    end;
end;
end
else
    inherited WndProc(M);
end;

```

This method handles some notification messages that permit the AppBar to respond to changes that may occur in the shell while the application is running. The remainder of the AppBar component code is shown in Listing 24.3.

LISTING 24.3 AppBars.pas, the Unit Containing the Base Class for AppBar Support

```

unit AppBars;

interface

uses Windows, Messages, SysUtils, Forms, ShellAPI, Classes, Controls;

type
    TAppBarEdge = (abeTop, abeBottom, abeLeft, abeRight);

    EAppBarError = class(Exception);

    TAppBar = class(TCustomForm)
    private
        FABD: TAppBarData;
        FDockedHeight: Integer;
        FDockedWidth: Integer;
        FEdge: TAppBarEdge;
        FOnEdgeChanged: TNotifyEvent;
    end;

```

```

FTopMost: Boolean;
procedure WMActivate(var M: TMessage); message WM_ACTIVATE;
procedure WMWindowPosChanged(var M: TMessage); message WM_WINDOWPOSCHANGED;
function SendAppBarMsg(Msg: DWORD): UINT;
procedure SetAppBarEdge(Value: TAppBarEdge);
procedure SetAppBarPos(Edge: UINT);
procedure SetTopMost(Value: Boolean);
procedure SetDockedHeight(const Value: Integer);
procedure SetDockedWidth(const Value: Integer);
protected
  procedure CreateParams(var Params: TCreateParams); override;
  procedure CreateWnd; override;
  procedure DestroyWnd; override;
  procedure WndProc(var M: TMessage); override;
public
  constructor CreateNew(AOwner: TComponent; Dummy: Integer = 0); override;
  property DockManager;
published
  property Action;
  property ActiveControl;
  property AutoScroll;
  property AutoSize;
  property BiDiMode;
  property BorderWidth;
  property Color;
  property Ctl3D;
  property DockedHeight: Integer read FDockedHeight write SetDockedHeight
    default 35;
  property DockedWidth: Integer read FDockedWidth write SetDockedWidth
    default 40;
  property UseDockManager;
  property DockSite;
  property DragKind;
  property DragMode;
  property Edge: TAppBarEdge read FEdge write SetAppBarEdge default abeTop;
  property Enabled;
  property ParentFont default False;
  property Font;
  property HelpFile;
  property HorzScrollBar;
  property Icon;
  property KeyPreview;
  property ObjectMenuItem;
  property ParentBiDiMode;
  property PixelsPerInch;
  property PopupMenu;

```

continues

LISTING 24.3 Continued

```
property PrintScale;
property Scaled;
property ShowHint;
property TopMost: Boolean read FTopMost write SetTopMost default False;
property VertScrollBar;
property Visible;
property OnActivate;
property OnCanResize;
property OnClick;
property OnClose;
property OnCloseQuery;
property OnConstrainedResize;
property OnCreate;
property OnDblClick;
property OnDestroy;
property OnDeactivate;
property OnDockDrop;
property OnDockOver;
property OnDragDrop;
property OnDragOver;
property OnEdgeChanged: TNotifyEvent read FOnEdgeChanged
    write FOnEdgeChanged;
property OnEndDock;
property OnGetSiteInfo;
property OnHide;
property OnHelp;
property OnKeyDown;
property OnKeyPress;
property OnKeyUp;
property OnMouseDown;
property OnMouseMove;
property OnMouseUp;
property OnMouseWheel;
property OnMouseWheelDown;
property OnMouseWheelUp;
property OnPaint;
property OnResize;
property OnShortCut;
property OnShow;
property OnStartDock;
property OnUnDock;
end;
```

implementation

```

var
  AppBarMsg: UINT;

constructor TAppBar.CreateNew(AOwner: TComponent; Dummy: Integer);
begin
  FDockedHeight := 35;
  FDockedWidth := 40;
  inherited CreateNew(AOwner, Dummy);
  ClientHeight := 35;
  Width := 100;
  BorderStyle := bsNone;
  BorderIcons := [];
  // set up the TAppBarData record
  FABD.cbSize := SizeOf(FABD);
  FABD.uCallbackMessage := AppBarMsg;
end;

procedure TAppBar.WMWindowPosChanged(var M: TMessage);
begin
  inherited;
  // Must inform shell that the AppBar position has changed
  SendAppBarMsg(ABM_WINDOWPOSCHANGED);
end;

procedure TAppBar.WMActivate(var M: TMessage);
begin
  inherited;
  // Must inform shell that the AppBar window was activated
  SendAppBarMsg(ABM_ACTIVATE);
end;

procedure TAppBar.WndProc(var M: TMessage);
var
  State: UINT;
begin
  if M.Msg = AppBarMsg then
  begin
    case M.WParam of
      // Sent when always on top or auto-hide state has changed.
      ABN_STATECHANGE:
        begin
          // Check to see whether the access bar is still ABS_ALWAYSONTOP.
          State := SendAppBarMsg(ABM_GETSTATE);
          if ABS_ALWAYSONTOP and State = 0 then
            SetTopMost(False)
          else

```

LISTING 24.3 Continued

```
        SetTopMost(True);
    end;
    // A full screen application has started, or the last
    // full-screen application has closed.
    ABN_FULLSCREENAPP:
    begin
        // Set the access bar's z-order appropriately.
        State := SendAppBarMsg(ABM_GETSTATE);
        if M.lParam <> 0 then begin
            if ABS_ALWAYSONTOP and State = 0 then
                SetTopMost(False)
            else
                SetTopMost(True);
        end
    else
        if State and ABS_ALWAYSONTOP <> 0 then
            SetTopMost(True);
        end;
        // Sent when something happened which may effect the AppBar position.
    ABN_POSCHANGED:
        // The taskbar or another access bar
        // has changed its size or position.
        SetAppBarPos(FABD.uEdge);
    end;
end
else
    inherited WndProc(M);
end;

function TAppBar.SendAppBarMsg(Msg: DWORD): UINT;
begin
    // Don't do AppBar stuff at design time... too funky
    if csDesigning in ComponentState then Result := 0
    else Result := SHAppBarMessage(Msg, FABD);
end;

procedure TAppBar.SetAppBarPos(Edge: UINT);
begin
    if csDesigning in ComponentState then Exit;
    FABD.uEdge := Edge;        // set edge
    with FABD.rc do
    begin
        // set coordinates to full-screen
        Top := 0;
        Left := 0;
        Right := Screen.Width;
```

```

Bottom := Screen.Height;
// Send ABM_QUERYPOS to obtain proper rect on edge
SendAppBarMsg(ABM_QUERYPOS);
// re-adjust rect based on that modified by ABM_QUERYPOS
case Edge of
  ABE_LEFT: Right := Left + FDockedWidth;
  ABE_RIGHT: Left := Right - FDockedWidth;
  ABE_TOP: Bottom := Top + FDockedHeight;
  ABE_BOTTOM: Top := Bottom - FDockedHeight;
end;
// Set the app bar position.
SendAppBarMsg(ABM_SETPOS);
end;
// Set the BoundsRect property so that it conforms to the
// bounding rectangle passed to the system.
BoundsRect := FABD.rc;
end;

procedure TAppBar.SetTopMost(Value: Boolean);
const
  WndPosArray: array[Boolean] of HWND = (HWND_BOTTOM, HWND_TOPMOST);
begin
  if FTopMost <> Value then
    begin
      FTopMost := Value;
      if not (csDesigning in ComponentState) then
        SetWindowPos(Handle, WndPosArray[Value], 0, 0, 0, 0, SWP_NOMOVE or
          SWP_NOSIZE or SWP_NOACTIVATE);
    end;
end;

procedure TAppBar.CreateParams(var Params: TCreateParams);
begin
  inherited CreateParams(Params);
  if not (csDesigning in ComponentState) then
    begin
      Params.ExStyle := Params.ExStyle or WS_EX_TOPMOST or WS_EX_WINDOWEDGE;
      Params.Style := Params.Style or WS_DLGFRAME;
    end;
end;

procedure TAppBar.CreateWnd;
begin
  inherited CreateWnd;
  FABD.hWnd := Handle;
  if not (csDesigning in ComponentState) then

```

LISTING 24.3 Continued

```
begin
  if SendAppBarMsg(ABM_NEW) = 0 then
    raise EAppBarError.Create('Failed to create AppBar');
  // Initialize the position
  SetAppBarEdge(FEdge);
end;
end;

procedure TAppBar.DestroyWnd;
begin
  // Must inform shell that the AppBar is going away
  SendAppBarMsg(ABM_REMOVE);
  inherited DestroyWnd;
end;

procedure TAppBar.SetAppBarEdge(Value: TAppBarEdge);
const
  EdgeArray: array[TAppBarEdge] of UINT =
    (ABE_TOP, ABE_BOTTOM, ABE_LEFT, ABE_RIGHT);
begin
  SetAppBarPos(EdgeArray[Value]);
  FEdge := Value;
  if Assigned(FOnEdgeChanged) then FOnEdgeChanged(Self);
end;

procedure TAppBar.SetDockedHeight(const Value: Integer);
begin
  if FDockedHeight <> Value then
    begin
      FDockedHeight := Value;
      SetAppBarEdge(FEdge);
    end;
end;

procedure TAppBar.SetDockedWidth(const Value: Integer);
begin
  if FDockedWidth <> Value then
    begin
      FDockedWidth := Value;
      SetAppBarEdge(FEdge);
    end;
end;

initialization
  AppBarMsg := RegisterWindowMessage('DDG AppBar Message');
end.
```

Using TAppBar

If you installed the software found on the CD-ROM accompanying this book, using a TAppBar should be a snap: just select the AppBar option from the DDG page of the File, New dialog. This invokes a wizard that will generate a unit containing a TAppBar component.

NOTE

Chapter 26, “Using Delphi’s Open Tools API,” demonstrates how to create a wizard that automatically generates a TAppBar. For the purposes of this chapter, you can ignore the wizard implementation for the time being. Just understand that some work is being done behind the scenes to generate the AppBar’s form and unit for you.

In this small sample application, TAppBar is used to create an application toolbar that contains buttons for various editing commands: Open, Save, Cut, Copy, and Paste. The buttons will manipulate a TMemO component found on the main form. The source code for this unit is shown in Listing 24.4, and Figure 24.5 shows the application in action with the AppBar control docked at the top of the screen.

LISTING 24.4 ApBarFrm.pas, Main Unit for the AppBar Demo Application

```
unit ApBarFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  AppBars, Menus, Buttons;

type
  TAppBarForm = class(TAppBar)
    sbOpen: TSpeedButton;
    sbSave: TSpeedButton;
    sbCut: TSpeedButton;
    sbCopy: TSpeedButton;
    sbPaste: TSpeedButton;
    OpenDialog: TOpenDialog;
    pmPopup: TPopupMenu;
    Top1: TMenuItem;
    Bottom1: TMenuItem;
    Left1: TMenuItem;
```

LISTING 24.4 Continued

```
    Right1: TMenuItem;
    N1: TMenuItem;
    Exit1: TMenuItem;
    procedure Right1Click(Sender: TObject);
    procedure sbOpenClick(Sender: TObject);
    procedure sbSaveClick(Sender: TObject);
    procedure sbCutClick(Sender: TObject);
    procedure sbCopyClick(Sender: TObject);
    procedure sbPasteClick(Sender: TObject);
    procedure Exit1Click(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure FormEdgeChanged(Sender: TObject);
private
    FLastChecked: TMenuItem;
    procedure MoveButtons;
end;

var
    AppBarForm: TAppBarForm;

implementation

uses Main;

{$R *.DFM}

{ TAppBarForm }

procedure TAppBarForm.MoveButtons;
// This method looks complicated, but it really just arranges the buttons
// properly depending on what side the AppBar is docked.
var
    DeltaCenter, NewPos: Integer;
begin
    if Edge in [abeTop, abeBottom] then
    begin
        DeltaCenter := (ClientHeight - sbOpen.Height) div 2;
        sbOpen.SetBounds(10, DeltaCenter, sbOpen.Width, sbOpen.Height);
        NewPos := sbOpen.Width + 20;
        sbSave.SetBounds(NewPos, DeltaCenter, sbOpen.Width, sbOpen.Height);
        NewPos := NewPos + sbOpen.Width + 10;
        sbCut.SetBounds(NewPos, DeltaCenter, sbOpen.Width, sbOpen.Height);
        NewPos := NewPos + sbOpen.Width + 10;
        sbCopy.SetBounds(NewPos, DeltaCenter, sbOpen.Width, sbOpen.Height);
        NewPos := NewPos + sbOpen.Width + 10;
    end;
end;
```

```
    sbPaste.SetBounds(NewPos, DeltaCenter, sbOpen.Width, sbOpen.Height);
end
else
begin
    DeltaCenter := (ClientWidth - sbOpen.Width) div 2;
    sbOpen.SetBounds(DeltaCenter, 10, sbOpen.Width, sbOpen.Height);
    NewPos := sbOpen.Height + 20;
    sbSave.SetBounds(DeltaCenter, NewPos, sbOpen.Width, sbOpen.Height);
    NewPos := NewPos + sbOpen.Height + 10;
    sbCut.SetBounds(DeltaCenter, NewPos, sbOpen.Width, sbOpen.Height);
    NewPos := NewPos + sbOpen.Height + 10;
    sbCopy.SetBounds(DeltaCenter, NewPos, sbOpen.Width, sbOpen.Height);
    NewPos := NewPos + sbOpen.Height + 10;
    sbPaste.SetBounds(DeltaCenter, NewPos, sbOpen.Width, sbOpen.Height);
end;
end;

procedure TAppBarForm.Right1Click(Sender: TObject);
begin
    FLastChecked.Checked := False;
    (Sender as TMenuItem).Checked := True;
    case TMenuItem(Sender).Caption[2] of
        'T': Edge := abeTop;
        'B': Edge := abeBottom;
        'L': Edge := abeLeft;
        'R': Edge := abeRight;
    end;
    FLastChecked := TMenuItem(Sender);
end;

procedure TAppBarForm.sbOpenClick(Sender: TObject);
begin
    if OpenFileDialog.Execute then
        MainForm.FileName := OpenFileDialog.FileName;
end;

procedure TAppBarForm.sbSaveClick(Sender: TObject);
begin
    MainForm.memEditor.Lines.SaveToFile(MainForm.FileName);
end;

procedure TAppBarForm.sbCutClick(Sender: TObject);
begin
    MainForm.memEditor.CutToClipboard;
end;
```

LISTING 24.4 Continued

```
procedure TAppBarForm.sbCopyClick(Sender: TObject);
begin
    MainForm.memEditor.CopyToClipboard;
end;

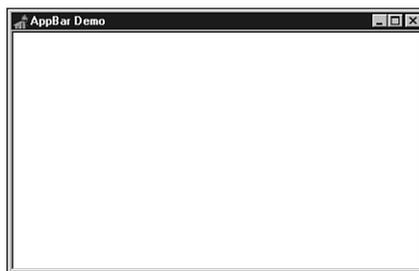
procedure TAppBarForm.sbPasteClick(Sender: TObject);
begin
    MainForm.memEditor.PasteFromClipboard;
end;

procedure TAppBarForm.Exit1Click(Sender: TObject);
begin
    Application.Terminate;
end;

procedure TAppBarForm.FormCreate(Sender: TObject);
begin
    FLastChecked := Top1;
end;

procedure TAppBarForm.FormEdgeChanged(Sender: TObject);
begin
    MoveButtons;
end;

end.
```

**FIGURE 24.5***TAppBar in action.*

Shell Links

The Windows shell exposes a series of interfaces that can be employed to manipulate different aspects of the shell. These interfaces are defined in the Sh1Obj unit. Discussing in-depth all the

objects in that unit could take a book in its own right, so for now we'll focus on one of the most useful (and most used) interfaces: `IShellLink`.

`IShellLink` is an interface that permits the creating and manipulating of shell links in your applications. In case you're unsure, most of the icons on your desktop are probably shell links. Additionally, each item in the shell's local Send To menu or the Documents menu (off of the Start menu) are all shell links. The `IShellLink` interface is defined as follows:

```
const

type
  IShellLink = interface(IUnknown)
    ['{000214EE-0000-0000-C000-000000000046}']
    function GetPath(pszFile: PAnsiChar; cchMaxPath: Integer;
      var pfd: TWin32FindData; fFlags: DWORD): HRESULT; stdcall;
    function GetIDList(var ppidl: PItemIDList): HRESULT; stdcall;
    function SetIDList(pidl: PItemIDList): HRESULT; stdcall;
    function GetDescription(pszName: PAnsiChar; cchMaxName: Integer): HRESULT;
      stdcall;
    function SetDescription(pszName: PAnsiChar): HRESULT; stdcall;
    function GetWorkingDirectory(pszDir: PAnsiChar; cchMaxPath: Integer):
      HRESULT;
      stdcall;
    function SetWorkingDirectory(pszDir: PAnsiChar): HRESULT; stdcall;
    function GetArguments(pszArgs: PAnsiChar; cchMaxPath: Integer): HRESULT;
      stdcall;
    function SetArguments(pszArgs: PAnsiChar): HRESULT; stdcall;
    function GetHotkey(var pwHotkey: Word): HRESULT; stdcall;
    function SetHotkey(wHotkey: Word): HRESULT; stdcall;
    function GetShowCmd(out piShowCmd: Integer): HRESULT; stdcall;
    function SetShowCmd(iShowCmd: Integer): HRESULT; stdcall;
    function GetIconLocation(pszIconPath: PAnsiChar; cchIconPath: Integer;
      out piIcon: Integer): HRESULT; stdcall;
    function SetIconLocation(pszIconPath: PAnsiChar; iIcon: Integer): HRESULT;
      stdcall;
    function SetRelativePath(pszPathRel: PAnsiChar; dwReserved: DWORD):
      HRESULT;
      stdcall;
    function Resolve(Wnd: HWND; fFlags: DWORD): HRESULT; stdcall;
    function SetPath(pszFile: PAnsiChar): HRESULT; stdcall;
  end;
```

NOTE

`IShellLink` and all its methods are described in detail in the Win32 online help, so we won't cover them here.

Obtaining an IShellLink Instance

Unlike working with shell extensions, which you'll learn about later in this chapter, you don't implement the `IShellLink` interface. Instead, this interface is implemented by the Windows shell, and you use the `CoCreateInstance()` COM function to create an instance. Here's an example:

```
var
  SL: IShellLink;
begin
  OleCheck(CoCreateInstance(CLSID_ShellLink, nil, CLSCTX_INPROC_SERVER,
    IShellLink, SL));
  // use SL here
end;
```

NOTE

Don't forget that before you can use any OLE functions, you must initialize the COM library using the `CoInitialize()` function. When you're through using COM, you must clean up by calling `CoUninitialize()`. These functions will be called for you by Delphi in an application that uses `ComObj` and contains a call to `Application.Initialize()`. Otherwise, you'll have to call these functions yourself.

Using IShellLink

Shell links seem kind of magical: you right-click on the desktop, create a new shortcut, and *something* happens that causes an icon to appear on the desktop. That *something* is actually a pretty mundane occurrence once you know what's going on. A *shell link* is actually just a file with an `.LNK` extension that lives in some particular directory. When Windows starts up, it looks in certain directories for LNK files, which represent links residing in different *shell folders*. These shell folders, or *special folders*, include items such as Network Neighborhood, Send To, Startup, the Desktop, and so on. The shell stores the link/folder correspondence in the System Registry—they're found mostly under the following key if you're interested in looking:

```
HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Explorer
➔\Shell Folders
```

Creating a shell link in a special folder, then, is just a matter of placing a link file in a particular directory. Rather than spelunking through the Registry, you can use the `SHGetSpecialFolderPath()` to obtain the directory path for the various special folders. This method is defined as follows:

```
function SHGetSpecialFolderPath(hwndOwner: HWND; lpszPath: PChar;
    nFolder: Integer; fCreate: BOOL): BOOL; stdcall;
```

`hwndOwner` contains the handle of a window that will serve as the owner to any dialogs the function may invoke.

`lpszPath` is a pointer to a buffer to receive the path. This buffer must be at least `MAX_PATH` characters in length.

`nFolder` identifies the special folder for which you want to obtain the path. Table 24.4 shows the possible values for this parameter and a description for each.

`fCreate` indicates whether a folder should be created if it does not exist.

TABLE 24.4 Possible Values for `nFolder`

<i>Flag</i>	<i>Description</i>
<code>CSIDL_ALTSTARTUP</code>	The directory that corresponds to the user's nonlocalized Startup program group.
<code>CSIDL_APPDATA</code>	The directory that serves as a common repository for application-specific data.
<code>CSIDL_BITBUCKET</code>	The directory containing file objects in the user's Recycle Bin. The location of this directory is not in the Registry; it's marked with the hidden and system attributes to prevent the user from moving or deleting it.
<code>CSIDL_COMMON_ALTSTARTUP</code>	The directory that corresponds to the nonlocalized Startup program group for all users.
<code>CSIDL_COMMON_DESKTOPDIRECTORY</code>	The directory that contains files and folders that appear on the desktop for all users.
<code>CSIDL_COMMON_FAVORITES</code>	The directory that serves as a common repository for all users' favorite items.
<code>CSIDL_COMMON_PROGRAMS</code>	The directory that contains the directories for the common program groups that appear on the Start menu for all users.
<code>CSIDL_COMMON_STARTMENU</code>	The directory that contains the programs and folders that appear on the Start menu for all users.
<code>CSIDL_COMMON_STARTUP</code>	The directory that contains the programs that appear in the Startup folder for all users.
<code>CSIDL_CONTROLS</code>	A virtual folder containing icons for the Control Panel applications.
<code>CSIDL_COOKIES</code>	The directory that serves as a common repository for Internet cookies.

TABLE 24.4 Continued

CSIDL_DESKTOP	The Windows Desktop virtual folder at the root of the namespace.
CSIDL_DESKTOPDIRECTORY	The directory used to physically store file objects on the desktop (not to be confused with the Desktop folder, itself).
CSIDL_DRIVES	The My Computer virtual folder containing everything on the local computer: storage devices, printers, and the Control Panel. The folder may also contain mapped network drives.
CSIDL_FAVORITES	The directory that serves as a common repository for the user's favorite items.
CSIDL_FONTS	A virtual folder containing fonts.
CSIDL_HISTORY	The directory that serves as a common repository for Internet history items.
CSIDL_INTERNET	A virtual folder representing the Internet.
CSIDL_INTERNET_CACHE	The directory that serves as a common repository for temporary Internet files.
CSIDL_NETHOOD	The directory that contains objects that appear in the Network Neighborhood.
CSIDL_NETWORK	The Network Neighborhood virtual folder representing the top level of the network hierarchy.
CSIDL_PERSONAL	The directory that serves as a common repository for documents.
CSIDL_PRINTERS	A virtual folder containing installed printers.
CSIDL_PRINTHOOD	The directory that serves as a common repository for printer links.
CSIDL_PROGRAMS	The directory that contains the user's program groups (which are also directories).
CSIDL_RECENT	The directory that contains the user's most recently used documents.
CSIDL_SENDTO	The directory that contains Send To menu items.
CSIDL_STARTMENU	The directory that contains Start menu items.
CSIDL_STARTUP	The directory that corresponds to the user's Startup program group. The system starts these programs whenever any user logs onto Windows NT or starts Windows 95 or 98.
CSIDL_TEMPLATES	The directory that serves as a common repository for document templates.

Creating a Shell Link

The `IShellLink` interface is an encapsulation of a shell link object, but it has no concept of how to read or write itself to a file on disk. However, implementers of the `IShellLink` interface are also required to support the `IPersistFile` interface in order to provide file access. `IPersistFile` is an interface that provides methods for reading and writing to and from disk, and it's defined as follows:

```
type
  IPersistFile = interface(IPersist)
    ['{0000010B-0000-0000-C000-000000000046}']
    function IsDirty: HRESULT; stdcall;
    function Load(pszFileName: POleStr; dwMode: Longint): HRESULT;
      stdcall;
    function Save(pszFileName: POleStr; fRemember: BOOL): HRESULT;
      stdcall;
    function SaveCompleted(pszFileName: POleStr): HRESULT;
      stdcall;
    function GetCurFile(out pszFileName: POleStr): HRESULT;
      stdcall;
  end;
```

NOTE

You'll find a complete description of `IPersistFile` and its methods in the Win32 online help.

Because the class that implements `IShellLink` is also required to implement `IPersistFile`, you can `QueryInterface` the `IShellLink` instance for an `IPersistFile` instance using the `as` operator, as shown here:

```
var
  SL: IShellLink;
  PF: IPersistFile;
begin
  OleCheck(CoCreateInstance(CLSID_ShellLink, nil, CLSCTX_INPROC_SERVER,
    IShellLink, SL));
  PF := SL as IPersistFile;
  // use PF and SL
end;
```

As mentioned earlier, using COM interface objects works the same as using normal Object Pascal objects. The following code, for example, creates a desktop shell link to the Notepad application:

```
procedure MakeNotepad;
const
  // NOTE: Assumed location for Notepad:
  AppName = 'c:\windows\notepad.exe';
var
  SL: IShellLink;
  PF: IPersistFile;
  LnkName: WideString;
begin
  OleCheck(CoCreateInstance(CLSID_ShellLink, nil, CLSCTX_INPROC_SERVER,
    IShellLink, SL));
  { IShellLink implementers are required to implement IPersistFile }
  PF := SL as IPersistFile;
  OleCheck(SL.SetPath(PChar(AppName))); // set link path to proper file
  { create a path location and filename for link file }
  LnkName := GetFolderLocation('Desktop') + '\' +
    ChangeFileExt(ExtractFileName(AppName), '.lnk');
  PF.Save(PWideChar(LnkName), True); // save link file
end;
```

In this procedure, the `SetPath()` method of `IShellLink` is used to point the link to an executable file or document (Notepad in this case). Then, a path and filename for the link is created using the path returned by `GetFolderLocation('Desktop')` (described earlier in this section) and by using the `ChangeFileExt()` function to change the extension of Notepad from `.EXE` to `.LNK`. This new filename is stored in `LnkName`. After that, the `Save()` method saves the link to a disk file. As you've learned, when the procedure terminates and the `SL` and `PF` interface instances fall out of scope, their respective references will be released.

Getting and Setting Link Information

As you can see from the definition of the `IShellLink` interface, it contains a number of `GetXXX()` and `SetXXX()` methods that allow you to get and set different aspects of the shell link. Consider the following record declaration, which contains fields for each of the possible values that can be set or retrieved:

```
type
  TShellLinkInfo = record
    PathName: string;
    Arguments: string;
    Description: string;
    WorkingDirectory: string;
    IconLocation: string;
    IconIndex: Integer;
    ShowCmd: Integer;
    HotKey: Word;
  end;
```

Given this record, you can create functions that retrieve the settings of a given shell link to the record or that set a link's values to those indicated by the record's contents. Such functions are shown in Listing 24.5; WinShell.pas is a unit that contains the complete source for these functions.

LISTING 24.5 WinShell.pas, the Unit Containing Functions that Operate on Shell Links

```
unit WinShell;

interface

uses SysUtils, Windows, Registry, ActiveX, ShlObj;

type
  EShellOLEError = class(Exception);

  TShellLinkInfo = record
    PathName: string;
    Arguments: string;
    Description: string;
    WorkingDirectory: string;
    IconLocation: string;
    IconIndex: integer;
    ShowCmd: integer;
    HotKey: word;
  end;

  TSpecialFolderInfo = record
    Name: string;
    ID: Integer;
  end;

const
  SpecialFolders: array[0..29] of TSpecialFolderInfo = (
    (Name: 'Alt Startup'; ID: CSIDL_ALTSTARTUP),
    (Name: 'Application Data'; ID: CSIDL_APPDATA),
    (Name: 'Recycle Bin'; ID: CSIDL_BITBUCKET),
    (Name: 'Common Alt Startup'; ID: CSIDL_COMMON_ALTSTARTUP),
    (Name: 'Common Desktop'; ID: CSIDL_COMMON_DESKTOPDIRECTORY),
    (Name: 'Common Favorites'; ID: CSIDL_COMMON_FAVORITES),
    (Name: 'Common Programs'; ID: CSIDL_COMMON_PROGRAMS),
    (Name: 'Common Start Menu'; ID: CSIDL_COMMON_STARTMENU),
    (Name: 'Common Startup'; ID: CSIDL_COMMON_STARTUP),
    (Name: 'Controls'; ID: CSIDL_CONTROLS),
    (Name: 'Cookies'; ID: CSIDL_COOKIES),
```

continues

LISTING 24.5 Continued

```
(Name: 'Desktop'; ID: CSIDL_DESKTOP),
(Name: 'Desktop Directory'; ID: CSIDL_DESKTOPDIRECTORY),
(Name: 'Drives'; ID: CSIDL_DRIVES),
(Name: 'Favorites'; ID: CSIDL_FAVORITES),
(Name: 'Fonts'; ID: CSIDL_FONTS),
(Name: 'History'; ID: CSIDL_HISTORY),
(Name: 'Internet'; ID: CSIDL_INTERNET),
(Name: 'Internet Cache'; ID: CSIDL_INTERNET_CACHE),
(Name: 'Network Neighborhood'; ID: CSIDL_NETWORK),
(Name: 'Network Top'; ID: CSIDL_NETWORK),
(Name: 'Personal'; ID: CSIDL_PERSONAL),
(Name: 'Printers'; ID: CSIDL_PRINTERS),
(Name: 'Printer Links'; ID: CSIDL_PRINTHOOD),
(Name: 'Programs'; ID: CSIDL_PROGRAMS),
(Name: 'Recent Documents'; ID: CSIDL_RECENT),
(Name: 'Send To'; ID: CSIDL_SENDTO),
(Name: 'Start Menu'; ID: CSIDL_STARTMENU),
(Name: 'Startup'; ID: CSIDL_STARTUP),
(Name: 'Templates'; ID: CSIDL_TEMPLATES));

function CreateShellLink(const AppName, Desc: string; Dest: Integer): string;
function GetSpecialFolderPath(Folder: Integer; CanCreate: Boolean): string;
procedure GetShellLinkInfo(const LinkFile: WideString;
    var SLI: TShellLinkInfo);
procedure SetShellLinkInfo(const LinkFile: WideString;
    const SLI: TShellLinkInfo);

implementation

uses ComObj;

function GetSpecialFolderPath(Folder: Integer; CanCreate: Boolean): string;
var
    FilePath: array[0..MAX_PATH] of char;
begin
    { Get path of selected location }
    SHGetSpecialFolderPathW(0, FilePath, Folder, CanCreate);
    Result := FilePath;
end;

function CreateShellLink(const AppName, Desc: string; Dest: Integer): string;
{ Creates a shell link for application or document specified in }
{ AppName with description Desc. Link will be located in folder }
{ specified by Dest, which is one of the string constants shown }
```

```

{ at the top of this unit. Returns the full path name of the }
{ link file. }
var
  SL: IShellLink;
  PF: IPersistFile;
  LnkName: WideString;
begin
  OleCheck(CoCreateInstance(CLSID_ShellLink, nil, CLSCTX_INPROC_SERVER,
    IShellLink, SL));
  { The IShellLink implementer must also support the IPersistFile }
  { interface. Get an interface pointer to it. }
  PF := SL as IPersistFile;
  OleCheck(SL.SetPath(PChar(AppName))); // set link path to proper file
  if Desc <> '' then
    OleCheck(SL.SetDescription(PChar(Desc))); // set description
  { create a path location and filename for link file }
  LnkName := GetSpecialFolderPath(Dest, True) + '\' +
    ChangeFileExt(AppName, 'lnk');
  PF.Save(PWideChar(LnkName), True); // save link file
  Result := LnkName;
end;

procedure GetShellLinkInfo(const LinkFile: WideString;
  var SLI: TShellLinkInfo);
{ Retrieves information on an existing shell link }
var
  SL: IShellLink;
  PF: IPersistFile;
  FindData: TWin32FindData;
  AStr: array[0..MAX_PATH] of char;
begin
  OleCheck(CoCreateInstance(CLSID_ShellLink, nil, CLSCTX_INPROC_SERVER,
    IShellLink, SL));
  { The IShellLink implementer must also support the IPersistFile }
  { interface. Get an interface pointer to it. }
  PF := SL as IPersistFile;
  { Load file into IPersistFile object }
  OleCheck(PF.Load(PWideChar(LinkFile), STGM_READ));
  { Resolve the link by calling the Resolve interface function. }
  OleCheck(SL.Resolve(0, SLR_ANY_MATCH or SLR_NO_UI));
  { Get all the info! }
  with SLI do
  begin
    OleCheck(SL.GetPath(AStr, MAX_PATH, FindData, SLGP_SHORTPATH));
    PathName := AStr;
    OleCheck(SL.GetArguments(AStr, MAX_PATH));
  end;
end;

```

LISTING 24.5 Continued

```
    Arguments := AStr;
    OleCheck(SL.GetDescription(AStr, MAX_PATH));
    Description := AStr;
    OleCheck(SL.GetWorkingDirectory(AStr, MAX_PATH));
    WorkingDirectory := AStr;
    OleCheck(SL.GetIconLocation(AStr, MAX_PATH, IconIndex));
    IconLocation := AStr;
    OleCheck(SL.GetShowCmd(ShowCmd));
    OleCheck(SL.GetHotKey(HotKey));
end;
end;

procedure SetShellLinkInfo(const LinkFile: WideString;
    const SLI: TShellLinkInfo);
{ Sets information for an existing shell link }
var
    SL: IShellLink;
    PF: IPersistFile;
begin
    OleCheck(CoCreateInstance(CLSID_ShellLink, nil, CLSCTX_INPROC_SERVER,
        IShellLink, SL));
    { The IShellLink implementer must also support the IPersistFile }
    { interface. Get an interface pointer to it. }
    PF := SL as IPersistFile;
    { Load file into IPersistFile object }
    OleCheck(PF.Load(PWideChar(LinkFile), STGM_SHARE_DENY_WRITE));
    { Resolve the link by calling the Resolve interface function. }
    OleCheck(SL.Resolve(0, SLR_ANY_MATCH or SLR_UPDATE or SLR_NO_UI));
    { Set all the info! }
    with SLI, SL do
    begin
        OleCheck(SetPath(PChar(PathName)));
        OleCheck(SetArguments(PChar(Arguments)));
        OleCheck(SetDescription(PChar(Description)));
        OleCheck(SetWorkingDirectory(PChar(WorkingDirectory)));
        OleCheck(SetIconLocation(PChar(IconLocation), IconIndex));
        OleCheck(SetShowCmd(ShowCmd));
        OleCheck(SetHotKey(HotKey));
    end;
    PF.Save(PWideChar(LinkFile), True); // save file
end;

end.
```

One method of `IShellLink` that has yet to be explained is the `Resolve()` method. `Resolve()` should be called after the `IPersistFile` interface of `IShellLink` is used to load a link file. This searches the specified link file and fills the `IShellLink` object with values specified in the file.

TIP

In the `GetShellLinkInfo()` function shown in Listing 24.5, notice the use of the `AString` local array into which values are retrieved. This technique is used rather than using the `SetLength()` to allocate space for the strings—using `SetLength()` on so many strings would cause fragmentation of the application's heap. Using `AString` as an intermediate prevents this from occurring. Additionally, because the length of the strings needs to be set only once, using `AString` ends up being slightly faster.

A Sample Application

These functions and interfaces might be fun and all, but they're nothing without a nifty application in which to show them off. The Shell Link project allows you to do just that. The main form of this project is shown in Figure 24.6.

Listing 24.6 shows the main unit for this project, `Main.pas`. Listings 24.7 and 24.8 show `NewLinkU.pas` and `PickU.pas`, two supporting units for the project.

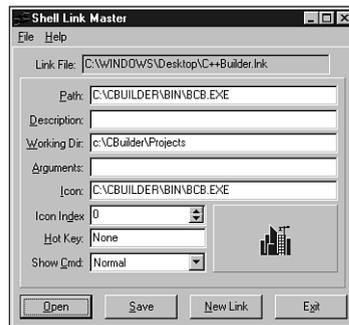


FIGURE 24.6

The Shell Link main form, showing one of the desktop links.

LISTING 24.6 Main.pas, Main Code for Shell Link Project

```
unit Main;
```

```
interface
```

continues

LISTING 24.6 Continued

uses

Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
StdCtrls, ComCtrls, ExtCtrls, Spin, WinShell, Menus;

type

```
TMainForm = class(TForm)
  Panel1: TPanel;
  btnOpen: TButton;
  edLink: TEdit;
  btnNew: TButton;
  btnSave: TButton;
  Label3: TLabel;
  Panel2: TPanel;
  Label1: TLabel;
  Label2: TLabel;
  Label4: TLabel;
  Label5: TLabel;
  Label6: TLabel;
  Label7: TLabel;
  Label8: TLabel;
  Label9: TLabel;
  edIcon: TEdit;
  edDesc: TEdit;
  edWorkDir: TEdit;
  edArg: TEdit;
  cbShowCmd: TComboBox;
  hkHotKey: THotKey;
  speIcnIdx: TSpinEdit;
  pnlIconPanel: TPanel;
  imgIconImage: TImage;
  btnExit: TButton;
  MainMenu1: TMainMenu;
  File1: TMenuItem;
  Open1: TMenuItem;
  Save1: TMenuItem;
  NewLink1: TMenuItem;
  N1: TMenuItem;
  Exit1: TMenuItem;
  Help1: TMenuItem;
  About1: TMenuItem;
  edPath: TEdit;
  procedure btnOpenClick(Sender: TObject);
  procedure btnNewClick(Sender: TObject);
  procedure edIconChange(Sender: TObject);
  procedure btnSaveClick(Sender: TObject);
  procedure btnExitClick(Sender: TObject);
```

```

    procedure About1Click(Sender: TObject);
private
    procedure GetControls(var SLI: TShellLinkInfo);
    procedure SetControls(const SLI: TShellLinkInfo);
    procedure ShowIcon;
    procedure OpenLinkFile(const LinkFileName: String);
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

uses PickU, NewLinkU, AboutU, CommCtrl, ShellAPI;

type
    THotKeyRec = record
        Char, ModCode: Byte;
    end;

procedure TMainForm.SetControls(const SLI: TShellLinkInfo);
{ Sets values of UI controls based on contents of SLI }
var
    Mods: THKModifiers;
begin
    with SLI do
    begin
        edPath.Text := PathName;
        edIcon.Text := IconLocation;
        { if icon name is blank and link is to exe, use exe name for icon }
        { path. This is done because the icon index is ignored if the }
        { icon path is blank, but an exe may contain more than one icon. }
        if (IconLocation = '') and
            (CompareText(ExtractFileExt(PathName), 'EXE') = 0) then
            edIcon.Text := PathName;
        edWorkDir.Text := WorkingDirectory;
        edArg.Text := Arguments;
        speIcnIdx.Value := IconIndex;
        edDesc.Text := Description;
        { SW_* constants start at 1 }
        cbShowCmd.ItemIndex := ShowCmd - 1;
        { Hot key char in low byte }
        hkHotKey.HotKey := Lo(HotKey);
        { Figure out which modifier flags are in high byte }

```

LISTING 24.6 Continued

```

    Mods := [];
    if (HOTKEYF_ALT and Hi(HotKey)) <> 0 then include(Mods, hkAlt);
    if (HOTKEYF_CONTROL and Hi(HotKey)) <> 0 then include(Mods, hkCtrl);
    if (HOTKEYF_EXT and Hi(HotKey)) <> 0 then include(Mods, hkExt);
    if (HOTKEYF_SHIFT and Hi(HotKey)) <> 0 then include(Mods, hkShift);
    { Set modifiers set }
    hkHotKey.Modifiers := Mods;
end;
ShowIcon;
end;

procedure TMainForm.GetControls(var SLI: TShellLinkInfo);
{ Gets values of UI controls and uses them to set values of SLI }
var
    CtlMods: THKModifiers;
    HR: THotKeyRec;
begin
    with SLI do
    begin
        PathName := edPath.Text;
        IconLocation := edIcon.Text;
        WorkingDirectory := edWorkDir.Text;
        Arguments := edArg.Text;
        IconIndex := speIcnIdx.Value;
        Description := edDesc.Text;
        { SW_* constants start at 1 }
        ShowCmd := cbShowCmd.ItemIndex + 1;
        { Get hot key character }
        word(HR) := hkHotKey.HotKey;
        { Figure out which modifier keys are being used }
        CtlMods := hkHotKey.Modifiers;
        with HR do begin
            ModCode := 0;
            if (hkAlt in CtlMods) then ModCode := ModCode or HOTKEYF_ALT;
            if (hkCtrl in CtlMods) then ModCode := ModCode or HOTKEYF_CONTROL;
            if (hkExt in CtlMods) then ModCode := ModCode or HOTKEYF_EXT;
            if (hkShift in CtlMods) then ModCode := ModCode or HOTKEYF_SHIFT;
        end;
        HotKey := word(HR);
    end;
end;

procedure TMainForm.ShowIcon;
{ Retrieves icon from appropriate file and shows in IconImage }
var

```

```

    HI: THandle;
    IcnFile: string;
    IconIndex: word;
begin
    { Get name of icon file }
    IcnFile := edIcon.Text;
    { If blank, use the exe name }
    if IcnFile = '' then
        IcnFile := edPath.Text;
    { Make sure file exists }
    if FileExists(IcnFile) then
        begin
            IconIndex := speIcnIdx.Value;
            { Extract icon from file }
            HI := ExtractAssociatedIcon(hInstance, PChar(IcnFile), IconIndex);
            { Assign icon handle to IconImage }
            imgIconImage.Picture.Icon.Handle := HI;
        end;
end;

procedure TMainForm.OpenLinkFile(const LinkFileName: string);
{ Opens a link file, get info, and displays info in UI }
var
    SLI: TShellLinkInfo;
begin
    edLink.Text := LinkFileName;
    try
        GetShellLinkInfo(LinkFileName, SLI);
    except
        on EShellOleError do
            MessageDlg('Error occurred while opening link', mtError, [mbOk], 0);
    end;
    SetControls(SLI);
end;

procedure TMainForm.btnOpenClick(Sender: TObject);
{ OnClick handler for OpenBtn }
var
    LinkFile: String;
begin
    if GetLinkFile(LinkFile) then
        OpenLinkFile(LinkFile);
end;

procedure TMainForm.btnNewClick(Sender: TObject);
{ OnClick handler for NewBtn }

```

LISTING 24.6 Continued

```
var
  FileName: string;
  Dest: Integer;
begin
  if GetNewLinkName(FileName, Dest) then
    OpenLinkFile(CreateShellLink(FileName, '', Dest));
end;

procedure TMainForm.edIconChange(Sender: TObject);
{ OnChange handler for IconEd and IcnIdxEd }
begin
  ShowIcon;
end;

procedure TMainForm.btnSaveClick(Sender: TObject);
{ OnClick handler for SaveBtn }
var
  SLI: TShellLinkInfo;
begin
  GetControls(SLI);
  try
    SetShellLinkInfo(edLink.Text, SLI);
  except
    on EShellOleError do
      MessageDlg('Error occurred while setting info', mtError, [mbOk], 0);
  end;
end;

procedure TMainForm.btnExitClick(Sender: TObject);
{ OnClick handler for ExitBtn }
begin
  Close;
end;

procedure TMainForm.About1Click(Sender: TObject);
{ OnClick handler for Help|About menu item }
begin
  AboutBox;
end;

end.
```

LISTING 24.7 NewLinkU.pas, the Unit with Form that Helps Create New Link

```
unit NewLinkU;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  Buttons, StdCtrls;

type
  TNewLinkForm = class(TForm)
    Label1: TLabel;
    Label2: TLabel;
    edLinkTo: TEdit;
    btnOk: TButton;
    btnCancel: TButton;
    cbLocation: TComboBox;
    sbOpen: TSpeedButton;
    OpenFileDialog: TOpenDialog;
    procedure sbOpenClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
  end;

function GetNewLinkName(var LinkTo: string; var Dest: Integer): Boolean;

implementation

uses WinShell;

{$R *.DFM}

function GetNewLinkName(var LinkTo: string; var Dest: Integer): Boolean;
{ Gets file name and destination folder for a new shell link. }
{ Only modifies params if Result = True. }
begin
  with TNewLinkForm.Create(Application) do
    try
      cbLocation.ItemIndex := 0;
      Result := ShowModal = mrOk;
      if Result then
        begin
          LinkTo := edLinkTo.Text;
          Dest := cbLocation.ItemIndex;
        end;
    finally

```

LISTING 24.7 Continued

```
    Free;
  end;
end;

procedure TNewLinkForm.sbOpenClick(Sender: TObject);
begin
  if OpenFileDialog.Execute then
    edLinkTo.Text := OpenFileDialog.FileName;
end;

procedure TNewLinkForm.FormCreate(Sender: TObject);
var
  I: Integer;
begin
  for I := Low(SpecialFolders) to High(SpecialFolders) do
    cbLocation.Items.Add(SpecialFolders[I].Name);
end;

end.
```

LISTING 24.8 PickU.pas, the Unit with Form that Enables the User to Choose Link Location

```
unit PickU;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, FileCtrl;

type
  TLinkForm = class(TForm)
    lbLinkFiles: TFileListBox;
    btnOk: TButton;
    btnCancel: TButton;
    cbLocation: TComboBox;
    Label1: TLabel;
    procedure lbLinkFilesDbClick(Sender: TObject);
    procedure cbLocationChange(Sender: TObject);
    procedure FormCreate(Sender: TObject);
  end;

function GetLinkFile(var S: String): Boolean;
```

```
implementation

{$R *.DFM}

uses WinShell, ShlObj;

function GetLinkFile(var S: String): Boolean;
{ Returns link file name in S. }
{ Only modifies S when Result is True. }
begin
  with TLinkForm.Create(Application) do
    try
      { Make sure location is selected }
      cbLocation.ItemIndex := 0;
      { Get path of selected location }
      cbLocationChange(nil);
      Result := ShowModal = mrOk;
      { Return full pathname for link file }
      if Result then
        S := lbLinkFiles.Directory + '\' +
          lbLinkFiles.Items[lbLinkFiles.ItemIndex];
    finally
      Free;
    end;
  end;
end;

procedure TLinkForm.lbLinkFilesDbClick(Sender: TObject);
begin
  ModalResult := mrOk;
end;

procedure TLinkForm.cbLocationChange(Sender: TObject);
var
  Folder: Integer;
begin
  { Get path of selected location }
  Folder := SpecialFolders[cbLocation.ItemIndex].ID;
  lbLinkFiles.Directory := GetSpecialFolderPath(Folder, False);
end;

procedure TLinkForm.FormCreate(Sender: TObject);
var
  I: Integer;
begin
  for I := Low(SpecialFolders) to High(SpecialFolders) do
```

continues

LISTING 24.8 Continued

```
        cbLocation.Items.Add(SpecialFolders[I].Name);  
end;  
  
end.
```

Shell Extensions

For the ultimate in extensibility, the Windows shell provides a means for you to develop code that executes from within the shell's own process and namespace. *Shell extensions* are implemented as in-process COM servers that are created and used by the shell.

NOTE

Because shell extensions are COM servers at heart, understanding them requires a basic understand of COM. If you're COM knowledge needs brushing up, Chapter 23, "COM and ActiveX," provides this foundation.

Several types of shell extensions are available to deal with a variety of the shell's aspects. Also known as a *handler*, a shell extension must implement one or more COM interfaces. The shell supports the following types of shell extensions:

- *Copy hook handlers* implement the `ICopyHook` interface. These shell extensions allow you to receive notifications whenever a folder is copied, deleted, moved, or renamed and to optionally prevent the operation from occurring.
- *Context menu handlers* implement the `IContextMenu` and `IShellExtInit` interfaces. These shell extensions enable you to add items to the context menu of a particular file object in the shell.
- *Drag-and-drop handlers* also implement the `IContextMenu` and `IShellExtInit` interfaces. These shell extensions are almost identical in implementation to context menu handlers, except that they're invoked when a user drags an object and drops it to a new location.
- *Icon handlers* implement the `IExtractIcon` and `IPersistFile` interfaces. Icon handlers allow you to provide different icons for multiple instances of the same type of file object.
- *Property sheet handlers* implement the `IShellPropSheetExt` and `IShellExtInit` interfaces, and they allow you to add pages to the properties dialog associated with a file type.

- *Drop target handlers* implement the `IDropTarget` and `IPersistFile` interfaces. These shell extensions allow you to control what happens when you drop one shell object on another.
- *Data object handlers* implement the `IDataObject` and `IPersistFile` interfaces, and they supply the data object used when files are being dragged and dropped or copied and pasted.

Debugging Shell Extensions

Before we get into the subject of actually writing shell extensions, consider the question of debugging shell extensions. Because shell extensions execute from within the shell's own process, how is it possible to "hook into" the shell in order to debug your shell extension?

The solution to the problem is based on the fact that the shell is an executable (not very different than any other application) called `explorer.exe`. `Explorer.exe` has a property, however, that is kind of unique: The first instance of `explorer.exe` will invoke the shell. Subsequent instances will simply invoke additional "Explorer" windows in the shell.

Using a little-known trick in the shell, it's possible to close the shell without closing Windows. Follow these steps to debug your shell extensions in Delphi:

1. Make `explorer.exe` the host application for your shell extension in the Run, Parameters dialog. Be sure to include the full path (that is, `c:\windows\explorer.exe`).
2. From the shell's Start menu, select Shut Down. This will invoke the Shut Down Windows dialog.
3. In the Shut Down Windows dialog, hold down `Ctrl+Alt+Shift` and click the No button. This will close the shell without closing Windows.
4. Using `Alt+Tab`, switch back to Delphi and run the shell extension. This will invoke a new copy of the shell running under the Delphi debugger. You can now set breakpoints in your code and debug as usual.
5. When you're ready to close Windows, you can still do so properly without the use of the shell: Use `Ctrl+Esc` to invoke the Tasks window and then select Windows, Shutdown Windows to close Windows.

The remainder of this chapter is dedicated to showing a cross section of the shell extensions just described. You'll learn about copy hook handlers, context menu handlers, and icon handlers.

The COM Object Wizard

Before discussing each of the shell extension DLLs, we should first mention a bit about how they're created. Because shell extensions are in-process COM servers, you can let the Delphi IDE do most of the grunt work in creating the source code for you. Work begins for all the shell extensions with the same two steps:

1. Select ActiveX Library from the ActiveX page of the New Items dialog. This will create a new COM server DLL into which you can insert COM objects.
2. Select COM Object from the ActiveX page of the New Items dialogs. This will invoke the COM Server Wizard. In the wizard's dialog, enter a name and description for your shell extension and select the Apartment threading model. Click OK, and a new unit containing the code for your COM object will be generated.

Copy Hook Handlers

As mentioned earlier, copy hook shell extensions allow you to install a handler that receives notifications whenever a folder is copied, deleted, moved, or renamed. After receiving this notification, the handler can optionally prevent the operation from occurring. Note that the handler is only called for folder and printer objects; it's not called for files and other objects.

The first step in creating a copy hook handler is to create an object that descends from `TComObject` and implements the `ICopyHook` interface. This interface is defined in the `Sh10bj` unit as follows:

```
type
  ICopyHook = interface(IUnknown)
    ['{000214EF-0000-0000-C000-000000000046}']
    function CopyCallback(Wnd: HWND; wFunc, wFlags: UINT;
      pszSrcFile: PAnsiChar; dwSrcAttribs: DWORD; pszDestFile: PAnsiChar;
      dwDestAttribs: DWORD): UINT; stdcall;
  end;
```

The CopyCallback() Method

As you can see, `ICopyHook` is a pretty simple interface, and it implements only one function: `CopyCallback()`. This function will be called whenever a shell folder is manipulated. The following paragraphs describe the parameters for this function.

`Wnd` is the handle of the window the copy hook handler should use as the parent for any windows it displays. `wFunc` indicates the operation being performed. This can be any one of the values shown in Table 24.5.

TABLE 24.5 The wFunc Values for CopyCallback()

<i>Constant</i>	<i>Value</i>	<i>Meaning</i>
FO_COPY	\$2	Copies the file specified by pszSrcFile to the location specified by pszDestFile.
FO_DELETE	\$3	Deletes the file specified by pszSrcFile.
FO_MOVE	\$1	Moves the file specified by pszSrcFile to the location specified by pszDestFile.
FO_RENAME	\$4	Renames the file specified by pszSrcFile.
PO_DELETE	\$13	Deletes the printer specified by pszSrcFile.
PO_PORTCHANGE	\$20	Changes the printer port. The pszSrcFile and pszDestFile parameters contain double null-terminated lists of strings. Each list contains the printer name followed by the port name. The port name in pszSrcFile is the current printer port, and the port name in pszDestFile is the new printer port.
PO_RENAME	\$14	Renames the printer specified by pszSrcFile.
PO_REN_PORT	\$34	A combination of PO_RENAME and PO_PORTCHANGE.

wFlags holds the flags that control the operation. This parameter can be a combination of the values shown in Table 24.6.

TABLE 24.6 The wFlags Values for CopyCallback()

<i>Constant</i>	<i>Value</i>	<i>Meaning</i>
FOF_ALLOWUNDO	\$40	Preserves undo information (when possible).
FOF_MULTIDESTFILES	\$1	The SHFileOperation() function specifies multiple destination files (one for each source file) rather than one directory where all the source files are to be deposited. A copy hook handler typically ignores this value.
FOF_NOCONFIRMATION	\$10	Responds with “Yes to All” for any dialog that’s displayed.
FOF_NOCONFIRMMKDIR	\$200	Does not confirm the creation of any needed directories if the operation requires a new directory to be created.
FOF_RENAMEONCOLLISION	\$8	Gives the file being operated on a new name (such as “Copy #1 of...”) in a copy, move, or rename operation when a file with the target name already exists.
FOF_SILENT	\$4	Does not displays a progress dialog.
FOF_SIMPLEPROGRESS	\$100	Displays a progress dialog, but the dialog doesn’t show the names of the files.

pszSourceFile is the name of the source folder, dwSrcAttribs holds the attributes of the source folder, pszDestFile is the name of the destination folder, and dwDestAttribs holds the attributes of the destination folder.

Unlike most methods, this interface does not return an OLE result code. Instead, it must return one of the values listed in Table 24.7, as defined in the Windows unit.

TABLE 24.7 The wFlags Values for CopyCallback()

<i>Constant</i>	<i>Value</i>	<i>Meaning</i>
IDYES	6	Allows the operation
IDNO	7	Prevents the operation on this file but continues with any other operations (for example, a batch copy operation)
IDCANCEL	2	Prevents the current operation and cancels any pending operations

TCopyHook Implementation

Being an object that implements one interface with one method, there isn't much to TCopyHook:

```
type
  TCopyHook = class(TComObject, ICopyHook)
  protected
    function CopyCallback(Wnd: HWND; wFunc, wFlags: UINT;
      pszSrcFile: PAnsiChar;
      dwSrcAttribs: DWORD; pszDestFile: PAnsiChar; dwDestAttribs: DWORD): UINT;
      stdcall;
  end;
```

The implementation of the CopyCallback() method is also small. The MessageBox() API function is called to confirm whatever operation is being attempted. Conveniently, the return value for MessageBox() will be the same as the return value for this method:

```
function TCopyHook.CopyCallback(Wnd: HWND; wFunc, wFlags: UINT;
  pszSrcFile: PAnsiChar; dwSrcAttribs: DWORD; pszDestFile: PAnsiChar;
  dwDestAttribs: DWORD): UINT;
const
  MyMessage: string = 'Are you sure you want to mess with "%s"?';
begin
  // confirm operation
  Result := MessageBox(Wnd, PChar(Format(MyMessage, [pszSrcFile])),
    'D4DG Shell Extension', MB_YESNO);
end;
```

TIP

You might wonder why the `MessageBox()` API function is used to display a message rather than using a Delphi function such as `MessageDlg()` or `ShowMessage()`. The reason is simple: size and efficiency. Calling any function out of the `Dialogs` or `Forms` unit would cause a great deal of VCL to be linked into the DLL. By keeping these units out of the `uses` clause, the shell extension DLL weighs in at svelte 70KB.

Believe it or not, that's all there is to the `TCopyHook` object itself. However, there's still one major detail to work through before calling it a day: The shell extension must be registered with the System Registry before it will function.

Registration

In addition to the normal registration required of any COM server, a copy hook handler must have an additional Registry entry under

```
HKEY_CLASSES_ROOT\directory\shellex\CopyHookHandlers
```

Furthermore, Windows NT requires that all shell extensions be registered as approved shell extensions under

```
HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion  
└─\Shell Extensions\Approved
```

You can take several approaches to registering shell extensions: They can be registered via a REG file or through an installation program. The shell extension DLL, itself, can be self-registering. Although it might be just a bit more work, the best solution is to make each shell extension DLL self-registering. This is cleaner, because it makes your shell extension a one-file, self-contained package.

As you learned in the last chapter, “COM and ActiveX,” COM objects are always created from class factories. Within the VCL framework, class factory objects are also responsible for registering the COM object they will create. If a COM object requires custom Registry entries (as is the case with a shell extension), setting these entries up is just a matter of overriding the class factory's `UpdateRegistry()` method. Listing 24.9 shows the completed `CopyMain` unit, which includes a specialized class factory used to perform custom registration.

LISTING 24.9 `CopyMain.pas`, Main Unit for Copy Hook Implementation

```
unit CopyMain;
```

```
interface
```

continues

LISTING 24.9 Continued

```
uses Windows, ComObj, ShlObj;

type
  TCopyHook = class(TComObject, ICopyHook)
  protected
    function CopyCallback(Wnd: HWND; wFunc, wFlags: UINT;
      pszSrcFile: PAnsiChar; dwSrcAttribs: DWORD;
      pszDestFile: PAnsiChar; dwDestAttribs: DWORD): UINT; stdcall;
  end;

  TCopyHookFactory = class(TComObjectFactory)
  protected
    function GetProgID: string; override;
    procedure ApproveShellExtension(Register: Boolean; const ClsID: string);
      virtual;
  public
    procedure UpdateRegistry(Register: Boolean); override;
  end;

implementation

uses ComServ, SysUtils, Registry;

{ TCopyHook }

// This is the method which is called by the shell for folder operations
function TCopyHook.CopyCallback(Wnd: HWND; wFunc, wFlags: UINT;
  pszSrcFile: PAnsiChar; dwSrcAttribs: DWORD; pszDestFile: PAnsiChar;
  dwDestAttribs: DWORD): UINT;
const
  MyMessage: string = 'Are you sure you want to mess with "%s"?';
begin
  // confirm operation
  Result := MessageBox(Wnd, PChar(Format(MyMessage, [pszSrcFile])),
    'D4DG Shell Extension', MB_YESNO);
end;

{ TCopyHookFactory }

function TCopyHookFactory.GetProgID: string;
begin
  // ProgID not needed for shell extension
  Result := '';
end;

procedure TCopyHookFactory.UpdateRegistry(Register: Boolean);
```

```

var
  ClsID: string;
begin
  ClsID := GUIDToString(ClassID);
  inherited UpdateRegistry(Register);
  ApproveShellExtension(Register, ClsID);
  if Register then
    // add shell extension clsid to CopyHookHandlers Reg entry
    CreateRegKey('directory\shellex\CopyHookHandlers\' + ClassName, '',
      ClsID)
  else
    DeleteRegKey('directory\shellex\CopyHookHandlers\' + ClassName);
end;

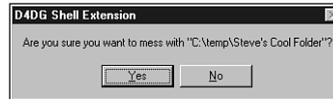
procedure TCopyHookFactory.ApproveShellExtension(Register: Boolean;
  const ClsID: string);
// This registry entry is required in order for the extension to
// operate correctly under Windows NT.
const
  SApproveKey = 'SOFTWARE\Microsoft\Windows\CurrentVersion\Shell
  Extensions\Approved';
begin
  with TRegistry.Create do
    try
      RootKey := HKEY_LOCAL_MACHINE;
      if not OpenKey(SApproveKey, True) then Exit;
      if Register then WriteString(ClsID, Description)
      else DeleteValue(ClsID);
    finally
      Free;
    end;
  end;
end;

const
  CLSID_CopyHook: TGUID = '{66CD5F60-A044-11D0-A9BF-00A024E3867F}';

initialization
  TCopyHookFactory.Create(ComServer, TCopyHook, CLSID_CopyHook,
    'D4DG_CopyHook', 'D4DG Copy Hook Shell Extension Example',
    ciMultiInstance, tmApartment);
end.

```

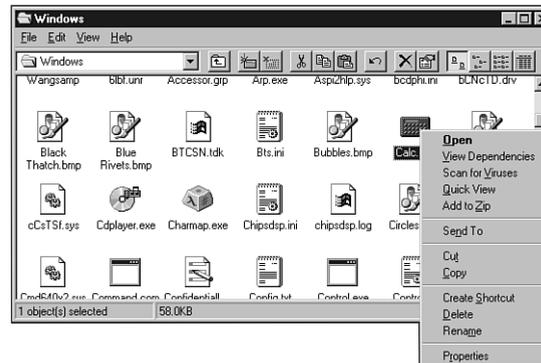
What makes the `TCopyHookFactory` class factory work is the fact that an instance of it, rather than the usual `TComObjectFactory`, is being created in the `initialization` part of the unit. Figure 24.7 shows what happens when you try to rename a folder in the shell after the copy hook shell extension DLL is installed.

**FIGURE 24.7**

The copy hook handler in action.

Context Menu Handlers

Context menu handlers enable you to add items to the local menu that are associated with file objects in the shell. A sample local menu for an EXE file is shown in Figure 24.8.

**FIGURE 24.8**

The shell local menu for an EXE file.

Context menu shell extensions work by implementing the `IShellExtInit` and `IContextMenu` interfaces. In this case, we'll implement these interfaces to create a context menu handler for Borland Package Library (BPL) files; the local menu for package files in the shell will provide an option for obtaining package information. This context menu handler object will be called `TContextMenu`, and, like the copy hook handler, `TContextMenu` will descend from `TComObject`.

IShellExtInit

The `IShellExtInit` interface is used to initialize a shell extension. This interface is defined in the `Sh10bj` unit as follows:

```
type
  IShellExtInit = interface(IUnknown)
    ['{000214E8-0000-0000-C000-000000000046}']
    function Initialize(pidlFolder: PItemIDList; lpobj: IDataObject;
```

```

    hKeyProgID: HKEY): HRESULT; stdcall;
end;

```

`Initialize()`, being the only method of this interface, is called to initialize the context menu handler. The following paragraphs describe the parameters for this method.

`pidlFolder` is a pointer to a `PItemIDList` (item identifier list) structure for the folder that contains the item whose context menu is being displayed. `lpdobj` holds the `IDataObject` interface object used to retrieve the objects being acted upon. `hkeyProgID` contains the Registry key for the file object or folder type.

The implementation for this method is shown in the following code. Upon first glance, the code might look complex, but it really boils down to three things: a call to `lpobj.GetData()` to obtain data from `IDataObject` and two calls to `DragQueryFile()` (one call to obtain the number of files and the other to obtain the filename). The filename is stored in the object's `FFilename` field. Here's the code:

```

function TContextMenu.Initialize(pidlFolder: PItemIDList; lpdobj: IDataObject;
    hKeyProgID: HKEY): HRESULT;
var
    Medium: TStgMedium;
    FE: TFormatEtc;
begin
    try
        // Fail the call if lpdobj is nil.
        if lpdobj = nil then
            begin
                Result := E_FAIL;
                Exit;
            end;
        with FE do
            begin
                cfFormat := CF_HDROP;
                ptd := nil;
                dwAspect := DVASPECT_CONTENT;
                lindex := -1;
                tymed := TYMED_HGLOBAL;
            end;
        // Render the data referenced by the IDataObject pointer to an HGLOBAL
        // storage medium in CF_HDROP format.
        Result := lpdobj.GetData(FE, Medium);
        if Failed(Result) then Exit;
    try
        // If only one file is selected, retrieve the file name and store it in
        // szFile. Otherwise fail the call.

```

```

    if DragQueryFile(Medium.hGlobal, $FFFFFFFF, nil, 0) = 1 then
    begin
        DragQueryFile(Medium.hGlobal, 0, FFFileName, SizeOf(FFFileName));
        Result := NOERROR;
    end
    else
        Result := E_FAIL;
    finally
        ReleaseStgMedium(medium);
    end;
except
    Result := E_UNEXPECTED;
end;
end;

```

IContextMenu

The IContextMenu interface is used to manipulate the pop-up menu associated with a file in the shell. This interface is defined in the Sh10bj unit as follows:

```

type
    IContextMenu = interface(IUnknown)
    [ '{000214E4-0000-0000-C000-000000000046}' ]
    function QueryContextMenu(Menu: HMENU;
        indexMenu, idCmdFirst, idCmdLast, uFlags: UINT): HRESULT; stdcall;
    function InvokeCommand(var lpici: TCMInvokeCommandInfo): HRESULT; stdcall;
    function GetCommandString(idCmd, uType: UINT; pwReserved: PUINT;
        pszName: LPSTR; cchMax: UINT): HRESULT; stdcall;
    end;

```

After the handler has been initialized through the IShellExtInit interface, the next method to be called is IContextMenu.QueryContextMenu(). The parameters passed to this method include a menu handle, the index at which to insert the first menu item, the minimum and maximum values for menu item IDs, and flags that indicate menu attributes. The following TContextMenu implementation of this method adds a menu item with the text “Package Info...” to the menu handle passed in the Menu parameter (note that the return value for QueryContextMenu() is the index of the last menu item inserted plus one):

```

function TContextMenu.QueryContextMenu(Menu: HMENU; indexMenu, idCmdFirst,
    idCmdLast, uFlags: UINT): HRESULT;
begin
    FMenuIdx := indexMenu;
    // Add one menu item to context menu
    InsertMenu (Menu, FMenuIdx, MF_STRING or MF_BYPOSITION, idCmdFirst,
        'Package Info...');

```

```

    // Return index of last inserted item + 1
    Result := FMenuIdx + 1;
end;

```

The next method called by the shell is `GetCommandString()`. This method is intended to retrieve the language-independent command string or help string for a particular menu item. The parameters for this method include the menu item offset, flags indicating the type of information to receive, a reserved parameter, and a string buffer and buffer size. The following `TContextMenu` implementation of this method only needs to deal with providing the help string for the menu item:

```

function TContextMenu.GetCommandString(idCmd, uType: UINT; pwReserved: PUINT;
    pszName: LPSTR; cchMax: UINT): HRESULT;
begin
    Result := S_OK;
    try
        // make sure menu index is correct, and shell is asking for help string
        if (idCmd = FMenuIdx) and ((uType and GCS_HELPTEXT) <> 0) then
            // return help string for menu item
            StrLCopy(pszName, 'Get information for the selected package.', cchMax)
        else
            Result := E_INVALIDARG;
    except
        Result := E_UNEXPECTED;
    end;
end;

```

When you click the new item in the context menu, the shell will call the `InvokeCommand()` method. The method accepts a `TCMInvokeCommandInfo` record as a parameter. This record is defined in the `ShlObj` unit as follows:

```

type
    PCMInvokeCommandInfo = ^TCMInvokeCommandInfo;
    TCMInvokeCommandInfo = packed record
        cbSize: DWORD;           { must be SizeOf(TCMInvokeCommandInfo) }
        fMask: DWORD;           { any combination of CMIC_MASK_* }
        hwnd: HWND;             { might be NULL (indicating no owner window) }
        lpVerb: LPCSTR;         { either a string of MAKEINTRESOURCE(idOffset) }
        lpParameters: LPCSTR;   { might be NULL (indicating no parameter) }
        lpDirectory: LPCSTR;    { might be NULL (indicating no specific directory) }
        nShow: Integer;         { one of SW_ values for ShowWindow() API }
        dwHotKey: DWORD;
        hIcon: THandle;
    end;

```

The low word or the `lpVerb` field will contain the index of the menu item selected. Here's the implementation of this method:

```
function TContextMenu.InvokeCommand(var lpici: TCMInvokeCommandInfo): HRESULT;
begin
  Result := S_OK;
  try
    // Make sure we are not being called by an application
    if HiWord(Integer(lpici.lpVerb)) <> 0 then
      begin
        Result := E_FAIL;
        Exit;
      end;
    // Execute the command specified by lpici.lpVerb.
    // Return E_INVALIDARG if we are passed an invalid argument number.
    if LoWord(lpici.lpVerb) = FMenuIdx then
      ExecutePackInfoApp(FFileName, lpici.hwnd)
    else
      Result := E_INVALIDARG;
  except
    MessageBox(lpici.hwnd, 'Error obtaining package information.', 'Error',
      MB_OK or MB_ICONERROR);
    Result := E_FAIL;
  end;
end;
```

If all goes well, the `ExecutePackInfoApp()` function is called to invoke the `PackInfo.exe` application, which displays various information about a package. We won't go into the particulars of that application right now; however, it's discussed in detail in Chapter 13, "Hard-Core Techniques."

Registration

Context menu handlers must be registered under

```
HKEY_CLASSES_ROOT\<file type>\shellex\ContextMenuHandlers
```

in the System Registry. Following the model of the copy hook extension, registration capability is added to the DLL by creating a specialized `TComObject` descendant. The object is shown in Listing 24.10 along with the complete source code for the unit containing `TContextMenu`.

Figure 24.9 shows the local menu for the BPL file with the new item, and Figure 24.10 shows the `PackInfo.exe` window as invoked by the context menu handler.

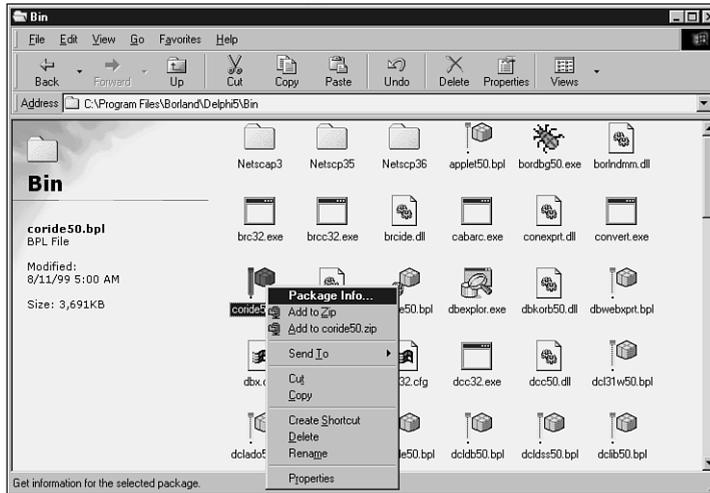


FIGURE 24.9
The context menu handler in action.

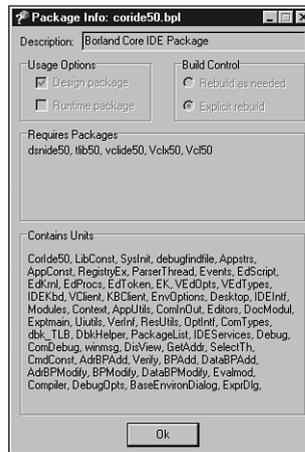


FIGURE 24.10
Obtaining package information from the context menu handler.

LISTING 24.10 ContMain.pas, Main Unit for Context Menu Handler Implementation

```
unit ContMain;

interface

uses Windows, ComObj, ShlObj, ActiveX;

type
  TContextMenu = class(TComObject, IContextMenu, IShellExtInit)
  private
    FFileName: array[0..MAX_PATH] of char;
    FMenuIdx: UINT;
  protected
    // IContextMenu methods
    function QueryContextMenu(Menu: HMENU; indexMenu, idCmdFirst, idCmdLast,
      uFlags: UINT): HRESULT; stdcall;
    function InvokeCommand(var lpici: TCMInvokeCommandInfo): HRESULT; stdcall;
    function GetCommandString(idCmd, uType: UINT; pwReserved: PUINT;
      pszName: LPSTR; cchMax: UINT): HRESULT; stdcall;
    // IShellExtInit method
    function Initialize(pidlFolder: PItemIDList; lpdobj: IDataObject;
      hKeyProgID: HKEY): HRESULT; reintroduce; stdcall;
  end;

  TContextMenuFactory = class(TComObjectFactory)
  protected
    function GetProgID: string; override;
    procedure ApproveShellExtension(Register: Boolean; const ClsID: string);
      virtual;
  public
    procedure UpdateRegistry(Register: Boolean); override;
  end;

implementation

uses ComServ, SysUtils, ShellAPI, Registry;

procedure ExecutePackInfoApp(const FileName: string; ParentWnd: HWND);
const
  SPackInfoApp = '%sPackInfo.exe';
  SCmdLine = '"%s" %s';
  SErrorStr = 'Failed to execute PackInfo: '#13#10#13#10;
var
  PI: TProcessInformation;
  SI: TStartupInfo;
  ExeName, ExeCmdLine: string;
```

```

    Buffer: array[0..MAX_PATH] of char;
begin
    // Get directory of this DLL. Assume EXE being executed is in same dir.
    GetModuleFileName(HInstance, Buffer, SizeOf(Buffer));
    ExeName := Format(SPackInfoApp, [ExtractFilePath(Buffer)]);
    ExeCmdLine := Format(SCmdLine, [ExeName, FileName]);
    FillChar(SI, SizeOf(SI), 0);
    SI.cb := SizeOf(SI);
    if not CreateProcess(PChar(ExeName), PChar(ExeCmdLine), nil, nil, False,
        0, nil, nil, SI, PI) then
        MessageBox(ParentWnd, PChar(SErrorStr + SysErrorMessage(GetLastError)),
            'Error', MB_OK or MB_ICONERROR);
end;

{ TContextMenu }

{ TContextMenu.IContextMenu }

function TContextMenu.QueryContextMenu(Menu: HMENU; indexMenu, idCmdFirst,
    idCmdLast, uFlags: UINT): HRESULT;
begin
    FMenuIdx := indexMenu;
    // Add one menu item to context menu
    InsertMenu (Menu, FMenuIdx, MF_STRING or MF_BYPOSITION, idCmdFirst,
        'Package Info...');
    // Return index of last inserted item + 1
    Result := FMenuIdx + 1;
end;

function TContextMenu.InvokeCommand(var lpici: TCMInvokeCommandInfo): HRESULT;
begin
    Result := S_OK;
    try
        // Make sure we are not being called by an application
        if HiWord(Integer(lpici.lpVerb)) <> 0 then
            begin
                Result := E_FAIL;
                Exit;
            end;
        // Execute the command specified by lpici.lpVerb.
        // Return E_INVALIDARG if we are passed an invalid argument number.
        if LoWord(lpici.lpVerb) = FMenuIdx then
            ExecutePackInfoApp(FFileName, lpici.hwnd)
        else
            Result := E_INVALIDARG;
    except

```

LISTING 24.10 Continued

```
    MessageBox(lpici.hwnd, 'Error obtaining package information.', 'Error',
        MB_OK or MB_ICONERROR);
    Result := E_FAIL;
end;
end;

function TContextMenu.GetCommandString(idCmd, uType: UINT; pwReserved: PUINT;
    pszName: LPSTR; cchMax: UINT): HRESULT;
begin
    Result := S_OK;
    try
        // make sure menu index is correct, and shell is asking for help string
        if (idCmd = FMenuIdx) and ((uType and GCS_HELPTEXT) <> 0) then
            // return help string for menu item
            StrLCopy(pszName, 'Get information for the selected package.', cchMax)
        else
            Result := E_INVALIDARG;
        except
            Result := E_UNEXPECTED;
        end;
    end;
end;

{ TContextMenu.IShellExtInit }

function TContextMenu.Initialize(pidlFolder: PItemIDList; lpobj: IDataObject;
    hKeyProgID: HKEY): HRESULT;
var
    Medium: TStgMedium;
    FE: TFormatEtc;
begin
    try
        // Fail the call if lpobj is nil.
        if lpobj = nil then
            begin
                Result := E_FAIL;
                Exit;
            end;
        with FE do
            begin
                cfFormat := CF_HDROP;
                ptd := nil;
                dwAspect := DVASPECT_CONTENT;
                lindex := -1;
                tymed := TYMED_HGLOBAL;
            end;
        end;
    end;
```

```

// Render the data referenced by the IDataObject pointer to an HGLOBAL
// storage medium in CF_HDROP format.
Result := lpdoj.GetData(FE, Medium);
if Failed(Result) then Exit;
try
  // If only one file is selected, retrieve the file name and store it in
  // szFile. Otherwise fail the call.
  if DragQueryFile(Medium.hGlobal, $FFFFFFFF, nil, 0) = 1 then
  begin
    DragQueryFile(Medium.hGlobal, 0, FFileName, SizeOf(FFileName));
    Result := NOERROR;
  end
  else
    Result := E_FAIL;
  finally
    ReleaseStgMedium(medium);
  end;
except
  Result := E_UNEXPECTED;
end;
end;

{ TContextMenuFactory }

function TContextMenuFactory.GetProgID: string;
begin
  // ProgID not required for context menu shell extension
  Result := '';
end;

procedure TContextMenuFactory.UpdateRegistry(Register: Boolean);
var
  ClsID: string;
begin
  ClsID := GUIDToString(ClassID);
  inherited UpdateRegistry(Register);
  ApproveShellExtension(Register, ClsID);
  if Register then
  begin
    // must register .bpl as a file type
    CreateRegKey('.bpl', '', 'DelphiPackageLibrary');
    // register this DLL as a context menu handler for .bpl files
    CreateRegKey('BorlandPackageLibrary\shellex\ContextMenuHandlers\' +
      ClassName, '', ClsID);
  end
end

```

LISTING 24.10 Continued

```
    else begin
        DeleteRegKey('.bpl');
        DeleteRegKey('BorlandPackageLibrary\shellex\ContextMenuHandlers\' +
            ClassName);
    end;
end;

procedure TContextMenuFactory.ApproveShellExtension(Register: Boolean;
    const ClsID: string);
// This registry entry is required in order for the extension to
// operate correctly under Windows NT.
const
    SApproveKey = 'SOFTWARE\Microsoft\Windows\CurrentVersion\
    Shell Extensions\Approved';
begin
    with TRegistry.Create do
        try
            RootKey := HKEY_LOCAL_MACHINE;
            if not OpenKey(SApproveKey, True) then Exit;
            if Register then WriteString(ClsID, Description)
            else DeleteValue(ClsID);
        finally
            Free;
        end;
    end;
end;

const
    CLSID_CopyHook: TGUID = '{7C5E74A0-D5E0-11D0-A9BF-E886A83B9BE5}';

initialization
    TContextMenuFactory.Create(ComServer, TContextMenu, CLSID_CopyHook,
        'D4DG_ContextMenu', 'D4DG Context Menu Shell Extension Example',
        ciMultiInstance, tmApartment);
end.
```

Icon Handlers

Icon handlers enable you to cause different icons to be used for multiple instance of the same type of file. In this example, the `TIconHandler` icon handler object provides different icons for different types of Borland Package (BPL) files. Depending on whether a package is runtime, design time, both, or none, a different icon will be displayed in a shell folder.

Package Flags

Before getting into the implementations of the interfaces necessary for this shell extension, take a moment to examine the method that determines the type of a particular package file. The method returns `TPackType`, which is defined as follows:

```
TPackType = (ptDesign, ptDesignRun, ptNone, ptRun);
```

Now here's the method:

```
function TIconHandler.GetPackageType: TPackType;
var
  PackMod: HMODULE;
  PackFlags: Integer;
begin
  // Since we only need to get into the package's resources,
  // LoadLibraryEx with LOAD_LIBRARY_AS_DATAFILE provides a speed-
  // efficient means for loading the package.
  PackMod := LoadLibraryEx(PChar(FFileName), 0, LOAD_LIBRARY_AS_DATAFILE);
  if PackMod = 0 then
  begin
    Result := ptNone;
    Exit;
  end;
  try
    GetPackageInfo(PackMod, nil, PackFlags, PackInfoProc);
  finally
    FreeLibrary(PackMod);
  end;
  // mask off all but design and run flags, and return result
  case PackFlags and (pfDesignOnly or pfRunOnly) of
    pfDesignOnly: Result := ptDesign;
    pfRunOnly: Result := ptRun;
    pfDesignOnly or pfRunOnly: Result := ptDesignRun;
  else
    Result := ptNone;
  end;
end;
```

This method works by calling the `GetPackageInfo()` method from the `SysUtils` unit to obtain the package flags. An interesting point to note concerning performance optimization is that the `LoadLibraryEx()` API function is called rather than Delphi's `LoadPackage()` procedure to load the package library. Internally, the `LoadPackage()` procedure calls the `LoadLibrary()` API to load the BPL and then calls `InitializePackage()` to execute the initialization code for each of the units in the package. Because all we want to do is get the package flags, and because the package flags reside in a resource linked to the BPL, we can safely load the package with `LoadLibraryEx()` using the `LOAD_LIBRARY_AS_DATAFILE` flag.

Icon Handler Interfaces

As mentioned earlier, icon handlers must support both the `IExtractIcon` (defined in `Sh10Obj`) and `IPersistFile` (defined in the `ActiveX` unit) interfaces. These interfaces are shown here:

```
type
  IExtractIcon = interface(IUnknown)
    [{000214EB-0000-0000-C000-000000000046}]
    function GetIconLocation(uFlags: UINT; szIconFile: PAnsiChar; cchMax: UINT;
      out piIndex: Integer; out pwFlags: UINT): HRESULT; stdcall;
    function Extract(pszFile: PAnsiChar; nIconIndex: UINT;
      out phiconLarge, phiconSmall: HICON; nIconSize: UINT): HRESULT; stdcall;
  end;

  IPersistFile = interface(IPersist)
    [{0000010B-0000-0000-C000-000000000046}]
    function IsDirty: HRESULT; stdcall;
    function Load(pszFileName: POleStr; dwMode: Longint): HRESULT; stdcall;
    function Save(pszFileName: POleStr; fRemember: BOOL): HRESULT; stdcall;
    function SaveCompleted(pszFileName: POleStr): HRESULT; stdcall;
    function GetCurFile(out pszFileName: POleStr): HRESULT; stdcall;
  end;
```

Although this might look like a lot of work, it's really not; only two of these methods actually have to be implemented. The first file that must be implemented is `IPersistFile.Load()`. This is the method that's called to initialize the shell extension, and in it, you must save the filename passed via the `pszFileName` parameter. Here's the `TExtractIcon` implementation of this method:

```
function TIconHandler.Load(pszFileName: POleStr; dwMode: Longint): HRESULT;
begin
  // this method is called to initialize the icon handler shell
  // extension. We must save the file name which is passed in pszFileName
  FFileName := pszFileName;
  Result := S_OK;
end;
```

The other method that must be implemented is `IExtractIcon.GetIconLocation()`. The parameters for this method are discussed in the following paragraphs.

`uFlags` indicates the type of icon to be displayed. This parameter can be `0`, `GIL_FOR SHELL`, or `GIL_OPENICON`. `GIL_FOR SHELL` means the icon is to be displayed in a shell folder. `GIL_OPENICON` means the icon should be in the "open" state if images for both the open and closed states are available. If this flag is not specified, the icon should be in the normal, or "closed," state. This flag is typically used for folder objects.

szIconFile is the buffer to receive the icon location, and cchMax is the size of the buffer. piIndex is an integer that receives the icon index, which further describes the icon location. pwFlags receives zero or more of the values shown in Table 24.8.

TABLE 24.8 The pwFlags Values for GetIconLocation()

<i>Flag</i>	<i>Meaning</i>
GIL_DONTCACHE	The physical image bits for this icon should not be cached by the caller. This distinction is important to consider because a GIL_DONTCACHELOCATION flag may be introduced in future versions of the shell.
GIL_NOTFILENAME	The location is not a filename/index pair. Callers that decide to extract the icon from the location must call this object's IExtractIcon.Extract() method to obtain the desired icon images.
GIL_PERCLASS	All objects of this class have the same icon. This flag is used internally by the shell. Typical implementations of IExtractIcon do not require this flag because it implies that an icon handler is not required to resolve the icon on a per-object basis. The recommended method for implementing per-class icons is to register a default icon for the class.
GIL_PERINSTANCE	Each object of this class has its own icon. This flag is used internally by the shell to handle cases such as setup.exe, where more than one object with identical names might be known to the shell and use different icons. Typical implementations of IExtractIcon do not require this flag.
GIL_SIMULATEDOC	The caller should create a document icon using the specified icon.

The TIconHandler implementation of GetIconLocation() is shown here:

```
function TIconHandler.GetIconLocation(uFlags: UINT; szIconFile: PAnsiChar;
  cchMax: UINT; out piIndex: Integer; out pwFlags: UINT): HRESULT;
begin
  Result := S_OK;
  try
    // return this DLL for name of module to find icon
    GetModuleFileName(HInstance, szIconFile, cchMax);
    // tell shell not to cache image bits, in case icon changes
    // and that each instance may have its own icon
    pwFlags := GIL_DONTCACHE or GIL_PERINSTANCE;
    // icon index coincides with TPackType
    piIndex := Ord(GetPackageType);
  except
    // if there's an error, use the default package icon
    piIndex := Ord(ptNone);
  end;
end;
```

continues

The icons are linked into the shell extension DLL as a resource file, so the name of the current file, as returned by `GetModuleFileName()`, is written to the `szIconFile` buffer. Also, the icons are arranged in such a way that the index of an icon for a package type corresponds to the package type's index into the `TPackType` enumeration, so the return value of `GetPackageType()` is assigned to `piIndex`.

Registration

Icon handlers must be registered under the

```
HKEY_CLASSES_ROOT\file type\shellex\IconHandler
```

key in the Registry. Again, a descendant of `TComObjectFactory` is created to deal with the registration of this shell extension. This is shown in Listing 24.11 along with the rest of the source code for the icon handler.

Figure 24.11 shows a shell folder containing packages of different types. Notice the different icons for different types of packages.



FIGURE 24.11

The result of using the icon handler.

LISTING 24.11 IconMain.pas, the Main Unit for Icon Handler Implementation

```
unit IconMain;

interface
```

```

uses Windows, ActiveX, ComObj, ShlObj;

type
  TPackType = (ptDesign, ptDesignRun, ptNone, ptRun);

  TIconHandler = class(TComObject, IExtractIcon, IPersistFile)
  private
    FFileName: string;
    function GetPackageType: TPackType;
  protected
    // IExtractIcon methods
    function GetIconLocation(uFlags: UINT; szIconFile: PAnsiChar; cchMax: UINT;
      out piIndex: Integer; out pwFlags: UINT): HRESULT; stdcall;
    function Extract(pszFile: PAnsiChar; nIconIndex: UINT;
      out phiconLarge, phiconSmall: HICON; nIconSize: UINT): HRESULT; stdcall;
    // IPersist method
    function GetClassID(out classID: TCLSID): HRESULT; stdcall;
    // IPersistFile methods
    function IsDirty: HRESULT; stdcall;
    function Load(pszFileName: POleStr; dwMode: Longint): HRESULT; stdcall;
    function Save(pszFileName: POleStr; fRemember: BOOL): HRESULT; stdcall;
    function SaveCompleted(pszFileName: POleStr): HRESULT; stdcall;
    function GetCurFile(out pszFileName: POleStr): HRESULT; stdcall;
  end;

  TIconHandlerFactory = class(TComObjectFactory)
  protected
    function GetProgID: string; override;
    procedure ApproveShellExtension(Register: Boolean; const ClsID: string);
      virtual;
  public
    procedure UpdateRegistry(Register: Boolean); override;
  end;

implementation

uses SysUtils, ComServ, Registry;

{ TIconHandler }

procedure PackInfoProc(const Name: string; NameType: TNameType; Flags: Byte;
  Param: Pointer);
begin
  // we don't need to implement this procedure because we are only
  // interested in package flags, not contained units and required pkgs.
end;

```

continues

LISTING 24.11 Continued

```
function TIconHandler.GetPackageType: TPackType;
var
  PackMod: HMODULE;
  PackFlags: Integer;
begin
  // Since we only need to get into the package's resources,
  // LoadLibraryEx with LOAD_LIBRARY_AS_DATAFILE provides a speed-
  // efficient means for loading the package.
  PackMod := LoadLibraryEx(PChar(FFileName), 0, LOAD_LIBRARY_AS_DATAFILE);
  if PackMod = 0 then
  begin
    Result := ptNone;
    Exit;
  end;
  try
    GetPackageInfo(PackMod, nil, PackFlags, PackInfoProc);
  finally
    FreeLibrary(PackMod);
  end;
  // mask off all but design and run flags, and return result
  case PackFlags and (pfDesignOnly or pfRunOnly) of
    pfDesignOnly: Result := ptDesign;
    pfRunOnly: Result := ptRun;
    pfDesignOnly or pfRunOnly: Result := ptDesignRun;
  else
    Result := ptNone;
  end;
end;

{ TIconHandler.IExtractIcon }

function TIconHandler.GetIconLocation(uFlags: UINT; szIconFile: PAnsiChar;
  cchMax: UINT; out piIndex: Integer; out pwFlags: UINT): HRESULT;
begin
  Result := S_OK;
  try
    // return this DLL for name of module to find icon
    GetModuleFileName(HInstance, szIconFile, cchMax);
    // tell shell not to cache image bits, in case icon changes
    // and that each instance may have its own icon
    pwFlags := GIL_DONTCACHE or GIL_PERINSTANCE;
    // icon index coincides with TPackType
    piIndex := Ord(GetPackageType);
  except
```

```
    // if there's an error, use the default package icon
    piIndex := Ord(ptNone);
end;
end;

function TIconHandler.Extract(pszFile: PAnsiChar; nIconIndex: UINT;
    out phiconLarge, phiconSmall: HICON; nIconSize: UINT): HRESULT;
begin
    // This method only needs to be implemented if the icon is stored in
    // some type of user-defined data format. Since our icon is in a
    // plain old DLL, we just return S_FALSE.
    Result := S_FALSE;
end;

{ TIconHandler.IPersist }

function TIconHandler.GetClassID(out classID: TCLSID): HRESULT;
begin
    // this method is not called for icon handlers
    Result := E_NOTIMPL;
end;

{ TIconHandler.IPersistFile }

function TIconHandler.IsDirty: HRESULT;
begin
    // this method is not called for icon handlers
    Result := S_FALSE;
end;

function TIconHandler.Load(pszFileName: POleStr; dwMode: Longint): HRESULT;
begin
    // this method is called to initialize the icon handler shell
    // extension. We must save the file name which is passed in pszFileName
    FFileName := pszFileName;
    Result := S_OK;
end;

function TIconHandler.Save(pszFileName: POleStr; fRemember: BOOL): HRESULT;
begin
    // this method is not called for icon handlers
    Result := E_NOTIMPL;
end;

function TIconHandler.SaveCompleted(pszFileName: POleStr): HRESULT;
begin
```

continues

LISTING 24.11 Continued

```
// this method is not called for icon handlers
Result := E_NOTIMPL;
end;

function TIconHandler.GetCurFile(out pszFileName: POleStr): HRESULT;
begin
    // this method is not called for icon handlers
    Result := E_NOTIMPL;
end;

{ TIconHandlerFactory }

function TIconHandlerFactory.GetProgID: string;
begin
    // ProgID not required for context menu shell extension
    Result := '';
end;

procedure TIconHandlerFactory.UpdateRegistry(Register: Boolean);
var
    ClsID: string;
begin
    ClsID := GUIDToString(ClassID);
    inherited UpdateRegistry(Register);
    ApproveShellExtension(Register, ClsID);
    if Register then
    begin
        // must register .bpl as a file type
        CreateRegKey('.bpl', '', 'BorlandPackageLibrary');
        // register this DLL as an icon handler for .bpl files
        CreateRegKey('BorlandPackageLibrary\shellex\IconHandler', '', ClsID);
    end
    else begin
        DeleteRegKey('.bpl');
        DeleteRegKey('BorlandPackageLibrary\shellex\IconHandler');
    end;
end;

procedure TIconHandlerFactory.ApproveShellExtension(Register: Boolean;
    const ClsID: string);
// This registry entry is required in order for the extension to
// operate correctly under Windows NT.
const
    SApproveKey = 'SOFTWARE\Microsoft\Windows\CurrentVersion\
    Shell Extensions\Approved';
```

```
begin
  with TRegistry.Create do
    try
      RootKey := HKEY_LOCAL_MACHINE;
      if not OpenKey(SApproveKey, True) then Exit;
      if Register then WriteString(ClsID, Description)
      else DeleteValue(ClsID);
    finally
      Free;
    end;
  end;
end;

const
  CLSID_IconHandler: TGUID = '{ED6D2F60-DA7C-11D0-A9BF-90D146FC32B3}';

initialization
  TIconHandlerFactory.Create(ComServer, TIconHandler, CLSID_IconHandler,
    'D4DG_IconHandler', 'D4DG Icon Handler Shell Extension Example',
    ciMultiInstance, tmApartment);
end.
```

Summary

This chapter covered all the different aspects of extending the Windows shell: tray-notification icons, AppBars, shell links, and a variety of shell extensions. It built upon some of the knowledge you obtained in the last chapter when working with COM and ActiveX. In the next chapter, “Creating ActiveX Controls,” you’ll take this knowledge even further as you learn to develop ActiveX controls.

Creating ActiveX Controls

CHAPTER

25

IN THIS CHAPTER

- **Why Create ActiveX Controls? 1298**
- **Creating an ActiveX Control 1298**
- **ActiveForms 1346**
- **Adding Properties to ActiveForms 1346**
- **ActiveX on the Web 1355**
- **Summary 1369**

For many developers, the ability to easily create ActiveX controls is one of the most compelling features Delphi brings to the table. ActiveX is a standard for programming language-independent controls that can function in a variety of environments, including Delphi, C++Builder, Visual Basic, and Internet Explorer. These controls can be as simple as a static text control or as complex as a fully functional spreadsheet or word processor. Traditionally, ActiveX controls are quite complicated and difficult to write, but Delphi brings ActiveX control creation to the masses by allowing you to convert a relatively easy-to-create VCL component or form into an ActiveX control.

This chapter will not teach you everything there is to know about ActiveX controls—that would take a thick book in its own right. What this chapter will demonstrate is how ActiveX control creation works in Delphi and how to use the Delphi wizards and framework to make Delphi-created ActiveX controls work for you.

NOTE

The capability to create ActiveX controls is provided only with the Professional and Enterprise editions of Delphi.

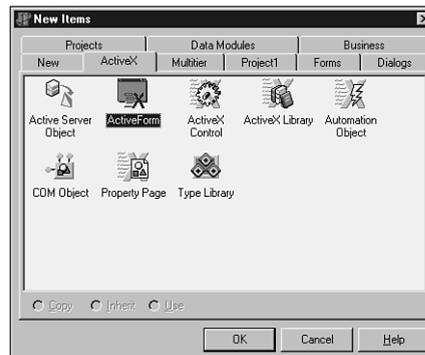
Why Create ActiveX Controls?

As a Delphi developer, you may be completely happy with the capabilities of native VCL components and forms, and you might be wondering why you should even bother creating ActiveX controls. There are several reasons. First, if you are a professional component developer, the payoff can be huge; by converting your VCL controls into ActiveX controls, your potential market is not merely fellow Delphi and C++Builder developers but also users of practically any Win32 development tool. Second, even if you are not a component vendor, you can take advantage of ActiveX controls to add content and functionality to World Wide Web pages.

Creating an ActiveX Control

Delphi's one-step wizards make creating an ActiveX control a simple process. However, as you will soon learn, the wizard is just the beginning if you want your controls to really shine.

To help you become familiar with Delphi's ActiveX capabilities, Figure 25.1 shows the ActiveX page of the New Items dialog, which appears when you select File, New from the main menu. Many of the items shown here will be described as this chapter progresses.

**FIGURE 25.1**

The ActiveX page of the New Items dialog.

The first icon in this dialog represents an ActiveForm (described later in this chapter), and you can click it to invoke a wizard that aids you in creating an ActiveForm. Note that ActiveForms are only slightly different from regular ActiveX controls, so we will refer to both generically as *ActiveX controls* throughout this chapter.

Next, you see the icon representing an ActiveX control. Clicking here will invoke the ActiveX Control Wizard, which we will describe in the next section.

The third icon represents an ActiveX library. Click this icon to create a new library project that exports the four ActiveX server functions described in Chapter 23, “COM-Based Technologies.” This can be used as a starting point before adding an ActiveX control to the project.

The Automation Object Wizard, represented by the next icon, is described in Chapter 23.

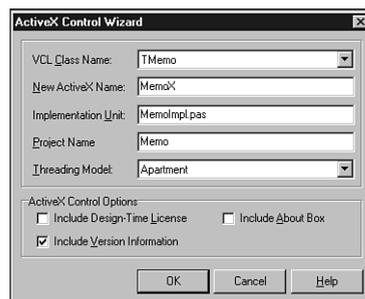
The next icon is the COM Object Wizard. The wizard invoked by clicking this icon enables you to create a plain COM object. You learned about this wizard in the previous chapter when you created shell extensions.

Clicking the icon at the far right enables you to add a property page to the current project. *Property pages* allow visual editing of ActiveX controls, and you will see an example of creating a property page and integrating it into your ActiveX control project later in this chapter.

The final icon represents a type library; you can click it when you wish to add a type library to your project. Because the wizards for ActiveX controls and ActiveForms (as well as Automation objects) automatically add a type library to the project, you will rarely use this option.

The ActiveX Control Wizard

Clicking the ActiveX Control icon on the ActiveX page of the New Items dialog will invoke the ActiveX Control Wizard, which is shown in Figure 25.2.

**FIGURE 25.2**

The ActiveX Control Wizard.

This wizard allows you to choose a VCL control class to encapsulate as an ActiveX control. Additionally, it allows you to specify the name of the ActiveX control class, the name of the file that will contain the implementation of the new ActiveX control, and the name of the project in which the ActiveX control will reside.

VCL Controls in the ActiveX Control Wizard

If you examine the list of VCL controls in the drop-down combo box in the ActiveX Control Wizard, you will notice that not all VCL components are found in the list. A VCL control must meet three criteria in order to be listed in the wizard:

- The VCL control must reside in a currently installed design package (that is, it must be on the Component Palette).
- The VCL control must descend from `TWinControl`. Currently, nonwindowed controls cannot be encapsulated as ActiveX controls.
- The VCL control must not have been excluded from the list with the `RegisterNonActiveX()` procedure. `RegisterNonActiveX()` is described in detail in the Delphi online help.

Many standard VCL components are excluded from the list because they either do not make sense as ActiveX controls or would require significant work beyond the wizard's scope in order to function as ActiveX controls. `TDBGrid` is a good example of a VCL control that does not make sense as an ActiveX control; it requires another VCL class (`TDataSource`) as a property in order to function, and this is not possible using ActiveX. `TTreeView` is an example of a control that would require significant work beyond the wizard to encapsulate as an ActiveX control, because the `TTreeView` nodes would be difficult to represent in ActiveX.

NOTE

Although the ActiveX wizard does not allow you to automatically generate an ActiveX control from a non-`TWinControl` control, it is possible to write such a control by hand using the Delphi ActiveX (DAX) framework.

ActiveX Control Options

The lower portion of the ActiveX Control Wizard dialog allows you to set certain options that will become a part of the ActiveX control. These options consist of three check boxes:

- *Make Control Licensed.* When this option is selected, a license (LIC) file will be generated along with the control project. In order for other developers to use the generated ActiveX control in a development environment, they will need to have the LIC file in addition to the ActiveX control (OCX) file.
- *Include Version Information.* When selected, this option will cause a `VersionInfo` resource to be linked into the OCX file. In addition, the string file information in the `VersionInfo` resource includes a value called `OLESelfRegister`, which is set to 1. This setting is required for some older ActiveX control hosts, such as Visual Basic 4.0. You can edit a project's `VersionInfo` data in the `VersionInfo` page of the Project Options dialog.
- *Include About Box.* Select this option in order to include an “About box” dialog with your ActiveX control. The About box is usually available in ActiveX container applications by selecting an option from a local right-click menu on the ActiveX control. The About box generated is a regular Delphi form that you can edit to your liking.

How VCL Controls Are Encapsulated

After you finish describing your control in the ActiveX Control Wizard and click the OK button, the wizard goes about the task of writing the wrapper to encapsulate the selected VCL control as an ActiveX control. The end result is an ActiveX library project that includes a working ActiveX control, but a lot of interesting stuff is going on behind the scenes. Here is a description of the steps involved in encapsulating a VCL control as an ActiveX control:

1. The wizard determines which unit contains the VCL control. That unit is then handed to the compiler, and the compiler generates special symbolic information for the VCL control's properties, methods, and events.
2. A type library is created for the project. It contains an interface to hold properties and methods, a dispinterface to hold events, and a coclass to represent the ActiveX control.

3. The wizard iterates over all the symbol information for the VCL control, adding qualified properties and methods to the interface in the type library and qualified events to the dispinterface.

NOTE

The description of step 3 begs the following question: What constitutes a *qualified* property, method, or event for inclusion in the type library? In order to qualify for inclusion in the type library, properties must be of an Automation-compatible type, and the parameters and return values of the methods and events must also be of an Automation-compatible type. Recall from Chapter 23, “COM-Based Technologies,” that Automation-compatible types include Byte, SmallInt, Integer, Single, Double, Currency, TDateTime, WideString, WordBool, PSafeArray, TDecimal, OleVariant, IUnknown, IDispatch.

However, there are exceptions to this rule. In addition to Automation-compatible types, parameters of type TStrings, TPicture, and TFont are also permitted. For these types, the wizard will employ special adapter objects that allow them to be wrapped with an ActiveX-compatible IDispatch or dispinterface.

4. Once all the qualifying properties, methods, and events have been added, the type library editor generates a file that is an Object Pascal translation of the type library contents.
5. The wizard then generates the implementation file for the ActiveX control. This implementation file contains a TActiveXControl object that implements the interface described in the type library. The wizard automatically writes *forwarders* for interface properties and methods. These forwarder methods forward method calls from the ActiveX control wrapper into the control, and they forward events from the VCL control out to the ActiveX control.

To help illustrate what we are describing here, we have provided the following listings. They belong to an ActiveX control project created from a TMemo VCL control. This project is saved as Memo.dpr. Listing 25.1 shows the project file, Listing 25.2 shows the type library file, and Listing 25.3 shows the implementation file generated for the control. Also, Figure 25.3 shows the contents of the type library editor.

LISTING 25.1 The Project File: Memo.dpr

```
library Memo;  
  
uses  
    ComServ,  
    Memo_TLB in 'Memo_TLB.pas',
```

```

MemoImpl in 'MemoImpl.pas' {MemoX: CoClass},
About in 'About.pas' {MemoXAbout};

{$E ocx}

exports
  DllGetClassObject,
  DllCanUnloadNow,
  DllRegisterServer,
  DllUnregisterServer;

{$R *.TLB}

{$R *.RES}

begin
end.

```

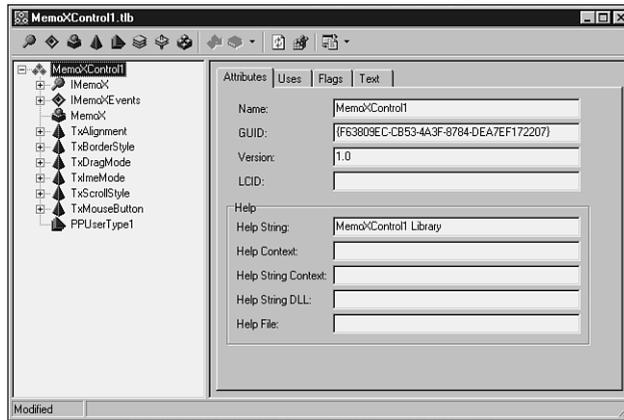


FIGURE 25.3

Memo, as shown in the type library editor.

LISTING 25.2 The Type Library File: Memo_TLB.pas

```

unit Memo_TLB;

// ***** //
// WARNING
// -----
// The types declared in this file were generated from data read from a

```

continues

LISTING 25.2 Continued

```

// Type Library. If this type library is explicitly or indirectly (via
// another type library referring to this type library) re-imported, or the
// 'Refresh' command of the Type Library Editor activated while editing the
// Type Library, the contents of this file will be regenerated and all
// manual modifications will be lost.
// *****

// PASTLWTR : $Revision: 1.88 $
// File generated on 8/23/99 12:22:29 AM from Type Library described below.

// *****//
// NOTE:
// Items guarded by $IFDEF_LIVE_SERVER_AT_DESIGN_TIME are used by properties
// which return objects that may need to be explicitly created via a function
// call prior to any access via the property. These items have been disabled
// in order to prevent accidental use from within the object inspector. You
// may enable them by defining LIVE_SERVER_AT_DESIGN_TIME or by selectively
// removing them from the $IFDEF blocks. However, such items must still be
// programmatically created via a method of the appropriate CoClass before
// they can be used.
// *****//
// Type Lib: X:\work\d5dg\code\Ch25\Memo\Memo.tlb (1)
// IID\LCID: {0DB4686F-09C5-11D2-AE5C-00A024E3867F}\0
// Helpfile:
// DepndLst:
// (1) v2.0 stdole, (C:\WINDOWS\SYSTEM\STDOLE2.TLB)
// (2) v4.0 StdVCL, (C:\WINDOWS\SYSTEM\STDVCL40.DLL)
// *****//
{$TYPEDADDRESS OFF} // Unit must be compiled without type-checked pointers.
interface

uses Windows, ActiveX, Classes, Graphics, OleServer, OleCtrls, StdVCL;

// *****//
// GUIDS declared in the TypeLibrary. Following prefixes are used:
// Type Libraries : LIBID_xxxx
// CoClasses : CLASS_xxxx
// DISPInterfaces : DIID_xxxx
// Non-DISP interfaces: IID_xxxx
// *****//
const
  // TypeLibrary Major and minor versions
  MemoMajorVersion = 1;
  MemoMinorVersion = 0;

```

```
LIBID_Memo: TGUID = '{0DB4686F-09C5-11D2-AE5C-00A024E3867F}';

IID_IMemoX: TGUID = '{0DB46870-09C5-11D2-AE5C-00A024E3867F}';
DIID_IMemoXEvents: TGUID = '{0DB46872-09C5-11D2-AE5C-00A024E3867F}';
CLASS_MemoX: TGUID = '{0DB46874-09C5-11D2-AE5C-00A024E3867F}';

// *****//
// Declaration of Enumerations defined in Type Library
// *****//
// Constants for enum TxAlignment
type
  TxAlignment = ToleEnum;
const
  taLeftJustify = $00000000;
  taRightJustify = $00000001;
  taCenter = $00000002;

// Constants for enum TxBiDiMode
type
  TxBiDiMode = ToleEnum;
const
  bdLeftToRight = $00000000;
  bdRightToLeft = $00000001;
  bdRightToLeftNoAlign = $00000002;
  bdRightToLeftReadingOnly = $00000003;

// Constants for enum TxBorderStyle
type
  TxBorderStyle = ToleEnum;
const
  bsNone = $00000000;
  bsSingle = $00000001;

// Constants for enum TxDragMode
type
  TxDragMode = ToleEnum;
const
  dmManual = $00000000;
  dmAutomatic = $00000001;

// Constants for enum TxImeMode
type
  TxImeMode = ToleEnum;
const
  imDisable = $00000000;
  imClose = $00000001;
```

continues

LISTING 25.2 Continued

```
    imOpen = $00000002;
    imDontCare = $00000003;
    imSAlpha = $00000004;
    imAlpha = $00000005;
    imHira = $00000006;
    imSKata = $00000007;
    imKata = $00000008;
    imChinese = $00000009;
    imSHanguel = $0000000A;
    imHanguel = $0000000B;

// Constants for enum TxScrollStyle
type
    TxScrollStyle = T01eEnum;
const
    ssNone = $00000000;
    ssHorizontal = $00000001;
    ssVertical = $00000002;
    ssBoth = $00000003;

// Constants for enum TxMouseButton
type
    TxMouseButton = T01eEnum;
const
    mbLeft = $00000000;
    mbRight = $00000001;
    mbMiddle = $00000002;

type

// *****//
// Forward declaration of types defined in TypeLibrary
// *****//
    IMemoX = interface;
    IMemoXDisp = dispinterface;
    IMemoXEvents = dispinterface;

// *****//
// Declaration of CoClasses defined in Type Library
// (NOTE: Here we map each CoClass to its Default Interface)
// *****//
    MemoX = IMemoX;

// *****//
// Interface: IMemoX
```

```
// Flags:      (4416) Dual OleAutomation Dispatchable
// GUID:      {0DB46870-09C5-11D2-AE5C-00A024E3867F}
// *****//
IMemoX = interface(IDispatch)
['{0DB46870-09C5-11D2-AE5C-00A024E3867F}']
function Get_Alignment: TxAlignment; safecall;
procedure Set_Alignment(Value: TxAlignment); safecall;
function Get_BiDiMode: TxBiDiMode; safecall;
procedure Set_BiDiMode(Value: TxBiDiMode); safecall;
function Get_BorderStyle: TxBorderStyle; safecall;
procedure Set_BorderStyle(Value: TxBorderStyle); safecall;
function Get_Color: OLE_COLOR; safecall;
procedure Set_Color(Value: OLE_COLOR); safecall;
function Get_Ctl3D: WordBool; safecall;
procedure Set_Ctl3D(Value: WordBool); safecall;
function Get_DragCursor: Smallint; safecall;
procedure Set_DragCursor(Value: Smallint); safecall;
function Get_DragMode: TxDragMode; safecall;
procedure Set_DragMode(Value: TxDragMode); safecall;
function Get_Enabled: WordBool; safecall;
procedure Set_Enabled(Value: WordBool); safecall;
function Get_Font: IFontDisp; safecall;
procedure _Set_Font(const Value: IFontDisp); safecall;
procedure Set_Font(var Value: IFontDisp); safecall;
function Get_HideSelection: WordBool; safecall;
procedure Set_HideSelection(Value: WordBool); safecall;
function Get_ImeMode: TxImeMode; safecall;
procedure Set_ImeMode(Value: TxImeMode); safecall;
function Get_ImeName: WideString; safecall;
procedure Set_ImeName(const Value: WideString); safecall;
function Get_MaxLength: Integer; safecall;
procedure Set_MaxLength(Value: Integer); safecall;
function Get_OEMConvert: WordBool; safecall;
procedure Set_OEMConvert(Value: WordBool); safecall;
function Get_ParentColor: WordBool; safecall;
procedure Set_ParentColor(Value: WordBool); safecall;
function Get_ParentCtl3D: WordBool; safecall;
procedure Set_ParentCtl3D(Value: WordBool); safecall;
function Get_ParentFont: WordBool; safecall;
procedure Set_ParentFont(Value: WordBool); safecall;
function Get_ReadOnly: WordBool; safecall;
procedure Set_ReadOnly(Value: WordBool); safecall;
function Get_ScrollBars: TxScrollStyle; safecall;
procedure Set_ScrollBars(Value: TxScrollStyle); safecall;
function Get_Visible: WordBool; safecall;
procedure Set_Visible(Value: WordBool); safecall;
```

continues

LISTING 25.2 Continued

```
function Get_WantReturns: WordBool; safecall;
procedure Set_WantReturns(Value: WordBool); safecall;
function Get_WantTabs: WordBool; safecall;
procedure Set_WantTabs(Value: WordBool); safecall;
function Get_WordWrap: WordBool; safecall;
procedure Set_WordWrap(Value: WordBool); safecall;
function GetControlsAlignment: TxAlignment; safecall;
procedure Clear; safecall;
procedure ClearSelection; safecall;
procedure CopyToClipboard; safecall;
procedure CutToClipboard; safecall;
procedure PasteFromClipboard; safecall;
procedure Undo; safecall;
procedure ClearUndo; safecall;
procedure SelectAll; safecall;
function Get_CanUndo: WordBool; safecall;
function Get_Modified: WordBool; safecall;
procedure Set_Modified(Value: WordBool); safecall;
function Get_SelLength: Integer; safecall;
procedure Set_SelLength(Value: Integer); safecall;
function Get_SelStart: Integer; safecall;
procedure Set_SelStart(Value: Integer); safecall;
function Get_SelText: WideString; safecall;
procedure Set_SelText(const Value: WideString); safecall;
function Get_Text: WideString; safecall;
procedure Set_Text(const Value: WideString); safecall;
function Get_DoubleBuffered: WordBool; safecall;
procedure Set_DoubleBuffered(Value: WordBool); safecall;
procedure FlipChildren(AllLevels: WordBool); safecall;
function DrawTextBiDiModeFlags(Flags: Integer): Integer; safecall;
function DrawTextBiDiModeFlagsReadingOnly: Integer; safecall;
procedure InitiateAction; safecall;
function IsRightToLeft: WordBool; safecall;
function UseRightToLeftAlignment: WordBool; safecall;
function UseRightToLeftReading: WordBool; safecall;
function UseRightToLeftScrollBar: WordBool; safecall;
function Get_Cursor: Smallint; safecall;
procedure Set_Cursor(Value: Smallint); safecall;
function ClassNameIs(const Name: WideString): WordBool; safecall;
procedure AboutBox; safecall;
property Alignment: TxAlignment read Get_Alignment write Set_Alignment;
property BiDiMode: TxBiDiMode read Get_BiDiMode write Set_BiDiMode;
property BorderStyle: TxBorderStyle read Get_BorderStyle write
    Set_BorderStyle;
property Color: OLE_COLOR read Get_Color write Set_Color;
```

```

property Ctl13D: WordBool read Get_Ctl13D write Set_Ctl13D;
property DragCursor: Smallint read Get_DragCursor write Set_DragCursor;
property DragMode: TxDragMode read Get_DragMode write Set_DragMode;
property Enabled: WordBool read Get_Enabled write Set_Enabled;
property Font: IFontDisp read Get_Font write _Set_Font;
property HideSelection: WordBool read Get_HideSelection write
    Set_HideSelection;
property ImeMode: TxImeMode read Get_ImeMode write Set_ImeMode;
property ImeName: WideString read Get_ImeName write Set_ImeName;
property MaxLength: Integer read Get_MaxLength write Set_MaxLength;
property OEMConvert: WordBool read Get_OEMConvert write Set_OEMConvert;
property ParentColor: WordBool read Get_ParentColor write Set_ParentColor;
property ParentCtl13D: WordBool read Get_ParentCtl13D write Set_ParentCtl13D;
property ParentFont: WordBool read Get_ParentFont write Set_ParentFont;
property ReadOnly: WordBool read Get_ReadOnly write Set_ReadOnly;
property ScrollBars: TxScrollStyle read Get_ScrollBars write
Set_ScrollBars;
property Visible: WordBool read Get_Visible write Set_Visible;
property WantReturns: WordBool read Get_WantReturns write Set_WantReturns;
property WantTabs: WordBool read Get_WantTabs write Set_WantTabs;
property WordWrap: WordBool read Get_WordWrap write Set_WordWrap;
property CanUndo: WordBool read Get_CanUndo;
property Modified: WordBool read Get_Modified write Set_Modified;
property SelLength: Integer read Get_SelLength write Set_SelLength;
property SelStart: Integer read Get_SelStart write Set_SelStart;
property SelText: WideString read Get_SelText write Set_SelText;
property Text: WideString read Get_Text write Set_Text;
property DoubleBuffered: WordBool read Get_DoubleBuffered write
    Set_DoubleBuffered;
property Cursor: Smallint read Get_Cursor write Set_Cursor;
end;

// *****//
// DispIntf: IMemoXDisp
// Flags:      (4416) Dual OleAutomation Dispatchable
// GUID:      {0DB46870-09C5-11D2-AE5C-00A024E3867F}
// *****//
IMemoXDisp = dispinterface
    ['{0DB46870-09C5-11D2-AE5C-00A024E3867F}']
    property Alignment: TxAlignment dispid 1;
    property BiDiMode: TxBiDiMode dispid 2;
    property BorderStyle: TxBorderStyle dispid 3;
    property Color: OLE_COLOR dispid -501;
    property Ctl13D: WordBool dispid 4;
    property DragCursor: Smallint dispid 5;
    property DragMode: TxDragMode dispid 6;

```

continues

LISTING 25.2 Continued

```
property Enabled: WordBool dispid -514;
property Font: IFontDisp dispid -512;
property HideSelection: WordBool dispid 7;
property ImeMode: TxImeMode dispid 8;
property ImeName: WideString dispid 9;
property MaxLength: Integer dispid 10;
property OEMConvert: WordBool dispid 11;
property ParentColor: WordBool dispid 12;
property ParentCtl3D: WordBool dispid 13;
property ParentFont: WordBool dispid 14;
property ReadOnly: WordBool dispid 15;
property ScrollBars: TxScrollStyle dispid 16;
property Visible: WordBool dispid 17;
property WantReturns: WordBool dispid 18;
property WantTabs: WordBool dispid 19;
property WordWrap: WordBool dispid 20;
function GetControlsAlignment: TxAlignment; dispid 21;
procedure Clear; dispid 22;
procedure ClearSelection; dispid 23;
procedure CopyToClipboard; dispid 24;
procedure CutToClipboard; dispid 25;
procedure PasteFromClipboard; dispid 27;
procedure Undo; dispid 28;
procedure ClearUndo; dispid 29;
procedure SelectAll; dispid 31;
property CanUndo: WordBool readonly dispid 33;
property Modified: WordBool dispid 34;
property SelLength: Integer dispid 35;
property SelStart: Integer dispid 36;
property SelText: WideString dispid 37;
property Text: WideString dispid -517;
property DoubleBuffered: WordBool dispid 39;
procedure FlipChildren(AllLevels: WordBool); dispid 40;
function DrawTextBiDiModeFlags(Flags: Integer): Integer; dispid 43;
function DrawTextBiDiModeFlagsReadingOnly: Integer; dispid 44;
procedure InitiateAction; dispid 46;
function IsRightToLeft: WordBool; dispid 47;
function UseRightToLeftAlignment: WordBool; dispid 52;
function UseRightToLeftReading: WordBool; dispid 53;
function UseRightToLeftScrollBar: WordBool; dispid 54;
property Cursor: Smallint dispid 55;
function ClassNameIs(const Name: WideString): WordBool; dispid 59;
procedure AboutBox; dispid -552;
end;
```

```
// *****//
// DispIntf: IMemoXEvents
// Flags: (4096) Dispatchable
// GUID: {0DB46872-09C5-11D2-AE5C-00A024E3867F}
// *****//
IMemoXEvents = dispinterface
  ['{0DB46872-09C5-11D2-AE5C-00A024E3867F}']
  procedure OnChange; dispid 1;
  procedure OnClick; dispid 2;
  procedure OnDblClick; dispid 3;
  procedure OnKeyPress(var Key: Smallint); dispid 9;
end;

// *****//
// OLE Control Proxy class declaration
// Control Name : TMemoX
// Help String : MemoX Control
// Default Interface: IMemoX
// Def. Intf. DISP? : No
// Event Interface: IMemoXEvents
// TypeFlags : (34) CanCreate Control
// *****//
TMemoXOnKeyPress = procedure(Sender: TObject; var Key: Smallint) of object;

TMemoX = class(TOLEControl)
private
  FOnChange: TNotifyEvent;
  FOnClick: TNotifyEvent;
  FOnDblClick: TNotifyEvent;
  FOnKeyPress: TMemoXOnKeyPress;
  FIntf: IMemoX;
  function GetControlInterface: IMemoX;
protected
  procedure CreateControl;
  procedure InitControlData; override;
public
  function GetControlsAlignment: TxAlignment;
  procedure Clear;
  procedure ClearSelection;
  procedure CopyToClipboard;
  procedure CutToClipboard;
  procedure PasteFromClipboard;
  procedure Undo;
  procedure ClearUndo;
  procedure SelectAll;
```

continues

LISTING 25.2 Continued

```
procedure FlipChildren(AllLevels: WordBool);
function DrawTextBiDiModeFlags(Flags: Integer): Integer;
function DrawTextBiDiModeFlagsReadingOnly: Integer;
procedure InitiateAction;
function IsRightToLeft: WordBool;
function UseRightToLeftAlignment: WordBool;
function UseRightToLeftReading: WordBool;
function UseRightToLeftScrollBar: WordBool;
function ClassNameIs(const Name: WideString): WordBool;
procedure AboutBox;
property ControlInterface: IMemoX read GetControlInterface;
property DefaultInterface: IMemoX read GetControlInterface;
property CanUndo: WordBool index 33 read GetWordBoolProp;
property Modified: WordBool index 34 read GetWordBoolProp write
    SetWordBoolProp;
property SelLength: Integer index 35 read GetIntegerProp write
    SetIntegerProp;
property SelStart: Integer index 36 read GetIntegerProp write
    SetIntegerProp;
property SelText: WideString index 37 read GetWideStringProp write
    SetWideStringProp;
property Text: WideString index -517 read GetWideStringProp write
    SetWideStringProp;
property DoubleBuffered: WordBool index 39 read GetWordBoolProp write
    SetWordBoolProp;
published
property Alignment: ToleEnum index 1 read GetTOleEnumProp write
    SetTOleEnumProp stored False;
property BiDiMode: ToleEnum index 2 read GetTOleEnumProp write
    SetTOleEnumProp stored False;
property BorderStyle: ToleEnum index 3 read GetTOleEnumProp write
    SetTOleEnumProp stored False;
property Color: TColor index -501 read GetTColorProp write
    SetTColorProp stored False;
property Ctl3D: WordBool index 4 read GetWordBoolProp write
    SetWordBoolProp stored False;
property DragCursor: Smallint index 5 read GetSmallintProp write
    SetSmallintProp stored False;
property DragMode: ToleEnum index 6 read GetTOleEnumProp write
    SetTOleEnumProp stored False;
property Enabled: WordBool index -514 read GetWordBoolProp write
    SetWordBoolProp stored False;
property Font: TFont index -512 read GetTFontProp write SetTFontProp
    stored False;
property HideSelection: WordBool index 7 read GetWordBoolProp write
```

```
    SetWordBoolProp stored False;
property ImeMode: TOLEEnum index 8 read GetTOLEEnumProp write
    SetTOLEEnumProp stored False;
property ImeName: WideString index 9 read GetWideStringProp write
    SetWideStringProp stored False;
property MaxLength: Integer index 10 read GetIntegerProp write
    SetIntegerProp stored False;
property OEMConvert: WordBool index 11 read GetWordBoolProp write
    SetWordBoolProp stored False;
property ParentColor: WordBool index 12 read GetWordBoolProp write
    SetWordBoolProp stored False;
property ParentCtl3D: WordBool index 13 read GetWordBoolProp write
    SetWordBoolProp stored False;
property ParentFont: WordBool index 14 read GetWordBoolProp write
    SetWordBoolProp stored False;
property ReadOnly: WordBool index 15 read GetWordBoolProp write
    SetWordBoolProp stored False;
property ScrollBars: TOLEEnum index 16 read GetTOLEEnumProp write
    SetTOLEEnumProp stored False;
property Visible: WordBool index 17 read GetWordBoolProp write
    SetWordBoolProp stored False;
property WantReturns: WordBool index 18 read GetWordBoolProp write
    SetWordBoolProp stored False;
property WantTabs: WordBool index 19 read GetWordBoolProp write
    SetWordBoolProp stored False;
property WordWrap: WordBool index 20 read GetWordBoolProp write
    SetWordBoolProp stored False;
property Cursor: Smallint index 55 read GetSmallintProp write
    SetSmallintProp stored False;
property OnChange: TNotifyEvent read FOnChange write FOnChange;
property OnClick: TNotifyEvent read FOnClick write FOnClick;
property OnDblClick: TNotifyEvent read FOnDblClick write FOnDblClick;
property OnKeyPress: TMemOXOnKeyPress read FOnKeyPress write FOnKeyPress;
end;
```

```
procedure Register;
```

```
implementation
```

```
uses ComObj;
```

```
procedure TMemOX.InitControlData;
```

```
const
```

```
  CEventDispIDs: array [0..3] of DWORD = (
    $00000001, $00000002, $00000003, $00000009);
```

```
  CTFontIDs: array [0..0] of DWORD = (
```

continues

LISTING 25.2 Continued

```
    $FFFFFFE0);
  CControlData: TControlData2 = (
    ClassID: '{0DB46874-09C5-11D2-AE5C-00A024E3867F}';
    EventIID: '{0DB46872-09C5-11D2-AE5C-00A024E3867F}';
    EventCount: 4;
    EventDispIDs: @CEventDispIDs;
    LicenseKey: nil (*HR:$80040154*);
    Flags: $0000002D;
    Version: 401;
    FontCount: 1;
    FontIDs: @CTFontIDs);
begin
  ControlData := @CControlData;
  TControlData2(CControlData).FirstEventOfs := Cardinal(@@FOnChange) -
    Cardinal(Self);
end;

procedure TMemoX.CreateControl;

  procedure DoCreate;
  begin
    FIntf := IUnknown(OleObject) as IMemoX;
  end;

begin
  if FIntf = nil then DoCreate;
end;

function TMemoX.GetControlInterface: IMemoX;
begin
  CreateControl;
  Result := FIntf;
end;

function TMemoX.GetControlsAlignment: TxAlignment;
begin
  Result := DefaultInterface.GetControlsAlignment;
end;

procedure TMemoX.Clear;
begin
  DefaultInterface.Clear;
end;

procedure TMemoX.ClearSelection;
```

```
begin
  DefaultInterface.ClearSelection;
end;

procedure TMemoX.CopyToClipboard;
begin
  DefaultInterface.CopyToClipboard;
end;

procedure TMemoX.CutToClipboard;
begin
  DefaultInterface.CutToClipboard;
end;

procedure TMemoX.PasteFromClipboard;
begin
  DefaultInterface.PasteFromClipboard;
end;

procedure TMemoX.Undo;
begin
  DefaultInterface.Undo;
end;

procedure TMemoX.ClearUndo;
begin
  DefaultInterface.ClearUndo;
end;

procedure TMemoX.SelectAll;
begin
  DefaultInterface.SelectAll;
end;

procedure TMemoX.FlipChildren(AllLevels: WordBool);
begin
  DefaultInterface.FlipChildren(AllLevels);
end;

function TMemoX.DrawTextBiDiModeFlags(Flags: Integer): Integer;
begin
  Result := DefaultInterface.DrawTextBiDiModeFlags(Flags);
end;

function TMemoX.DrawTextBiDiModeFlagsReadingOnly: Integer;
begin
```

continues

LISTING 25.2 Continued

```
    Result := DefaultInterface.DrawTextBiDiModeFlagsReadingOnly;
end;

procedure TMemoX.InitiateAction;
begin
    DefaultInterface.InitiateAction;
end;

function TMemoX.IsRightToLeft: WordBool;
begin
    Result := DefaultInterface.IsRightToLeft;
end;

function TMemoX.UseRightToLeftAlignment: WordBool;
begin
    Result := DefaultInterface.UseRightToLeftAlignment;
end;

function TMemoX.UseRightToLeftReading: WordBool;
begin
    Result := DefaultInterface.UseRightToLeftReading;
end;

function TMemoX.UseRightToLeftScrollBar: WordBool;
begin
    Result := DefaultInterface.UseRightToLeftScrollBar;
end;

function TMemoX.ClassNameIs(const Name: WideString): WordBool;
begin
    Result := DefaultInterface.ClassNameIs(Name);
end;

procedure TMemoX.AboutBox;
begin
    DefaultInterface.AboutBox;
end;

procedure Register;
begin
    RegisterComponents('ActiveX',[TMemoX]);
end;

end.
```

NOTE

If you examine the code in Listing 25.2 carefully, you will notice that, in addition to type library information, Memo_TLB.pas also contains a class called TMemox, which is the ToleControl wrapper for the ActiveX control. This enables you to add a Delphi-created ActiveX control to the palette simply by adding the generated xxx_TLB unit to a design package.

LISTING 25.3 The Implementation File: MemoImpl.pas

```
unit MemoImpl;

interface

uses
  Windows, ActiveX, Classes, Controls, Graphics, Menus, Forms, StdCtrls,
  ComServ, StdVCL, AXCtrls, Memo_TLB;

type
  TMemox = class(TActiveXControl, IMemoX)
  private
    { Private declarations }
    FDelphiControl: TMemo;
    FEvents: IMemoXEvents;
    procedure ChangeEvent(Sender: TObject);
    procedure ClickEvent(Sender: TObject);
    procedure DblClickEvent(Sender: TObject);
    procedure KeyPressEvent(Sender: TObject; var Key: Char);
  protected
    { Protected declarations }
    procedure DefinePropertyPages(DefinePropertyPage: TDefinePropertyPage);
      override;
    procedure EventSinkChanged(const EventSink: IUnknown); override;
    procedure InitializeControl; override;
    function ClassNameIs(const Name: WideString): WordBool; safecall;
    function DrawTextBiDiModeFlags(Flags: Integer): Integer; safecall;
    function DrawTextBiDiModeFlagsReadingOnly: Integer; safecall;
    function Get_Alignment: TAlignment; safecall;
    function Get_BiDiMode: TxBiDiMode; safecall;
    function Get_BorderStyle: TxBorderStyle; safecall;
    function Get_CanUndo: WordBool; safecall;
    function Get_Color: OLE_COLOR; safecall;
    function Get_Ct13D: WordBool; safecall;
```

continues

LISTING 25.3 Continued

```
function Get_Cursor: Smallint; safecall;
function Get_DoubleBuffered: WordBool; safecall;
function Get_DragCursor: Smallint; safecall;
function Get_DragMode: TxDragMode; safecall;
function Get_Enabled: WordBool; safecall;
function Get_Font: IFontDisp; safecall;
function Get_HideSelection: WordBool; safecall;
function Get_ImeMode: TxImeMode; safecall;
function Get_ImeName: WideString; safecall;
function Get_MaxLength: Integer; safecall;
function Get_Modified: WordBool; safecall;
function Get_OEMConvert: WordBool; safecall;
function Get_ParentColor: WordBool; safecall;
function Get_ParentCtl3D: WordBool; safecall;
function Get_ParentFont: WordBool; safecall;
function Get_ReadOnly: WordBool; safecall;
function Get_ScrollBars: TxScrollStyle; safecall;
function Get_SelLength: Integer; safecall;
function Get_SelStart: Integer; safecall;
function Get_SelText: WideString; safecall;
function Get_Text: WideString; safecall;
function Get_Visible: WordBool; safecall;
function Get_WantReturns: WordBool; safecall;
function Get_WantTabs: WordBool; safecall;
function Get_WordWrap: WordBool; safecall;
function GetControlsAlignment: TxAlignment; safecall;
function IsRightToLeft: WordBool; safecall;
function UseRightToLeftAlignment: WordBool; safecall;
function UseRightToLeftReading: WordBool; safecall;
function UseRightToLeftScrollBar: WordBool; safecall;
procedure _Set_Font(const Value: IFontDisp); safecall;
procedure AboutBox; safecall;
procedure Clear; safecall;
procedure ClearSelection; safecall;
procedure ClearUndo; safecall;
procedure CopyToClipboard; safecall;
procedure CutToClipboard; safecall;
procedure FlipChildren(AllLevels: WordBool); safecall;
procedure InitiateAction; safecall;
procedure PasteFromClipboard; safecall;
procedure SelectAll; safecall;
procedure Set_Alignment(Value: TxAlignment); safecall;
procedure Set_BiDiMode(Value: TxBiDiMode); safecall;
procedure Set_BorderStyle(Value: TxBorderStyle); safecall;
procedure Set_Color(Value: OLE_COLOR); safecall;
```

```

procedure Set_Ctl13D(Value: WordBool); safecall;
procedure Set_Cursor(Value: Smallint); safecall;
procedure Set_DoubleBuffered(Value: WordBool); safecall;
procedure Set_DragCursor(Value: Smallint); safecall;
procedure Set_DragMode(Value: TxDragMode); safecall;
procedure Set_Enabled(Value: WordBool); safecall;
procedure Set_Font(var Value: IFontDisp); safecall;
procedure Set_HideSelection(Value: WordBool); safecall;
procedure Set_ImeMode(Value: TxImeMode); safecall;
procedure Set_ImeName(const Value: WideString); safecall;
procedure Set_MaxLength(Value: Integer); safecall;
procedure Set_Modified(Value: WordBool); safecall;
procedure Set_OEMConvert(Value: WordBool); safecall;
procedure Set_ParentColor(Value: WordBool); safecall;
procedure Set_ParentCtl13D(Value: WordBool); safecall;
procedure Set_ParentFont(Value: WordBool); safecall;
procedure Set_ReadOnly(Value: WordBool); safecall;
procedure Set_ScrollBars(Value: TxScrollStyle); safecall;
procedure Set_SelLength(Value: Integer); safecall;
procedure Set_SelStart(Value: Integer); safecall;
procedure Set_SelText(const Value: WideString); safecall;
procedure Set_Text(const Value: WideString); safecall;
procedure Set_Visible(Value: WordBool); safecall;
procedure Set_WantReturns(Value: WordBool); safecall;
procedure Set_WantTabs(Value: WordBool); safecall;
procedure Set_WordWrap(Value: WordBool); safecall;
procedure Undo; safecall;
end;

```

implementation

uses ComObj, About;

```
{ TMemox }
```

```
procedure TMemox.DefinePropertyPages(DefinePropertyPage: TDefinePropertyPage);
begin
```

```
  { Define property pages here. Property pages are defined by calling
    DefinePropertyPage with the class id of the page. For example,
    DefinePropertyPage(Class_MemoxPage); }
```

```
end;
```

```
procedure TMemox.EventSinkChanged(const EventSink: IUnknown);
begin
```

```
  FEvents := EventSink as IMemoxEvents;
```

```
end;
```

LISTING 25.3 Continued

```
procedure TMemoX.InitializeControl;
begin
    FDelphiControl := Control as TMemo;
    FDelphiControl.OnChange := ChangeEvent;
    FDelphiControl.OnClick := ClickEvent;
    FDelphiControl.OnDb1Click := Db1ClickEvent;
    FDelphiControl.OnKeyPress := KeyPressEvent;
end;

function TMemoX.ClassNameIs(const Name: WideString): WordBool;
begin
    Result := FDelphiControl.ClassNameIs(Name);
end;

function TMemoX.DrawTextBiDiModeFlags(Flags: Integer): Integer;
begin
    Result := FDelphiControl.DrawTextBiDiModeFlags(Flags);
end;

function TMemoX.DrawTextBiDiModeFlagsReadingOnly: Integer;
begin
    Result := FDelphiControl.DrawTextBiDiModeFlagsReadingOnly;
end;

function TMemoX.Get_Alignment: TxAlignment;
begin
    Result := Ord(FDelphiControl.Alignment);
end;

function TMemoX.Get_BiDiMode: TxBiDiMode;
begin
    Result := Ord(FDelphiControl.BiDiMode);
end;

function TMemoX.Get_BorderStyle: TxBorderStyle;
begin
    Result := Ord(FDelphiControl.BorderStyle);
end;

function TMemoX.Get_CanUndo: WordBool;
begin
    Result := FDelphiControl.CanUndo;
end;

function TMemoX.Get_Color: OLE_COLOR;
begin
```

```
    Result := OLE_COLOR(FDelphiControl.Color);
end;

function TMemoX.Get_Ctl3D: WordBool;
begin
    Result := FDelphiControl.Ctl3D;
end;

function TMemoX.Get_Cursor: Smallint;
begin
    Result := Smallint(FDelphiControl.Cursor);
end;

function TMemoX.Get_DoubleBuffered: WordBool;
begin
    Result := FDelphiControl.DoubleBuffered;
end;

function TMemoX.Get_DragCursor: Smallint;
begin
    Result := Smallint(FDelphiControl.DragCursor);
end;

function TMemoX.Get_DragMode: TxDragMode;
begin
    Result := Ord(FDelphiControl.DragMode);
end;

function TMemoX.Get_Enabled: WordBool;
begin
    Result := FDelphiControl.Enabled;
end;

function TMemoX.Get_Font: IFontDisp;
begin
    GetOleFont(FDelphiControl.Font, Result);
end;

function TMemoX.Get_HideSelection: WordBool;
begin
    Result := FDelphiControl.HideSelection;
end;

function TMemoX.Get_ImeMode: TxImeMode;
begin
    Result := Ord(FDelphiControl.ImeMode);
```

continues

LISTING 25.3 Continued

```
end;

function TMemoX.Get_ImeName: WideString;
begin
  Result := WideString(FDelphiControl.ImeName);
end;

function TMemoX.Get_MaxLength: Integer;
begin
  Result := FDelphiControl.MaxLength;
end;

function TMemoX.Get_Modified: WordBool;
begin
  Result := FDelphiControl.Modified;
end;

function TMemoX.Get_OEMConvert: WordBool;
begin
  Result := FDelphiControl.OEMConvert;
end;

function TMemoX.Get_ParentColor: WordBool;
begin
  Result := FDelphiControl.ParentColor;
end;

function TMemoX.Get_ParentCtl3D: WordBool;
begin
  Result := FDelphiControl.ParentCtl3D;
end;

function TMemoX.Get_ParentFont: WordBool;
begin
  Result := FDelphiControl.ParentFont;
end;

function TMemoX.Get_ReadOnly: WordBool;
begin
  Result := FDelphiControl.ReadOnly;
end;

function TMemoX.Get_ScrollBars: TxScrollStyle;
begin
  Result := Ord(FDelphiControl.ScrollBars);
end;
```

```
end;

function TMemoX.Get_SelLength: Integer;
begin
    Result := FDelphiControl.SelLength;
end;

function TMemoX.Get_SelStart: Integer;
begin
    Result := FDelphiControl.SelStart;
end;

function TMemoX.Get_SelText: WideString;
begin
    Result := WideString(FDelphiControl.SelText);
end;

function TMemoX.Get_Text: WideString;
begin
    Result := WideString(FDelphiControl.Text);
end;

function TMemoX.Get_Visible: WordBool;
begin
    Result := FDelphiControl.Visible;
end;

function TMemoX.Get_WantReturns: WordBool;
begin
    Result := FDelphiControl.WantReturns;
end;

function TMemoX.Get_WantTabs: WordBool;
begin
    Result := FDelphiControl.WantTabs;
end;

function TMemoX.Get_WordWrap: WordBool;
begin
    Result := FDelphiControl.WordWrap;
end;

function TMemoX.GetControlsAlignment: TxAlignment;
begin
    Result := TxAlignment(FDelphiControl.GetControlsAlignment);
end;
```

continues

LISTING 25.3 Continued

```
function TMemoX.IsRightToLeft: WordBool;
begin
    Result := FDelphiControl.IsRightToLeft;
end;

function TMemoX.UseRightToLeftAlignment: WordBool;
begin
    Result := FDelphiControl.UseRightToLeftAlignment;
end;

function TMemoX.UseRightToLeftReading: WordBool;
begin
    Result := FDelphiControl.UseRightToLeftReading;
end;

function TMemoX.UseRightToLeftScrollBar: WordBool;
begin
    Result := FDelphiControl.UseRightToLeftScrollBar;
end;

procedure TMemoX._Set_Font(const Value: IFontDisp);
begin
    SetOleFont(FDelphiControl.Font, Value);
end;

procedure TMemoX.AboutBox;
begin
    ShowMemoXAbout;
end;

procedure TMemoX.Clear;
begin
    FDelphiControl.Clear;
end;

procedure TMemoX.ClearSelection;
begin
    FDelphiControl.ClearSelection;
end;

procedure TMemoX.ClearUndo;
begin
    FDelphiControl.ClearUndo;
end;
```

```
procedure TMemoX.CopyToClipboard;
begin
  FDelphiControl.CopyToClipboard;
end;

procedure TMemoX.CutToClipboard;
begin
  FDelphiControl.CutToClipboard;
end;

procedure TMemoX.FlipChildren(AllLevels: WordBool);
begin
  FDelphiControl.FlipChildren(AllLevels);
end;

procedure TMemoX.InitiateAction;
begin
  FDelphiControl.InitiateAction;
end;

procedure TMemoX.PasteFromClipboard;
begin
  FDelphiControl.PasteFromClipboard;
end;

procedure TMemoX.SelectAll;
begin
  FDelphiControl.SelectAll;
end;

procedure TMemoX.Set_Alignment(Value: TxAlignment);
begin
  FDelphiControl.Alignment := TAlignment(Value);
end;

procedure TMemoX.Set_BiDiMode(Value: TxBiDiMode);
begin
  FDelphiControl.BiDiMode := TBiDiMode(Value);
end;

procedure TMemoX.Set_BorderStyle(Value: TxBorderStyle);
begin
  FDelphiControl.BorderStyle := TBorderStyle(Value);
end;

procedure TMemoX.Set_Color(Value: OLE_COLOR);
```

continues

LISTING 25.3 Continued

```
begin
  FDelphiControl.Color := TColor(Value);
end;

procedure TMemoX.Set_Ctl3D(Value: WordBool);
begin
  FDelphiControl.Ctl3D := Value;
end;

procedure TMemoX.Set_Cursor(Value: Smallint);
begin
  FDelphiControl.Cursor := TCursor(Value);
end;

procedure TMemoX.Set_DoubleBuffered(Value: WordBool);
begin
  FDelphiControl.DoubleBuffered := Value;
end;

procedure TMemoX.Set_DragCursor(Value: Smallint);
begin
  FDelphiControl.DragCursor := TCursor(Value);
end;

procedure TMemoX.Set_DragMode(Value: TxDragMode);
begin
  FDelphiControl.DragMode := TDragMode(Value);
end;

procedure TMemoX.Set_Enabled(Value: WordBool);
begin
  FDelphiControl.Enabled := Value;
end;

procedure TMemoX.Set_Font(var Value: IFontDisp);
begin
  SetOleFont(FDelphiControl.Font, Value);
end;

procedure TMemoX.Set_HideSelection(Value: WordBool);
begin
  FDelphiControl.HideSelection := Value;
end;

procedure TMemoX.Set_ImeMode(Value: TxImeMode);
```

```
begin
  FDelphiControl.ImeMode := TImeMode(Value);
end;

procedure TMemoX.Set_ImeName(const Value: WideString);
begin
  FDelphiControl.ImeName := TImeName(Value);
end;

procedure TMemoX.Set_MaxLength(Value: Integer);
begin
  FDelphiControl.MaxLength := Value;
end;

procedure TMemoX.Set_Modified(Value: WordBool);
begin
  FDelphiControl.Modified := Value;
end;

procedure TMemoX.Set_OEMConvert(Value: WordBool);
begin
  FDelphiControl.OEMConvert := Value;
end;

procedure TMemoX.Set_ParentColor(Value: WordBool);
begin
  FDelphiControl.ParentColor := Value;
end;

procedure TMemoX.Set_ParentCtl3D(Value: WordBool);
begin
  FDelphiControl.ParentCtl3D := Value;
end;

procedure TMemoX.Set_ParentFont(Value: WordBool);
begin
  FDelphiControl.ParentFont := Value;
end;

procedure TMemoX.Set_ReadOnly(Value: WordBool);
begin
  FDelphiControl.ReadOnly := Value;
end;

procedure TMemoX.Set_ScrollBars(Value: TxScrollStyle);
begin
```

continues

LISTING 25.3 Continued

```
    FDelphiControl.ScrollBars := TScrollStyle(Value);
end;

procedure TMemoX.Set_SelLength(Value: Integer);
begin
    FDelphiControl.SelLength := Value;
end;

procedure TMemoX.Set_SelStart(Value: Integer);
begin
    FDelphiControl.SelStart := Value;
end;

procedure TMemoX.Set_SelText(const Value: WideString);
begin
    FDelphiControl.SelText := String(Value);
end;

procedure TMemoX.Set_Text(const Value: WideString);
begin
    FDelphiControl.Text := TCaption(Value);
end;

procedure TMemoX.Set_Visible(Value: WordBool);
begin
    FDelphiControl.Visible := Value;
end;

procedure TMemoX.Set_WantReturns(Value: WordBool);
begin
    FDelphiControl.WantReturns := Value;
end;

procedure TMemoX.Set_WantTabs(Value: WordBool);
begin
    FDelphiControl.WantTabs := Value;
end;

procedure TMemoX.Set_WordWrap(Value: WordBool);
begin
    FDelphiControl.WordWrap := Value;
end;

procedure TMemoX.Undo;
```

```
begin
  FDelphiControl.Undo;
end;

procedure TMemoX.ChangeEvent(Sender: TObject);
begin
  if FEvents <> nil then FEvents.OnChange;
end;

procedure TMemoX.ClickEvent(Sender: TObject);
begin
  if FEvents <> nil then FEvents.OnClick;
end;

procedure TMemoX.DblClickEvent(Sender: TObject);
begin
  if FEvents <> nil then FEvents.OnDblClick;
end;

procedure TMemoX.KeyPressEvent(Sender: TObject; var Key: Char);
var
  TempKey: Smallint;
begin
  TempKey := Smallint(Key);
  if FEvents <> nil then FEvents.OnKeyPress(TempKey);
  Key := Char(TempKey);
end;

initialization
  TActiveXControlFactory.Create(ComServer, TMemoX, TMemo, Class_MemoX, 1, '',
    0, tmApartment);
end.
```

There is no doubt that Listings 25.1 through 25.3 contain a lot of code. Sometimes the sheer volume of code can make something appear daunting and difficult; however, if you look closely, you will see that no rocket science is involved in these files. What is pretty nifty is that you now have a fully functional ActiveX control (including an interface, a type library, and events) based on a memo control, and you have yet to write a line of code!

Note the helper functions that are used to convert back and forth between properties of `IStrings` and `IFont` to the native Delphi `TStrings` and `TFont` types. Each of these routines operates in a similar manner: They provide a bridge between an Object Pascal class and an Automation-compatible dispatch interface. Table 25.1 shows a list of VCL classes and their Automation interface equivalents.

TABLE 25.1 VCL Classes and their Corresponding Automation Interfaces

<i>VCL Class</i>	<i>Automation Interface</i>
TFont	IFont
TPicture	IPicture
TStrings	IStrings

NOTE

ActiveX defines the IFont and IPicture interfaces. However, the IStrings type is defined in VCL. Delphi provides a redistributable file named StdVc140.dll that contains the type library that defines this interface. This library must be installed and registered on client machines in order for applications using an ActiveX control with IStrings properties to function properly.

The ActiveX Framework

The Delphi ActiveX framework (or *DAX*, for short) resides in the `AxCtrl1` unit. An ActiveX control could be described as an Automation object on steroids, because it must implement the `IDispatch` interface (in addition to many others). Because of this fact, the DAX framework is similar to that of Automation objects, which you learned about in Chapter 23.

`TActiveXControl` is a `TAutoObject` descendent that implements the interfaces required of an ActiveX control. The DAX framework works as a dual-object framework, where the ActiveX control portion contained in `TActiveXControl` communicates with a separate `TWinControl` class that contains the VCL control.

Like all COM objects, ActiveX controls are created from factories. DAX's

`TActiveXControlFactory` serves as the factory for the `TActiveXControl` object. An instance of one of these factories is created in the initialization section of each control implementation file. The constructor for this class is defined as follows:

```
constructor TActiveXControlFactory.Create(ComServer: TComServerObject;  
    ActiveXControlClass: TActiveXControlClass;  
    WinControlClass: TWinControlClass; const ClassID: TGUID;  
    ToolboxBitmapID: Integer; const LicStr: string; MiscStatus: Integer;  
    ThreadingModel: TThreadingModel = tmSingle);
```

`ComServer` holds an instance of `TComServer`. Generally, the `ComServer` global declared in the `ComServ` unit is passed in this parameter.

`ActiveXControlClass` contains the name of the `TActiveXControl` descendant that is declared in the implementation file.

`WinControlClass` contains the name of the VCL `TWinControl` descendent that you want to encapsulate as an ActiveX control.

`ClassID` holds the CLSID of the control coclass as listed in the type library editor.

`ToolboxBitmapID` contains the resource identifier of the bitmap that should be used as the control's representation on the Component Palette.

`LicStr` holds the string that should be used as the control's license key string. If this is empty, the control is not licensed.

`MiscStatus` holds the `OLEMISC_XXX` status flags for the control. These flags are defined in the ActiveX unit. These `OLEMISC` flags are entered into the System Registry when the ActiveX control is registered. `OLEMISC` flags provide ActiveX control containers with information regarding various attributes of the ActiveX control. For example, there are `OLEMISC` flags that indicate how a control is painted and whether a control can contain other controls. These flags are fully documented on the Microsoft Developer's Network under the topic "OLEMISC."

Finally, `ThreadingModel` identifies the threading model that this control will be registered as supporting. It is important to note that setting this parameter to some particular threading model does not guarantee that your control is safer for that particular model; it only affects how the control is registered. Building in thread safety is up to you as the developer. See Chapter 23 for a discussion of each of the threading models.

Simple Frame Controls

One of the `OLEMISC_XXX` flags is `OLEMISC_SIMPLEFRAME`, which will automatically be added if `csAcceptsControls` is included in the VCL control's `ControlStyle` set. This makes the ActiveX control a simple frame control capable of containing other ActiveX controls in an ActiveX container application. The `TActiveXControl` class contains the necessary message-handling infrastructure to make simple frame controls work correctly. Occasionally, the wizard will add this flag to a control that you do not want to serve as a simple frame; in this case, it is okay to remove the flag from the class factory constructor call.

The Reflector Window

Some VCL controls require notification messages in order to properly function. For this purpose, DAX will create a reflector window whose job is to receive messages and forward them on to the VCL control. Standard VCL controls that require a reflector window will have the `csReflector` member included in their `ControlStyle` set. If you have a custom `TWinControl` that operates using notification messages, you should be sure to add this member to the `ControlStyle` set in the control's constructor.

Design Time Versus Runtime

VCL provides a simple means for determining whether a control is currently in design mode or run mode—by checking for the `csDesigning` member in the `ComponentState` set. Although you can to make this distinction for ActiveX controls, it is not so straightforward. It involves obtaining a pointer to the container's `IAmbientDispatch` dispinterface and checking the `UserMode` property on that dispinterface. You can use the following function for this purpose:

```
function IsControlRunning(Control: IUnknown): Boolean;
var
    OleObj: IOleObject;
    Site: IOleClientSite;
begin
    Result := True;
    // Get control's IOleObject pointer. From that, get container's
    // IOleClientSite. From that, get IAmbientDispatch.
    if (Control.QueryInterface(IOleObject, OleObj) = S_OK) and
        (OleObj.GetClientSite(Site) = S_OK) and (Site <> nil) then
        Result := (Site as IAmbientDispatch).UserMode;
end;
```

Control Licensing

We mentioned earlier in this chapter that the default DAX scheme for licensing involves an LIC file that should accompany the ActiveX control OCX file on development machines. As you saw earlier, the license string is one of the parameters to the ActiveX control's class factory constructor. When `Make Control Licensed` is selected in the wizard, this option will generate a GUID string that will be inserted into both the constructor call and the LIC file (you are free to modify the string later if you so choose). When the control is used at design time in a development tool, DAX will attempt to match the license string in the class factory with a string in the LIC file. If a match occurs, the control instance will be created. When an application that includes the licensed ActiveX control is compiled, the license string is embedded in the application, and the LIC file is not required to run the application.

The LIC file scheme for licensing is not the only one under the sun. For example, some developers find the use of an additional file cumbersome and prefer to store a license key in the Registry. Fortunately, DAX makes it very easy to implement an alternative licensing scheme such as this. The license check occurs in a `TActiveXControlFactory` method called `HasMachineLicense()`. By default, this method attempts to look up the licensing string in the LIC file, but you can have this method perform whatever check you want to determine licensing. For example, Listing 25.4 shows a `TActiveXControlFactory` descendent that looks in the Registry for the license key.

LISTING 25.4 An Alternative Scheme for Licensing

```
{ TRegLicAxControlFactory }

type
  TRegLicActiveXControlFactory = class(TActiveXControlFactory)
  protected
    function HasMachineLicense: Boolean; override;
  end;

function TRegLicActiveXControlFactory.HasMachineLicense: Boolean;
var
  Reg: TRegistry;
begin
  Result := True;
  if not SupportsLicensing then Exit;
  Reg := TRegistry.Create;
  try
    Reg.RootKey := HKEY_CLASSES_ROOT;
    // control is licensed if key is in registry
    Result := Reg.OpenKey('\Licenses\' + LicString, False);
  finally
    Reg.Free;
  end;
end;
```

A Registry file (REG) can be used to place the license key in the Registry on a licensed machine. This is shown in Listing 25.5.

LISTING 25.5 The Licensing REG File

```
REGEDIT4

[HKEY_CLASSES_ROOT\Licenses\{C06EFEA0-06B2-11D1-A9BF-B18A9F703311}]
@= "Licensing info for DDG demo ActiveX control"
```

Property Pages

Property pages provide a means for modifying the properties of an ActiveX control through a custom dialog. A control's property pages are added as pages in a tabbed dialog that is created by ActiveX. Property page dialogs are usually invoked from a local right-click menu provided by the control's host container.

Standard Property Pages

DAX provides standard property pages for properties of type `IStrings`, `IPicture`, `TColor`, and `IFont`. The CLSIDs for these property pages are found in the `AxCtrls` unit. They are declared as follows:

```
const
  { Delphi property page CLSIDs }
  Class_DColorPropPage: TGUID = '{5CFF5D59-5946-11D0-BDEF-00A024D1875C}';
  Class_DFontPropPage: TGUID = '{5CFF5D5B-5946-11D0-BDEF-00A024D1875C}';
  Class_DPicturePropPage: TGUID = '{5CFF5D5A-5946-11D0-BDEF-00A024D1875C}';
  Class_DStringPropPage: TGUID = '{F42D677E-754B-11D0-BDFB-00A024D1875C}';
```

Using any of these property pages in your control is a simple matter: Just pass one of these CLSIDs to the `DefinePropertyPage()` procedural parameter in the `DefinePropertyPages()` method of your ActiveX control, as shown here:

```
procedure TMemoX.DefinePropertyPages(DefinePropertyPage: TDefinePropertyPage);
begin
  DefinePropertyPage(Class_DColorPropPage);
  DefinePropertyPage(Class_DFontPropPage);
  DefinePropertyPage(Class_DStringPropPage);
end;
```

Figures 25.4 through 25.7 show each of the standard DAX property pages.

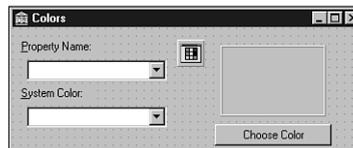


FIGURE 25.4

DAX Colors property page.

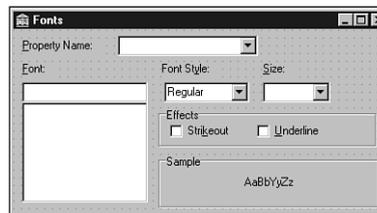
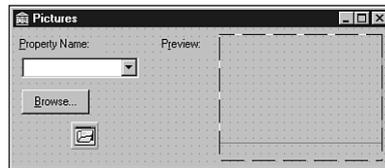


FIGURE 25.5

DAX Fonts property page.

**FIGURE 25.6**

DAX Strings property page.

**FIGURE 25.7**

DAX Pictures property page.

Each of these property pages operates similarly: The combo box contains the names of each of the properties of the specified type. You just select the property name, set the value in the dialog, and then click OK to modify the selected property.

NOTE

If you want to use the standard DAX property pages, you must distribute `StdVc140.dll` along with your OCX file. As mentioned earlier in this chapter, this file contains the definition for `IStrings` as well as the `IProvider` and `IDataBroker` interfaces. Additionally, `StdVc140.dll` contains the implementation for each of the DAX property pages. You must also ensure that both the OCX file and `StdVc140.dll` have been registered on the target machine.

Custom Property Pages

To help illustrate the creation of custom property pages, we will create a control that is more interesting than the simple Memo control we have been working with so far. Listing 25.6 shows the implementation file for the `TCardX` ActiveX control. This control is an encapsulation of the playing card VCL control that comes from the Cards unit, which you will find in the `\Code\Comps` subdirectory of the CD-ROM accompanying this book.

LISTING 25.6 CardImpl.pas: Implementation File for the TCardX ActiveX Control

```
unit CardImpl;

interface

uses
  Windows, ActiveX, Classes, Controls, Graphics, Menus, Forms, StdCtrls,
  ComServ, StdVCL, AXCtrls, AxCard_TLB, Cards;

type
  TCardX = class(TActiveXControl, ICardX)
  private
    { Private declarations }
    FDelphiControl: TCard;
    FEvents: ICardXEvents;
    procedure ClickEvent(Sender: TObject);
    procedure DblClickEvent(Sender: TObject);
    procedure KeyPressEvent(Sender: TObject; var Key: Char);
  protected
    { Protected declarations }
    procedure DefinePropertyPages(DefinePropertyPage: TDefinePropertyPage);
      override;
    procedure EventSinkChanged(const EventSink: IUnknown); override;
    procedure InitializeControl; override;
    function ClassNameIs(const Name: WideString): WordBool; safecall;
    function DrawTextBiDiModeFlags(Flags: Integer): Integer; safecall;
    function DrawTextBiDiModeFlagsReadOnly: Integer; safecall;
    function Get_BackColor: OLE_COLOR; safecall;
    function Get_BiDiMode: TxBiDiMode; safecall;
    function Get_Color: OLE_COLOR; safecall;
    function Get_Cursor: Smallint; safecall;
    function Get_DoubleBuffered: WordBool; safecall;
    function Get_DragCursor: Smallint; safecall;
    function Get_DragMode: TxDragMode; safecall;
    function Get_Enabled: WordBool; safecall;
    function Get_FaceUp: WordBool; safecall;
    function Get_ParentColor: WordBool; safecall;
    function Get_Suit: TxCardSuit; safecall;
    function Get_Value: TxCardValue; safecall;
    function Get_Visible: WordBool; safecall;
    function GetControlsAlignment: TxAlignment; safecall;
    function IsRightToLeft: WordBool; safecall;
    function UseRightToLeftAlignment: WordBool; safecall;
    function UseRightToLeftReading: WordBool; safecall;
    function UseRightToLeftScrollBar: WordBool; safecall;
    procedure FlipChildren(AllLevels: WordBool); safecall;
```

```
procedure InitiateAction; safecall;
procedure Set_BackColor(Value: OLE_COLOR); safecall;
procedure Set_BiDiMode(Value: TxBiDiMode); safecall;
procedure Set_Color(Value: OLE_COLOR); safecall;
procedure Set_Cursor(Value: Smallint); safecall;
procedure Set_DoubleBuffered(Value: WordBool); safecall;
procedure Set_DragCursor(Value: Smallint); safecall;
procedure Set_DragMode(Value: TxDragMode); safecall;
procedure Set_Enabled(Value: WordBool); safecall;
procedure Set_FaceUp(Value: WordBool); safecall;
procedure Set_ParentColor(Value: WordBool); safecall;
procedure Set_Suit(Value: TxCardSuit); safecall;
procedure Set_Value(Value: TxCardValue); safecall;
procedure Set_Visible(Value: WordBool); safecall;
procedure AboutBox; safecall;
end;

implementation

uses ComObj, About, CardPP;

{ TCardX }

procedure TCardX.DefinePropertyPages(DefinePropertyPage: TDefinePropertyPage);
begin
  DefinePropertyPage(Class_DColorPropPage);
  DefinePropertyPage(Class_CardPropPage);
end;

procedure TCardX.EventSinkChanged(const EventSink: IUnknown);
begin
  FEvents := EventSink as ICardXEvents;
end;

procedure TCardX.InitializeControl;
begin
  FDelphiControl := Control as TCard;
  FDelphiControl.OnClick := ClickEvent;
  FDelphiControl.OnDbClick := DbClickEvent;
  FDelphiControl.OnKeyPress := KeyPressEvent;
end;

function TCardX.ClassNameIs(const Name: WideString): WordBool;
begin
  Result := FDelphiControl.ClassNameIs(Name);
end;
```

continues

LISTING 25.6 Continued

```
function TCardX.DrawTextBiDiModeFlags(Flags: Integer): Integer;
begin
    Result := FDelphiControl.DrawTextBiDiModeFlags(Flags);
end;

function TCardX.DrawTextBiDiModeFlagsReadingOnly: Integer;
begin
    Result := FDelphiControl.DrawTextBiDiModeFlagsReadingOnly;
end;

function TCardX.Get_BackColor: OLE_COLOR;
begin
    Result := OLE_COLOR(FDelphiControl.BackColor);
end;

function TCardX.Get_BiDiMode: TxBiDiMode;
begin
    Result := Ord(FDelphiControl.BiDiMode);
end;

function TCardX.Get_Color: OLE_COLOR;
begin
    Result := OLE_COLOR(FDelphiControl.Color);
end;

function TCardX.Get_Cursor: Smallint;
begin
    Result := Smallint(FDelphiControl.Cursor);
end;

function TCardX.Get_DoubleBuffered: WordBool;
begin
    Result := FDelphiControl.DoubleBuffered;
end;

function TCardX.Get_DragCursor: Smallint;
begin
    Result := Smallint(FDelphiControl.DragCursor);
end;

function TCardX.Get_DragMode: TxDragMode;
begin
    Result := Ord(FDelphiControl.DragMode);
end;
```

```
function TCardX.Get_Enabled: WordBool;
begin
  Result := FDelphiControl.Enabled;
end;

function TCardX.Get_FaceUp: WordBool;
begin
  Result := FDelphiControl.FaceUp;
end;

function TCardX.Get_ParentColor: WordBool;
begin
  Result := FDelphiControl.ParentColor;
end;

function TCardX.Get_Suit: TxCardSuit;
begin
  Result := Ord(FDelphiControl.Suit);
end;

function TCardX.Get_Value: TxCardValue;
begin
  Result := Ord(FDelphiControl.Value);
end;

function TCardX.Get_Visible: WordBool;
begin
  Result := FDelphiControl.Visible;
end;

function TCardX.GetControlsAlignment: TxAlignment;
begin
  Result := TxAlignment(FDelphiControl.GetControlsAlignment);
end;

function TCardX.IsRightToLeft: WordBool;
begin
  Result := FDelphiControl.IsRightToLeft;
end;

function TCardX.UseRightToLeftAlignment: WordBool;
begin
  Result := FDelphiControl.UseRightToLeftAlignment;
end;

function TCardX.UseRightToLeftReading: WordBool;
```

continues

LISTING 25.6 Continued

```
begin
  Result := FDelphiControl.UseRightToLeftReading;
end;

function TCardX.UseRightToLeftScrollBar: WordBool;
begin
  Result := FDelphiControl.UseRightToLeftScrollBar;
end;

procedure TCardX.FlipChildren(AllLevels: WordBool);
begin
  FDelphiControl.FlipChildren(AllLevels);
end;

procedure TCardX.InitiateAction;
begin
  FDelphiControl.InitiateAction;
end;

procedure TCardX.Set_BackColor(Value: OLE_COLOR);
begin
  FDelphiControl.BackColor := TColor(Value);
end;

procedure TCardX.Set_BiDiMode(Value: TxBiDiMode);
begin
  FDelphiControl.BiDiMode := TBiDiMode(Value);
end;

procedure TCardX.Set_Color(Value: OLE_COLOR);
begin
  FDelphiControl.Color := TColor(Value);
end;

procedure TCardX.Set_Cursor(Value: Smallint);
begin
  FDelphiControl.Cursor := TCursor(Value);
end;

procedure TCardX.Set_DoubleBuffered(Value: WordBool);
begin
  FDelphiControl.DoubleBuffered := Value;
end;

procedure TCardX.Set_DragCursor(Value: Smallint);
```

```
begin
  FDelphiControl.DragCursor := TCursor(Value);
end;

procedure TCardX.Set_DragMode(Value: TxDragMode);
begin
  FDelphiControl.DragMode := TDragMode(Value);
end;

procedure TCardX.Set_Enabled(Value: WordBool);
begin
  FDelphiControl.Enabled := Value;
end;

procedure TCardX.Set_FaceUp(Value: WordBool);
begin
  FDelphiControl.FaceUp := Value;
end;

procedure TCardX.Set_ParentColor(Value: WordBool);
begin
  FDelphiControl.ParentColor := Value;
end;

procedure TCardX.Set_Suit(Value: TxCardsuit);
begin
  FDelphiControl.Suit := TCardSuit(Value);
end;

procedure TCardX.Set_Value(Value: TxCardsuit);
begin
  FDelphiControl.Value := TCardValue(Value);
end;

procedure TCardX.Set_Visible(Value: WordBool);
begin
  FDelphiControl.Visible := Value;
end;

procedure TCardX.ClickEvent(Sender: TObject);
begin
  if FEvents <> nil then FEvents.OnClick;
end;

procedure TCardX.Db1ClickEvent(Sender: TObject);
begin
```

continues

LISTING 25.6 Continued

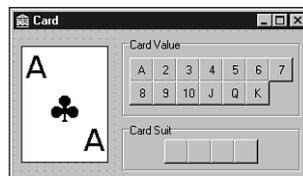
```
    if FEvents <> nil then FEvents.OnDbClick;
end;

procedure TCardX.KeyPressEvent(Sender: TObject; var Key: Char);
var
    TempKey: Smallint;
begin
    TempKey := Smallint(Key);
    if FEvents <> nil then FEvents.OnKeyPress(TempKey);
    Key := Char(TempKey);
end;

procedure TCardX.AboutBox;
begin
    ShowCardXAbout;
end;

initialization
    TActiveXControlFactory.Create(ComServer, TCardX, TCard, Class_CardX,
        1, '', 0, tmApartment);
end.
```

This unit is essentially what was generated by the wizard, except for the two lines of code shown in the `DefinePropertyPages()` method. In this method, you can see that we employ the standard VCL Color property page in addition to a custom property page whose CLSID is defined as `Class_CardPropPage`. This property page was created by selecting the Property Page item from the ActiveX page of the New Items dialog. Figure 25.8 shows this property page in the Form Designer, and Listing 25.7 shows the source code for this property page.

**FIGURE 25.8**

A property page in the Form Designer.

LISTING 25.7 The Property Page Unit: CardPP.pas

```
unit CardPP;

interface

uses SysUtils, Windows, Messages, Classes, Graphics, Controls, StdCtrls,
    ExtCtrls, Forms, ComServ, ComObj, StdVcl, AxCtrls, Buttons, Cards,
    AxCard_TLB;

type
  TCardPropPage = class(TPropertyPage)
    Card1: TCard;
    ValueGroup: TGroupBox;
    SpeedButton1: TSpeedButton;
    SpeedButton2: TSpeedButton;
    SpeedButton3: TSpeedButton;
    SpeedButton4: TSpeedButton;
    SpeedButton5: TSpeedButton;
    SpeedButton6: TSpeedButton;
    SpeedButton7: TSpeedButton;
    SpeedButton8: TSpeedButton;
    SpeedButton9: TSpeedButton;
    SpeedButton10: TSpeedButton;
    SpeedButton11: TSpeedButton;
    SpeedButton12: TSpeedButton;
    SuitGroup: TGroupBox;
    SpeedButton13: TSpeedButton;
    SpeedButton14: TSpeedButton;
    SpeedButton15: TSpeedButton;
    SpeedButton16: TSpeedButton;
    SpeedButton17: TSpeedButton;
    procedure FormCreate(Sender: TObject);
    procedure SpeedButton1Click(Sender: TObject);
  protected
    procedure UpdatePropertyPage; override;
    procedure UpdateObject; override;
  end;

const
  Class_CardPropPage: TGUID = '{C06EFEA1-06B2-11D1-A9BF-B18A9F703311}';

implementation

{$R *.DFM}
```

continues

LISTING 25.7 Continued

```
procedure TCardPropPage.UpdatePropertyPage;
var
  i: Integer;
  AValue, ASuit: Integer;
begin
  // get suit and value
  AValue := OleObject.Value;
  ASuit := OleObject.Suit;
  // set card correctly
  Card1.Value := TCardValue(AValue);
  Card1.Suit := TCardSuit(ASuit);
  // set correct value speedbutton
  with ValueGroup do
    for i := 0 to ControlCount - 1 do
      if (Controls[i] is TSpeedButton) and
        (TSpeedButton(Controls[i]).Tag = AValue) then
        TSpeedButton(Controls[i]).Down := True;
  // set correct suit speedbutton
  with SuitGroup do
    for i := 0 to ControlCount - 1 do
      if (Controls[i] is TSpeedButton) and
        (TSpeedButton(Controls[i]).Tag = ASuit) then
        TSpeedButton(Controls[i]).Down := True;
end;

procedure TCardPropPage.UpdateObject;
var
  i: Integer;
begin
  // set correct value speedbutton
  with ValueGroup do
    for i := 0 to ControlCount - 1 do
      if (Controls[i] is TSpeedButton) and TSpeedButton(Controls[i]).Down then
      begin
        OleObject.Value := TSpeedButton(Controls[i]).Tag;
        Break;
      end;
  // set correct suit speedbutton
  with SuitGroup do
    for i := 0 to ControlCount - 1 do
      if (Controls[i] is TSpeedButton) and TSpeedButton(Controls[i]).Down then
      begin
        OleObject.Suit := TSpeedButton(Controls[i]).Tag;
        Break;
      end;
end;
```

```
procedure TCardPropPage.FormCreate(Sender: TObject);
const
  // ordinal values of "suit" characters in Symbol font:
  SSuits: PChar = #167#168#169#170;
var
  i: Integer;
begin
  // set up captions of suit speedbuttons using high
  // characters in Symbol font
  with SuitGroup do
    for i := 0 to ControlCount - 1 do
      if Controls[i] is TSpeedButton then
        TSpeedButton(Controls[i]).Caption := SSuits[i];
end;

procedure TCardPropPage.SpeedButton1Click(Sender: TObject);
begin
  if Sender is TSpeedButton then
    begin
      with TSpeedButton(Sender) do
        begin
          if Parent = ValueGroup then
            Card1.Value := TCardValue(Tag)
          else if Parent = SuitGroup then
            Card1.Suit := TCardSuit(Tag);
          end;
          Modified;
        end;
    end;
end;

initialization
  TActiveXPropertyPageFactory.Create(
    ComServer,
    TCardPropPage,
    Class_CardPropPage);
end.
```

You must communicate with the ActiveX control from the property page using its `IOleObject` field. `IOleObject` is a variant that holds a reference to the control's `IDispatch` interface. The `UpdatePropertyPage()` and `UpdateObject()` methods are generated by the wizard. `UpdatePropertyPage()` is called when the property page is invoked. In this method, you must set the contents of the page to match the current values of the ActiveX control as indicated in the `IOleObject` property. `UpdateObject()` will be called when the user clicks the OK or Apply button in the Property Page dialog. In this method, you should use the `IOleObject` property to set the ActiveX control properties to those indicated by the property page.

In this example, the property page allows you to edit the suit or value of the TCardX ActiveX control. As you modify the suit or value using speedbuttons in the dialog, a TCard VCL control residing on the property page is changed to reflect the current suit and value. Notice also that when a speedbutton is clicked, the property page's `Modified()` procedure is called to set the modified flag of the Property Page dialog. This enables the Apply button on the dialog.

This property page is shown in action in Figure 25.9.

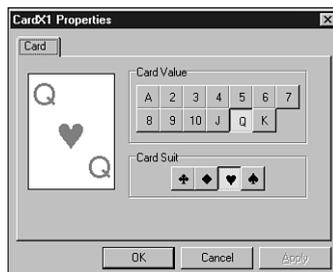


FIGURE 25.9

The Card property page in action.

ActiveForms

Functionally, ActiveForms work very much the same as the ActiveX controls you learned about earlier in this chapter. The primary difference is that the VCL control upon which you base an ActiveX control does not really change after you run the wizard, whereas the whole point of an ActiveForm is that it changes constantly as it is manipulated in the designer. Because the ActiveForm's wizard and framework are essentially the same as the ones for ActiveX controls, we will not rehash that material. Instead, let's focus on some interesting things you can do with ActiveForms.

Adding Properties to ActiveForms

One problem with ActiveForms is that their representation in the type library consists of "flat" interfaces rather than the nested components you are familiar with in VCL. This means that if you have a form with several buttons, they cannot easily be addressed in the VCL manner of `ActiveForm.Button.ButtonProperty` as an ActiveForm. Instead, the easiest way to accomplish this is to surface the button properties in question as properties of the ActiveForm itself. The DAX framework makes adding properties to ActiveForms a pretty painless process; you just need to follow a couple steps. Here is what's required to publish the `Caption` property of a button on an ActiveForm:

1. Add a new published property to the ActiveForm declaration in the implementation file. This property will be called `ButtonCaption`, and it will have reader and writer methods that modify the `Caption` property of the button.
2. Add a new property of the same name to the ActiveForm's interface in the type library. Delphi will automatically write the skeletons for the reader and writer methods for this property, and you must implement them by reading and writing the ActiveForm's `ButtonCaption` property.

The implementation file for this component is shown in Listing 25.8.

LISTING 25.8 Adding Properties to ActiveForms

```
unit AFImpl;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  ActiveX, AxCtrls, AFrm_TLB, StdCtrls;

type
  TFormX = class(TActiveForm, IActiveFormX)
    Button1: TButton;
  private
    { Private declarations }
    FEvents: IActiveFormXEvents;
    procedure ActivateEvent(Sender: TObject);
    procedure ClickEvent(Sender: TObject);
    procedure CreateEvent(Sender: TObject);
    procedure DblClickEvent(Sender: TObject);
    procedure DeactivateEvent(Sender: TObject);
    procedure DestroyEvent(Sender: TObject);
    procedure KeyPressEvent(Sender: TObject; var Key: Char);
    procedure PaintEvent(Sender: TObject);
    function GetButtonCaption: string;
    procedure SetButtonCaption(const Value: string);
  protected
    { Protected declarations }
    procedure DefinePropertyPages(DefinePropertyPage: TDefinePropertyPage);
      override;
    procedure EventSinkChanged(const EventSink: IUnknown); override;
    function Get_Active: WordBool; safecall;
    function Get_AutoScroll: WordBool; safecall;
    function Get_AutoSize: WordBool; safecall;
    function Get_AxBorderStyle: TxAxFormBorderStyle; safecall;
```

continues

LISTING 25.8 Continued

```
function Get_BiDiMode: TxBiDiMode; safecall;
function Get_Caption: WideString; safecall;
function Get_Color: OLE_COLOR; safecall;
function Get_Cursor: Smallint; safecall;
function Get_DoubleBuffered: WordBool; safecall;
function Get_DropTarget: WordBool; safecall;
function Get_Enabled: WordBool; safecall;
function Get_Font: IFontDisp; safecall;
function Get_HelpFile: WideString; safecall;
function Get_KeyPreview: WordBool; safecall;
function Get_PixelsPerInch: Integer; safecall;
function Get_PrintScale: TxPrintScale; safecall;
function Get_Scaled: WordBool; safecall;
function Get_Visible: WordBool; safecall;
procedure _Set_Font(const Value: IFontDisp); safecall;
procedure AboutBox; safecall;
procedure Set_AutoScroll(Value: WordBool); safecall;
procedure Set_AutoSize(Value: WordBool); safecall;
procedure Set_AxBorderStyle(Value: TxActiveFormBorderStyle); safecall;
procedure Set_BiDiMode(Value: TxBiDiMode); safecall;
procedure Set_Caption(const Value: WideString); safecall;
procedure Set_Color(Value: OLE_COLOR); safecall;
procedure Set_Cursor(Value: Smallint); safecall;
procedure Set_DoubleBuffered(Value: WordBool); safecall;
procedure Set_DropTarget(Value: WordBool); safecall;
procedure Set_Enabled(Value: WordBool); safecall;
procedure Set_Font(var Value: IFontDisp); safecall;
procedure Set_HelpFile(const Value: WideString); safecall;
procedure Set_KeyPreview(Value: WordBool); safecall;
procedure Set_PixelsPerInch(Value: Integer); safecall;
procedure Set_PrintScale(Value: TxPrintScale); safecall;
procedure Set_Scaled(Value: WordBool); safecall;
procedure Set_Visible(Value: WordBool); safecall;
function Get_ButtonCaption: WideString; safecall;
procedure Set_ButtonCaption(const Value: WideString); safecall;
public
  { Public declarations }
  procedure Initialize; override;
published
  property ButtonCaption: string read GetButtonCaption
    write SetButtonCaption;
end;

implementation
```

```
uses ComObj, ComServ, About1;

{$R *.DFM}

{ TFormX }

procedure TFormX.DefinePropertyPages(DefinePropertyPage:
  TDefinePropertyPage);
begin
  { Define property pages here. Property pages are defined by calling
    DefinePropertyPage with the class id of the page. For example,
    DefinePropertyPage(Class_ActiveFormXPage); }
end;

procedure TFormX.EventSinkChanged(const EventSink: IUnknown);
begin
  FEvents := EventSink as IActiveFormXEvents;
end;

procedure TFormX.Initialize;
begin
  inherited Initialize;
  OnActivate := ActivateEvent;
  OnClick := ClickEvent;
  OnCreate := CreateEvent;
  OnDblClick := DblClickEvent;
  OnDeactivate := DeactivateEvent;
  OnDestroy := DestroyEvent;
  OnKeyPress := KeyPressEvent;
  OnPaint := PaintEvent;
end;

function TFormX.Get_Active: WordBool;
begin
  Result := Active;
end;

function TFormX.Get_AutoScroll: WordBool;
begin
  Result := AutoScroll;
end;

function TFormX.Get_AutoSize: WordBool;
begin
  Result := AutoSize;
end;
```

continues

LISTING 25.8 Continued

```
function TActiveFormX.Get_AxBorderStyle: TxAxFormBorderStyle;
begin
  Result := Ord(AxBorderStyle);
end;

function TActiveFormX.Get_BiDiMode: TxBiDiMode;
begin
  Result := Ord(BiDiMode);
end;

function TActiveFormX.Get_Caption: WideString;
begin
  Result := WideString(Caption);
end;

function TActiveFormX.Get_Color: OLE_COLOR;
begin
  Result := OLE_COLOR(Color);
end;

function TActiveFormX.Get_Cursor: Smallint;
begin
  Result := Smallint(Cursor);
end;

function TActiveFormX.Get_DoubleBuffered: WordBool;
begin
  Result := DoubleBuffered;
end;

function TActiveFormX.Get_DropTarget: WordBool;
begin
  Result := DropTarget;
end;

function TActiveFormX.Get_Enabled: WordBool;
begin
  Result := Enabled;
end;

function TActiveFormX.Get_Font: IFontDisp;
begin
  GetOleFont(Font, Result);
end;
```

```
function TActiveFormX.Get_HelpFile: WideString;
begin
  Result := WideString(HelpFile);
end;

function TActiveFormX.Get_KeyPreview: WordBool;
begin
  Result := KeyPreview;
end;

function TActiveFormX.Get_PixelsPerInch: Integer;
begin
  Result := PixelsPerInch;
end;

function TActiveFormX.Get_PrintScale: TxPrintScale;
begin
  Result := Ord(PrintScale);
end;

function TActiveFormX.Get_Scaled: WordBool;
begin
  Result := Scaled;
end;

function TActiveFormX.Get_Visible: WordBool;
begin
  Result := Visible;
end;

procedure TActiveFormX._Set_Font(const Value: IFontDisp);
begin
  SetOleFont(Font, Value);
end;

procedure TActiveFormX.AboutBox;
begin
  ShowActiveFormXAbout;
end;

procedure TActiveFormX.Set_AutoScroll(Value: WordBool);
begin
  AutoScroll := Value;
end;

procedure TActiveFormX.Set_AutoSize(Value: WordBool);
```

continues

LISTING 25.8 Continued

```
begin
  AutoSize := Value;
end;

procedure TActiveFormX.Set_AxBorderStyle(Value: TActiveFormBorderStyle);
begin
  AxBorderStyle := TActiveFormBorderStyle(Value);
end;

procedure TActiveFormX.Set_BiDiMode(Value: TBiDiMode);
begin
  BiDiMode := TBiDiMode(Value);
end;

procedure TActiveFormX.Set_Caption(const Value: WideString);
begin
  Caption := TCaption(Value);
end;

procedure TActiveFormX.Set_Color(Value: OLE_COLOR);
begin
  Color := TColor(Value);
end;

procedure TActiveFormX.Set_Cursor(Value: Smallint);
begin
  Cursor := TCursor(Value);
end;

procedure TActiveFormX.Set_DoubleBuffered(Value: WordBool);
begin
  DoubleBuffered := Value;
end;

procedure TActiveFormX.Set_DropTarget(Value: WordBool);
begin
  DropTarget := Value;
end;

procedure TActiveFormX.Set_Enabled(Value: WordBool);
begin
  Enabled := Value;
end;

procedure TActiveFormX.Set_Font(var Value: IFontDisp);
```

```
begin
  SetOleFont(Font, Value);
end;

procedure TActiveFormX.Set_HelpFile(const Value: WideString);
begin
  HelpFile := String(Value);
end;

procedure TActiveFormX.Set_KeyPreview(Value: WordBool);
begin
  KeyPreview := Value;
end;

procedure TActiveFormX.Set_PixelsPerInch(Value: Integer);
begin
  PixelsPerInch := Value;
end;

procedure TActiveFormX.Set_PrintScale(Value: TxPrintScale);
begin
  PrintScale := TPrintScale(Value);
end;

procedure TActiveFormX.Set_Scaled(Value: WordBool);
begin
  Scaled := Value;
end;

procedure TActiveFormX.Set_Visible(Value: WordBool);
begin
  Visible := Value;
end;

procedure TActiveFormX.ActivateEvent(Sender: TObject);
begin
  if FEvents <> nil then FEvents.OnActivate;
end;

procedure TActiveFormX.ClickEvent(Sender: TObject);
begin
  if FEvents <> nil then FEvents.OnClick;
end;

procedure TActiveFormX.CreateEvent(Sender: TObject);
begin
```

continues

LISTING 25.8 Continued

```
    if FEvents <> nil then FEvents.OnCreate;
end;

procedure TActiveFormX.DblClickEvent(Sender: TObject);
begin
    if FEvents <> nil then FEvents.OnDblClick;
end;

procedure TActiveFormX.DeactivateEvent(Sender: TObject);
begin
    if FEvents <> nil then FEvents.OnDeactivate;
end;

procedure TActiveFormX.DestroyEvent(Sender: TObject);
begin
    if FEvents <> nil then FEvents.OnDestroy;
end;

procedure TActiveFormX.KeyPressEvent(Sender: TObject; var Key: Char);
var
    TempKey: Smallint;
begin
    TempKey := Smallint(Key);
    if FEvents <> nil then FEvents.OnKeyPress(TempKey);
    Key := Char(TempKey);
end;

procedure TActiveFormX.PaintEvent(Sender: TObject);
begin
    if FEvents <> nil then FEvents.OnPaint;
end;

function TActiveFormX.GetButtonCaption: string;
begin
    Result := Button1.Caption;
end;

procedure TActiveFormX.SetButtonCaption(const Value: string);
begin
    Button1.Caption := Value;
end;

function TActiveFormX.Get_ButtonCaption: WideString;
begin
    Result := ButtonCaption;
end;
```

```
end;

procedure TActiveFormX.Set_ButtonCaption(const Value: WideString);
begin
    ButtonCaption := Value;
end;

initialization
    TActiveFormFactory.Create(ComServer, TActiveFormControl, TActiveFormX,
        Class_ActiveFormX, 1, '', OLEMISC_SIMPLEFRAME or OLEMISC_ACTSLIKELABEL,
        tmApartment);
end.
```

ActiveX on the Web

An ideal use for ActiveForms is as a vehicle for delivering small applications over the World Wide Web. Smaller ActiveX controls are also useful for enhancing the appearance and usefulness of Web pages. However, in order to get the most out of Delphi-written ActiveX controls on the Web, you need to know a few things about control streaming, safety, and communication with the browser.

Communicating with the Web Browser

Because ActiveX controls can run within the context of a Web browser, it makes sense that Web browsers expose functions and interfaces that allow ActiveX controls to manipulate them. Most of these functions and interfaces are located in the `UrlMon` unit (that's Jamaican Web talk). Among the simplest of these functions are the `HlinkXXX()` functions, which cause the browser to hyperlink to different locations. For example, the `HlinkGoForward()` and `HlinkGoBack()` functions cause the browser to travel forward or back in its location stack. The `HlinkNavigateString()` function causes the browser to travel to a specified URL. These functions are defined in `UrlMon` as follows:

```
function HlinkGoBack(pUnk: IUnknown): HRESULT; stdcall;
function HlinkGoForward(pUnk: IUnknown): HRESULT; stdcall;
function HlinkNavigateString(pUnk: IUnknown; szTarget: PWideChar): HRESULT;
    stdcall;
```

The `pUnk` parameter for each of these functions is the `IUnknown` interface for the ActiveX control. In the case of ActiveX controls, you can pass `Control` as `IUnknown` in this parameter. In the case of ActiveForms, you should pass `IUnknown(VclComObject)` in this parameter. The `szTarget` parameter of `HlinkNavigateString()` represents the URL you want to use.

A more ambitious task would be to use the `URLDownloadToFile()` function to download a file from the server to the local machine. This method is defined in `UrlMon` as follows:

```
function URLDownloadToFile(p1: IUnknown; p2: PChar; p3: PChar; p4: DWORD;
    p5: IBindStatusCallback): HRESULT; stdcall;
```

Helpful parameter names, eh? p1 represents the IUnknown interface for the ActiveX control, similar to the pUnk parameter of the HLinkXXX() functions. p2 holds the URL of the file to be downloaded. p3 is the name of the local file that will be filled with the data of the file specified by p2. p4 must be set to 0, and p5 holds an optional IBindStatusCallback interface pointer. This interface can be used to obtain incremental information on the file as it downloads.

Listing 25.9 shows the implementation file for an ActiveForm that implements these methods. It also demonstrates a simple example of implementing the IBindStatusCallback interface.

LISTING 25.9 An ActiveForm that Uses UrlMon Functions

```
unit UrlTestMain;

interface

uses
    Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
    ActiveX, AxCtrls, UrlTest_TLB, UrlMon, StdCtrls, MPlayer, ExtCtrls,
    ComCtrls;

type
    TUrlTestForm = class(TActiveForm, IUrlTestForm, IBindStatusCallback)
        GroupBox1: TGroupBox;
        Label1: TLabel;
        Label2: TLabel;
        Label3: TLabel;
        MediaPlayer1: TMediaPlayer;
        Panel1: TPanel;
        Button1: TButton;
        StatusPanel: TPanel;
        ProgressBar1: TProgressBar;
        ServerName: TEdit;
        StaticText1: TStaticText;
        procedure Label1Click(Sender: TObject);
        procedure Label2Click(Sender: TObject);
        procedure Label3Click(Sender: TObject);
        procedure Button1Click(Sender: TObject);
    private
        { Private declarations }
        FEvents: IUrlTestFormEvents;
        procedure ActivateEvent(Sender: TObject);
        procedure ClickEvent(Sender: TObject);
        procedure CreateEvent(Sender: TObject);
        procedure Db1ClickEvent(Sender: TObject);
    end;
end;
```

```

procedure DeactivateEvent(Sender: TObject);
procedure DestroyEvent(Sender: TObject);
procedure KeyPressEvent(Sender: TObject; var Key: Char);
procedure PaintEvent(Sender: TObject);
protected
{ IBindStatusCallback }
function OnStartBinding(dwReserved: DWORD; pib: IBinding): HRESULT;
    stdcall;
function GetPriority(out nPriority): HRESULT; stdcall;
function OnLowResource(reserved: DWORD): HRESULT; stdcall;
function OnProgress(ulProgress, ulProgressMax, ulStatusCode: ULONG;
    szStatusText: LPCWSTR): HRESULT; stdcall;
function OnStopBinding( hRes: HRESULT; szError: PWideChar ): HRESULT;
    stdcall;
function GetBindInfo(out grfBINF: DWORD; var bindinfo: TBindInfo):
    HRESULT;
    stdcall;
function OnDataAvailable(grfBSCF: DWORD; dwSize: DWORD;
    formatetc: PFormatEtc; stgmed: PStgMedium): HRESULT; stdcall;
function OnObjectAvailable(const iid: TGUID; punk: IUnknown): HRESULT;
    stdcall;
{ UrlTestForm }
procedure EventSinkChanged(const EventSink: IUnknown); override;
procedure Initialize; override;
function Get_Active: WordBool; safecall;
function Get_AutoScroll: WordBool; safecall;
function Get_AxBorderStyle: TxActiveFormBorderStyle; safecall;
function Get_Caption: WideString; safecall;
function Get_Color: OLE_COLOR; safecall;
function Get_Cursor: Smallint; safecall;
function Get_DropTarget: WordBool; safecall;
function Get_Enabled: WordBool; safecall;
function Get_Font: IFontDisp; safecall;
function Get_HelpFile: WideString; safecall;
function Get_KeyPreview: WordBool; safecall;
function Get_PixelsPerInch: Integer; safecall;
function Get_PrintScale: TxPrintScale; safecall;
function Get_Scaled: WordBool; safecall;
function Get_Visible: WordBool; safecall;
function Get_WindowState: TxWindowState; safecall;
procedure Set_AutoScroll(Value: WordBool); safecall;
procedure Set_AxBorderStyle(Value: TxActiveFormBorderStyle); safecall;
procedure Set_Caption(const Value: WideString); safecall;
procedure Set_Color(Color: OLE_COLOR); safecall;
procedure Set_Cursor(Value: Smallint); safecall;
procedure Set_DropTarget(Value: WordBool); safecall;

```

continues

LISTING 25.9 Continued

```
    procedure Set_Enabled(Value: WordBool); safecall;
    procedure Set_Font(const Font: IFontDisp); safecall;
    procedure Set_HelpFile(const Value: WideString); safecall;
    procedure Set_KeyPreview(Value: WordBool); safecall;
    procedure Set_PixelsPerInch(Value: Integer); safecall;
    procedure Set_PrintScale(Value: TxPrintScale); safecall;
    procedure Set_Scaled(Value: WordBool); safecall;
    procedure Set_Visible(Value: WordBool); safecall;
    procedure Set_WindowState(Value: TxWindowState); safecall;
public
    { Public declarations }
end;

implementation

uses ComObj, ComServ;

{$R *.DFM}

{ TUrlTestForm.IBindStatusCallback }

function TUrlTestForm.OnStartBinding(dwReserved: DWORD; pib: IBinding):
    HRESULT;
begin
    Result := S_OK;
end;

function TUrlTestForm.GetPriority(out nPriority): HRESULT;
begin
    HRESULT(Result) := S_OK;
end;

function TUrlTestForm.OnLowResource(reserved: DWORD): HRESULT;
begin
    Result := S_OK;
end;

function TUrlTestForm.OnProgress(u1Progress, u1ProgressMax, u1StatusCode:
    ULONG;
    szStatusText: LPCWSTR): HRESULT; stdcall;
begin
    Result := S_OK;
    ProgressBar1.Max := u1ProgressMax;
    ProgressBar1.Position := u1Progress;
    StatusPanel.Caption := szStatusText;
```

```
end;

function TUrlTestForm.OnStopBinding(hRes: HRESULT; szError: PWideChar ):
    HRESULT;
begin
    Result := S_OK;
    if hRes = S_OK then
        begin
            MediaPlayer1.FileName := 'c:\temp\testavi.avi';
            MediaPlayer1.Open;
            MediaPlayer1.Play;
        end;
end;

function TUrlTestForm.GetBindInfo(out grfBINDF: DWORD; var bindinfo:
    TBindInfo):
    HRESULT; stdcall;
begin
    Result := S_OK;
end;

function TUrlTestForm.OnDataAvailable(grfBSCF: DWORD; dwSize: DWORD;
    formatetc: PFormatEtc; stgmed: PStgMedium): HRESULT; stdcall;
begin
    Result := S_OK;
end;

function TUrlTestForm.OnObjectAvailable(const iid: TGUID; punk: IUnknown):
    HRESULT; stdcall;
begin
    Result := S_OK;
end;

{ TUrlTestForm }

procedure TUrlTestForm.EventSinkChanged(const EventSink: IUnknown);
begin
    FEvents := EventSink as IUrlTestFormEvents;
end;

procedure TUrlTestForm.Initialize;
begin
    OnActivate := ActivateEvent;
    OnClick := ClickEvent;
    OnCreate := CreateEvent;
    OnDb1Click := Db1ClickEvent;
```

continues

LISTING 25.9 Continued

```
OnDeactivate := DeactivateEvent;
OnDestroy := DestroyEvent;
OnKeyPress := KeyPressEvent;
OnPaint := PaintEvent;
end;

function TUrlTestForm.Get_Active: WordBool;
begin
    Result := Active;
end;

function TUrlTestForm.Get_AutoScroll: WordBool;
begin
    Result := AutoScroll;
end;

function TUrlTestForm.Get_AxBorderStyle: TxActiveFormBorderStyle;
begin
    Result := Ord(AxBorderStyle);
end;

function TUrlTestForm.Get_Caption: WideString;
begin
    Result := WideString(Caption);
end;

function TUrlTestForm.Get_Color: OLE_COLOR;
begin
    Result := Color;
end;

function TUrlTestForm.Get_Cursor: Smallint;
begin
    Result := Smallint(Cursor);
end;

function TUrlTestForm.Get_DropTarget: WordBool;
begin
    Result := DropTarget;
end;

function TUrlTestForm.Get_Enabled: WordBool;
begin
    Result := Enabled;
end;
```

```
function TUrlTestForm.Get_Font: IFontDisp;
begin
  GetOleFont(Font, Result);
end;

function TUrlTestForm.Get_HelpFile: WideString;
begin
  Result := WideString(HelpFile);
end;

function TUrlTestForm.Get_KeyPreview: WordBool;
begin
  Result := KeyPreview;
end;

function TUrlTestForm.Get_PixelsPerInch: Integer;
begin
  Result := PixelsPerInch;
end;

function TUrlTestForm.Get_PrintScale: TxPrintScale;
begin
  Result := Ord(PrintScale);
end;

function TUrlTestForm.Get_Scaled: WordBool;
begin
  Result := Scaled;
end;

function TUrlTestForm.Get_Visible: WordBool;
begin
  Result := Visible;
end;

function TUrlTestForm.Get_WindowState: TxWindowState;
begin
  Result := Ord(WindowState);
end;

procedure TUrlTestForm.Set_AutoScroll(Value: WordBool);
begin
  AutoScroll := Value;
end;

procedure TUrlTestForm.Set_AxBorderStyle(Value: TxActiveFormBorderStyle);
```

continues

LISTING 25.9 Continued

```
begin
  AxBorderStyle := TActiveFormBorderStyle(Value);
end;

procedure TUrlTestForm.Set_Caption(const Value: WideString);
begin
  Caption := TCaption(Value);
end;

procedure TUrlTestForm.Set_Color(Color: OLE_COLOR);
begin
  Self.Color := Color;
end;

procedure TUrlTestForm.Set_Cursor(Value: Smallint);
begin
  Cursor := TCursor(Value);
end;

procedure TUrlTestForm.Set_DropTarget(Value: WordBool);
begin
  DropTarget := Value;
end;

procedure TUrlTestForm.Set_Enabled(Value: WordBool);
begin
  Enabled := Value;
end;

procedure TUrlTestForm.Set_Font(const Font: IFontDisp);
begin
  SetOleFont(Self.Font, Font);
end;

procedure TUrlTestForm.Set_HelpFile(const Value: WideString);
begin
  HelpFile := String(Value);
end;

procedure TUrlTestForm.Set_KeyPreview(Value: WordBool);
begin
  KeyPreview := Value;
end;

procedure TUrlTestForm.Set_PixelsPerInch(Value: Integer);
```

```
begin
  PixelsPerInch := Value;
end;

procedure TUrlTestForm.Set_PrintScale(Value: TPrintScale);
begin
  PrintScale := TPrintScale(Value);
end;

procedure TUrlTestForm.Set_Scaled(Value: WordBool);
begin
  Scaled := Value;
end;

procedure TUrlTestForm.Set_Visible(Value: WordBool);
begin
  Visible := Value;
end;

procedure TUrlTestForm.Set_WindowState(Value: TWindowState);
begin
  WindowState := TWindowState(Value);
end;

procedure TUrlTestForm.ActivateEvent(Sender: TObject);
begin
  if FEvents <> nil then FEvents.OnActivate;
end;

procedure TUrlTestForm.ClickEvent(Sender: TObject);
begin
  if FEvents <> nil then FEvents.OnClick;
end;

procedure TUrlTestForm.CreateEvent(Sender: TObject);
begin
  if FEvents <> nil then FEvents.OnCreate;
end;

procedure TUrlTestForm.DblClickEvent(Sender: TObject);
begin
  if FEvents <> nil then FEvents.OnDblClick;
end;

procedure TUrlTestForm.DeactivateEvent(Sender: TObject);
begin
```

continues

LISTING 25.9 Continued

```
    if FEvents <> nil then FEvents.OnDeactivate;
end;

procedure TUrlTestForm.DestroyEvent(Sender: TObject);
begin
    if FEvents <> nil then FEvents.OnDestroy;
end;

procedure TUrlTestForm.KeyPressEvent(Sender: TObject; var Key: Char);
var
    TempKey: Smallint;
begin
    TempKey := Smallint(Key);
    if FEvents <> nil then FEvents.OnKeyPress(TempKey);
    Key := Char(TempKey);
end;

procedure TUrlTestForm.PaintEvent(Sender: TObject);
begin
    if FEvents <> nil then FEvents.OnPaint;
end;

procedure TUrlTestForm.Label1Click(Sender: TObject);
begin
    HLinkNavigateString(IUnknown(VCLComObject), 'http://www.inprise.com');
end;

procedure TUrlTestForm.Label2Click(Sender: TObject);
begin
    HLinkGoForward(IUnknown(VCLComObject));
end;

procedure TUrlTestForm.Label3Click(Sender: TObject);
begin
    HLinkGoBack(IUnknown(VCLComObject));
end;

procedure TUrlTestForm.Button1Click(Sender: TObject);
begin
    // Note: you may have to change the name of the AVI file shown in the first
    // parameter to Format to another AVI file which resides on your server.
    URLDownloadToFile(IUnknown(VCLComObject),
        PChar(Format('http://%s/delphi3.avi', [ServerName.Text])),
        'c:\temp\testavi.avi', 0, Self);
end;
```

```
initialization
```

```
  TActiveFormFactory.Create(ComServer, TActiveFormControl1, TUrlTestForm,  
    Class_UrlTestForm, 1, '', OLEMISC_SIMPLEFRAME or OLEMISC_ACTSLIKELABEL,  
    tmApartment);
```

```
end.
```

The `URLDownloadToFile()` example downloads an AVI file from the server and plays it in a `TMediaPlayer`. Note that this example expects to find a file called `Speedis.avi` in the root of the server (you will find it in the `\Runimage\Delphi50\Demos\Coolstuff` directory of your Delphi 5 CD), so you may need to change the code depending on what AVI files you have on your machine. Figure 25.10 shows this ActiveForm in action inside of Internet Explorer.

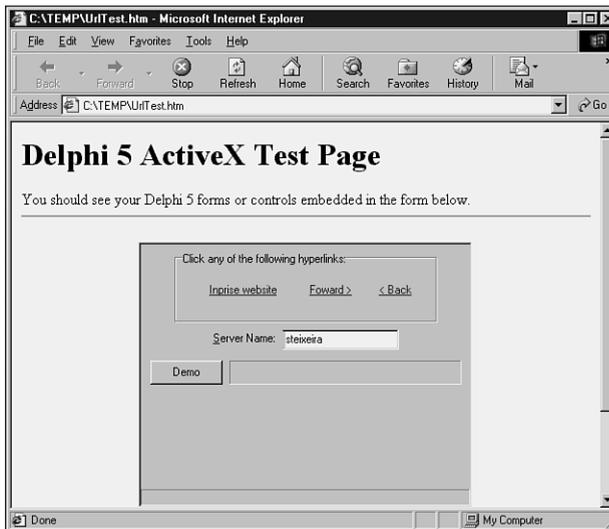


FIGURE 25.10

The ActiveForm running in Internet Explorer.

Web Deployment

The Delphi IDE contains a very convenient feature that helps you deploy your ActiveX projects over the Web. This option is accessible when you are editing an ActiveX project from Project, Web Deployment Options on the main menu. The main page of this dialog is shown in Figure 25.11.

The Project Page

On this page, Target Dir represents the pathname to which you want to deploy the ActiveX project. Note that this assumes you are able to map a drive to your Web server—the contents of

the edit control must be a regular or UNC pathname. Note also that you should not type in a filename, just a path.

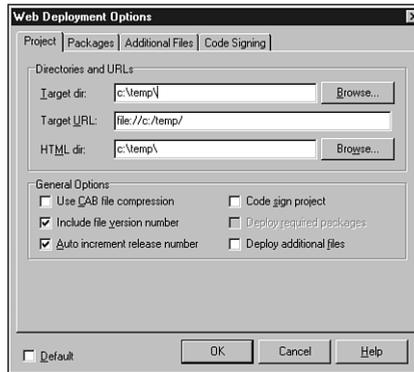


FIGURE 25.11

The Project page of the Web Deployment Options dialog.

Target URL is the URL that references the same directory specified in Target Dir. This must be a valid URL that uses a standard URL prefix (`http://`, `file://`, `ftp://`, and so on). Again, do not include a filename here, just a pathname URL.

HTML Dir is another pathname that dictates where the generated HTML file will be copied. Typically, this is the same as Target Dir.

This dialog also enables you to choose several project deployment options:

- *Use CAB file compression.* Selecting this options will cause your OCX file to be compressed using the Microsoft Cabinet (CAB) format. This is recommended for controls you plan to deploy to clients who use low-bandwidth Web links.
- *Include file version number.* This option indicates whether to include a version number in the generated HTML or INF file. Doing so is recommended, because it provides a means by which users can avoid downloading the control if they already have the most recent version.
- *Autoincrement release number.* When checked, this option causes the release number portion of your `VersionInfo` resources to be automatically incremented after deployment.

NOTE

You must have Internet Explorer 3.02 or greater and Authenticode 2.0 in addition to a certificate from a provider such as VeriSign in order to code-sign files.

- *Deploy required packages.* If your project is built with packages, simply checking this box will automatically include packages used by your project in the file deployment set.
- *Deploy additional files.* By checking this box, you can add files shown on the Additional Files page to your file deployment set.

Packages and Additional Files

The Packages and Additional Files pages are shown in Figures 25.12 and 25.13. The only difference between the pages is that the Packages page is filled automatically based on the packages used by the project, and files are added to and removed from the Additional Files page by you.

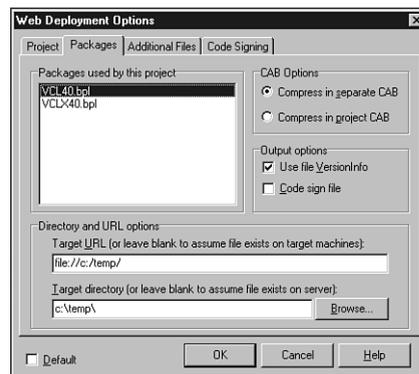


FIGURE 25.12
The Packages page.

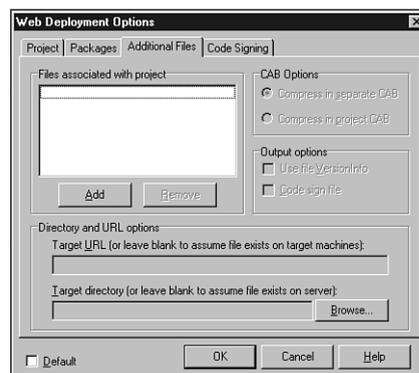


FIGURE 25.13
The Additional Files page.

When you choose to use CAB compression on the Project page, the CAB Options group of the Packages and Additional Files pages enable you to select whether you want the file compressed with the OCX or in a separate CAB file. It is generally more efficient to compress each file in its own CAB, because then the user will not have to download files that they potentially already have installed on their machines. Here are some other options you should be familiar with:

- If the Use File VersionInfo option is selected, the deployment engine will determine whether the selected file has VersionInfo and, if so, will stamp the version number contained in VersionInfo in the INF file.
- The Target URL edit box will default to the same location as the target URL from the Project page. This is the URL from which the file can be downloaded. If you are assuming that the client of your ActiveX control already has this file installed, leave this value blank.
- The Target Directory edit box allows you to specify the directory to which the particular file should be copied. Leave this blank if the file already exists on the server and should not be recopied to the server.

Code Signing

The Code Signing page, shown in Figure 25.14, allows you to specify the location of the certificate file and private key file associated with your certificate. In addition, you can specify a title for your application, a URL for your application or company, the type of encryption you want to use, and whether to timestamp your certificate. It is recommended that you choose to timestamp as you code-sign so that the signature will remain valid even after your certificate expires.

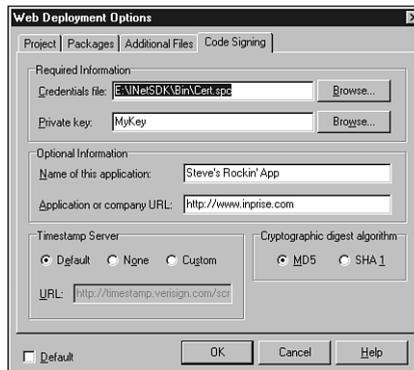


FIGURE 25.14

The Code Signing page.

General Tips

If you make an error on the Project page, your control will usually appear on the Web page as a box with a red × in the upper-left corner. If this happens, you should check the generated HTM file and the INF file (if you are deploying multiple files) for errors. The most common problem is an incorrect URL specified for the control.

Summary

That about sums it up for the topic of creating ActiveX controls and ActiveForms in Delphi. This chapter provided a lot of insight into the inner workings of the ActiveX wizards to help you work within and extend the Delphi ActiveX framework for your benefit. This chapter also built upon the COM and ActiveX knowledge you gained in the previous two chapters—you are well on your way to becoming an expert ActiveX programmer. Now it's time to change gears. The next chapter, “Using Delphi's Open Tools API,” focuses on using Delphi's Open Tools API to get inside the IDE.

Using Delphi's Open Tools API

CHAPTER

26

IN THIS CHAPTER

- **Open Tools Interfaces** 1372
- **Using the Open Tools API** 1374
- **Form Wizards** 1402
- **Summary** 1410

Have you ever thought to yourself, “Delphi is great, but why doesn’t the IDE perform this little task that I’d like it to?” If you have, then have no fear. The Open Tools API is for you. The Delphi Open Tools API provides you with the capability of creating your own tools that work closely with Delphi’s IDE. In this chapter, you will learn about the different interfaces that make up the Open Tools API, how to use the interfaces, and also how to leverage your newly found expertise to write a fully featured wizard.

Open Tools Interfaces

The Open Tools API is composed of eight units, each containing one or more objects that provide interfaces to a variety of facilities in the IDE. Using these interfaces enables you to write your own Delphi wizards, version control managers, and component and property editors. You will also gain a window into Delphi’s IDE and editor through any of these add-ons.

With the exception of the interfaces designed for component and property editors, the Open Tools interface objects provide an all-virtual interface to the outside world—meaning that using these interface objects involves working only with the objects’ virtual functions. You cannot access the objects’ data fields, properties, or static functions. Because of this, the Open Tools interface objects follow the COM standard (see Chapter 23, “COM and ActiveX”). With a little work on your part, these interfaces can be used by any programming language that supports COM. In this chapter, you will work only with Delphi, but you should know that the capacity for using other languages is available (in case you just can’t get enough of C++).

NOTE

The complete Open Tools API is available only with the Delphi Professional and Client/Server Suite. Delphi Standard has the capability to use add-ons created with the Open Tools API, but it cannot create add-ons because it contains only the units for creating component and property editors. You can find the source code for the Open Tools interfaces in the `\Delphi 5\Source\ToolsAPI` subdirectory.

Table 26.1 shows the units that make up the Open Tools API and the interfaces they provide. The term *interface* is used loosely here because it does not refer to Delphi’s native interface types. Because the Open Tools API predates Delphi’s native interface support, the Open Tools API uses regular Delphi classes with virtual abstract methods as substitutes for true interfaces. The use of true interfaces has been phased into the Open Tools API over the past few versions of Delphi, and the current incarnation of the Open Tools API is primarily interface-based.

TABLE 26.1 Units in the Open Tools API

<i>Unit Name</i>	<i>Purpose</i>
ToolsAPI	Contains the latest interface-based Open Tools API elements. The contents of this unit essentially supersede the pre-Delphi 5 Open Tools API units that use abstract classes to manipulate menus, notifications, the file system, the editor, and wizard add-ins. It also contains new interfaces for manipulating the debugger, IDE key mappings, projects, project groups, packages, and the To Do list.
VirtIntf*	Defines the base <code>TInterface</code> class from which other interfaces are derived. This unit also defines <code>TStream</code> class, which is a wrapper around a VCL <code>TStream</code> .
IStreams*	Defines <code>TMemoryStream</code> , <code>TFileStream</code> , and <code>TVirtualStream</code> classes, which are descendants of <code>TStream</code> . These interfaces can be used to hook into the IDE's own streaming mechanism.
ToolIntf*	Defines <code>TMenuItemIntf</code> and <code>TMainMenuIntf</code> classes, which enable the Open Tools developer to create and modify menus in the Delphi IDE. This unit also defines the <code>TAddInNotifier</code> class, which allows add-in tools to be notified of certain events within the IDE. Most importantly, this unit defines the <code>TToolServices</code> class, which provides an interface into various portions of the Delphi IDE (such as the editor, component library, Code Editor, Form Designer, and file system).
VCSIntf	Defines the <code>TIVCSClient</code> class, which enables the Delphi IDE to communicate with version-control software.
FileIntf*	Defines the <code>TVirtualFileSystem</code> class, which the Delphi IDE uses for filing. Wizards, version-control managers, and property and component editors can use this interface to hook into Delphi's own file system to perform special file operations.
EditIntf*	Defines classes necessary for manipulating the Delphi Code Editor and Form Designer. The <code>TIEditReader</code> class provides read access to an editor buffer. <code>TIEditWriter</code> provides write access to the same. <code>TIEditView</code> is defined as an individual view of an edit buffer. <code>TIEditInterface</code> is the base interface to the editor, which can be used to obtain the previously mentioned editor interfaces. The <code>TComponentInterface</code> class is an interface to an individual component sitting on a form at design time. <code>TIFormInterface</code> is the base interface to a design-time form or data module. <code>TIResourceEntry</code> is an interface for the raw data in a project's resource (*.res) file. <code>TIResourceFile</code> is a higher-level interface to the project resource file. <code>TIModuleNotifier</code> is a class that provides notifications when various events occur for a particular module. Finally, <code>TIModuleInterface</code> is the interface for any file or module open in the IDE.

continues

TABLE 26.1 Continued

<i>Unit Name</i>	<i>Purpose</i>
ExptIntf*	Defines the abstract TIEExpert class from which all experts descend.
DsgnIntf	Defines the IFormDesigner interface and the TPropertyEditor and TComponentEditor classes, which are used to create custom property and component editors.

*Functionality replaced by the ToolsAPI unit. Exists only for backward compatibility with versions prior to Delphi 5.

NOTE

You might wonder where all this wizard stuff is documented in Delphi. We assure you that it is documented, but it isn't easy to find. Each of these units contains complete documentation for the interface, classes, methods, and procedures declared within. We will not regurgitate the same information that these units contain, so we urge you to take a look at the units for complete documentation.

Using the Open Tools API

Now that you know what's what, it is time to get your hands dirty and look at some actual code. This section focuses primarily on writing wizards by using the Open Tools API. We will not discuss the building of version-control systems because the interest for such a topic is arguably limited. For examples of component and property editors, you should look at Chapter 21, "Writing Delphi Custom Components," and Chapter 22, "Advanced Component Techniques."

A Dumb Wizard

To start out, you will create a very simple wizard appropriately dubbed the *Dumb wizard*. The minimum requirement in creating a wizard is to create a class that implements the IOTAWizard interface. For reference, IOTAWizard is defined in the ToolsAPI unit as follows:

```
type
  IOTAWizard = interface(IOTANotifier)
    ['{B75C0CE0-EEA6-11D1-9504-00608CCBF153}']
    { Expert UI strings }
    function GetIDString: string;
    function GetName: string;
    function GetState: TWizardState;
    { Launch the AddIn }
```

```

    procedure Execute;
end;

```

This interface mainly consists of some `GetXXX()` functions that are designed to be overridden by the descendant classes in order to provide specific information for each wizard. The `Execute()` method is the business end of `IOTAWizard`. `Execute()` is called by the IDE when the user selects your wizard from the main menu or the New Items menu, and it is in this method that the wizard should be created and invoked.

If you have a keen eye, you may have noticed that `IOTAWizard` descends from another interface, called `IOTANotifier`. `IOTANotifier` is an interface defined in the `ToolsAPI` unit that contains methods that can be called by the IDE to notify a wizard of various occurrences. This interface is defined as the following:

```

type
  IOTANotifier = interface(IUnknown)
    ['{F17A7BCF-E07D-11D1-AB0B-00C04FB16FB3}']
    { This procedure is called immediately after the item is successfully
    ↪saved.
      This is not called for IOTAWizards }
    procedure AfterSave;
    { This function is called immediately before the item is saved. This is not
      called for IOTAWizard }
    procedure BeforeSave;
    { The associated item is being destroyed so all references should be
    ↪dropped.
      Exceptions are ignored. }
    procedure Destroyed;
    { This associated item was modified in some way. This is not called for
      IOTAWizards }
    procedure Modified;
  end;

```

As the comments in the source code indicate, most of these methods are not called for simple `IOTAWizard` wizards. Because of this, `ToolsAPI` provides a class called `TNotifierObject` that provides empty implementations for `IOTANotifier` methods. You may choose to descend your wizards from this class to take advantage of the convenience of having the `IOTANotifier` methods implemented for you.

Wizards are not much use without a means to invoke them, and one of the simplest ways to do that is through a menu pick. If you want to place your wizard on Delphi's main menu, you just need to implement the `IOTAMenuWizard` interface, which is defined in all its complexity in `ToolsAPI` as the following:

```

type
  IOTAMenuWizard = interface(IOTAWizard)
    ['{B75C0CE2-EEA6-11D1-9504-00608CCBF153}']

```

```
    function GetMenuText: string;
end;
```

As you can see, this interface descends from `IOTAWizard` and adds only one additional method to return the menu text string.

To jump right in and pull together your knowledge thus far, Listing 26.1 shows the `DumbWiz.pas` unit, which contains the source code for `TDumbWizard`.

LISTING 26.1 `DumbWiz.pas`, a Simple Wizard Implementation

```
unit DumbWiz;

interface

uses
    ShareMem, SysUtils, Windows, ToolsAPI;

type
    TDumbWizard = class(TNotifierObject, IOTAWizard, IOTAMenuWizard)
        // IOTAWizard methods
        function GetIDString: string;
        function GetName: string;
        function GetState: TWizardState;
        procedure Execute;
        // IOTAMenuWizard method
        function GetMenuText: string;
    end;

procedure Register;

implementation

uses Dialogs;

function TDumbWizard.GetName: string;
begin
    Result := 'Dumb Wizard';
end;

function TDumbWizard.GetState: TWizardState;
begin
    Result := [wsEnabled];
end;

function TDumbWizard.GetIDString: String;
begin
```

```
    Result := 'DDG.DumbWizard';
end;

procedure TDumbWizard.Execute;
begin
    MessageDlg('This is a dumb wizard.', mtInformation, [mbOk], 0);
end;

function TDumbWizard.GetMenuText: string;
begin
    Result := 'Dumb Wizard';
end;

procedure Register;
begin
    RegisterPackageWizard(TDumbWizard.Create);
end;

end.
```

The `IOTAWizard.GetName()` function should return a unique name for this wizard.

`IOTAWizard.GetState()` returns the state of a `wsStandard` wizard on the main menu. The return value of this function is a set that can contain `wsEnabled` and/or `wsChecked`, depending on how you want the menu item to appear in the IDE. This function is called every time the wizard is shown in order to determine how to paint the menu.

`IOTAWizard.GetIDString()` should return a globally unique string identifier for the wizard. Convention dictates that the return value of this string should be in the following format:

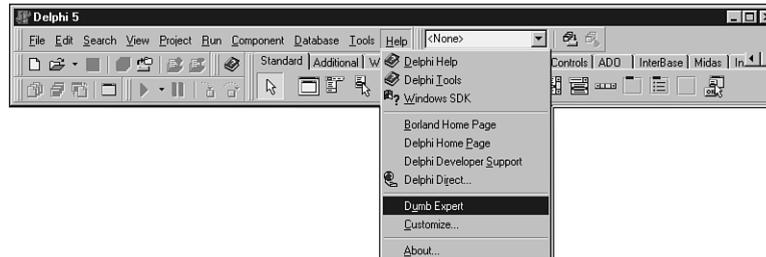
`CompanyName.WizardName`

`IOTAWizard.Execute()` invokes the wizard. As Listing 26.1 shows, the `Execute()` method for `TDumbWizard` does not do much. Later in this chapter, however, you will see some wizards that actually do perform tasks.

`IOTAMenuWizard.GetMenuText()` returns the text that should appear on the main menu. This function is called every time the user pulls down the Help menu, so it is possible to dynamically change the value of the menu text as your wizard runs.

Take a look at the call to `RegisterPackageWizard()` inside the `Register()` procedure. You might notice that this is very similar to the syntax used for registering components, component editors, and property editors for inclusion in the component library, as described in Chapter 21 and Chapter 22. The reason for this similarity is that this type of wizard is stored in a package that is part of the component library, along with components and the like. You can also store wizards in a standalone DLL, as you will see in the next example.

This wizard is installed just like a component: Select the components, Install Component option from the main menu, and add the unit to a new or existing package. Once this is installed, the menu choice to invoke the wizard appears under the Help menu, as shown in Figure 26.1. You can see the outstanding output of this wizard in Figure 26.2.

**FIGURE 26.1**

The Dumb wizard on the main menu.

**FIGURE 26.2**

The Dumb wizard in action.

The Wizard Wizard

A little more work is involved in creating a DLL-based wizard (as opposed to a component library-based wizard). In addition to demonstrating the creation of a DLL-based wizard, the Wizard wizard example has a couple of ulterior motives, including illustrating how DLL wizards relate to the Registry and how to maintain one source code base that targets either an EXE or a DLL wizard.

NOTE

DLLs are discussed in greater detail in Chapter 9, "Dynamic Link Libraries."

TIP

There is no hard-and-fast rule that dictates whether a wizard should reside in a package in the component library or a DLL. From a user's perspective, the primary difference between the two is that component library wizards require a simple package installation to be rebuilt, whereas DLL wizards require a Registry entry, and Delphi must be exited and restarted for changes to take effect. However, as a developer, package wizards are a bit easier to deal with for a number of reasons. Namely, exceptions propagate between your wizard and the IDE automatically, you do not have to use `sharemem.dll` for memory management, you do not have to do anything special to initialize the DLL's application variable, and pop-up hints and mouse enter/exit messages will work properly.

With this in mind, you should consider using a DLL wizard when you want the wizard to install with a minimum amount of work on the part of the end user.

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For Delphi to recognize a DLL wizard, it must have an entry in the system Registry under the following key:

```
HKEY_CURRENT_USER\Software\Borland\Delphi\5.0\Experts
```

Figure 26.3 shows sample entries using the Windows RegEdit application.

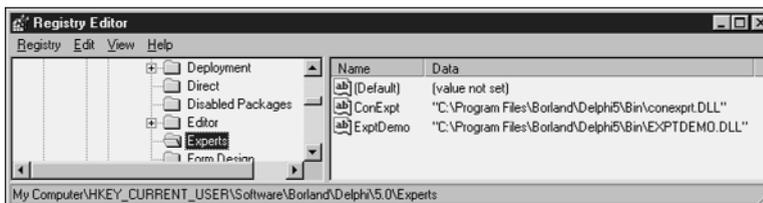


FIGURE 26.3

Delphi wizard entries viewed with RegEdit.

Wizard Interface

The purpose of the Wizard wizard is to provide an interface to add, modify, and delete DLL wizard entries from the Registry without having to use the cumbersome RegEdit application. First, let's examine `InitWiz.pas`, the unit containing the wizard class (see Listing 26.2).

LISTING 26.2 `InitWiz.pas`, the Unit Containing the DLL Wizard Class

```
unit InitWiz;

interface

uses Windows, ToolsAPI;

type
  TWizardWizard = class(TNotifierObject, IOTAWizard, IOTAMenuWizard)
    // IOTAWizard methods
    function GetIDString: string;
    function GetName: string;
    function GetState: TWizardState;
    procedure Execute;
    // IOTAMenuWizard method
    function GetMenuText: string;
  end;

function InitWizard(const BorlandIDEServices: IBorlandIDEServices;
  RegisterProc: TWizardRegisterProc;
  var Terminate: TWizardTerminateProc): Boolean stdcall;

var
  { Registry key where Delphi 5 wizards are kept. EXE version uses default, }
  { whereas DLL version gets key from ToolServices.GetBaseRegistryKey }
  SDelphiKey: string = '\Software\Borland\Delphi\5.0\Experts';

implementation

uses SysUtils, Forms, Controls, Main;

function TWizardWizard.GetName: string;
{ Return name of expert }
begin
  Result := 'WizardWizard';
end;

function TWizardWizard.GetState: TWizardState;
{ This expert is always enabled }
```

```
begin
    Result := [wsEnabled];
end;

function TWizardWizard.GetIDString: String;
{ "Vendor.AppName" ID string for expert }
begin
    Result := 'DDG.WizardWizard';
end;

function TWizardWizard.GetMenuText: string;
{ Menu text for expert }
begin
    Result := 'Wizard Wizard';
end;

procedure TWizardWizard.Execute;
{ Called when expert is chosen from the main menu. }
{ This procedure creates, shows, and frees the main form. }
begin
    MainForm := TMainForm.Create(Application);
    try
        MainForm.ShowModal;
    finally
        MainForm.Free;
    end;
end;

function InitWizard(const BorlandIDEServices: IBorlandIDEServices;
    RegisterProc: TWizardRegisterProc;
    var Terminate: TWizardTerminateProc): Boolean stdcall;
var
    Svcs: IOTAServices;
begin
    Result := BorlandIDEServices <> nil;
    if Result then
    begin
        Svcs := BorlandIDEServices as IOTAServices;
        ToolsAPI.BorlandIDEServices := BorlandIDEServices;
        Application.Handle := Svcs.GetParentHandle;
        SDelphiKey := Svcs.GetBaseRegistryKey + '\Experts';
        RegisterProc(TWizardWizard.Create);
    end;
end;

end.
```

You should notice a couple of differences between this unit and the one used to create the Dumb wizard. Most important, an initialization function of type `TWizardInitProc` is required as an entry point for the IDE into the wizard DLL. In this case, that function is called `InitWizard()`. This function performs a number of wizard initialization tasks, including the following:

- Obtaining a `IOTAServices` interface from the `BorlandIDEServices` parameter.
- Saving the `BorlandIDEServices` interface pointer for use at a later time.
- Setting the handle of the DLL's `Application` variable to the value returned by `IOTAServices.GetParentHandle()`. `GetParentHandle()` returns the window handle of the window that must serve as the parent to all top-level windows created by the wizard.
- Passing the newly created instance of the wizard to the `RegisterProc()` procedure in order to register the wizard with the IDE. `RegisterProc()` will be called once for each wizard instance the DLL registers with the IDE.
- Optionally, `InitWizard()` can also assign a procedure of type `TWizardTerminateProc` to the `Terminate` parameter to serve as an exit procedure for the wizard. This procedure will be called immediately before the wizard is unloaded by the IDE, and in it you may perform any necessary cleanup. This parameter is initially `nil`, so if you do not need to perform any special cleanup, leave its value as `nil`.

CAUTION

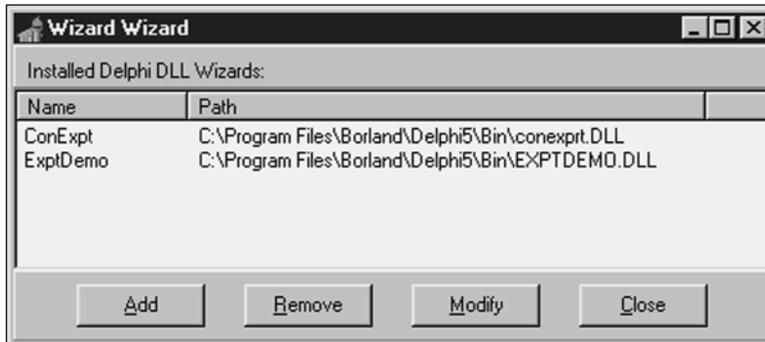
The wizard initialization method must use the `stdcall` calling convention.

CAUTION

Any DLL wizards that call Open Tools API functions that have string parameters must have the `ShareMem` unit in their `uses` clause; otherwise, Delphi will raise an access violation when the wizard instance is freed.

The Wizard User Interface

The `Execute()` method is a bit more complex this time around. It creates an instance of the wizard's `MainForm`, shows it modally, and then frees the instance. Figure 26.4 shows a picture of this form, and Listing 26.3 shows the `Main.pas` unit in which `MainForm` exists.



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FIGURE 26.4

MainForm in the Wizard wizard.

LISTING 26.3 Main.pas, the Main Unit of the Wizard Wizard

```

unit Main;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ExtCtrls, Registry, AddModU, ComCtrls, Menus;

type
  TMainForm = class(TForm)
    TopPanel: TPanel;
    Label1: TLabel;
    BottomPanel: TPanel;
    WizList: TListView;
    PopupMenu1: TPopupMenu;
    Add1: TMenuItem;
    Remove1: TMenuItem;
    Modify1: TMenuItem;
    AddBtn: TButton;
    RemoveBtn: TButton;
    ModifyBtn: TButton;
    CloseBtn: TButton;
    procedure RemoveBtnClick(Sender: TObject);
    procedure CloseBtnClick(Sender: TObject);
    procedure AddBtnClick(Sender: TObject);
    procedure ModifyBtnClick(Sender: TObject);
  end;

```

continues

LISTING 26.3 Continued

```
    procedure FormCreate(Sender: TObject);
private
    procedure DoAddMod(Action: TAddModAction);
    procedure RefreshReg;
end;

var
    MainForm: TMainForm;

implementation

uses InitWiz;

{$R *.DFM}

var
    DelReg: TRegistry;

procedure TMainForm.RemoveBtnClick(Sender: TObject);
{ Handler for Remove button click. Removes selected item from registry. }
var
    Item: TListItem;
begin
    Item := WizList.Selected;
    if Item <> nil then
    begin
        if MessageDlg(Format('Remove item "%s"', [Item.Caption]), mtConfirmation,
            [mbYes, mbNo], 0) = mrYes then
            DelReg.DeleteValue(Item.Caption);
        RefreshReg;
    end;
end;

procedure TMainForm.CloseBtnClick(Sender: TObject);
{ Handler for Close button click. Closes app. }
begin
    Close;
end;

procedure TMainForm.DoAddMod(Action: TAddModAction);
{ Adds a new expert item to registry or modifies existing one. }
var
    OrigName, ExpName, ExpPath: String;
    Item: TListItem;
```

```

begin
  if Action = amaModify then          // if modify...
  begin
    Item := WizList.Selected;
    if Item = nil then Exit;          // make sure item is selected
    ExpName := Item.Caption;          // init variables
    if Item.SubItems.Count > 0 then
      ExpPath := Item.SubItems[0];
    OrigName := ExpName;              // save original name
  end;
  { Invoke dialog which allows user to add or modify entry }
  if AddModWiz(Action, ExpName, ExpPath) then
  begin
    { if action is Modify, and the name was changed, handle it }
    if (Action = amaModify) and (OrigName <> ExpName) then
      DelReg.RenameValue(OrigName, ExpName);
    DelReg.WriteString(ExpName, ExpPath); // write new value
  end;
  RefreshReg;                        // update listbox
end;

procedure TMainForm.AddBtnClick(Sender: TObject);
{ Handler for Add button click }
begin
  DoAddMod(amaAdd);
end;

procedure TMainForm.ModifyBtnClick(Sender: TObject);
{ Handler for Modify button click }
begin
  DoAddMod(amaModify);
end;

procedure TMainForm.RefreshReg;
{ Refreshes listbox with contents of registry }
var
  i: integer;
  TempList: TStringList;
  Item: TListItem;
begin
  WizList.Items.Clear;
  TempList := TStringList.Create;
  try
    { Get expert names from registry }
    DelReg.GetValueNames(TempList);
    { Get path strings for each expert name }

```

continues

LISTING 26.3 Continued

```
    for i := 0 to TempList.Count - 1 do
    begin
        Item := WizList.Items.Add;
        Item.Caption := TempList[i];
        Item.SubItems.Add(DelReg.ReadString(TempList[i]));
    end;
finally
    TempList.Free;
end;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
    RefreshReg;
end;

initialization
    DelReg := TRegistry.Create;           // create registry object
    DelReg.RootKey := HKEY_CURRENT_USER; // set root key
    DelReg.OpenKey(SDelphiKey, True);    // open/create Delphi expert key
finalization
    DelReg.Free;                         // free registry object
end.
```

This is the unit responsible for providing the user interface for adding, removing, and modifying DLL wizard entries in the Registry. In the initialization section of this unit, a `TRegistry` object called `DelReg` is created. The `RootKey` property of `DelReg` is set to `HKEY_CURRENT_USER`, and it opens the `\Software\Borland\Delphi\5.0\Experts` key—the key used to keep track of DLL wizards—using its `OpenKey()` method.

When the wizard first comes up, a `TListView` component called `ExptList` is filled with the items and values from the previously mentioned Registry key. This is accomplished by first calling `DelReg.GetValueNames()` to retrieve the names of the items into a `TStringList`. A `TListItem` component is added to `ExptList` for each element in the string list, and the `DelReg.ReadString()` method is used to read the value for each item, which is placed in the `SubItems` list of `TListItem`.

The Registry work is done in the `RemoveBtnClick()` and `DoAddMod()` methods. `RemoveBtnClick()` is in charge of removing the currently selected wizard item from the Registry. It first checks to ensure that an item is highlighted; then it throws up a confirmation dialog. Finally, it does the deed by calling the `DelReg.DeleteValue()` method and passing `CurrentItem` as the parameter.

DoAddMod() accepts a parameter of type TAddModAction. This type is defined as follows:

type

```
TAddModAction = (amaAdd, amaModify);
```

As the values of the type imply, this variable indicates whether a new item is to be added or an existing item modified. This function first checks to see that there is a currently selected item or, if there isn't, that the Action parameter holds the value amaAdd. After that, if Action is amaModify, the existing wizard item and value are copied to the local variables ExpName and ExpPath. These values are then passed to a function called AddModExpert(), which is defined in the AddModU unit shown in Listing 26.4. This function invokes a dialog in which the user can enter new or modified name or path information for a wizard (see Figure 26.5). It returns True when the user exits the dialog with the OK button. At that point, an existing item is modified using DelReg.RenameValue(), and a new or modified value is written with DelReg.WriteString().

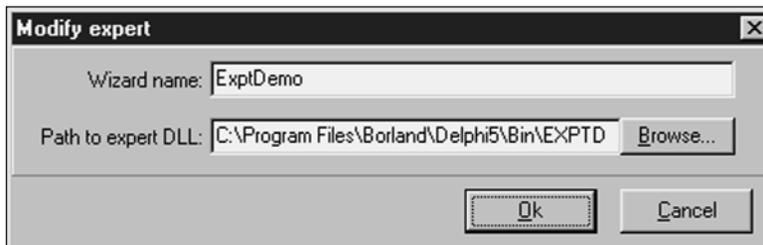


FIGURE 26.5

AddModForm in the Wizard wizard.

LISTING 26.4 AddModU.pas, the Unit that Adds and Modifies Wizard Entries in the Registry

```
unit AddModU;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ExtCtrls;

type
  TAddModAction = (amaAdd, amaModify);

  TAddModForm = class(TForm)
    OkBtn: TButton;
    CancelBtn: TButton;
```

continues

LISTING 26.4 Continued

```
    OpenFileDialog: TOpenDialog;
    Panel1: TPanel;
    Label1: TLabel;
    Label2: TLabel;
    PathEd: TEdit;
    NameEd: TEdit;
    BrowseBtn: TButton;
    procedure BrowseBtnClick(Sender: TObject);
private
    { Private declarations }
public
    { Public declarations }
end;

function AddModWiz(AAction: TAddModAction; var WizName, WizPath: String):
↳Boolean;

implementation

{$R *.DFM}

function AddModWiz(AAction: TAddModAction; var WizName, WizPath: String):
Boolean;
{ called to invoke dialog to add and modify registry entries }
const
    CaptionArray: array[TAddModAction] of string[31] =
        ('Add new expert', 'Modify expert');
begin
    with TAddModForm.Create(Application) do           // create dialog
    begin
        Caption := CaptionArray[AAction];           // set caption
        if AAction = amaModify then                 // if modify...
        begin
            NameEd.Text := WizName;                 // init name and
            PathEd.Text := WizPath;                 // path
        end;
        Result := ShowModal = mrOk;                 // show dialog
        if Result then                               // if Ok...
        begin
            WizName := NameEd.Text;                 // set name and
            WizPath := PathEd.Text;                 // path
        end;
        Free;
    end;
end;
end;
```

```
procedure TAddModForm.BrowseBtnClick(Sender: TObject);
begin
    if OpenFileDialog.Execute then
        PathEd.Text := OpenFileDialog.FileName;
end;

end.
```

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Dual Targets: EXE and DLL

As mentioned earlier, it is possible to maintain one set of source code modules that target both a DLL wizard and a standalone executable. This is possible through the use of compiler directives in the project file. Listing 26.5 shows `WizWiz.dpr`, the project file source code for this project.

LISTING 26.5 `WizWiz.dpr`, Main Project File for the `WizWiz` Project

```
{$ifdef BUILD_EXE}
program WizWiz;    // Build as EXE
{$else}
library WizWiz;   // Build as DLL
{$endif}

uses
{$ifndef BUILD_EXE}
    ShareMem,           // ShareMem required for DLL
    InitWiz in 'InitWiz.pas', // Wizard stuff
{$endif}
    ToolsAPI,
    Forms,
    Main in 'Main.pas' {MainForm},
    AddModU in 'AddModU.pas' {AddModForm};

{$ifdef BUILD_EXE}
{$R *.RES}                // required for EXE
{$else}
exports                    // required for DLL
    InitWizard name WizardEntryPoint; // required entry point
{$endif}

begin
{$ifdef BUILD_EXE}        // required for EXE...
    Application.Initialize;
    Application.CreateForm(TMainForm, MainForm);
    Application.Run;
{$endif}
end.
```

As the code shows, this project will build an executable if the `BUILD_EXE` conditional is defined. Otherwise, it will build a DLL-based wizard. You can define a conditional under Conditional Defines in the Directories/Conditionals page of the Project, Options dialog, which is shown in Figure 26.6.

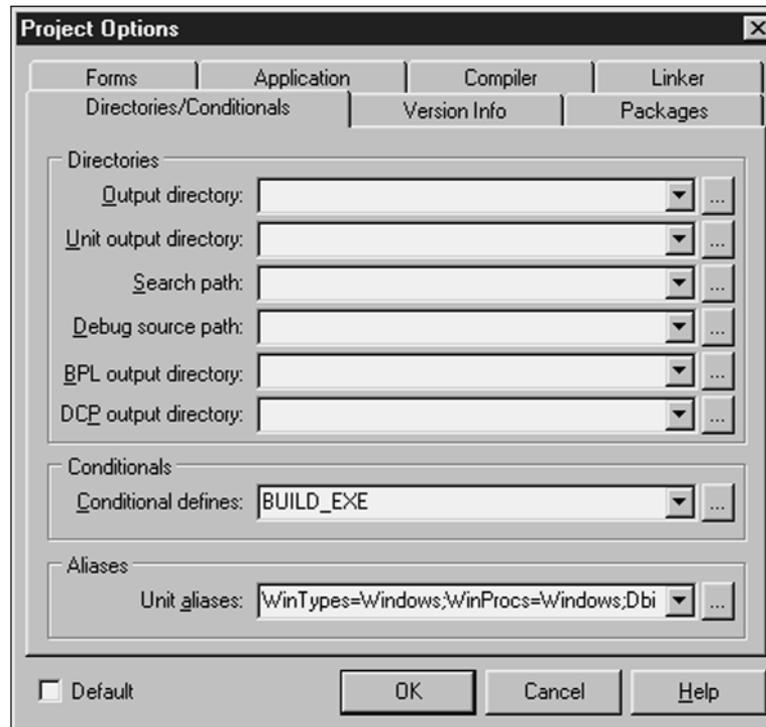


FIGURE 26.6

The Project Options dialog.

One final note concerning this project: Notice that the `InitWizard()` function from the `InitWiz` unit is being exported in the `exports` clause of the project file. You must export this function with the name `WizardEntryPoint`, which is defined in the `ToolsAPI` unit.

CAUTION

Borland does not provide a `ToolsAPI.dcu` file, meaning that EXEs or DLLs containing a reference to `ToolsAPI` in a `uses` clause can be built only *with packages*. Currently, it is not possible to build wizards without packages.

DDG Search

Remember the nifty little Delphi Search program you developed back in Chapter 11, “Writing Multithreaded Applications?” In this section, you will learn how you can turn that useful application into an even more useful Delphi wizard with just a little bit of code. This wizard is called DDG Search.

First, the unit that interfaces DDG Search to the IDE, `InitWiz.pas`, is shown in Listing 26.6. You will notice that this unit is very similar to the unit of the same name in the previous example. That’s on purpose. This unit is just a copy of the previous one with some necessary changes involving the name of the wizard and the `Execute()` method. Copying and pasting is what we call “old-fashioned inheritance.” After all, why do more typing than you have to?

LISTING 26.6 `InitWiz.pas`, the Unit Containing Wizard Logic for the DDGSrch Wizard

```
unit InitWiz;

interface

uses
  Windows, ToolsAPI;

type
  TSearchWizard = class(TNotifierObject, IOTAWizard, IOTAMenuWizard)
    // IOTAWizard methods
    function GetIDString: string;
    function GetName: string;
    function GetState: TWizardState;
    procedure Execute;
    // IOTAMenuWizard method
    function GetMenuText: string;
  end;

function InitWizard(const BorlandIDEServices: IBorlandIDEServices;
  RegisterProc: TWizardRegisterProc;
  var Terminate: TWizardTerminateProc): Boolean stdcall;

var
  ActionSvc: IOTAActionServices;

implementation

uses SysUtils, Dialogs, Forms, Controls, Main, PriU;

function TSearchWizard.GetName: string;
{ Return name of expert }
```

continues

LISTING 26.6 Continued

```
begin
    Result := 'DDG Search';
end;

function TSearchWizard.GetState: TWizardState;
{ This expert is always enabled on the menu }
begin
    Result := [wsEnabled];
end;

function TSearchWizard.GetIDString: String;
{ Return the unique Vendor.Product name of expert }
begin
    Result := 'DDG.DDGSearch';
end;

function TSearchWizard.GetMenuText: string;
{ Return text for Help menu }
begin
    Result := 'DDG Search Expert';
end;

procedure TSearchWizard.Execute;
{ Called when expert name is selected from Help menu of IDE. }
{ This function invokes the expert }
begin
    // if not created, created it and show it
    if MainForm = nil then
    begin
        MainForm := TMainForm.Create(Application);
        ThreadPriWin := TThreadPriWin.Create(Application);
        MainForm.Show;
    end
    else
    // if created then restore window and show it
    with MainForm do
    begin
        if not Visible then Show;
        if WindowState = wsMinimized then WindowState := wsNormal;
        SetFocus;
    end;
end;

function InitWizard(const BorlandIDEServices: IBorlandIDEServices;
    RegisterProc: TWizardRegisterProc;
```

```
    var Terminate: TWizardTerminateProc): Boolean stdcall;
var
    Svcs: IOTAServices;
begin
    Result := BorlandIDEServices <> nil;
    if Result then
    begin
        Svcs := BorlandIDEServices as IOTAServices;
        ActionSvc := BorlandIDEServices as IOTAActionServices;
        ToolsAPI.BorlandIDEServices := BorlandIDEServices;
        Application.Handle := Svcs.GetParentHandle;
        RegisterProc(TSearchWizard.Create);
    end;
end;

end.
```

The `Execute()` function of this wizard shows you something a bit different than what you have seen so far: The wizard's main form, `MainForm`, is being shown modelessly rather than modally. Of course, this requires a bit of extra housekeeping, because you have to know when a form is created and when the form variable is invalid. This can be accomplished by making sure the `MainForm` variable is set to `nil` when the wizard is inactive. More on this a bit later.

One other aspect of this project that has changed significantly since Chapter 11 is that the project file is now called `DDGSrch.dpr`. This file is shown in Listing 26.7.

LISTING 26.7 DDGSrch.dpr, Project File for the DDGSrch Project

```
library DDGSrch;

uses
    ShareMem,
    ToolsAPI,
    Main in 'MAIN.PAS' {MainForm},
    SrchIni in 'SrchIni.pas',
    SrchU in 'SrchU.pas',
    PriU in 'PriU.pas' {ThreadPriWin},
    InitWiz in 'InitWiz.pas',
    MemMap in '..\..\Utils\MemMap.pas',
    StrUtils in '..\..\Utils\StrUtils.pas';

{$R *.RES}

exports
    { Entry point which is called by Delphi IDE }
```

continues

LISTING 26.7 Continued

```
    InitWizard name WizardEntryPoint;  
  
begin  
end.
```

As you can see, this file is fairly small. The two important points are that it uses the library header to indicate that it is a DLL, and it exports the `InitWiz()` function for initialization by the Delphi IDE.

Only a couple of changes were made to the `Main` unit in this project. As mentioned earlier, the `MainForm` variable must be set to `nil` when the wizard is not active. As you learned in Chapter 2, “The Object Pascal Language,” the `MainForm` instance variable will automatically have the value `nil` upon application startup. Also, in the `OnClose` event handler for the form, the form instance is released and the `MainForm` global is reset to `nil`. Here is the method:

```
procedure TMainForm.FormClose(Sender: TObject; var Action: TCloseAction);  
begin  
    Action := caFree;  
    Application.OnShowHint := FOldShowHint;  
    MainForm := nil;  
end;
```

The finishing touch for this wizard is to bring up files in the IDE’s Code Editor when they are double-clicked in the list box in the main form. This logic is handled by a new `FileLBdblClick()` method, as follows:

```
procedure TMainForm.FileLBdblClick(Sender: TObject);  
{ Called when user double-clicks in listbox. Loads file into IDE }  
var  
    FileName: string;  
    Len: Integer;  
begin  
    FileName := FileLB.Items[FileLB.ItemIndex];  
    { make sure user clicked on a file... }  
    if (FileName <> '') and (Pos('File ', FileName) = 1) then  
    begin  
        { Trim "File " and ":" from string }  
        FileName := Copy(FileName, 6, Length(FileName));  
        Len := Length(FileName);  
        if FileName[Len] = ':' then SetLength(FileName, Len - 1);  
        { Open the project or file }  
        if CompareText(ExtractFileExt(FileName), '.DPR') = 0 then  
            ActionSvc.OpenProject(FileName, True)  
        else
```

```
        ActionSvc.OpenFile(FileName);
    end;
end;
```

This method employs the `OpenFile()` and `OpenProject()` methods of the `IOTAActionServices` in order to open a particular file.

Listing 26.8 shows the complete source code for the Main unit in the DDGSrch project, and Figure 26.7 shows the DDG Search wizard doing its thing inside the IDE.

26

USING DELPHI'S
OPEN TOOLS API

LISTING 26.8 Main.pas, the Main Unit for the DDGSrch Project

```
unit Main;

interface

uses
    SysUtils, WinTypes, WinProcs, Messages, Classes, Graphics, Controls,
    Forms, Dialogs, StdCtrls, Buttons, ExtCtrls, Menus, SrchIni,
    SrchU, ComCtrls, InitWiz;

type
    TMainForm = class(TForm)
        FileLB: TListBox;
        PopupMenu1: TPopupMenu;
        Font1: TMenuItem;
        N1: TMenuItem;
        Exit1: TMenuItem;
        FontDialog1: TFontDialog;
        StatusBar: TStatusBar;
        AlignPanel: TPanel;
        ControlPanel: TPanel;
        ParamsGB: TGroupBox;
        LFileSpec: TLabel;
        LToken: TLabel;
        lPathName: TLabel;
        EFileSpec: TEdit;
        EToken: TEdit;
        PathButton: TButton;
        OptionsGB: TGroupBox;
        cbCaseSensitive: TCheckBox;
        cbFileNamesOnly: TCheckBox;
        cbRecurse: TCheckBox;
        SearchButton: TBitBtn;
        CloseButton: TBitBtn;
        PrintButton: TBitBtn;
    end;
end;
```

continues

LISTING 26.8 Continued

```

    PriorityButton: TBitBtn;
    View1: TMenuItem;
    EPathName: TEdit;
    procedure SearchButtonClick(Sender: TObject);
    procedure PathButtonClick(Sender: TObject);
    procedure FileLBDrawItem(Control: TWinControl; Index: Integer;
        Rect: TRect; State: TOwnerDrawState);
    procedure Font1Click(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure PrintButtonClick(Sender: TObject);
    procedure CloseButtonClick(Sender: TObject);
    procedure FileLBdblClick(Sender: TObject);
    procedure FormResize(Sender: TObject);
    procedure PriorityButtonClick(Sender: TObject);
    procedure ETokenChange(Sender: TObject);
    procedure FormClose(Sender: TObject; var Action: TCloseAction);
private
    FOldShowHint: TShowHintEvent;
    procedure ReadIni;
    procedure WriteIni;
    procedure DoShowHint(var HintStr: string; var CanShow: Boolean;
        var HintInfo: THintInfo);
    procedure WMGetMinMaxInfo(var M: TWMGetMinMaxInfo); message
    WM_GETMINMAXINFO;
public
    Running: Boolean;
    SearchPri: integer;
    SearchThread: TSearchThread;
    procedure EnableSearchControls(Enable: Boolean);
end;

var
    MainForm: TMainForm;

implementation

{$R *.DFM}

uses Printers, ShellAPI, MemMap, FileCtrl, PriU;

procedure PrintStrings(Strings: TStrings);
{ This procedure prints all of the string in the Strings parameter }
var
    Prn: TextFile;

```

```

    i: word;
begin
  if Strings.Count = 0 then // Are there strings?
  begin
    MessageDlg('No text to print!', mtInformation, [mbOk], 0);
    Exit;
  end;
  AssignPrn(Prn);           // assign Prn to printer
  try
    Rewrite(Prn);          // open printer
  try
    for i := 0 to Strings.Count - 1 do // iterate over all strings
      writeln(Prn, Strings.Strings[i]); // write to printer
    finally
      CloseFile(Prn);      // close printer
    end;
  except
    on EInOutError do
      MessageDlg('Error Printing text.', mtError, [mbOk], 0);
  end;
end;

procedure TMainForm.WMGetMinMaxInfo(var M: TWMGetMinMaxInfo);
begin
  inherited;
  // prevent user from sizing form too small
  with M.MinMaxInfo^ do
  begin
    ptMinTrackSize.x := OptionsGB.Left + OptionsGB.Width - ParamsGB.Left + 10;
    ptMinTrackSize.y := 200;
  end;
end;

procedure TMainForm.EnableSearchControls(Enable: Boolean);
{ Enables or disables certain controls so options can't be modified }
{ while search is executing. }
begin
  SearchButton.Enabled := Enable;           // enabled/disable proper controls
  cbRecurse.Enabled := Enable;
  cbFileNamesOnly.Enabled := Enable;
  cbCaseSensitive.Enabled := Enable;
  PathButton.Enabled := Enable;
  EPathName.Enabled := Enable;
  EFileSpec.Enabled := Enable;
  EToken.Enabled := Enable;
  Running := not Enable;                    // set Running flag
end;

```

continues

LISTING 26.8 Continued

```
ETokenChange(nil);
with CloseButton do
begin
  if Enable then
  begin
    // set props of Close/Stop button
    Caption := '&Close';
    Hint := 'Close Application';
  end
  else begin
    Caption := '&Stop';
    Hint := 'Stop Searching';
  end;
end;
end;

procedure TMainForm.SearchButtonClick(Sender: TObject);
{ Called when Search button is clicked. Invokes search thread. }
begin
  EnableSearchControls(False);          // disable controls
  FileLB.Clear;                          // clear listbox
  { start thread }
  SearchThread := TSearchThread.Create(cbCaseSensitive.Checked,
    cbFileNamesOnly.Checked, cbRecurse.Checked, EToken.Text,
    EPathName.Text, EFileSpec.Text);
end;

procedure TMainForm.ETokenChange(Sender: TObject);
begin
  SearchButton.Enabled := not Running and (EToken.Text <> '');
end;

procedure TMainForm.PathButtonClick(Sender: TObject);
{ Called when Path button is clicked. Allows user to choose new path. }
var
  ShowDir: string;
begin
  ShowDir := EPathName.Text;
  if SelectDirectory(ShowDir, [], 0) then
    EPathName.Text := ShowDir;
end;

procedure TMainForm.FileLBDrawItem(Control: TWinControl;
  Index: Integer; Rect: TRect; State: TOwnerDrawState);
{ Called in order to owner draw listbox. }
var
```

```

CurStr: string;
begin
  with FileLB do
  begin
    CurStr := Items.Strings[Index];
    Canvas.FillRect(Rect);           // clear out rect
    if not cbFileNamesOnly.Checked then // if not filename only...
    { if current line is file name... }
    if (Pos('File ', CurStr) = 1) and
      (CurStr[Length(CurStr)] = ':') then
    begin
      Canvas.Font.Style := [fsUnderline]; // underline font
      Canvas.Font.Color := clRed;        // paint red
    end
    else
      Rect.Left := Rect.Left + 15;      // otherwise, indent
      DrawText(Canvas.Handle, PChar(CurStr), Length(CurStr), Rect,
        dt_SingleLine);
    end;
  end;
end;

procedure TMainForm.Font1Click(Sender: TObject);
{ Allows user to pick new font for listbox }
begin
  { Pick new listbox font }
  if FontDialog1.Execute then
    FileLB.Font := FontDialog1.Font;
end;

procedure TMainForm.FormDestroy(Sender: TObject);
{ OnDestroy event handler for form }
begin
  WriteIni;
end;

procedure TMainForm.FormCreate(Sender: TObject);
{ OnCreate event handler for form }
begin
  Application.HintPause := 0;          // don't wait to show hints
  FOldShowHint := Application.OnShowHint; // set up hints
  Application.OnShowHint := DoShowHint;
  ReadIni;                             // read reg INI file
end;

procedure TMainForm.DoShowHint(var HintStr: string; var CanShow: Boolean);

```

continues

LISTING 26.8 Continued

```
    var HintInfo: THintInfo);
{ OnHint event handler for Application }
begin
  { Display application hints on status bar }
  StatusBar.Panels[0].Text := HintStr;
  { Don't show tool tip if we're over our own controls }
  if (HintInfo.HintControl <> nil) and
    (HintInfo.HintControl.Parent <> nil) and
    ((HintInfo.HintControl.Parent = ParamsGB) or
    (HintInfo.HintControl.Parent = OptionsGB) or
    (HintInfo.HintControl.Parent = ControlPanel)) then
    CanShow := False;
  FOldShowHint(HintStr, CanShow, HintInfo);
end;

procedure TMainForm.PrintButtonClick(Sender: TObject);
{ Called when Print button is clicked. }
begin
  if MessageDlg('Send search results to printer?', mtConfirmation,
    [mbYes, mbNo], 0) = mrYes then
    PrintStrings(FileLB.Items);
end;

procedure TMainForm.CloseButtonClick(Sender: TObject);
{ Called to stop thread or close application }
begin
  // if thread is running then terminate thread
  if Running then SearchThread.Terminate
  // otherwise close app
  else Close;
end;

procedure TMainForm.FormResize(Sender: TObject);
{ OnResize event handler. Centers controls in form. }
begin
  { divide status bar into two panels with a 1/3 - 2/3 split }
  with StatusBar do
  begin
    Panels[0].Width := Width div 3;
    Panels[1].Width := Width * 2 div 3;
  end;
  { center controls in the middle of the form }
  ControlPanel.Left := (AlignPanel.Width div 2) - (ControlPanel.Width div 2);
```

```
end;

procedure TMainForm.PriorityButtonClick(Sender: TObject);
{ Show thread priority form }
begin
  ThreadPriWin.Show;
end;

procedure TMainForm.ReadIni;
{ Reads default values from Registry }
begin
  with SrchIniFile do
  begin
    EPathName.Text := ReadString('Defaults', 'LastPath', 'C:\');
    EFileSpec.Text := ReadString('Defaults', 'LastFileSpec', '*.');
    EToken.Text := ReadString('Defaults', 'LastToken', '');
    cbFileNamesOnly.Checked := ReadBool('Defaults', 'FNamesOnly', False);
    cbCaseSensitive.Checked := ReadBool('Defaults', 'CaseSens', False);
    cbRecurse.Checked := ReadBool('Defaults', 'Recurse', False);
    Left := ReadInteger('Position', 'Left', 100);
    Top := ReadInteger('Position', 'Top', 50);
    Width := ReadInteger('Position', 'Width', 510);
    Height := ReadInteger('Position', 'Height', 370);
  end;
end;

procedure TMainForm.WriteIni;
{ writes current settings back to Registry }
begin
  with SrchIniFile do
  begin
    WriteString('Defaults', 'LastPath', EPathName.Text);
    WriteString('Defaults', 'LastFileSpec', EFileSpec.Text);
    WriteString('Defaults', 'LastToken', EToken.Text);
    WriteBool('Defaults', 'CaseSens', cbCaseSensitive.Checked);
    WriteBool('Defaults', 'FNamesOnly', cbFileNamesOnly.Checked);
    WriteBool('Defaults', 'Recurse', cbRecurse.Checked);
    WriteInteger('Position', 'Left', Left);
    WriteInteger('Position', 'Top', Top);
    WriteInteger('Position', 'Width', Width);
    WriteInteger('Position', 'Height', Height);
  end;
end;

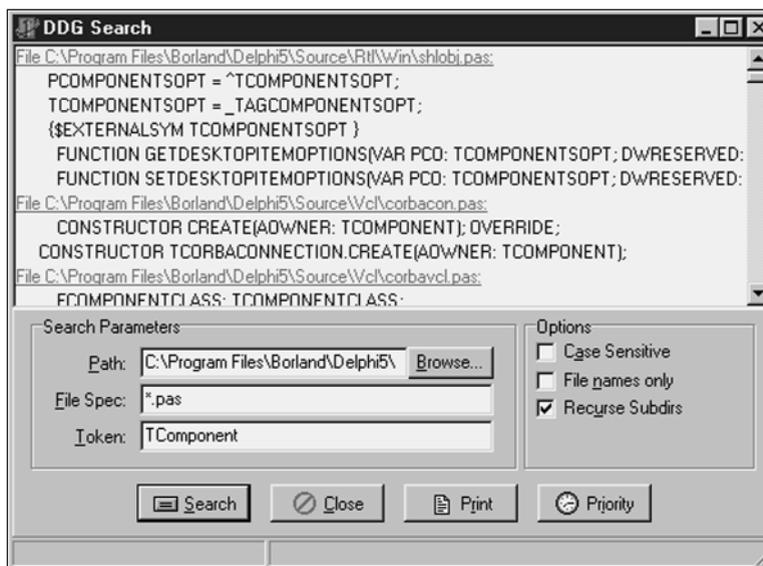
procedure TMainForm.FormClose(Sender: TObject; var Action: TCloseAction);
begin
```

continues

LISTING 26.8 Continued

```
Action := caFree;
Application.OnShowHint := FOldShowHint;
MainForm := nil;
end;

end.
```

**FIGURE 26.7**

The DDG Search wizard in action.

Form Wizards

Yet another type of wizard supported by the Open Tools API is the Form wizard. Once installed, Form wizards are accessed from the New Items dialog; they generate new forms and units for the user. Chapter 24, “Extending the Windows Shell,” employed this type of wizard to generate new AppBar forms; however, you did not get to see the code that made the wizard tick.

Creating a Form wizard is fairly straightforward, although you must implement a good number of interface methods. Creation of a Form wizard can be boiled down to five basic steps:

1. Create a class that descends from `TCustomForm`, `TDataModule`, or any `TWinControl` that will be used as the base form class. This class typically will reside in a separate unit from the wizard. In this case, `TAppBar` will serve as the base class.

2. Create a `TNotifierObject` descendent that implements the following interfaces: `IOTAWizard`, `IOTARepositoryWizard`, `IOTAFormWizard`, `IOTACreator`, and `IOTAModuleCreator`.
3. In your `IOTAWizard.Execute()` method, you typically will call `IOTAModuleServices.GetNewModuleAndClassName()` to obtain a new unit and class name for your wizard and `IOTAModuleServices.CreateModule()` to instruct the IDE to begin creation of the new module.
4. Many of the method implementations for the aforementioned interfaces are one-liners. The nontrivial ones include `IOTAModuleCreator`'s `NewFormFile()` and `NewImpl1File()` methods, which will return the code for the form and unit, respectively. The `IOTACreator.GetOwner()` method also can be a little tricky, but the following example gives you a good technique for adding the unit to the current project (if any).
5. Complete the `Register()` procedure for the wizard by registering a handler for your new form class using the `RegisterCustomModule()` procedure in the `DsgnIntf` unit and creating your wizard by calling the `RegisterPackageWizard()` procedure in the `ToolsAPI` unit.

Listing 26.9 shows the source code for `ABWizard.pas`, which is the `AppBar` wizard.

LISTING 26.9 `ABWizard.pas`, the Unit Containing the Implementation of the `AppBar` Wizard

```
unit ABWizard;

interface

uses Windows, Classes, ToolsAPI;

type
  TAppBarWizard = class(TNotifierObject, IOTAWizard, IOTARepositoryWizard,
    IOTAFormWizard, IOTACreator, IOTAModuleCreator)
  private
    FUnitIdent: string;
    FClassName: string;
    FFileName: string;
  protected
    // IOTAWizard methods
    function GetIDString: string;
    function GetName: string;
    function GetState: TWizardState;
    procedure Execute;
    // IOTARepositoryWizard / IOTAFormWizard methods
    function GetAuthor: string;
```

continues

LISTING 26.9 Continued

```
function GetComment: string;
function GetPage: string;
function GetGlyph: HICON;
// IOTACreator methods
function GetCreatorType: string;
function GetExisting: Boolean;
function GetFileSystem: string;
function GetOwner: IOTAModule;
function GetUnnamed: Boolean;
// IOTAModuleCreator methods
function GetAncestorName: string;
function GetImplFileName: string;
function GetIntfFileName: string;
function GetFormName: string;
function GetMainForm: Boolean;
function GetShowForm: Boolean;
function GetShowSource: Boolean;
function NewFormFile(const FormIdent, AncestorIdent: string): IOTAFile;
function NewImplSource(const ModuleIdent, FormIdent,
    AncestorIdent: string): IOTAFile;
function NewIntfSource(const ModuleIdent, FormIdent,
    AncestorIdent: string): IOTAFile;
procedure FormCreated(const FormEditor: IOTAFormEditor);
end;

implementation

uses Forms, AppBars, SysUtils, DsgnIntf;

{$R CodeGen.res}

type
  TBaseFile = class(TInterfacedObject)
  private
    FModuleName: string;
    FFormName: string;
    FAncestorName: string;
  public
    constructor Create(const ModuleName, FormName, AncestorName: string);
  end;

  TUnitFile = class(TBaseFile, IOTAFile)
  protected
    function GetSource: string;
    function GetAge: TDateTime;
```

```
end;

TFormFile = class(TBaseFile, IOTAFile)
protected
    function GetSource: string;
    function GetAge: TDateTime;
end;

{ TBaseFile }

constructor TBaseFile.Create(const ModuleName, FormName,
    AncestorName: string);
begin
    inherited Create;
    FModuleName := ModuleName;
    FFormName := FormName;
    FAncestorName := AncestorName;
end;

{ TUnitFile }

function TUnitFile.GetSource: string;
var
    Text: string;
    ResInstance: THandle;
    HRes: HRSRC;
begin
    ResInstance := FindResourceHInstance(HInstance);
    HRes := FindResource(ResInstance, 'CODEGEN', RT_RCDATA);
    Text := PChar(LockResource(LoadResource(ResInstance, HRes)));
    SetLength(Text, SizeOfResource(ResInstance, HRes));
    Result := Format(Text, [FModuleName, FFormName, FAncestorName]);
end;

function TUnitFile.GetAge: TDateTime;
begin
    Result := -1;
end;

{ TFormFile }

function TFormFile.GetSource: string;
const
    FormText =
        'object %0:s: T%0:s'#13#10'end';
begin
```

continues

LISTING 26.9 Continued

```
    Result := Format(FormText, [FFormName]);
end;

function TFormFile.GetAge: TDateTime;
begin
    Result := -1;
end;

{ TAppBarWizard }

{ TAppBarWizard.IOTAWizard }

function TAppBarWizard.GetIDString: string;
begin
    Result := 'DDG.AppBarWizard';
end;

function TAppBarWizard.GetName: string;
begin
    Result := 'DDG AppBar Wizard';
end;

function TAppBarWizard.GetState: TWizardState;
begin
    Result := [wsEnabled];
end;

procedure TAppBarWizard.Execute;
begin
    (BorlandIDEServices as IOTAModuleServices).GetNewModuleAndClassName(
        'AppBar', FUnitIdent, FClassName, FFileName);
    (BorlandIDEServices as IOTAModuleServices).CreateModule(Self);
end;

{ TAppBarWizard.IOTARepositoryWizard / TAppBarWizard.IOTAFormWizard }

function TAppBarWizard.GetGlyph: HICON;
begin
    Result := 0; // use standard icon
end;

function TAppBarWizard.GetPage: string;
begin
    Result := 'DDG';
end;
```

```
function TAppBarWizard.GetAuthor: string;
begin
  Result := 'Delphi 5 Developer's Guide';
end;

function TAppBarWizard.GetComment: string;
begin
  Result := 'Creates a new AppBar form.'
end;

{ TAppBarWizard.IOTACreator }

function TAppBarWizard.GetCreatorType: string;
begin
  Result := '';
end;

function TAppBarWizard.GetExisting: Boolean;
begin
  Result := False;
end;

function TAppBarWizard.GetFileSystem: string;
begin
  Result := '';
end;

function TAppBarWizard.GetOwner: IOTAModule;
var
  I: Integer;
  ModServ: IOTAModuleServices;
  Module: IOTAModule;
  ProjGrp: IOTAProjectGroup;
begin
  Result := nil;
  ModServ := BorlandIDEServices as IOTAModuleServices;
  for I := 0 to ModServ.ModuleCount - 1 do
  begin
    Module := ModSErv.Modules[I];
    // find current project group
    if CompareText(ExtractFileExt(Module.FileName), '.bpg') = 0 then
      if Module.QueryInterface(IOTAProjectGroup, ProjGrp) = S_OK then
        begin
          // return active project of group
          Result := ProjGrp.GetActiveProject;
          Exit;
        end;
      end;
  end;
end;
```

continues

LISTING 26.9 Continued

```
        end;
    end;
end;

function TAppBarWizard.GetUnnamed: Boolean;
begin
    Result := True;
end;

{ TAppBarWizard.IOTAModuleCreator }

function TAppBarWizard.GetAncestorName: string;
begin
    Result := 'AppBar';
end;

function TAppBarWizard.GetImplFileName: string;
var
    CurrDir: array[0..MAX_PATH] of char;
begin
    // Note: full path name required!
    GetCurrentDirectory(SizeOf(CurrDir), CurrDir);
    Result := Format('%s\s.pas', [CurrDir, FUnitIdent, '.pas']);
end;

function TAppBarWizard.GetIntfFileName: string;
begin
    Result := '';
end;

function TAppBarWizard.GetFormName: string;
begin
    Result := FClassName;
end;

function TAppBarWizard.GetMainForm: Boolean;
begin
    Result := False;
end;

function TAppBarWizard.GetShowForm: Boolean;
begin
    Result := True;
end;
```

```
function TAppBarWizard.GetShowSource: Boolean;
begin
    Result := True;
end;

function TAppBarWizard.NewFormFile(const FormIdent,
    AncestorIdent: string): IOTAFile;
begin
    Result := TFormFile.Create('', FormIdent, AncestorIdent);
end;

function TAppBarWizard.NewImplSource(const ModuleIdent, FormIdent,
    AncestorIdent: string): IOTAFile;
begin
    Result := TUnitFile.Create(ModuleIdent, FormIdent, AncestorIdent);
end;

function TAppBarWizard.NewIntfSource(const ModuleIdent, FormIdent,
    AncestorIdent: string): IOTAFile;
begin
    Result := nil;
end;

procedure TAppBarWizard.FormCreated(const FormEditor: IOTAFormEditor);
begin
    // do nothing
end;

end.
```

This unit employs an interesting trick for source code generation: The unformatted source code is stored in an RES file that is linked with the \$R directive. This is a very flexible way to store a wizard's source code so that it can be readily modified. The RES file is built by including a text file and RCDATA resource in an RC file and then compiling that RC file with BRCC32. Listings 26.10 and 26.11 show the contents of CodeGen.txt and CodeGen.rc.

LISTING 26.10 CodeGen.txt, the Resource Template for the AppBar Wizard

```
unit %0:s;

interface

uses
    Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
    Dialogs, AppBars;
```

continues

LISTING 26.10 Continued

```
type
  T%1:s = class(%2:s)
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  %1:s: T%1:s;

implementation

{$R *.DFM}

end.
```

LISTING 26.11 CODEGEN.RC

```
CODEGEN RCDATA CODEGEN.TXT
```

Registration of the custom module and wizard occurs inside a `Register()` procedure in the design package containing the wizard using the following two lines:

```
RegisterCustomModule(TAppBar, TCustomModule);
RegisterPackageWizard(TAppBarWizard.Create);
```

Summary

After reading this chapter, you should have a greater understanding of the various units and interfaces involved in the Delphi Open Tools API. In particular, you should know and understand the issues involved in creating wizards that plug into the IDE. The next chapter, “CORBA Development with Delphi,” completes this part of the book with a thorough discussion of the CORBA technology and its implementation in Delphi.

CORBA Development with Delphi

CHAPTER

27

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The acronym CORBA stands for *Common Object Request Broker Architecture*. CORBA is a specification, developed by the Object Management Group (OMG), that defines a standards-based architecture for building language- and platform-neutral object implementations. The OMG is an independent consortium of companies and industry experts who adhere strictly to the goal of developing standards for open, platform-neutral, distributed object architectures. Unlike some competing standards (such as Microsoft's COM/DCOM), the OMG does not offer any implementations of the standards it defines.

Object Request Brokers

The workhorse of the CORBA architecture is the Object Request Broker (ORB). The ORB provides the implementation of the CORBA specification and is the glue (or *middleware*) that holds the entire solution together. If you're familiar with Microsoft's COM/DCOM technology, you'll notice that the ORB provides runtime, security, and transport layers similar to that of the COM/DCOM library. All communication between client and server passes through the ORB so that method calls and parameters can be resolved into the address space of the caller or callee (marshaling). The ORB also provides many helper routines that can be called directly from a client or server, similar to the functionality that `oleaut32.dll` provides for COM/DCOM. As previously mentioned, the CORBA specification provides no default implementation of an ORB library. Because building an ORB is no trivial task, CORBA developers are dependent on third parties to supply CORBA-compliant ORB implementations. The good news is that ORB implementations are currently available from many vendors and for all the major platforms (such as Windows and UNIX) as well as some more obscure operating systems. Currently, the two most widely recognized CORBA implementations are the Inprise VisiBroker ORB and the IONA Orbix ORB.

Interfaces

A single CORBA solution can be comprised of various objects, developed in a heterogeneous mix of development languages and executing on a variety of different platforms. Therefore, there needs to be some standard way for the objects to represent themselves to other objects, clients, and the ORB. This representation is accomplished using an interface. An *interface* defines a list of available methods and their parameters but does not serve to implement any functionality of these routines. When a CORBA object implements an interface, it's guaranteeing that it implements all the methods defined by the interface. At its lowest level, an interface is simply a function table or list of entry points into specific methods. Because this construct can be represented on any hardware platform and by any serious development tool, interfaces become the common tongue of the CORBA world. Because the syntax of development languages can differ widely, the OMG has defined the Interface Definition Language (IDL),

which is used for defining CORBA interfaces. IDL is the standard language for defining CORBA interfaces, and many development tools are able to translate IDL into their native syntax in order to allow developers to easily construct CORBA-compliant interfaces. With Delphi, we won't need to manually write IDL; instead, the type library editor will allow us to visually define our interfaces and optionally export the corresponding IDL code.

Stubs and Skeletons

The CORBA mechanism works using proxies. The use of proxies is currently the leading design pattern for solving the complex problems associated with passing data between distributed objects. A proxy sits on both the client and server side and makes it appear to the client or server that it is communicating with a local process. The ORB then handles all the messy details that need to occur between the proxies (for example, marshaling, network communication, and so on). This architecture, as shown in Figure 27.1, affords the developers of a CORBA client or server some protection from low-level transport details and allows them to focus on correctly implementing their specific business solution. In CORBA terms, the proxy that represents the server that a client communicates with is called a *stub*, and a proxy that represents a client on the server side is called a *skeleton*. When you're creating a CORBA server object using the Delphi wizard, a unit containing interface definitions for the stub and skeleton will be automatically generated.

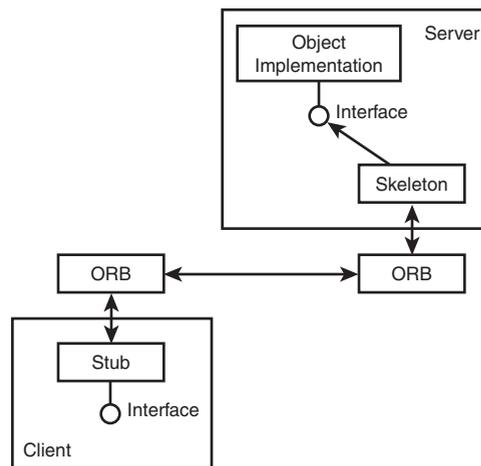


FIGURE 27.1

A simplified schematic of the CORBA architecture.

The VisiBroker ORB

As mentioned previously, CORBA is a standard that requires some third party to actually implement the ORB services. The CORBA support offered in Delphi 4 and 5 uses the VisiBroker ORB from Inprise to implement the CORBA specification. The VisiBroker product provides full support for the CORBA specification as well as many VisiBroker extensions such as naming and event services. Because full coverage of the VisiBroker product is outside the scope of this chapter, we'll focus on the parts of VisiBroker that are most pertinent to Delphi's CORBA implementation. More information on VisiBroker, including product documentation, can be found at www.borland.com/visibroker.

VisiBroker Runtime Support Services

Included with the VisiBroker ORB libraries are various runtime support services that function to hold the whole CORBA/VisiBroker distributed architecture together. We'll discuss each of these.

Smart Agent (osagent)

The VisiBroker Smart Agent provides *object location* services to CORBA applications. Use of the Smart Agent provides the CORBA environment with location transparency. That is, clients are not concerned with the location of the servers themselves; clients simply need to be able to locate the Smart Agent and it will handle the details of finding an appropriate server. A Smart Agent must be running somewhere on your local network. Multiple Smart Agents in a single network can be configured to listen on different ports, in effect providing multiple *ORB domains*. This might be useful for providing a production ORB environment and a development ORB environment. Smart Agents can also be configured to communicate with Smart Agents residing on different local networks, thus extending the range of your CORBA infrastructure.

Object Activation Daemon

The VisiBroker Object Activation Daemon (OAD) provides services for dynamically launching servers when their services are needed. The Smart Agent can only bind clients to implementations of objects that are already running. However, if a CORBA object implementation is registered with the Object Activation Daemon, the Smart Agent and the OAD can cooperate and launch the server process if there isn't one available.

The Interface Repository

The Interface Repository (IREP) is an online database of object type information. This repository is necessary for clients who wish to dynamically bind (late-bind) to CORBA interfaces. The ORB can use the type information in the interface repository for correctly marshaling late-bound method invocations. In order for dynamic binding to be used, the Interface Repository

must be running somewhere on the network that's accessible to clients, and the interface to be used must be registered with the repository.

VisiBroker Administration Tools

In order to configure and administer the aforementioned runtime support tools, the Delphi VisiBroker package ships with an assortment of GUI and command-line administration utilities. We list them in Table 27.1 for completeness but defer the details on their usage until they're needed later in this chapter.

TABLE 27.1 VisiBroker Administration Tools

<i>Tool</i>	<i>Purpose</i>
osagent	Used for administering the Smart Agent
osfind	Enumerates object implementations available on the network
oad	Used for administering the OAD
oadutil	Used for registering, unregistering, and listing interfaces with the OAD
irep	Used to administer the Interface Repository
idl2ir	Utility for registering IDL with the Interface Repository
vregedit	Allows for easy Registry (Windows) changes to Smart Agent defaults
vbver	Reports version numbers of the VisiBroker services

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Delphi CORBA Support

The CORBA support introduced in Delphi (starting with version 4) has been often criticized. Although there are limitations, many of the rumors are exaggerated or simply wrong. To begin with, the support in Delphi is indeed a “true” CORBA implementation. The VisiBroker ORB for C++ (`orb_br.dll`) is used underneath and is wrapped by a dynamic link library (`orbpas50.dll`) in order to allow Pascal and Delphi interface definitions and data types to work with the VisiBroker ORB.

One area that usually causes CORBA purists to cringe is when they look at Delphi-generated stub and skeleton code and see references to GUIDs and `IUnknown` and `IDispatch` interfaces. These constructs reek of COM/DCOM, and most CORBA supporters wish to have them far from their beloved CORBA implementations. Many myths have been circulated surrounding the existence of these COM beasts, including that CORBA calls go through COM, or that parameters are marshaled twice (once through COM and once through CORBA). Before running amok with all kinds of crazy assumptions, let's examine why these COM definitions exist in a Delphi-generated CORBA server:

- To begin with, when interfaces were added to Delphi, it was done with COM in mind. All Delphi interfaces “inherit” from the base COM interface (IUnknown). This means that when you define an interface in Delphi that’s to be used with CORBA, the three additional methods of IUnknown (QueryInterface, AddRef, and Release) must be implemented. This is true even for a CORBA interface; the base implementation of the TCorbaImplementation class implements these methods for the Delphi developer.
- Second, when creating a CORBA object using the Delphi wizard, you’ll notice that a COM “dual” interface is created by default. By examining the generated stub and skeleton unit, you see that the CORBA interface inherits from IDispatch and defines a dispinterface. Although this is unnecessary for CORBA (and you can alter the definition to inherit from IUnknown), the object implementation must define the additional methods of IDispatch in order for these objects to compile properly. The class declarations of TCorbaDispatchStub and TCorbaImplementation implement the four additional methods of IDispatch. Careful inspection of this code will show that the implementations do not really do anything; they are present so that the type library editor can be used with CORBA objects.
- Finally, the interfaces that are generated by the wizard contain GUIDs (or IIDs). These are unique identifiers that COM uses to identify interfaces. Although CORBA does not use GUIDs itself in order to identify objects or interfaces, some internal VCL routines use these GUIDs in order to uniquely identify the CORBA interfaces. For this reason, GUIDs should not be removed from the interfaces generated by the CORBA Object Wizard.

As you can see from this discussion, the COM entities that are generated by the Delphi CORBA wizard may be less of a cost than some developers think. One beneficial side effect of this—a feature that’s unique to Delphi—is that it becomes very easy to build classes that can be exposed through both COM/DCOM and CORBA at the same time!

At the time of writing, the most glaring weakness of Delphi’s CORBA implementation is the lack of a utility for converting IDL to Pascal (Idl2Pas), a tool that’s currently available from Inprise for both Java and C++. It’s a common misconception that Delphi does not have the ability to early-bind to a CORBA server written in a different language. A more correct statement would be that a Delphi developer cannot *easily* early-bind to a CORBA server written in another language. Delphi clients can perform static (early) binding or dynamic (late) binding to CORBA servers written in Delphi or any other language. However, the inability of Delphi to import an IDL file and generate Pascal code that the compiler can understand makes it much more difficult to early-bind to CORBA servers that are written in other languages. Due to this, a developer must manually code CORBA stub classes when desiring to early-bind a Delphi client to a CORBA object implemented in C++ or Java. Inprise is currently working on an

Idl2Pas converter that will simplify Delphi/CORBA development and should soon be available as an add-on to Delphi 5. Later in this chapter we will provide an introductory look at this new technology.

CORBA Support Classes

The Delphi CORBA framework uses a mixture of interface and implementation inheritance in order to enable developers to create CORBA clients and servers. CORBA work is accomplished primarily by implementing interfaces for objects, stubs, and skeletons. Because interfaces do not support the concept of inheriting implementation code, this task could become quite tedious because all interfaces would need to reimplement common calls to the CORBA ORB. To address this, Delphi provides a group of VCL base classes that implement the methods of the primary CORBA interfaces (for example, `ICorbaObject`, `ISkeletonObject`, and `IStubObject`). The primary base classes are shown in Figure 27.2 and are described in the following list.

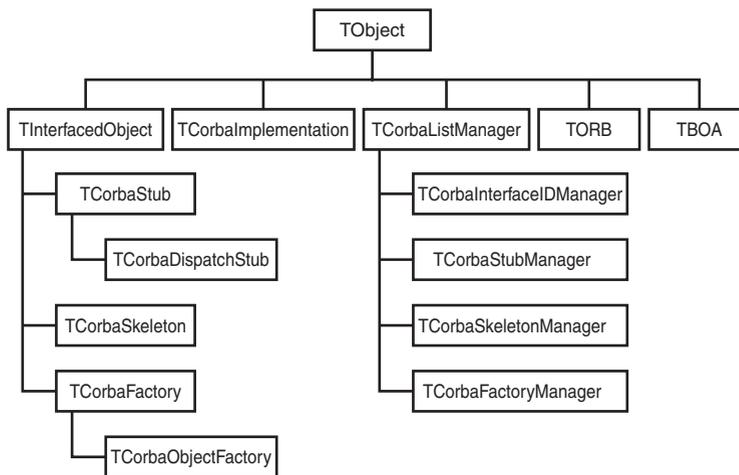


FIGURE 27.2

The VCL's CORBA support hierarchy.

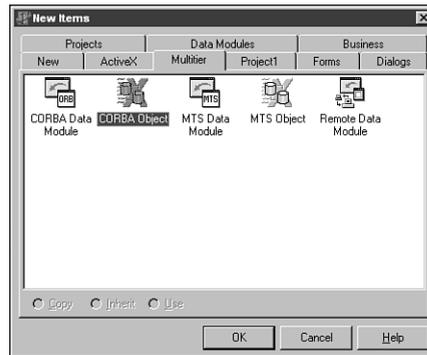
- `TCorbaImplementation`. This class supports `IUnknown` (interfaces) and provides interface-querying and reference-counting capabilities. The methods of `IDispatch` are also stubbed out on this class so that dual interfaces added from the type library editor are supported. Delphi CORBA objects will descend from this class.
- `TCorbaStub`. This class implements the `ICorbaObject` and `IStubObject` interfaces. `TCorbaStub` is the base class for all stubs generated by the Delphi Type Library Editor.

A stub is used to marshal interface calls for a CORBA client. Developers wishing (or having) to provide their own marshaling will create `TCorbaStub` descendants.

- `TCorbaDispatchStub`. This class inherits from `TCorbaStub` and implements (stubs out) the methods of the COM interface `IDispatch`. This is so those interfaces that are created with the Delphi Type Library Editor that inherit from `IDispatch` can be used with CORBA.
- `TCorbaSkeleton`. This class implements the `ISkeletonObject` interface and is responsible for communicating with the ORB and passing calls on the server object. Unlike the stub, the skeleton class does not actually implement the interface of the server. Instead, the skeleton holds a reference to the server and invokes methods on this reference.
- `TCorbaFactory` and `TCorbaObjectFactory`. `TCorbaFactory` is the base class for objects that can create CORBA object instances. `TCorbaObjectFactory` can instantiate any descendants of `TCorbaImplementation`.
- `TCorbaListManager` (and subclasses). The Delphi CORBA framework must keep track of various entities at runtime, such as skeletons, stubs, factories, and interface IDs. `TCorbaListManager` is a base class that provides support for thread synchronization. This allows the VCL to provide internal housekeeping in a thread-safe manner. Typically, a developer will not need to do much with these list manager classes except for occasionally registering a custom stub object.
- `TBOA`. This is the Delphi class that represents the Basic Object Adapter (BOA), a CORBA mechanism for communication between the ORB and the skeleton. The `TBOA` class is a “singleton” object and never needs to be instantiated directly.
- `TORB`. The `TORB` class is how the Delphi VCL communicates with the VisiBroker ORB. Like the `TBOA` class, the `TORB` class is a “singleton” and should never be instantiated directly. The implementations of many of `TORB`'s methods call functions in `orbpas50.dll`, which in turn calls routines in the VisiBroker C++ ORB (`orb_br.dll`).

CORBA Object Wizard

The classes just listed are relatively straightforward and represent just about all the VCL CORBA classes that a Delphi developer should have to deal with. However, you may be happy to know that there's a Delphi wizard that helps you properly implement your CORBA objects. Use the File, New menu to invoke Delphi's Object Repository, as shown in Figure 27.3, and select the Multitier tab.

**FIGURE 27.3**

The Delphi Object Repository/CORBA Wizard.

Now click CORBA Object and you'll see the CORBA Object Wizard pictured in Figure 27.4.

**FIGURE 27.4**

The CORBA Object Wizard.

Fill in the class name with the desired name for your CORBA object and interface. Note that you should probably not use the standard Delphi convention of starting your class name with a *T*, because this will be automatically added for you. For example, if you enter *MyObject*, a Delphi class named `TMyObject` will be generated that implements the interface `IMyObject`.

The Instancing option determines how object instances are handed out to clients. One of the following two options may be chosen:

- *Shared Instance*. This model is normally used for CORBA development. Each client uses a single shared instance of the object implementation. CORBA servers that use this model should be built as “stateless” servers. Because many clients may be sharing a single instance, any particular client is not guaranteed to find the server in the exact same state that it was in after the last call.
- *Instance-per-client*. The instance-per-client model constructs a unique instance of an object for each client that requests an object's service. This model allows for the construction of “state” objects that maintain a consistent state across client calls. However,

this model can be more resource-intensive because it requires servers to track the state of connected clients so that objects can be freed when clients are finished with them.

The Threading Model option specifies how your CORBA objects will be called. Two options are available here:

- *Single-threaded*. Each object instance will be called from a single thread; therefore, the object itself does not need to be made thread-safe. Note that the CORBA server application may contain multiple objects or instances; therefore, global or shared data must still be made thread-safe.
- *Multithreaded*. Although each client connection will make calls on a dedicated client thread, objects can receive concurrent calls from multiple threads. In this scenario, global as well as object data must be made thread-safe. The most difficult scenario to implement (regarding threading concerns) is you're when using a shared object instance with the multithreaded model. The simplest would be the single-threaded, instance-per-client model.

Keep in mind that simply selecting a threading option does not serve to implement your servers or objects in a thread-safe manner. These options are purely for specifying the threading model your object supports. It remains your responsibility to implement your CORBA servers in a thread-safe manner, based on the threading model desired.

After you've successfully completed the CORBA wizard, two Pascal code units will be generated. A stub/skeleton unit will be generated that follows the naming pattern *YourProject_TLB.pas*. This file will contain the definition of the main interface of your object, a stub and skeleton class, a CORBA class factory class, and code to register the stub, skeleton, and interface with the appropriate Delphi mechanisms. Listing 27.1 shows the code generated for a class named "MyFirstCORBAServer."

LISTING 27.1 A Delphi-Generated Stub and Skeleton Unit

```
unit FirstCorbaServer_TLB;

// ***** //
// WARNING
// -----
// The types declared in this file were generated from data read from a
// Type Library. If this type library is explicitly or indirectly (via
// another type library referring to this type library) re-imported, or the
// 'Refresh' command of the Type Library Editor activated while editing the
// Type Library, the contents of this file will be regenerated and all
// manual modifications will be lost.
// ***** //
```

```

// PASTLWTR : $Revision: 1.88 $
// File generated on 11/02/1999 4:01:10 PM from Type Library described below.

// ***** //
// Type Lib: C:\ICON99\FirstCORBAServer\FirstCorbaServer.tlb (1)
// IID\LCID: {CE8DB340-913A-11D3-9706-0000861F6726}\0
// Helpfile:
// DepndLst:
// (1) v2.0 stdole, (C:\WINDOWS\SYSTEM\STDOLE2.TLB)
// (2) v4.0 StdVCL, (C:\WINDOWS\SYSTEM\STDVCL40.DLL)
// ***** //
{$TYPEDADDRESS OFF} // Unit must be compiled without type-checked pointers.
interface

uses Windows, ActiveX, Classes, Graphics, OleServer, OleCtrls, StdVCL,
    SysUtils, CORBAObj, OrbPas, CorbaStd;

// *****//
// GUIDS declared in the TypeLibrary. Following prefixes are used:
// Type Libraries      : LIBID_xxxx
// CoClasses           : CLASS_xxxx
// DISPInterfaces     : DIID_xxxx
// Non-DISP interfaces: IID_xxxx
// *****//
const
    // TypeLibrary Major and minor versions
    FirstCorbaServerMajorVersion = 1;
    FirstCorbaServerMinorVersion = 0;

    LIBID_FirstCorbaServer: TGUID = '{CE8DB340-913A-11D3-9706-0000861F6726}';

    IID_IMyFirstCorbaServer: TGUID = '{CE8DB341-913A-11D3-9706-0000861F6726}';
    CLASS_MyFirstCorbaServer: TGUID = '{CE8DB343-913A-11D3-9706-0000861F6726}';
type

// *****//
// Forward declaration of types defined in TypeLibrary
// *****//
    IMyFirstCorbaServer = interface;
    IMyFirstCorbaServerDisp = dispinterface;

// *****//
// Declaration of CoClasses defined in Type Library
// (NOTE: Here we map each CoClass to its Default Interface)
// *****//

```

*continues***27**

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LISTING 27.1 Continued

```

MyFirstCorbaServer = IMyFirstCorbaServer;

// *****//
// Interface: IMyFirstCorbaServer
// Flags:      (4416) Dual OleAutomation Dispatchable
// GUID:       {CE8DB341-913A-11D3-9706-0000861F6726}
// *****//
IMyFirstCorbaServer = interface(IDispatch)
    ['{CE8DB341-913A-11D3-9706-0000861F6726}']
    procedure SayHelloWorld; safecall;
end;

// *****//
// DispIntf:  IMyFirstCorbaServerDisp
// Flags:      (4416) Dual OleAutomation Dispatchable
// GUID:       {CE8DB341-913A-11D3-9706-0000861F6726}
// *****//
IMyFirstCorbaServerDisp = dispinterface
    ['{CE8DB341-913A-11D3-9706-0000861F6726}']
    procedure SayHelloWorld; dispid 1;
end;

TMyFirstCorbaServerStub = class(TCorbaDispatchStub, IMyFirstCorbaServer)
public
    procedure SayHelloWorld; safecall;
end;

TMyFirstCorbaServerSkeleton = class(TCorbaSkeleton)
private
    FIntf: IMyFirstCorbaServer;
public
    constructor Create(const InstanceName: string; const Impl: IUnknown);
        override;
    procedure GetImplementation(out Impl: IUnknown); override; stdcall;
published
    procedure SayHelloWorld(const InBuf: IMarshalInBuffer; Cookie: Pointer);
end;

// *****//
// The Class CoMyFirstCorbaServer provides a Create and CreateRemote method to
// create instances of the default interface IMyFirstCorbaServer exposed by
// the CoClass MyFirstCorbaServer. The functions are intended to be used by
// clients wishing to automate the CoClass objects exposed by the
// server of this typelibrary.

```

```
// *****//
CoMyFirstCorbaServer = class
  class function Create: IMyFirstCorbaServer;
  class function CreateRemote(const MachineName: string):
    ↪IMyFirstCorbaServer;
end;

TMyFirstCorbaServerCorbaFactory = class
  class function CreateInstance(const InstanceName: string):
    IMyFirstCorbaServer;
end;

implementation

uses ComObj;

{ TMyFirstCorbaServerStub }

procedure TMyFirstCorbaServerStub.SayHelloWorld;
var
  OutBuf: IMarshalOutBuffer;
  InBuf: IMarshalInBuffer;
begin
  FStub.CreateRequest('SayHelloWorld', True, OutBuf);
  FStub.Invoke(OutBuf, InBuf);
end;

{ TMyFirstCorbaServerSkeleton }

constructor TMyFirstCorbaServerSkeleton.Create(const InstanceName: string;
  const Impl: IUnknown);
begin
  inherited;
  inherited InitSkeleton('MyFirstCorbaServer', InstanceName,
    'IDL:FirstCorbaServer/IMyFirstCorbaServer:1.0', tmMultiThreaded, True);
  FIntf := Impl as IMyFirstCorbaServer;
end;

procedure TMyFirstCorbaServerSkeleton.GetImplementation(out Impl: IUnknown);
begin
  Impl := FIntf;
end;

procedure TMyFirstCorbaServerSkeleton.SayHelloWorld(
  const InBuf: IMarshalInBuffer; Cookie: Pointer);
var
```

LISTING 27.1 Continued

```
    OutBuf: IMarshalOutBuffer;
begin
    FIntf.SayHelloWorld;
    FSkeleton.GetReplyBuffer(Cookie, OutBuf);
end;

class function CoMyFirstCorbaServer.Create: IMyFirstCorbaServer;
begin
    Result := CreateComObject(CLASS_MyFirstCorbaServer) as IMyFirstCorbaServer;
end;

class function CoMyFirstCorbaServer.CreateRemote(const MachineName: string):
    IMyFirstCorbaServer;
begin
    Result := CreateRemoteComObject(MachineName, CLASS_MyFirstCorbaServer) as
        IMyFirstCorbaServer;
end;

class function TMyFirstCorbaServerCorbaFactory.CreateInstance(
    const InstanceName: string): IMyFirstCorbaServer;
begin
    Result := CorbaFactoryCreateStub(
        'IDL:FirstCorbaServer/MyFirstCorbaServerFactory:1.0', 'MyFirstCorbaServer',
        InstanceName, '', IMyFirstCorbaServer) as IMyFirstCorbaServer;
end;

initialization
    CorbaStubManager.RegisterStub(IMyFirstCorbaServer, TMyFirstCorbaServerStub);
    CorbaInterfaceIDManager.RegisterInterface(IMyFirstCorbaServer,
        'IDL:FirstCorbaServer/IMyFirstCorbaServer:1.0');
    CorbaSkeletonManager.RegisterSkeleton(IMyFirstCorbaServer,
        TMyFirstCorbaServerSkeleton);

end.
```

Upon examination of this stub and skeleton unit, one interesting point to note is that the skeleton class does not actually implement the `IMyFirstCorbaServer` interface. The skeleton will have the same methods as the supported interface, but you'll notice that the parameters are different. The methods of the skeleton will receive raw, marshaled information and must then unmarshal the parameters and pass them to the appropriate interface. For this reason, the skeleton does not implement the interface directly. Instead, the skeleton will hold an internal reference to the supported interface and delegate its calls to this internal reference.

The second unit generated will contain the framework for implementing your object. A Delphi class that descends from `TCorbaImplementation` and implements your main interface will be generated. This unit will also create an instance of the factory that's responsible for creating the CORBA object. A typical CORBA object implementation unit would look like the code shown in Listing 27.2.

LISTING 27.2 A Delphi-Generated CORBA Object Implementation

```
unit uMyFirstCorbaServer;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, ComObj, StdVcl,
  CorbaObj, FirstCorbaServer_TLB;

type

  TMyFirstCorbaServer = class(TCorbaImplementation, IMyFirstCorbaServer)
  private
    { Private declarations }
  public
    { Public declarations }
  protected
    procedure SayHelloWorld; safecall;
  end;

implementation

uses CorbInit;

procedure TMyFirstCorbaServer.SayHelloWorld;
begin
  //Implement method here.
end;

initialization
  TCorbaObjectFactory.Create('MyFirstCorbaServerFactory', 'MyFirstCorbaServer',
    'IDL:FirstCorbaServer/MyFirstCorbaServer:1.0', IMyFirstCorbaServer,
    TMyFirstCorbaServer, iMultiInstance, tmSingleThread);
end.
```

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This unit will eventually contain the code that implements all the methods of the `IMyFirstCORBAServer` interface as well as any internal functionality of the `TMyFirstCORBAServer` class. By using classical implementation inheritance descending from `TCorbaImplementation`, the implementation will automatically be able to become a CORBA object. By supporting the `IMyFirstCorbaServer` interface, the object guarantees it will satisfy the contract of this interface. In lieu of manually declaring the object's interface and implementation, we'll now turn to the Delphi Visual Type Library Editor.

The Delphi Type Library Editor

To fully implement this custom CORBA object, code must be added to both the stub and skeleton unit and the object implementation unit listed previously. Although at first this may appear to be a somewhat daunting task, the Delphi Type Library Editor is available to help you with the process. Proceed to the Delphi main menu and select View, Type Library. You'll see the window shown in Figure 27.5, which visually represents the interfaces and other entities defined in the stub and skeleton unit.

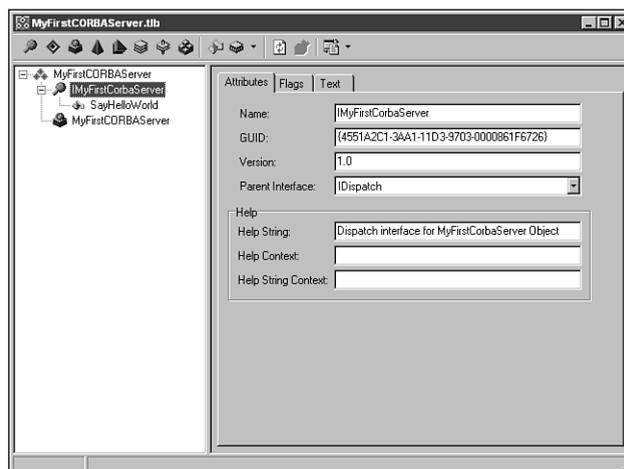


FIGURE 27.5

The Delphi Visual Type Library Editor.

At this point, you can select the `IMyFirstCorbaServer` interface in the editor and click the speedbutton to add a new method. Once the method has been added, you can use the editor's visual interface to define parameters, return types, and so on. Note that not all the data types shown as possible parameter types in the Type Library Editor are valid for CORBA objects. Because the Type Library Editor currently is a dual-purpose tool for both COM and CORBA, many of the data types are valid for COM/Automation objects only. Consult the Delphi help

files for exhaustive lists of valid CORBA (IDL) data types. Once you've used the Type Library Editor to add the methods of your interface, clicking the Refresh speedbutton will regenerate the code in your project. The stub and skeleton unit will be refreshed, and empty implementation methods will be added to your implementation unit. All that's left for you to do is to fill in the code and implement the empty methods that the Type Library Editor generates.

NOTE

Delphi 5 contains a new feature that will generate component wrappers for CoClasses contained in a type library. Unfortunately, wrappers are generated whether you are importing an existing type library or creating one of your own. These component wrappers are not appropriate for a CORBA object, so you should perform the following steps to prevent generation of this additional code. From the Delphi menu, select Project, Import Type Library. When the dialog box appears, clear the "Generate Component Wrapper" check box and close the dialog box by clicking Close in the upper right corner. Finally, click the Refresh speedbutton in the Type Library Editor. The extraneous code will be eliminated from your application.

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Creating CORBA Solutions with Delphi 5

Now that we have discussed the basic CORBA framework and IDE tools in Delphi, we are going to apply our knowledge by creating a CORBA server. Then we'll finish by building a client that will use our custom CORBA server.

Building a CORBA Server

Having examined the basics of creating a CORBA server, we'll now go into detail and construct a CORBA server from start to finish. Our objective is to create a middle-tier CORBA object that can accept SQL queries from a client, query a database, and send results back to the calling client. Our implementation will use the Borland Database Engine (BDE) in order to easily retrieve data from a database server. Keep in mind that this dependency is only a consideration from the standpoint of the server object. The client application needs no knowledge (or deployment) of the BDE, and the server could easily be adapted to retrieve data using other mechanisms such as Delphi 5's new ADO datasets or even a custom TDataset.

Invoking the CORBA Object Wizard

Create a new Delphi application and then invoke the CORBA Object Wizard as described earlier. The name of our object will be QueryServer; this will produce an interface named IQueryServer and an implementation class with the name TQueryServer. Choose Instance-Per-Client for the Instancing option because our object will support data navigation (for example,

First, Next, and so on) and therefore is not a stateless object. In order to avoid the complexities of writing thread-safe code at this point, select Single-Threaded for the Threading Model option. After you click OK, the stub and skeleton unit as well as the object's implementation unit will be added to the project.

You may notice that the default Delphi application contains a form by default. A Delphi GUI application must have a form in order to remain in the main Windows message loop. Most CORBA server applications have no need for a visual form; therefore, we could solve this by entering

```
Application.ShowMainForm := False;
```

in the project file of the application. For this example, we would like to verify that the server is running, so we'll leave the form visible and provide a TLabel to inform us that our CORBA server is active. This form is shown in Figure 27.6.



FIGURE 27.6

Our CORBA server's main form.

Be aware that this form should be considered global data. Even though we've created the CORBA object with a single-threaded model, the CORBA server application could contain other objects that are servicing calls on other threads. Therefore, accessing this form from the code of the object would not be considered thread-safe.

Using the Type Library Editor

Now that we've generated the necessary code to implement our CORBA object, we're going to use the Type Library Editor to add support methods to our interface. We're going to add functionality to our IQueryServer interface to allow clients to log in to a database and send SQL statements, navigate the data, and retrieve a row at a time of the result set. This is accomplished by selecting the IQueryServer interface and clicking the New Method speedbutton. As each of our new methods are added, we can name them using the Name edit box on the Attributes tab. For each new method, you may also need to use the grid on the Parameters tab of the Type Library Editor in order to supply parameter types and return values. After adding several methods to provide our desired functionality, the Type Library Editor will look like Figure 27.7.

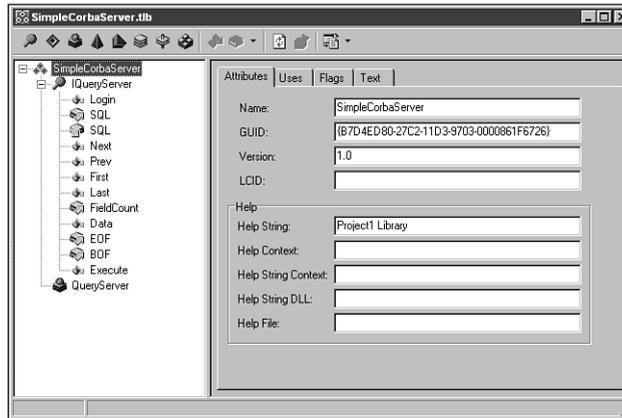


FIGURE 27.7

IQueryServer methods in the Type Library Editor.

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Implementing the Methods of IQueryServer

Now that we've defined the interface of our CORBA object, what remains to be done is to implement the code to make the exposed methods work. Our implementation class will encapsulate a TDatabase and a TQuery in order to provide access to the BDE and server data. The remainder of the work is trivial—the interface methods will simply call the provided functionality of the TDatabase and TQuery VCL components.

The only method that will be a little more involved to implement is the Data method (function). This method will retrieve the entire row of data that's currently positioned in the query results. Because we're returning multiple values, we need some type of structure to be returned that represents these values appropriately. In IDL, this would usually involve the use of a *sequence*, which is a varying array of some data type. The Type Library Editor does not currently allow us to define an IDL sequence, so we'll make the return type of the Data method be an OLEVariant. This OLEVariant will actually be an array that holds the column values for the positioned row in each of its elements. We can use an OLEVariant for this task because IDL has a similar construct called an Any that can hold any valid IDL data type. The IDL that Delphi generates (shown later) will recognize an OLEVariant as an IDL Any, and the Delphi CORBA framework will allow this value to be converted to an Any and correctly marshaled to and from the ORB. In fact, there's a type declared in the Delphi VCL called TAny that maps directly to a Variant. All we'll need to do is create an array of Variant types and pass this as the return value of our Data function, as follows:

```
function TQueryServer.Data: OleVariant;
var
  i : integer;
```

```

begin
  //Pack and send data.
  Result := VarArrayCreate([0,FQuery.FieldCount-1],varOLEStr);
  for i := 0 to FQuery.FieldCount - 1 do
    begin
      Result[i] := FQuery.Fields[i].AsString;
    end;
  end;
end;

```

Once we implement the remainder of our methods, we'll have a stub and skeleton unit, as shown in Listing 27.3.

LISTING 27.3 The Stub and Skeleton Unit for IQueryServer

```

unit SimpleCorbaServer_TLB;

// ***** //
// WARNING
// -----
// The types declared in this file were generated from data read from a
// Type Library. If this type library is explicitly or indirectly (via
// another type library referring to this type library) re-imported, or the
// 'Refresh' command of the Type Library Editor activated while editing the
// Type Library, the contents of this file will be regenerated and all
// manual modifications will be lost.
// ***** //

// PASTLWTR : $Revision: 1.88 $
// File generated on 11/02/1999 6:01:08 PM from Type Library described below.

// ***** //
// Type Lib: C:\ICON99\CORBA Server\SimpleCorbaServer.tlb (1)
// IID\LCID: {B7D4ED80-27C2-11D3-9703-0000861F6726}\0
// Helpfile:
// DepndLst:
// (1) v2.0 stdole, (C:\WINDOWS\SYSTEM\STDOLE2.TLB)
// (2) v4.0 StdVCL, (C:\WINDOWS\SYSTEM\STDVCL40.DLL)
// ***** //
{$TYPEDADDRESS OFF} // Unit must be compiled without type-checked pointers.
interface

uses Windows, ActiveX, Classes, Graphics, OleServer, OleCtrls, StdVCL,
    SysUtils, CORBAObj, OrbPas, CorbaStd;

// *****//
// GUIDS declared in the TypeLibrary. Following prefixes are used:

```

```

// Type Libraries      : LIBID_xxxx
// CoClasses          : CLASS_xxxx
// DISPInterfaces     : DIID_xxxx
// Non-DISP interfaces: IID_xxxx
// *****//
const
  // TypeLibrary Major and minor versions
  SimpleCorbaServerMajorVersion = 1;
  SimpleCorbaServerMinorVersion = 0;

  LIBID_SimpleCorbaServer: TGUID = '{B7D4ED80-27C2-11D3-9703-0000861F6726}';

  IID_IQueryServer: TGUID = '{B7D4ED81-27C2-11D3-9703-0000861F6726}';
  CLASS_QueryServer: TGUID = '{B7D4ED83-27C2-11D3-9703-0000861F6726}';
type

// *****//
// Forward declaration of types defined in TypeLibrary
// *****//
  IQueryServer = interface;
  IQueryServerDisp = dispinterface;

// *****//
// Declaration of CoClasses defined in Type Library
// (NOTE: Here we map each CoClass to its Default Interface)
// *****//
  QueryServer = IQueryServer;

// *****//
// Interface: IQueryServer
// Flags:      (4416) Dual OleAutomation Dispatchable
// GUID:       {B7D4ED81-27C2-11D3-9703-0000861F6726}
// *****//
  IQueryServer = interface(IDispatch)
    ['{B7D4ED81-27C2-11D3-9703-0000861F6726}']
    function Login(const Db: WideString; const User: WideString;
      const Password: WideString): WordBool; safecall;
    function Get_SQL: WideString; safecall;
    procedure Set_SQL(const Value: WideString); safecall;
    procedure Next; safecall;
    procedure Prev; safecall;
    procedure First; safecall;
    procedure Last; safecall;
    function Get_FieldCount: Integer; safecall;
    function Data: OleVariant; safecall;

```

LISTING 27.3 Continued

```

    function Get_EOF: WordBool; safecall;
    function Get_BOF: WordBool; safecall;
    function Execute: WordBool; safecall;
    property SQL: WideString read Get_SQL write Set_SQL;
    property FieldCount: Integer read Get_FieldCount;
    property EOF: WordBool read Get_EOF;
    property BOF: WordBool read Get_BOF;
end;

// *****//
// DispIntf: IQueryServerDisp
// Flags: (4416) Dual OleAutomation Dispatchable
// GUID: {B7D4ED81-27C2-11D3-9703-0000861F6726}
// *****//
IQueryServerDisp = dispinterface
['{B7D4ED81-27C2-11D3-9703-0000861F6726}']
    function Login(const Db: WideString; const User: WideString;
        const Password: WideString): WordBool; dispid 1;
    property SQL: WideString dispid 2;
    procedure Next; dispid 3;
    procedure Prev; dispid 4;
    procedure First; dispid 5;
    procedure Last; dispid 6;
    property FieldCount: Integer readonly dispid 7;
    function Data: OleVariant; dispid 8;
    property EOF: WordBool readonly dispid 9;
    property BOF: WordBool readonly dispid 11;
    function Execute: WordBool; dispid 12;
end;

TQueryServerStub = class(TCorbaDispatchStub, IQueryServer)
public
    function Login(const Db: WideString; const User: WideString;
        const Password: WideString): WordBool; safecall;
    function Get_SQL: WideString; safecall;
    procedure Set_SQL(const Value: WideString); safecall;
    procedure Next; safecall;
    procedure Prev; safecall;
    procedure First; safecall;
    procedure Last; safecall;
    function Get_FieldCount: Integer; safecall;
    function Data: OleVariant; safecall;
    function Get_EOF: WordBool; safecall;
    function Get_BOF: WordBool; safecall;
    function Execute: WordBool; safecall;

```

```

end;

TQueryServerSkeleton = class(TCorbaSkeleton)
private
    FIntf: IQueryServer;
public
    constructor Create(const InstanceName: string; const Impl: IUnknown);
        override;
    procedure GetImplementation(out Impl: IUnknown); override; stdcall;
published
    procedure Login(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure Get_SQL(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure Set_SQL(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure Next(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure Prev(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure First(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure Last(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure Get_FieldCount(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure Data(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure Get_EOF(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure Get_BOF(const InBuf: IMarshalInBuffer; Cookie: Pointer);
    procedure Execute(const InBuf: IMarshalInBuffer; Cookie: Pointer);
end;

// *****//
// The Class CoQueryServer provides a Create and CreateRemote method to
// create instances of the default interface IQueryServer exposed by
// the CoClass QueryServer. The functions are intended to be used by
// clients wishing to automate the CoClass objects exposed by the
// server of this typelibrary.
// *****//
CoQueryServer = class
    class function Create: IQueryServer;
    class function CreateRemote(const MachineName: string): IQueryServer;
end;

TQueryServerCorbaFactory = class
    class function CreateInstance(const InstanceName: string): IQueryServer;
end;

implementation

uses ComObj;

{ TQueryServerStub }

```

LISTING 27.3 Continued

```
function TQueryServerStub.Login(const Db: WideString; const User: WideString;
                                const Password: WideString): WordBool;
var
  OutBuf: IMarshalOutBuffer;
  InBuf: IMarshalInBuffer;
begin
  FStub.CreateRequest('Login', True, OutBuf);
  OutBuf.PutWideText(PWideChar(Pointer(Db)));
  OutBuf.PutWideText(PWideChar(Pointer(User)));
  OutBuf.PutWideText(PWideChar(Pointer(Password)));
  FStub.Invoke(OutBuf, InBuf);
  Result := UnmarshalWordBool(InBuf);
end;

function TQueryServerStub.Get_SQL: WideString;
var
  OutBuf: IMarshalOutBuffer;
  InBuf: IMarshalInBuffer;
begin
  FStub.CreateRequest('Get_SQL', True, OutBuf);
  FStub.Invoke(OutBuf, InBuf);
  Result := UnmarshalWideText(InBuf);
end;

procedure TQueryServerStub.Set_SQL(const Value: WideString);
var
  OutBuf: IMarshalOutBuffer;
  InBuf: IMarshalInBuffer;
begin
  FStub.CreateRequest('Set_SQL', True, OutBuf);
  OutBuf.PutWideText(PWideChar(Pointer(Value)));
  FStub.Invoke(OutBuf, InBuf);
end;

procedure TQueryServerStub.Next;
var
  OutBuf: IMarshalOutBuffer;
  InBuf: IMarshalInBuffer;
begin
  FStub.CreateRequest('Next', True, OutBuf);
  FStub.Invoke(OutBuf, InBuf);
end;

procedure TQueryServerStub.Prev;
var
```

```
    OutBuf: IMarshalOutBuffer;
    InBuf: IMarshalInBuffer;
begin
    FStub.CreateRequest('Prev', True, OutBuf);
    FStub.Invoke(OutBuf, InBuf);
end;

procedure TQueryServerStub.First;
var
    OutBuf: IMarshalOutBuffer;
    InBuf: IMarshalInBuffer;
begin
    FStub.CreateRequest('First', True, OutBuf);
    FStub.Invoke(OutBuf, InBuf);
end;

procedure TQueryServerStub.Last;
var
    OutBuf: IMarshalOutBuffer;
    InBuf: IMarshalInBuffer;
begin
    FStub.CreateRequest('Last', True, OutBuf);
    FStub.Invoke(OutBuf, InBuf);
end;

function TQueryServerStub.Get_FieldCount: Integer;
var
    OutBuf: IMarshalOutBuffer;
    InBuf: IMarshalInBuffer;
begin
    FStub.CreateRequest('Get_FieldCount', True, OutBuf);
    FStub.Invoke(OutBuf, InBuf);
    Result := InBuf.GetLong;
end;

function TQueryServerStub.Data: OleVariant;
var
    OutBuf: IMarshalOutBuffer;
    InBuf: IMarshalInBuffer;
begin
    FStub.CreateRequest('Data', True, OutBuf);
    FStub.Invoke(OutBuf, InBuf);
    Result := UnmarshalAny(InBuf);
end;

function TQueryServerStub.Get_EOF: WordBool;
```

LISTING 27.3 Continued

```
var
  OutBuf: IMarshalOutBuffer;
  InBuf: IMarshalInBuffer;
begin
  FStub.CreateRequest('Get_EOF', True, OutBuf);
  FStub.Invoke(OutBuf, InBuf);
  Result := UnmarshalWordBool(InBuf);
end;

function TQueryServerStub.Get_BOF: WordBool;
var
  OutBuf: IMarshalOutBuffer;
  InBuf: IMarshalInBuffer;
begin
  FStub.CreateRequest('Get_BOF', True, OutBuf);
  FStub.Invoke(OutBuf, InBuf);
  Result := UnmarshalWordBool(InBuf);
end;

function TQueryServerStub.Execute: WordBool;
var
  OutBuf: IMarshalOutBuffer;
  InBuf: IMarshalInBuffer;
begin
  FStub.CreateRequest('Execute', True, OutBuf);
  FStub.Invoke(OutBuf, InBuf);
  Result := UnmarshalWordBool(InBuf);
end;

{ TQueryServerSkeleton }

constructor TQueryServerSkeleton.Create(const InstanceName: string;
  const Impl: IUnknown);
begin
  inherited;
  inherited InitSkeleton('QueryServer', InstanceName,
    'IDL:SimpleCorbaServer/IQueryServer:1.0', tmMultiThreaded, True);
  FIntf := Impl as IQueryServer;
end;

procedure TQueryServerSkeleton.GetImplementation(out Impl: IUnknown);
begin
  Impl := FIntf;
end;
```

```
procedure TQueryServerSkeleton.Login(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
  Retval: WordBool;
  Db: WideString;
  User: WideString;
  Password: WideString;
begin
  Db := UnmarshalWideText(InBuf);
  User := UnmarshalWideText(InBuf);
  Password := UnmarshalWideText(InBuf);
  Retval := FIntf.Login(Db, User, Password);
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
  MarshalWordBool(OutBuf, Retval);
end;

procedure TQueryServerSkeleton.Get_SQL(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
  Retval: WideString;
begin
  Retval := FIntf.Get_SQL;
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
  OutBuf.PutWideText(PWideChar(Pointer(Retval)));
end;

procedure TQueryServerSkeleton.Set_SQL(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
  Value: WideString;
begin
  Value := UnmarshalWideText(InBuf);
  FIntf.Set_SQL(Value);
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
end;

procedure TQueryServerSkeleton.Next(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
begin
  FIntf.Next;
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
end;
```

LISTING 27.3 Continued

```
end;

procedure TQueryServerSkeleton.Prev(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
begin
  FIntf.Prev;
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
end;

procedure TQueryServerSkeleton.First(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
begin
  FIntf.First;
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
end;

procedure TQueryServerSkeleton.Last(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
begin
  FIntf.Last;
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
end;

procedure TQueryServerSkeleton.Get_FieldCount(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
  Retval: Integer;
begin
  Retval := FIntf.Get_FieldCount;
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
  OutBuf.PutLong(Retval);
end;

procedure TQueryServerSkeleton.Data(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
  Retval: OleVariant;
```

```
begin
  Retval := FIntf.Data;
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
  MarshalAny(OutBuf, Retval);
end;

procedure TQueryServerSkeleton.Get_EOF(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
  Retval: WordBool;
begin
  Retval := FIntf.Get_EOF;
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
  MarshalWordBool(OutBuf, Retval);
end;

procedure TQueryServerSkeleton.Get_BOF(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
  Retval: WordBool;
begin
  Retval := FIntf.Get_BOF;
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
  MarshalWordBool(OutBuf, Retval);
end;

procedure TQueryServerSkeleton.Execute(const InBuf: IMarshalInBuffer;
  Cookie: Pointer);
var
  OutBuf: IMarshalOutBuffer;
  Retval: WordBool;
begin
  Retval := FIntf.Execute;
  FSkeleton.GetReplyBuffer(Cookie, OutBuf);
  MarshalWordBool(OutBuf, Retval);
end;

class function CoQueryServer.Create: IQueryServer;
begin
  Result := CreateComObject(CLASS_QueryServer) as IQueryServer;
end;

class function CoQueryServer.CreateRemote(const MachineName: string):
  IQueryServer;
```

LISTING 27.3 Continued

```
begin
  Result := CreateRemoteComObject(MachineName, CLASS_QueryServer) as
    IQueryServer;
end;

class function TQueryServerCorbaFactory.CreateInstance(
  const InstanceName: string): IQueryServer;
begin
  Result := CorbaFactoryCreateStub(
    'IDL:SimpleCorbaServer/QueryServerFactory:1.0', 'QueryServer',
    InstanceName, '', IQueryServer) as IQueryServer;
end;

initialization
  CorbaStubManager.RegisterStub(IQueryServer, TQueryServerStub);
  CorbaInterfaceIDManager.RegisterInterface(IQueryServer,
    'IDL:SimpleCorbaServer/IQueryServer:1.0');
  CorbaSkeletonManager.RegisterSkeleton(IQueryServer, TQueryServerSkeleton);

end.
```

Notice that the Type Library Editor in conjunction with the Delphi wizards have generated all the necessary code to correctly marshal parameters. Parameters are marshaled from the stub to the ORB and are unmarshaled from the skeleton to the actual object implementation.

The only code we'll have to write is shown in Listing 27.4. You can see we only have to deal with correctly implementing our object's behavior; we don't have to get into the messy details of CORBA and parameter marshaling.

LISTING 27.4 The Implementation Unit for TQueryServer

```
unit uQueryServer;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, ComObj, StdVcl,
  CorbaObj, db, dbtables, orbpas, SimpleCorbaServer_TLB, frmqueryserver;

type

  TQueryServer = class(TCorbaImplementation, IQueryServer)
  private
    { Private declarations }
  end;
```

```

    FDatabase: TDatabase;
    FQuery: TQuery;
public
    { Public declarations }
    constructor Create(Controller: IObject; AFactory: TCorbaFactory); override;
    destructor Destroy; override;
protected
    function Data: OleVariant; safecall;
    function Get_BOF: WordBool; safecall;
    function Get_EOF: WordBool; safecall;
    function Get_FieldCount: Integer; safecall;
    function Get_SQL: WideString; safecall;
    function Login(const Db, User, Password: WideString): WordBool; safecall;
    procedure First; safecall;
    procedure Last; safecall;
    procedure Next; safecall;
    procedure Prev; safecall;
    procedure Set_SQL(const Value: WideString); safecall;
    function Execute: WordBool; safecall;
end;

implementation

uses CorbInit;

function TQueryServer.Data: OleVariant;
var
    i : integer;
begin
    //Pack and send data.
    Result := VarArrayCreate([0, FQuery.FieldCount-1], varOLEStr);
    for i := 0 to FQuery.FieldCount - 1 do
        begin
            Result[i] := FQuery.Fields[i].AsString;
        end;
    end;
end;

function TQueryServer.Get_BOF: WordBool;
begin
    Result := FQuery.BOF;
end;

function TQueryServer.Get_EOF: WordBool;
begin
    Result := FQuery.EOF;
end;

```

LISTING 27.4 Continued

```
function TQueryServer.Get_FieldCount: Integer;
begin
    Result := FQuery.FieldCount;
end;

function TQueryServer.Get_SQL: WideString;
begin
    Result := FQuery.SQL.Text;
end;

function TQueryServer.Login(const Db, User,
    Password: WideString): WordBool;
begin
    if FDatabase.Connected then FDatabase.Close;
    FDatabase.AliasName := Db;
    FDatabase.Params.Clear;
    FDatabase.Params.Add('USER NAME=' + User);
    FDatabase.Params.Add('PASSWORD=' + Password);
    FDatabase.Open;
end;

procedure TQueryServer.First;
begin
    FQuery.First;
end;

procedure TQueryServer.Last;
begin
    FQuery.Last;
end;

procedure TQueryServer.Next;
begin
    FQuery.Next;
end;

procedure TQueryServer.Prev;
begin
    FQuery.Prior;
end;

procedure TQueryServer.Set_SQL(const Value: WideString);
begin
    FQuery.SQL.Clear;
    FQuery.SQL.Add(Value);
end;
```

```
end;

constructor TQueryServer.Create(Controller: IObject;
  AFactory: TCorbaFactory);
begin
  inherited Create(Controller,AFactory);
  FDatabase := TDatabase.Create(nil);
  FDatabase.LoginPrompt := false;
  FDatabase.DatabaseName := 'CorbaDb';
  FDatabase.HandleShared := true;
  FQuery := TQuery.Create(nil);
  FQuery.DatabaseName := 'CorbaDb';
end;

destructor TQueryServer.Destroy;
begin
  FQuery.Free;
  FDatabase.Free;
  inherited Destroy;
end;

function TQueryServer.Execute: WordBool;
begin
  FQuery.Close;
  FQuery.Open;
end;

initialization
  TCorbaObjectFactory.Create('QueryServerFactory', 'QueryServer',
    'IDL:SimpleCorbaServer/QueryServerFactory:1.0', IQueryServer,
    TQueryServer, iMultiInstance, tmSingleThread);
end.
```

One VCL detail you should note in the code in Listing 27.4 is the correct handling of the `TDatabase` object. The BDE namespace only allows for one uniquely named database within the same session. Because we could have multiple `TQueryServer` objects within this CORBA server that are sharing a single `TSession` object, we must set the `HandleShared` property of the `TDatabase` to `True`. If we don't do this, the next client that causes a new `TQueryServer` to be created will not be able to connect.

From the Type Library Editor, you can view the IDL that represents our interface. Click the drop-down arrow on the `Export to IDL` speedbutton in the Type Library Editor and select `Export to CORBA IDL` (note that this is similar but yet different from Microsoft IDL, or *MIDL*). You'll see the IDL code in the Delphi editor, as shown in Listing 27.5.

LISTING 27.5 The CORBA IDL for IQueryServer

```
module SimpleCorbaServer
{
    interface IQueryServer;

    interface IQueryServer
    {
        boolean Login(in wstring Db, in wstring User, in wstring Password);
        wstring Get_SQL();
        wstring Set_SQL(in wstring Value);
        void Next();
        void Prev();
        void First();
        void Last();
        long Get_FieldCount();
        any Data();
        boolean Get_EOF();
        boolean Get_BOF();
        boolean Execute();
    };

    interface QueryServerFactory
    {
        IQueryServer CreateInstance(in string InstanceName);
    };
};
```

Notice that the COM data types we selected in the Type Library Editor have all been properly converted to their IDL equivalents. This IDL can be imported into any other tools that support CORBA. Development tools such as CBuilder and JBuilder will generate wrapper classes so that clients written in these languages can easily use the functionality of our Delphi CORBA object.

NOTE

The IDL generated by Delphi, shown in Listing 27.5, is actually slightly incorrect. The `Set_SQL` function should not be returning a value. Although Delphi should correctly handle this, the problem stems from the fact that we added a property (SQL) in the Type Library Editor. Properties are recognized by COM but are not a construct normally found in CORBA. Delphi has created the read and write methods for the

property, but has not exported the write method to IDL correctly. This problem can be avoided by only declaring methods on your CORBA interfaces, or by manually editing the generated IDL to correct the declaration as follows:

```
void Set_SQL(in wstring Value);
```

Running the CORBA Server

The construction of our query server is finally complete. Now it's time to run the CORBA server application and let the VisiBroker ORB know that our object is available to clients. In order for clients to locate and connect to CORBA object implementations using the VisiBroker ORB, the VisiBroker Smart Agent must be running somewhere on your local network. The agent does not have to be running on the same computer as the client or the server. The Smart Agent can be launched from the command line (on Windows NT the Smart Agent can be run as a service) by typing

```
OSAGENT [-options]
```

from the command prompt, where valid options are as follows:

- -p. Sets a port for the agent to listen on
- -v. Prints debugging information to `osagent.log`
- -?. Prints usage information to `osagent.log`
- -c. Runs `osagent` in console mode (only on NT; default for 95/98)

If you are manually starting the Smart Agent on Windows NT, it is important to launch `osagent` using the `-c` switch. This will allow an `osagent` that has been installed as an NT service to run as a console application. An example of starting the Smart Agent on Windows NT as a console application to listen for requests on port 14005 would look as follows:

```
osagent -c -p 14005.
```

Once the Smart Agent is running on the network, you can run the project we've just built and it will register itself with the Smart Agent and become available for client connections. Note that at this point you must actually run the server application; there is no built-in facility for launching a server (as in DCOM) unless you use the OAD.

Building an Early-Bound CORBA Client

Now that we have an available CORBA server serving objects, we can proceed to the next step and create a CORBA client with Delphi. We're going to build a simple client that uses the `IQueryServer` interface prepared earlier to read data from the server and populate a string grid with the retrieved data. It's important to realize that we're reaping the benefits of a multitier

architecture here. Our client only needs access to the VisiBroker ORB software and does not need any knowledge whatsoever of Delphi datasets or the Borland Database Engine (BDE).

A CORBA client can communicate via two ways with a CORBA object: early binding and late binding. *Early binding* means that the compiler can compile direct calls to the v-table of the stub. This not only offers performance benefits, but the compiler can provide type checking to ensure that you're passing correct parameter data types. In a late-binding scenario, all remote calls are made through the Any data type. Calls are slower because parameter information must be obtained from the VisiBroker Interface Repository and the incorrect parameter types are not detected until runtime. In order for Delphi to early-bind to a stub, the compiler must be supplied with some Pascal representation on the stub interface. With objects built in other languages, this becomes more difficult because Delphi 5 currently does not ship with a utility to convert IDL files into Pascal. In our case, we've built the server in Delphi and the wizards have generated a Pascal version of the stub interface. Therefore, we can early-bind to our server by simply including the stub and skeleton unit from the preceding example in the uses clause of our client.

Creating the CORBA Client

We'll first create a simple Delphi GUI application that will serve to view the results we obtain from the IQueryServer interface, as shown in Figure 27.8.

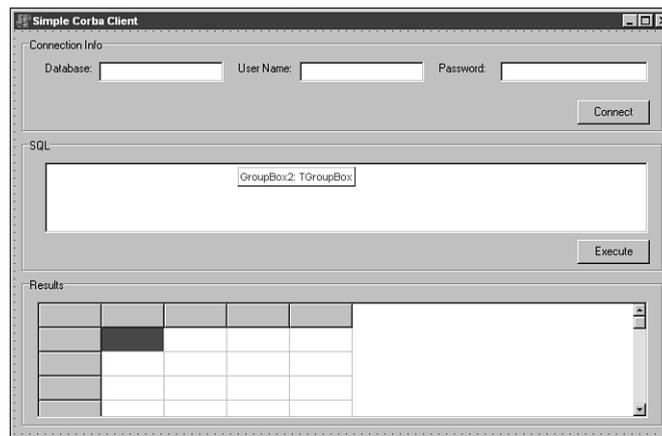


FIGURE 27.8

Our CORBA client GUI.

Having done this, we'll add the stub and skeleton unit from the server example to the uses clause of our form's unit (SimpleCorbaServer_TLB.pas).

Connecting to the CORBA Server

All that remains is to connect to our server and begin to make method calls against the remote interface. The used stub and skeleton unit defines a class factory for IQueryServer (named TQueryServerCorbaFactory). This class provides a class function (so we don't need to create an instance of TQueryServerCorbaFactory) named CreateInstance that will create the appropriate stub object and return the IQueryServer interface to us. We can then proceed to make early-bound calls to the remote IQueryServer interface. The only other nontrivial work in this client is to call the Data method of IQueryServer and unbundle the OLEVariant array in order to populate our string grid. This is done in the ExecuteClick event of our client. The complete implementation of our CORBA client is shown in Listing 27.6.

LISTING 27.6 The Implementation of SimpleCorbaClient

```
unit ufrmCorbaClient;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, SimpleCorbaServer_TLB, corbaObj, Grids;

type
  TForm1 = class(TForm)
    GroupBox1: TGroupBox;
    Label2: TLabel;
    edtDatabase: TEdit;
    Label3: TLabel;
    edtUserName: TEdit;
    Label4: TLabel;
    edtPassword: TEdit;
    Button5: TButton;
    GroupBox2: TGroupBox;
    memoSQL: TMemo;
    GroupBox3: TGroupBox;
    Button6: TButton;
    grdCorbaData: TStringGrid;
    procedure ConnectClick(Sender: TObject);
    procedure ExecuteClick(Sender: TObject);
  private
    { Private declarations }
    FQueryServer: IQueryServer;
  public
    { Public declarations }
  end;
```

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LISTING 27.6 Continued

```
var
  Form1: TForm1;

implementation

{$R *.DFM}

procedure TForm1.ConnectClick(Sender: TObject);
begin
  if not(assigned(FQueryServer)) then
    FQueryServer := TQueryServerCorbaFactory.CreateInstance('SimpleServer');
  FQueryServer.Login(edtDatabase.Text,edtUserName.Text,edtPassword.Text);
end;

procedure TForm1.ExecuteClick(Sender: TObject);
var
  i,j: integer;
  CorbaData : OLEVariant;
begin
  FQueryServer.SQL := memoSQL.Text;
  FQueryServer.Execute;

  grdCorbaData.ColCount := FQueryServer.FieldCount;
  grdCorbaData.RowCount := 0;
  j := 0;

  while not(FQueryServer.EOF) do
  begin
    inc(j);
    grdCorbaData.RowCount := j;
    CorbaData := (FQueryServer.Data);
    for i := 0 to FQueryServer.FieldCount - 1 do
    begin
      grdCorbaData.Cells[i + 1,j-1] := CorbaData[i];
    end;
    FQueryServer.Next;
  end;
end;

end.
```

Provided that you've launched the Smart Agent and the server is running where the Smart Agent can see it, you can now run this application and retrieve data from our CORBA server!

Building a Late-Bound CORBA Client

We're now going to modify our CORBA client so that it uses late binding to communicate with the remote interface. In CORBA we use what's called the *Dynamic Invocation Interface* (DII). Late binding is not necessary here because both the server and client were developed with Delphi. However, it's a useful technique to learn if you wish to easily use CORBA servers developed in other languages.

First, we can remove the stub and skeleton unit from the uses clause of our form's unit. Remember that if the server had been written in Java (for example), this would not be available for you to use anyway.

Second, our client now has no knowledge of the interface IQueryServer. Therefore, we'll change the data type of the encapsulated FQueryServer field from type IQueryServer to type TAny.

Third, we need to acquire a generic CORBA stub in a different manner than before. We can call the global Pascal CorbaBind method (from the CorbaObj unit) and pass the repository ID of the factory we're requesting. After we've acquired the factory, we can call the CreateInstance method of the factory that will return a generic interface. We can keep this interface in an Any and call late-bound methods from the reference. The complete source for the late-bound client is shown in Listing 27.7.

LISTING 27.7 The Late-Bound Query Server Client

```
unit ufrmCorbaClientLate;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, corbaObj, Grids;

type
  TForm1 = class(TForm)
    GroupBox1: TGroupBox;
    Label2: TLabel;
    edtDatabase: TEdit;
    Label3: TLabel;
    edtUserName: TEdit;
    Label4: TLabel;
    edtPassword: TEdit;
    Button5: TButton;
    GroupBox2: TGroupBox;
    memoSQL: TMemo;
  end;
```

continues

LISTING 27.7 Continued

```
    GroupBox3: TGroupBox;
    Button6: TButton;
    grdCorbaData: TStringGrid;
    procedure ConnectClick(Sender: TObject);
    procedure ExecuteClick(Sender: TObject);
private
    { Private declarations }
    FQueryServer: TAny;
public
    { Public declarations }
end;

var
    Form1: TForm1;

implementation

{$R *.DFM}

procedure TForm1.ConnectClick(Sender: TObject);
var
    Factory: TAny;
    User, Pass: WideString;
begin
    Factory := CorbaBind('IDL:SimpleCorbaServer/QueryServerFactory:1.0');
    FQueryServer := Factory.CreateInstance('');
    User := WideString(edtUserName.Text);
    Pass := WideString(edtPassword.Text);
    FQueryServer.Login(WideString(edtDatabase.Text), User, Pass);
end;

procedure TForm1.ExecuteClick(Sender: TObject);
var
    i, j: integer;
    CorbaData : OLEVariant;
begin
    FQueryServer.Set_SQL((memoSQL.Text));
    FQueryServer.Execute;

    grdCorbaData.ColCount := FQueryServer.Get_FieldCount;
    grdCorbaData.RowCount := 0;
    j := 0;

    while not(FQueryServer.Get_EOF) do
```

```
begin
  inc(j);
  grdCorbaData.RowCount := j;
  CorbaData := FQueryServer.Data;
  for i := 0 to FQueryServer.Get_FieldCount - 1 do
    begin
      grdCorbaData.Cells[i + 1,j-1] := CorbaData[i];
    end;
  FQueryServer.Next;
end;
end;

end.
```

You'll notice a couple other changes in the source code for the late-bound client.

IDL does not support the notion of “properties” as in COM. When we use early binding, we can get away with this because the compiler simply resolves to the address of the getter or setter method for the property. When we use late binding, the DII does not know about a property so we must call the getter or setter method explicitly. For example, instead of reading `FieldCount`, we would call `Get_FieldCount`.

All DII parameters are passed as `Any` types that store the data type as well. Some values need to be explicitly cast in order for the data type of the `Any` to be set correctly. For example, sending a string value to the `Login` method's `Db` parameter will cause the `Any`'s type to be set to `varString`. This will result in a bad parameter error unless the string is cast to a `WideString` so that the `Any`'s type is set to `varOleStr` (a `WideString`).

Finally, in addition to the Smart Agent, the `VisiBroker Interface Repository` must be running somewhere on your network and the `IQueryServer` interface must be registered with the `Interface Repository`. The `Interface Repository` is like an online database that allows the ORB to look up interface information for use with DII. The `VisiBroker Interface Repository` can be launched from the command line using the command

```
IREP [-console] IRname [file.idl]
```

The only required argument here is `IRname`. Because multiple `Interface Repository` instances can be running, this one needs to be identified somehow. The `-console` argument specifies whether the `Interface Repository` runs in console mode (the default is GUI mode), and the `file.idl` argument can specify an initial IDL file to be loaded when the repository starts. Additional IDL files can be loaded using the menu option (if running as GUI) or by running the `idl2ir` utility.

Cross-Language CORBA

At the time of writing, an Inprise-supplied Id12Pas compiler is still not present in Delphi; however, a pre-release version of such a tool does currently exist. In this section, we will discuss the steps required to manually early-bind to a CORBA server written in another language as well as take an introductory look at the forthcoming Id12Pas compiler.

Hand-Marshaling a Java CORBA Server

The following example uses a very simple CORBA server constructed in Java (JBuilder) that's to be called from a Delphi application. The IDL for the CORBA server is shown in Listing 27.8.

LISTING 27.8 The IDL for a Simple Java Server

```
module CorbaServer {  
    interface SimpleText {  
        string setText(in string txt);  
    };  
};
```

Provided the CORBA server has been registered with the Interface Repository, Delphi can easily access the server using DII (this code is shown in Listing 27.9 in the `btnDelphiTextEarly` method).

In order to early-bind without an Id12Pas compiler, we must hand-code our own stub class to perform the marshaling code. Although this is not exactly rocket science, it can be quite tedious and error-prone for a large number of methods. We must also register the stub class and the interface for the stub class with the proper Delphi mechanisms. Listing 27.9 contains the entire code.

LISTING 27.9 The Code for Accessing a Java Server from the Delphi Client (Early and Late Bound)

```
unit uDelphiClient;  
  
interface  
  
uses  
    Windows, Messages, SysUtils, CorbInit, CorbaObj, orbpas, Classes,  
    Graphics, Controls, Forms, Dialogs, StdCtrls;  
  
type  
  
    ISimpleText = interface  
        ['{49F25940-3C3C-11D3-9703-0000861F6726}']
```

```
    function SetText(const txt: String): String;
end;

TSimpleTextStub = class(TCorbaStub, ISimpleText)
public
    function SetText(const txt: String): String;
end;

TForm1 = class(TForm)
    edtDelphiText: TEdit;
    btnDelphiTextLate: TButton;
    btnDelphiTextEarlyClick: TButton;
    edtResult: TEdit;
    procedure btnDelphiTextLateClick(Sender: TObject);
    procedure btnDelphiTextEarlyClickClick(Sender: TObject);
private
    { Private declarations }
public
    { Public declarations }
end;

var
    Form1: TForm1;

implementation

{$R *.DFM}

procedure TForm1.btnDelphiTextLateClick(Sender: TObject);
var
    JavaServer: TAny;
begin
    JavaServer := ORB.Bind('IDL:CorbaServer/SimpleText:1.0');
    edtResult.Text := JavaServer.setText(edtDelphiText.text);
end;

{ TSimpleTextStub }

function TSimpleTextStub.SetText(const txt: String): String;
var
    InBuf: IMarshalInBuffer;
    OutBuf: IMarshalOutBuffer;
begin
    FStub.CreateRequest('setText', True, OutBuf);
    OutBuf.PutText(pchar(txt));
    FStub.Invoke(OutBuf, InBuf);
```

LISTING 27.9 Continued

```
    Result := UnmarshalText(InBuf);
end;

procedure TForm1.btnDelphiTextEarlyClickClick(Sender: TObject);
var
    JavaServer: ISimpleText;
begin
    JavaServer := CorbaBind(ISimpleText) as ISimpleText;
    edtResult.Text := JavaServer.SetText(edtDelphiText.text);
end;

initialization
    CorbaStubManager.RegisterStub(ISimpleText, TSimpleTextStub);
    CorbaInterfaceIDManager.RegisterInterface(ISimpleText,
        'IDL:CorbaServer/SimpleText:1.0');

end.
```

You will notice that the above code looks very similar to the code generated by the Type Library Editor when we create a CORBA object within Delphi. We have added our own descendant of `TCorbaStub` that will serve to provide client-side marshaling. Note that it is not necessary to descend from `TCorbaDispatchStub` because the Type Library Editor is not involved here. Next we implement our custom stub to marshal the parameters to and from the CORBA marshaling buffer interfaces: `IMarshalInBuffer` and `IMarshalOutBuffer`. These interfaces contain convenient methods for reading and writing various data types to the buffers. Consult the Delphi 5 online help for more information on using these methods. Finally, we need to register our custom stub and our interface with the Delphi CORBA framework. This code is shown in the initialization part of our unit.

The Inprise Id12Pas Compiler

As evident from the code in Listing 27.9, hand-marshaling a large CORBA object would require a great deal of work. The solution to this problem lies in the availability of an `Id12Pas` compiler that can automatically generate the appropriate marshaling code for our stub. By the time you read this chapter, such a tool should be available from Inprise. We will conclude this section by taking a brief look at the current per-release version of `Id12Pas`.

The Inprise `Id12Pas` compiler is implemented in Java and therefore requires a Java VM to be installed on your development machine. A suitable Java Runtime Environment (JRE) is provided when you install Delphi 5. The current pre-release `Id12Pas` compiler is not yet integrated into the Delphi IDE, so we must invoke the compiler from the command line using the supplied `Id12Pas.bat` batch file. The command necessary to invoke `Id12Pas` on `SimpleText.idl` and store the generated files in `c:\idl` would look as follows:

```
IDL2PAS -root_dir c:\idl SimpleText.idl
```

The Idl2Pas compiler will generate two files in the specified directory, named after the module name included in the idl file. For our example, CorbaServer_i.pas will contain the Pascal declarations for the idl interfaces and is shown in Listing 27.10.

LISTING 27.10 Interface Definitions Generated from Idl2Pas

```
unit CorbaServer_i;

// This file was generated on 4 Nov 1999 17:58:12 GMT by version
// 01.09.00.A2.032c of the Inprise VisiBroker idl2pas CORBA IDL compiler.

//Delphi Pascal unit CorbaServer_i for the CorbaServer IDL module.
// The purpose of this file is to declare the interfaces and variables used in
// the associated client (CorbaServer_c)
// and/or server      (CorbaServer_s) units.

//This unit contains the pascal interface code for IDL module CorbaServer.

(* IDL Source      : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
      SimpleText.idl", line 1
** IDL Name       : module
** Repository Id  : IDL:CorbaServer:1.0
** IDL definition :
*)

interface

uses
  CORBA;

type
  //These forward references have been supplied to resolve dependencies between
  //the following interfaces.
  SimpleText = interface;
  //These interface definitions were generated from the IDL from which this
  //unit originated.

  //Signature for the "CorbaServer_i.SimpleText" interface derived from the IDL
  //interface "SimpleText".

(* IDL Source      : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
      SimpleText.idl", line 2
** IDL Name       : interface
```

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continues

LISTING 27.10 Continued

```
** Repository Id : IDL:CorbaServer/SimpleText:1.0
** IDL definition :
*)
SimpleText = interface
  [{C8864064-C211-B145-29DB-CD5119D884CD}]

  //Interface methods representing IDL operations.

  (* IDL Source      : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
    SimpleText.idl", line 3
  ** IDL Name       : operation
  ** Repository Id  : IDL:CorbaServer/SimpleText/setText:1.0
  ** IDL definition :
  *)
  function  setText (const txt : AnsiString): AnsiString;
end;

implementation

  //The implementation code (if any) is located in the associated _C file.

initialization

end.
```

The second generated file, `CorbaServer_c.pas`, contains the implementation code for the stub class as well as a helper object (`TSimpleTextHelper`) that facilitates the passing of non-simple data type such as structs, unions, and user-defined data types. The generated implementation code is shown in Listing 27.11.

LISTING 27.11 Stub and Helper Classes Generated from `Id12Pas`

```
unit CorbaServer_c;

// c:\icon99\MultiLanguage\MyProjects\CorbaServer\SimpleText.idl.

//Delphi Pascal unit CorbaServer_i for the CorbaServer IDL module.
// The purpose of this file is to implement the client-side classes (stubs)
// required by the associated Interface unit (CorbaServer_i).
// This unit must be matched with it's associated skeleton unit on the server
// side.
```

```
//This unit contains the stub code for IDL module CorbaServer.

(* IDL Source      : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
                    SimpleText.idl", line 1
** IDL Name       : module
** Repository Id  : IDL:CorbaServer:1.0
** IDL definition :
*)

interface

uses
  CORBA,
  CorbaServer_i;

type
  //These forward references have been supplied to resolve dependencies between
  //the following interfaces.
  TSimpleTextHelper = class;
  TSimpleTextStub = class;
  //These stub and helper interfaces were generated from the IDL from which
  //this unit originated.

  //Pascal helper class "CorbaServer_c.TSimpleTextHelper" for the Pascal
  //interface "CorbaServer_i.SimpleText".

(* IDL Source      : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
                    SimpleText.idl", line 2
** IDL Name       : interface
** Repository Id  : IDL:CorbaServer/SimpleText:1.0
** IDL definition :
*)

TSimpleTextHelper = class
  class procedure Insert(const A: CORBA.Any;
    const Value: CorbaServer_i.SimpleText);
  class function Extract(const A: CORBA.Any): CorbaServer_i.SimpleText;
  class function TypeCode: CORBA.TypeCode;
  class function RepositoryId: string;
  class function Read(const Input: CORBA.InputStream):
    CorbaServer_i.SimpleText;
  class procedure Write(const Output: CORBA.OutputStream;
    const Value: CorbaServer_i.SimpleText);
  class function Narrow(const Obj: CORBA.CORBAObject; IsA: Boolean = False):
    CorbaServer_i.SimpleText;
  class function Bind(const InstanceName: string = '');
```

LISTING 27.11 Continued

```

        HostName : string = ''): CorbaServer_i.SimpleText; overload;
    class function Bind(Options: BindOptions;
        const InstanceName: string = ''; HostName: string = ''):
        CorbaServer_i.SimpleText; overload;
end;

//Pascal stub class "CorbaServer_c.TSimpleTextStub supporting the Pascal
//interface "CorbaServer_i.SimpleText".

(* IDL Source      : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
    SimpleText.idl", line 2
** IDL Name       : interface
** Repository Id  : IDL:CorbaServer/SimpleText:1.0
** IDL definition :
*)

TSimpleTextStub = class(CORBA.TCORBAObject, CorbaServer_i.SimpleText)
public

    (* IDL Source      : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
        SimpleText.idl", line 3
    ** IDL Name       : operation
    ** Repository Id  : IDL:CorbaServer/SimpleText/setText:1.0
    ** IDL definition :
    *)
    function setText ( const txt : AnsiString): AnsiString; virtual;

end;

implementation
//These stub and helper implementations were generated from the IDL from
//which this unit originated.

//Implementation of the Pascal helper class "CorbaServer_c.TSimpleTextHelper"
//supporting the Pascal interface "CorbaServer_i.SimpleText.

(* IDL Source      : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
    SimpleText.idl", line 2
** IDL Name       : interface
** Repository Id  : IDL:CorbaServer/SimpleText:1.0
** IDL definition :
*)

class procedure TSimpleTextHelper.Insert(const A: CORBA.Any;
    const Value: CorbaServer_i.SimpleText);

```

```
begin
  //TAnyHelper.InsertObject(Value);
end;

class function TSimpleTextHelper.Extract(const A: CORBA.Any):
  CorbaServer_i.SimpleText;
begin
  //TAnyHelper.ExtractObject as CorbaServer_i.SimpleText;
end;

class function TSimpleTextHelper.TypeCode: CORBA.TypeCode;
begin
  Result := ORB.CreateInterfaceTC(RepositoryId, 'CorbaServer_i.SimpleText');
end;

class function TSimpleTextHelper.RepositoryId: string;
begin
  Result := 'IDL:CorbaServer/SimpleText:1.0';
end;

class function TSimpleTextHelper.Read(const Input: CORBA.InputStream):
  CorbaServer_i.SimpleText;
var
  Obj: CORBA.CORBAObject;
begin
  Input.ReadObject(Obj);
  Result := Narrow(Obj, True)
end;

class procedure TSimpleTextHelper.Write(const Output: CORBA.OutputStream;
  const Value: CorbaServer_i.SimpleText);
begin
  Output.WriteObject(Value as CORBA.CORBAObject);
end;

class function TSimpleTextHelper.Narrow(const Obj: CORBA.CORBAObject;
  IsA: Boolean): CorbaServer_i.SimpleText;
begin
  Result := nil;
  if (Obj = nil) or (Obj.QueryInterface(CorbaServer_i.SimpleText, Result) = 0)
  then Exit;
  if IsA and Obj._IsA(RepositoryId) then
    Result := TSimpleTextStub.Create(Obj);
end;
```

LISTING 27.11 Continued

```
class function TSimpleTextHelper.Bind(const InstanceName: string = '';
  HostName: string = ''): CorbaServer_i.SimpleText;
begin
  Result := Narrow(ORB.bind(RepositoryId, InstanceName, HostName), True);
end;

class function TSimpleTextHelper.Bind(
  Options: BindOptions; const InstanceName: string = '';
  HostName: string = ''): CorbaServer_i.SimpleText;
begin
  Result := Narrow(ORB.bind(RepositoryId, Options, InstanceName, HostName),
    True);
end;
//Implementation of the Pascal stub class "CorbaServer_c.TSimpleTextStub"
//supporting the Pascal "CorbaServer_i.SimpleText" interface.

//Implementation of Interface methods representing IDL operations.

(* IDL Source      : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
  SimpleText.idl", line 3
** IDL Name       : operation
** Repository Id  : IDL:CorbaServer/SimpleText/setText:1.0
** IDL definition :
*)
function TSimpleTextStub.setText ( const txt : AnsiString): AnsiString;
var
  Output: CORBA.OutputStream;
  Input : CORBA.InputStream;
begin
  inherited _CreateRequest('setText',True, Output);
  Output.WriteString(txt);
  inherited _Invoke(Output, Input);
  Input.ReadString(Result);
end;

initialization

//These stub and helper initialization calls were generated from the IDL from
//which this unit originated.

//Initialization of the Pascal helper class "CorbaServer_c.TSimpleTextStub".

(* IDL Source      : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
  SimpleText.idl", line 2
```

```
** IDL Name      : interface
** Repository Id : IDL:CorbaServer/SimpleText:1.0
** IDL definition :
*)
CORBA.InterfaceIDManager.RegisterInterface(CorbaServer_i.SimpleText,
    CorbaServer_c.TSimpleTextHelper.RepositoryId);

//Initialization of the CorbaServer_c.TSimpleTextStub interface stub for the
//CorbaServer_i.SimpleTextInterface.

(* IDL Source    : "c:\icon99\MultiLanguage\MyProjects\CorbaServer\
    SimpleText.idl", line 2
** IDL Name      : interface
** Repository Id : IDL:CorbaServer/SimpleText:1.0
** IDL definition :
*)
CORBA.StubManager.RegisterStub(CorbaServer_i.SimpleText,
    CorbaServer_c.TSimpleTextStub);

end.
```

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You may notice that the marshaling code contained within the `setText` method of the generated code differs slightly from the code we wrote to hand-marshall this same interface. This is because the `Id12Pas` tool uses a different DLL to provide ORB/Pascal access (`OrbPas33.dll`) and provides two new Pascal units that supplement the Delphi CORBA framework (`Corba.pas`, `OrbPas30.pas`). These new additions will peacefully coexist and not replace the units and libraries currently shipping with Delphi 5.

The release of the Inprise `Id12Pas` compiler will help you to simplify some of the more difficult CORBA tasks such as calling servers written in other languages, marshaling non-simple data types, and handling custom user exceptions.

Deploying the VisiBroker ORB

The VisiBroker ORB requires a runtime deployment license. Although Delphi 5 Enterprise includes the VisiBroker services in the development environment, you should check with Inprise before actually deploying your solutions.

ORB services will need to be deployed on server machines as well as client computers. As mentioned previously, many of the other VisiBroker services (such as `osagent`, `irep`, and `oad`) can be executing anywhere in your local network; therefore, deployment of these services may not be necessary on all machines that are using ORB software. As mentioned, the primary C++ ORB used with Delphi is the dynamic link library `orb_br.dll`. A common problem reported

with Windows VisiBroker installations is that the DOS path is not correctly defined. This must be done in order for the system to locate the ORB DLLs. Also, remember that Delphi uses a special “thunking” layer (`orbpas50.dll`) in order to map IDL interfaces to Delphi interfaces and provide other access to the C++ ORB. `orbpas50.dll` must also be deployed for all Delphi 5 CORBA installations.

Summary

In this chapter we’ve examined the basics of CORBA development with Delphi 5. We’ve created both CORBA clients and servers as well as experimented with both early and late binding. We’ve also looked at what’s required in order to early-bind to a CORBA server written in another language. Finally, we have taken a sneak peek at the Inprise `Id12Pas` compiler and demonstrated how the release of this tool will help simplify CORBA development with Delphi.

Database Development

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Writing Desktop Database Applications

CHAPTER

28

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In this chapter, you'll learn the art and science of accessing external database files from your Delphi applications. If you're new to database programming, we do assume a bit of database knowledge, but this chapter will get you started on the road to creating high-quality database applications. If database applications are "old hat" to you, you'll benefit from the chapter's demonstration of Delphi's spin on database programming. In this chapter, you first learn about datasets and techniques for manipulating them, and later you learn how to work with tables and queries specifically. Along the way, this chapter outlines the important points you need to know to be a productive Delphi database developer.

Delphi 5 ships with version 5.0 of the Borland Database Engine (BDE), which offers you the capability to communicate with Paradox, dBASE, Access, FoxPro, ODBC, ASCII text, and SQL database servers all in much the same manner. Unlike previous versions, the Standard edition of Delphi 5 does not contain database connectivity. The Professional edition provides connections to file-based Paradox, dBASE, Access, FoxPro, and ASCII text formats, in addition to connectivity to Local InterBase and ODBC data sources. Delphi Enterprise builds upon Delphi Professional, adding high-performance BDE SQL Links connections for InterBase, Microsoft SQL Server, Oracle, Informix Dynamic Server, Sybase Adaptive Server, and DB2. Additionally, Delphi Enterprise also provides ADOExpress components for native access to Microsoft ActiveX Data Objects (ADO) data sources. The topics discussed pertain primarily to using Delphi with file-based data, such as Paradox and dBASE tables, although the chapter will also touch on data access via ODBC and ADO. This chapter also serves as a primer for the next chapter, "Developing Client/Server Applications."

Working with Datasets

A *dataset* is a collection of rows and columns of data. Each *column* is of some homogeneous data type, and each *row* is made up of a collection of data of each column data type. Additionally, a column is also known as a *field*, and a row is sometimes called a *record*. VCL encapsulates a dataset into an abstract component called `TDataSet`. `TDataSet` introduces many of the properties and methods necessary for manipulating and navigating a dataset.

To help keep the nomenclature clear and to cover some of the basics, the following list explains some of the common database terms that are used in this and other database-oriented chapters:

- A *dataset* is a collection of discrete data records. Each record is made up of multiple fields. Each field can contain a different type of data (integer number, string, decimal number, graphic, and so on). Datasets are represented by VCL's abstract `TDataSet` class.
- A *table* is a special type of dataset. A table is generally a file containing records that are physically stored on a disk somewhere. VCL's `TTable` class encapsulates this functionality.

- A *query* is also a special type of dataset. Think of queries as “memory tables” that are generated by special commands that manipulate some physical table or set of tables. VCL has a `TQuery` class to handle queries.
- A *database* refers to a directory on a disk (when dealing with nonserver data such as Paradox and dBASE files) or a SQL database (when dealing with SQL servers). A database can contain multiple tables. As you may have guessed, VCL also has a `TDatabase` class.
- An *index* defines rules by which a table is ordered. To have an index on a particular field in a table means to sort its records based on the value that field holds for each record. The `TTable` component contains properties and methods that help you manipulate indexes.

NOTE

We mentioned earlier that this chapter assumes a bit of database knowledge. This chapter is not intended to be a primer on database programming, and we expect that you’re already familiar with the items in this list. If terms such as *database*, *table*, and *index* sound foreign to you, you might want to obtain an introductory text on database concepts.

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VCL Database Architecture

During the development of Delphi 3, VCL’s database architecture was significantly overhauled in order to open the dataset architecture to allow non-BDE datasets to more easily be used within Delphi. At the root of this architecture is the base `TDataSet` class. `TDataSet` is a component that provides an abstract representation of dataset records and fields. A number of methods of `TDataSet` can be overridden in order to create a component that communicates with some particular physical data format. Following this formula, VCL’s `TBDEDataSet` descends from `TDataSet` and serves as the base class for data sources that communicate via the BDE. If you’d like to learn how to create a `TDataSet` descendant to plug some type of custom data into this architecture, you’ll find an example in Chapter 30, “Extending Database VCL.”

BDE Data-Access Components

The Data Access page of the Component Palette contains the VCL components you’ll use to access and manage BDE datasets. These are shown in Figure 28.1. VCL represents datasets with three components: `TTable`, `TQuery`, and `TStoredProc`. These components all descend directly from the `TBDEDataSet` component, which descends from `TBDEDataSet` (which, in turn,

descends from `TDataSet`). As mentioned earlier, `TDataSet` is an abstract component that encapsulates dataset management, navigation, and manipulation. `TBDEDataSet` is an abstract component that represents a BDE-specific dataset. `TBDDataset` introduces concepts such as BDE databases and sessions (these are explained in detail in the next chapter). Throughout the rest of this chapter, we'll refer to this type of BDE-specific dataset simply as a *dataset*.

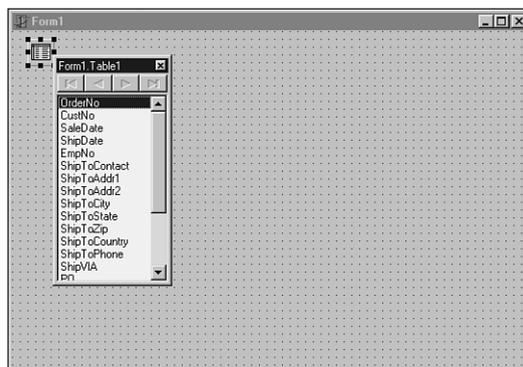


FIGURE 28.1

The Data Access page of the Component Palette.

As their names imply, `TTable` is a component that represents the structure and data contained within a database table, `TQuery` is a component representing the set of data returned from a SQL query operation, and `TStoredProc` encapsulates a stored procedure on a SQL server. In this chapter, for simplicity's sake, we use the `TTable` component when discussing datasets. Later, the `TQuery` component is covered in detail.

Opening a Dataset

Before you can do any nifty manipulation of your dataset, you must first open it. To open a dataset, simply call its `Open()` method, as shown in this example:

```
Table1.Open;
```

This is equivalent, by the way, to setting a dataset's `Active` property to `True`:

```
Table1.Active := True;
```

There's slightly less overhead in the latter method, because the `Open()` method ends up setting the `Active` property to `True`. However, the overhead is so minimal that it's not worth worrying about.

Once the dataset has been opened, you're free to manipulate it, as you'll see in just a moment. When you finish using the dataset, you should close it by calling its `Close()` method, like this:

```
Table1.Close;
```

Alternatively, you could close it by setting its `Active` property to `False`, like this:

```
Table1.Active := False;
```

TIP

When you're communicating with SQL servers, a connection to the database must be established when you first open a dataset in that database. When you close the last dataset in a database, your connection is terminated. Opening and closing these connections involves a certain amount of overhead. Therefore, if you find that you open and close the connection to the database often, use a `TDatabase` component instead to maintain a connection to a SQL server's database throughout many open and close operations. The `TDatabase` component is explained in more detail in the next chapter.

Navigating Datasets

`TDataSet` provides some simple methods for basic record navigation. The `First()` and `Last()` methods move you to the first and last records in the dataset, respectively, and the `Next()` and `Prior()` methods move you either one record forward or back in the dataset. Additionally, the `MoveBy()` method, which accepts an `Integer` parameter, moves you a specified number of records forward or back.

NOTE

One of the big, but less obvious, benefits of using the BDE is that it allows navigable SQL tables and queries. SQL data generally is not navigable—you can move forward through the rows of a query but not backward. Unlike ODBC, BDE makes SQL data navigable.

BOF, EOF, and Looping

`BOF` and `EOF` are Boolean properties of `TDataSet` that reveal whether the current record is the first or last record in the dataset. For example, you might need to iterate through each record in a dataset until reaching the last record. The easiest way to do so would be to employ a `while` loop to keep iterating over records until the `EOF` property returns `True`, as shown here:

```
Table1.First; // go to beginning of data set
while not Table1.EOF do // iterate over table
begin
```

```
// do some stuff with current record
Table1.Next; // move to next record
end;
```

CAUTION

Be sure to call the `Next()` method inside your `while-not-EOF` loop; otherwise, your application will get caught in an endless loop.

Avoid using a `repeat..until` loop to perform actions on a dataset. The following code may look OK on the surface, but bad things may happen if you try to use it on an empty dataset, because the `DoSomeStuff()` procedure will always execute at least once, regardless of whether the dataset contains records:

```
repeat
  DoSomeStuff;
  Table1.Next;
until Table1.EOF;
```

Because the `while-not-EOF` loop performs the check up front, you won't encounter such a problem with this construct.

Bookmarks

Bookmarks enable you to save your place in a dataset so that you can come back to the same spot at a later time. Bookmarks are very easy to use in Delphi because you only have one property to remember.

Delphi represents a bookmark as type `TBookmarkStr`. `TTable` has a property of this type called `Bookmark`. When you read from this property, you obtain a bookmark, and when you write to this property, you go to a bookmark. When you find a particularly interesting place in a dataset that you'd like to be able to get back to easily, here's the syntax to use:

```
var
  BM: TBookmarkStr;
begin
  BM := Table1.Bookmark;
```

When you want to return to the place in the dataset you marked, just do the reverse—set the `Bookmark` property to the value you obtained earlier by reading the `Bookmark` property:

```
Table1.Bookmark := BM;
```

TBookmarkStr is defined as an AnsiString, so memory is automatically managed for bookmarks (you never have to free them). If you'd like to clear an existing bookmark, just set it to an empty string:

```
BM := '';
```

Note that TBookmarkStr is an AnsiString for storage convenience. You should consider it an opaque data type and not depend on the implementation, because the bookmark data is completely determined by BDE and the underlying data layers.

NOTE

Although 32-bit Delphi still supports `GetBookmark()`, `GotoBookmark()`, and `FreeBookmark()` from Delphi 1.0, because the 32-bit Delphi technique is a bit cleaner and less prone to error, you should use this newer technique unless you have to maintain compatibility with 16-bit projects.

Navigational Example

You'll now create a small project that incorporates the TDataSet navigational methods and properties you just learned. This project will be called Navig8, and the main form for this project is shown in Figure 28.2.

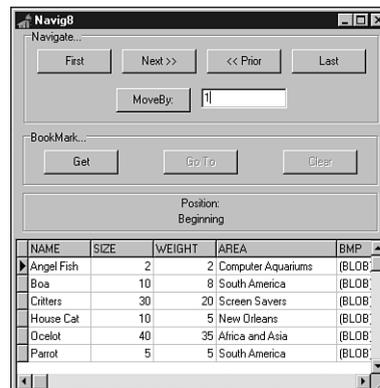


FIGURE 28.2

The Navig8 project's main form.

To display the data contained in a TTable object, this project will employ the TDBGrid component. The process of “wiring” a data-aware control such as the TDBGrid component to a dataset

requires several steps. The following list covers the steps for displaying Table1's data in DBGrid1:

1. Set Table1's DatabaseName property to an existing alias or directory. Use the DBDEMOS alias if you installed Delphi's sample programs.
2. Choose a table from the list presented in Table1's TableName property.
3. Drop a TDataSource component on the form and wire it to TTable by setting DataSource1's dataset property to Table1. TDataSource serves as a conduit between data sources and controls; it's explained in more detail earlier in the chapter.
4. Wire the TDBGrid component to the TDataSource component by setting DBGrid1's DataSource property to DataSource1.
5. Open the table by setting Table1's Active property to True.
6. Poof! You now have data in the grid control.

TIP

A shortcut for picking components from the drop-down list provided for the DataSet and DataSource properties is to double-click the area to the right of the property name in the Object Inspector. This sets the property value to the first item in the drop-down list.

The source code for main unit of Navig8, called Nav.pas, is shown in Listing 28.1.

LISTING 28.1 The Source Code for Nav.pas

```
unit Nav;  
  
interface  
  
uses  
  SysUtils, Windows, Messages, Classes, Controls, Forms, StdCtrls,  
  Grids, DBGrids, DB, DBTables, ExtCtrls;  
  
type  
  TForm1 = class(TForm)  
    Table1: TTable;  
    DataSource1: TDataSource;  
    DBGrid1: TDBGrid;  
    GroupBox1: TGroupBox;  
    GetButton: TButton;  
    GotoButton: TButton;
```

```
ClearButton: TButton;
GroupBox2: TGroupBox;
FirstButton: TButton;
LastButton: TButton;
NextButton: TButton;
PriorButton: TButton;
MoveByButton: TButton;
Edit1: TEdit;
Panel1: TPanel;
PosLbl: TLabel;
Label1: TLabel;
procedure FirstButtonClick(Sender: TObject);
procedure LastButtonClick(Sender: TObject);
procedure NextButtonClick(Sender: TObject);
procedure PriorButtonClick(Sender: TObject);
procedure MoveByButtonClick(Sender: TObject);
procedure DataSource1DataChange(Sender: TObject; Field: TField);
procedure GetButtonClick(Sender: TObject);
procedure GotoButtonClick(Sender: TObject);
procedure ClearButtonClick(Sender: TObject);
private
  BM: TBookmarkStr;
public
  { Public declarations }
end;

var
  Form1: TForm1;

implementation

{$R *.DFM}

procedure TForm1.FirstButtonClick(Sender: TObject);
begin
  Table1.First;      // Go to first record in table
end;

procedure TForm1.LastButtonClick(Sender: TObject);
begin
  Table1.Last;      // Go to last record in table
end;

procedure TForm1.NextButtonClick(Sender: TObject);
begin
  Table1.Next;      // Go to next record in table
```

LISTING 28.1 Continued

```
end;

procedure TForm1.PriorButtonClick(Sender: TObject);
begin
    Table1.Prior;          // Go to prior record in table
end;

procedure TForm1.MoveByButtonClick(Sender: TObject);
begin
    // Move a specified number of record forward or back in the table
    Table1.MoveBy(StrToInt(Edit1.Text));
end;

procedure TForm1.DataSource1DataChange(Sender: TObject; Field: TField);
begin
    // Set caption appropriately, depending on state of Table1 BOF/EOF
    if Table1.BOF then PosLbl.Caption := 'Beginning'
    else if Table1.EOF then PosLbl.Caption := 'End'
    else PosLbl.Caption := 'Somewheres in between';
end;

procedure TForm1.GetButtonClick(Sender: TObject);
begin
    BM := Table1.Bookmark;          // Get a bookmark
    GotoButton.Enabled := True;     // Enable/disable proper buttons
    GetButton.Enabled := False;
    ClearButton.Enabled := True;
end;

procedure TForm1.GotoButtonClick(Sender: TObject);
begin
    Table1.Bookmark := BM;         // Go to the bookmark position
end;

procedure TForm1.ClearButtonClick(Sender: TObject);
begin
    BM := '';                      // clear the bookmark
    GotoButton.Enabled := False;   // Enable/disable appropriate buttons
    GetButton.Enabled := True;
    ClearButton.Enabled := False;
end;

end.
```

This example illustrates quite well the fact that you can use Delphi's database classes to do quite a lot of database manipulation in your programs with very little code.

Note that you should initially set the `Enabled` properties of `GotoButton` and `FreeButton` to `False`, because you can't use them until a bookmark is allocated. The `FreeButtonClick()` and `GetButtonClick()` methods ensure that the proper buttons are enabled, depending on whether a bookmark has been set.

Most of the other procedures in this example are one-liners, although one method that does require some explanation is `TForm1.DataSource1DataChange()`. This method is wired to `DataSource1's OnDataChange` event, which fires every time a field value changes (for example, when you move from one record to another). This event checks to see whether you're at the beginning, in the middle, or at the end of a dataset; it then changes the label's caption appropriately. You'll learn more about the `TTable` and `TDataSource` events a bit later in this chapter.

BOF and EOF

You may notice that when you run the `Navig8` project, `PosLb1's` caption indicates that you're at the beginning of the dataset, which makes sense. However, if you move to the next record and back again, `PosLb1's` caption isn't aware that you're at the first record. Notice, however, that `PosLb1.Caption` does indicate `BOF` if you click the `Prior` button once more. Note that the same holds true for `EOF` if you try this at the end of the dataset. Why?

The reason is that the `BDE` cannot be sure you're at the beginning or end of the dataset anymore, because another user of the table (if it's a networked table) or even another process within your program could have added a record to the beginning or end of the table in the time it took you to move from the first to the second record and then back again.

With that in mind, `BOF` can only be `True` under one of the following circumstances:

- You just opened the dataset.
- You just called the dataset's `First()` method.
- A call to `TDataSet.Prior()` failed, indicating that there are no prior records.

Likewise, `EOF` can only be `True` under the following circumstances:

- You opened an empty dataset.
- You just called the dataset's `Last()` method.
- A call to `TDataSet.Next()` failed, indicating that there are no more records.

A subtle but important piece of information that you can garner from this list is that you know a dataset is empty when both `BOF` and `EOF` are `True`.

TDataSource

A `TDataSource` component was used in that last example, so let's digress for a moment to discuss this very important object. `TDataSource` is the conduit that enables data-access components such as `TTable` components to connect to data controls such as `TDBEdit` and `TDBLookupCombo` components. In addition to being the interface between datasets and data-aware controls, `TDataSource` contains a couple of handy properties and events that make your life easier when manipulating data.

The `State` property of `TDataSource` reveals the current state of the underlying dataset. The value of `State` tells you whether the dataset is currently inactive or in `Insert`, `Edit`, `SetKey`, or `CalcFields` mode, for example. The `State` property of `TDataSet` is explained in more detail later in this chapter. The `OnStateChange` event fires whenever the value of this property changes.

The `OnDataChange` event of `TDataSet` is executed whenever the dataset becomes active or a data-aware control informs the dataset that something has changed.

The `OnUpdateData` event occurs whenever a record is posted or updated. This is the event that causes data-aware controls to change their value based on the contents of the table. You can respond to the event yourself to keep track of such changes within your application.

Working with Fields

Delphi enables you to access the fields of any dataset through the `TField` object and its descendants. Not only can you get and set the value of a given field of the current record of a dataset, but you can also change the behavior of a field by modifying its properties. You can also modify the dataset, itself, by changing the visual order of fields, removing fields, or even creating new calculated or lookup fields.

Field Values

It's very easy to access field values from Delphi. `TDataSet` provides a default array property called `FieldValues[]` that returns the value of a particular field as a `Variant`. Because `FieldValues[]` is the default array property, you don't need to specify the property name to access the array. For example, the following piece of code assigns the value of `Table1`'s `CustName` field to `String S`:

```
S := Table1['CustName'];
```

You could just as easily store the value of an integer field called `CustNo` in an integer variable called `I`:

```
I := Table1['CustNo'];
```

A powerful corollary to this is the capability to store the values of several fields into a Variant array. The only catches are that the Variant array index must be zero based and the Variant array contents should be varVariant. The following code demonstrates this capability:

```
const
  AStr = 'The %s is of the %s category and its length is %f in.';
var
  VarArr: Variant;
  F: Double;
begin
  VarArr := VarArrayCreate([0, 2], varVariant);
  { Assume Table1 is attached to Biolife table }
  VarArr := Table1['Common_Name;Category;Length_In'];
  F := VarArr[2];
  ShowMessage(Format(AStr, [VarArr[0], VarArr[1], F]));
end;
```

Delphi 1 programmers will note that the `FieldValues[]` technique is much easier than the previous technique for accessing field values. That technique (which still works in 32-bit Delphi for backward compatibility) involves using `TDataset`'s `Fields[]` array property or `FieldsByName()` function to access individual `TField` objects associated with the dataset. The `TField` component provides information about a specific field.

`Fields[]` is a zero-based array of `TField` objects, so `Fields[0]` returns a `TField` representing the first logical field in the record. `FieldsByName()` accepts a string parameter that corresponds to a given field name in the table; therefore, `FieldsByName('OrderNo')` would return a `TField` component representing the `OrderNo` field in the current record of the dataset.

Given a `TField` object, you can retrieve or assign the field's value using one of the `TField` properties shown in Table 28.1.

TABLE 28.1 Properties to Access `TField` Values

<i>Property</i>	<i>Return Type</i>
<code>AsBoolean</code>	<code>Boolean</code>
<code>AsFloat</code>	<code>Double</code>
<code>AsInteger</code>	<code>Longint</code>
<code>AsString</code>	<code>String</code>
<code>AsDateTime</code>	<code>TDateTime</code>
<code>Value</code>	<code>Variant</code>

If the first field in the current dataset is a string, you can store its value in the `String` variable `S`, like this:

```
S := Table1.Fields[0].AsString;
```

The following code sets the integral variable `I` to contain the value of the 'OrderNo' field in the current record of the table:

```
I := Table1.FieldsByName('OrderNo').AsInteger;
```

Field Data Types

If you want to know the type of a field, look at `TField`'s `DataType` property, which indicates the data type with respect to the database table (irrespective of a corresponding Object Pascal type). The `DataType` property is of `TFieldType`, and `TFieldType` is defined as follows:

```
type
```

```
TFieldType = (ftUnknown, ftString, ftSmallint, ftInteger, ftWord,  
ftBoolean, ftFloat, ftCurrency, ftBCD, ftDate, ftTime, ftDateTime,  
ftBytes, ftVarBytes, ftAutoInc, ftBlob, ftMemo, ftGraphic, ftFmtMemo,  
ftParadoxOle, ftDBaseOle, ftTypedBinary, ftCursor, ftFixedChar,  
ftWideString, ftLargeint, ftADT, ftArray, ftReference, ftDataSet,  
ftOraBlob, ftOraClob, ftVariant, ftInterface, ftIDispatch, ftGuid);
```

There are descendants of `TField` designed to work specifically with many of the preceding data types. These are covered a bit later in this chapter.

Field Names and Numbers

To find the name of a specified field, use `TField`'s `FieldName` property. For example, the following code places the name of the first field in the current table in the `String` variable `S`:

```
var  
  S: String;  
begin  
  S := Table1.Fields[0].FieldName;  
end;
```

Likewise, you can obtain the number of a field you know only by name by using the `FieldNo` property. The following code stores the number of the `OrderNo` field in the `Integer` variable `I`:

```
var  
  I: integer;  
begin  
  I := Table1.FieldsByName('OrderNo').FieldNo;  
end;
```

NOTE

To determine how many fields a dataset contains, use `TDataset`'s `FieldList` property. `FieldList` represents a flattened view of all the nested fields in a table containing fields that are abstract data types (ADTs).

For backward compatibility, the `FieldCount` property still works, but it will skip over any ADT fields.

Manipulating Field Data

Here's a three-step process for editing one or more fields in the current record:

1. Call the dataset's `Edit()` method to put the dataset into Edit mode.
2. Assign new values to the fields of your choice.
3. Post the changes to the dataset either by calling the `Post()` method or by moving to a new record, which will automatically post the edit.

For instance, a typical record edit looks like this:

```
Table1.Edit;  
Table1['Age'] := 23;  
Table1.Post;
```

TIP

Sometimes you work with datasets that contain read-only data. Examples of this would include a table located on a CD-ROM drive or a query with a non-live result set. Before attempting to edit data, you can determine whether the dataset contains read-only data before you try to modify it by checking the value of the `CanModify` property. If `CanModify` is `True`, you have the green light to edit the dataset.

Along the same lines as editing data, you can insert or append records to a dataset in much the same way:

1. Call the dataset's `Insert()` or `Append()` method to put the dataset into Insert or Append mode.
2. Assign values to the dataset's fields.
3. Post the new record to the dataset either by calling `Post()` or by moving to a new record, which forces a post to occur.

NOTE

When you're in Edit, Insert, or Append mode, keep in mind that your changes will always post when you move off the current record. Therefore, be careful when you use the `Next()`, `Prior()`, `First()`, `Last()`, and `MoveBy()` methods while editing records.

If at some point, before your additions or modifications to the dataset are posted, you want to abandon your changes, you can do so by calling the `Cancel()` method. For instance, the following code cancels the edit before changes are posted to the table:

```
Table1.Edit;  
Table1['Age'] := 23;  
Table1.Cancel;
```

`Cancel()` undoes changes to the dataset, takes the dataset out of Edit, Append, or Insert mode, and puts it back into Browse mode.

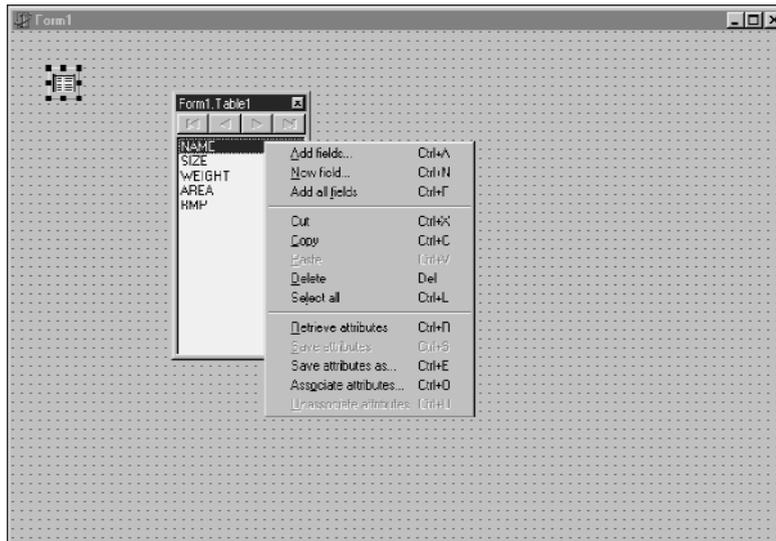
To round out the set of `TDataSet`'s record-manipulation methods, the `Delete()` method removes the current record from the dataset. For example, the following code deletes the last record in the table:

```
Table1.Last;  
Table1.Delete;
```

The Fields Editor

Delphi gives you a great degree of control and flexibility when working with dataset fields through the Fields Editor. You can view the Fields Editor for a particular dataset in the Form Designer, either by double-clicking the `TTable`, `TQuery`, or `TStoredProc` or by selecting Fields Editor from the dataset's local menu. The Fields Editor window enables you to determine which of a dataset's fields you want to work with and create new calculated or lookup fields. You can use a local menu to accomplish these tasks. The Fields Editor window with its local menu deployed is shown in Figure 28.3.

To demonstrate the usage of the Fields Editor, open a new project and drop a `TTable` component onto the main form. Set `Table1`'s `DatabaseName` property to `DBDEMOS` (this is the alias that points to the Delphi sample tables) and set the `TableName` property to `ORDERS.DB`. To provide some visual feedback, also drop a `TDataSource` and `TDBGrid` component on the form. Hook `DataSource1` to `Table1` and then hook `DBGrid1` to `DataSource1`. Now set `Table1`'s `Active` property to `True`, and you'll see `Table1`'s data in the grid.

**FIGURE 28.3**

The Fields Editor's local menu.

Adding Fields

Invoke the Fields Editor by double-clicking `Table1`, and you'll see the Fields Editor window, as shown in Figure 28.3. Let's say you want to limit your view of the table to only a few fields. Select `Add Fields` from the Fields Editor local menu. This will invoke the `Add Fields` dialog. Highlight the `OrderNo`, `CustNo`, and `ItemsTotal` fields in this dialog and click `OK`. The three selected fields will now be visible in the Fields Editor and in the grid.

Delphi creates `TField` descendant objects, which map to the dataset fields you select in the Fields Editor. For example, for the three fields mentioned in the preceding paragraph, Delphi adds the following declarations of `TField` descendants to the source code for your form:

```
Table1OrderNo: TFloatField;
Table1CustNo: TFloatField;
Table1ItemsTotal: TCurrencyField;
```

Notice that the name of the field object is the concatenation of the `TTable` name and the field name. Because these fields are created in code, you can also access `TField` descendant properties and methods in your code rather than solely at design time.

TField Descendants

Let's digress for just a moment on the topic of `TFields`. There are one or more different `TField` descendant objects for each field type (field types are described in the "Field Data

Types” section, earlier in this chapter). Many of these field types also map to Object Pascal data types. Table 28.2 shows the various classes in the TField hierarchy, their ancestor classes, their field types, and the Object Pascal types to which they equate.

TABLE 28.2 TField Descendants and their Field Types

<i>Field Class</i>	<i>Ancestor</i>	<i>Field Type</i>	<i>Object Pascal Type</i>
TStringField	TField	ftString	String
TWideStringField	TStringField	ftWideString	WideString
TGuidField	TStringField	ftGuid	TGUID
TNumericField	TField	*	*
TIntegerField	TNumericField	ftInteger	Integer
TSmallIntField	TIntegerField	ftSmallInt	SmallInt
TLargeIntField	TNumericField	ftLargeInt	Int64
TWordField	TIntegerField	ftWord	Word
TAutoIncField	TIntegerField	ftAutoInc	Integer
TFloatField	TNumericField	ftFloat	Double
TCurrencyField	TFloatField	ftCurrency	Currency
TBCDField	TNumericField	ftBCD	Double
TBooleanField	TField	ftBoolean	Boolean
TDateTimeField	TField	ftDateTime	TDateTime
TDateField	TDateTimeField	ftDate	TDateTime
TTimeField	TDateTimeField	ftTime	TDateTime
TBinaryField	TField	*	*
TBytesField	TBinaryField	ftBytes	None
TVarBytesField	TBytesField	ftVarBytes	None
TBlobField	TField	ftBlob	None
TMemoField	TBlobField	ftMemo	None
TGraphicField	TBlobField	ftGraphic	None
TObjectField	TField	*	*
TADTField	TObjectField	ftADT	None
TArrayField	TObjectField	ftArray	None
TDataSetField	TObjectField	ftDataSet	TDataSet
TReferenceField	TDataSetField	ftReference	

<i>Field Class</i>	<i>Ancestor</i>	<i>Field Type</i>	<i>Object Pascal Type</i>
TVariantField	TField	ftVariant	OleVariant
TInterfaceField	TField	ftInterface	IUnknown
TIDispatchField	TInterfaceField	ftIDispatch	IDispatch
TAggregateField	TField	None	None

*Denotes an abstract base class in the TField hierarchy

As Table 28.2 shows, BLOB and Object field types are special in that they don't map directly to native Object Pascal types. BLOB fields are discussed in more detail later in this chapter.

Fields and the Object Inspector

When you select a field in the Fields Editor, you can access the properties and events associated with that TField descendant object in the Object Inspector. This feature enables you to modify field properties such as minimum and maximum values, display formats, and whether the field is required as well as whether it's read-only. Some of these properties, such as `ReadOnly`, are obvious in their purpose, but some aren't quite as intuitive. Some of the less intuitive properties are covered later in this chapter. Figure 28.4 shows the `OrderNo` field focused in the Object Inspector.

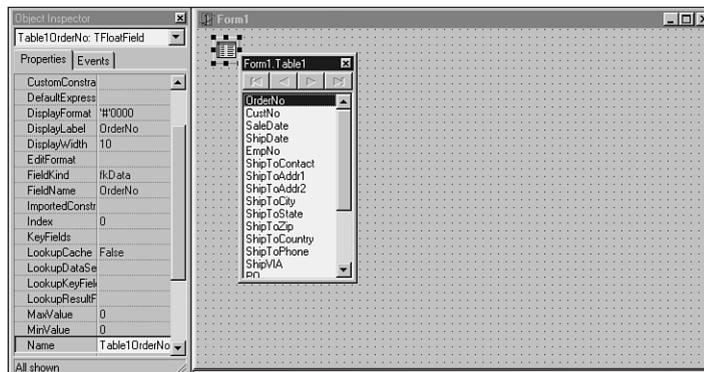


FIGURE 28.4

Editing a field's properties.

Switch to the Events page of the Object Inspector and you'll see that there are also events associated with field objects. The events `OnChange`, `OnGetText`, `OnSetText`, and `OnValidate` are all well-documented in the online help. Simply click to the left of the event in the Object

Inspector and press F1. Of these, OnChange is probably the most common to use. It enables you to perform some action whenever the contents of the field change (moving to another record or adding a record, for example).

Calculated Fields

You can also add calculated fields to a dataset using the Fields Editor. Let's say, for example, you wanted to add a field that figures the wholesale total for each entry in the ORDERS table, and the wholesale total was 32 percent of the normal total. Select New Field from the Fields Editor local menu, and you'll be presented with the New Field dialog, as shown in Figure 28.5. Enter the name, WholesaleTotal, for the new field in the Name edit control. The type of this field is Currency, so enter that in the Type edit control. Make sure the Calculated radio button is selected in the Field Type group; then press OK. Now the new field will show up in the grid, but it won't yet contain any data.

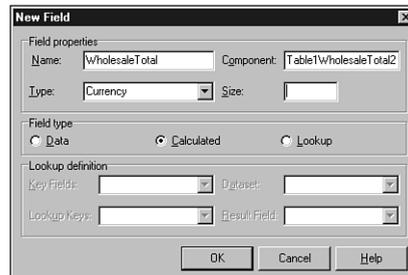


FIGURE 28.5

Adding a calculated field with the New Field dialog.

To cause the new field to become populated with data, you must assign a method to Table1's OnCalcFields event. The code for this event simply assigns the value of the WholesaleTotal field to be 32 percent of the value of the existing SalesTotal field. This method, which handles Table1.OnCalcFields, is shown here:

```
procedure TForm1.Table1CalcFields(DataSet: TDataSet);
begin
    DataSet['WholesaleTotal'] := DataSet['ItemsTotal'] * 0.68;
end;
```

Figure 28.6 shows that the WholesaleTotal field in the grid now contains the correct data.

Lookup Fields

Lookup fields enable you to create fields in a dataset that actually look up their values from another dataset. To illustrate this, you'll add a lookup field to the current project. The CustNo field of the ORDERS table doesn't mean anything to someone who doesn't have all the customer

numbers memorized. You can add a lookup field to `Table1` that looks into the `CUSTOMER` table and then, based on the customer number, retrieves the name of the current customer.



OrderNo	CustNo	ItemsTotal	Wholesale Total	CustName
#1003	CN 1351	\$1,250.00	\$850.00	Phyllis Spooner
#1004	CN 2156	\$7,885.00	\$5,361.80	Tanya Wagner
#1005	CN 1356	\$4,807.00	\$3,268.76	Chris Thomas
#1006	CN 1380	\$31,987.00	\$21,751.16	Ernest Barratt
#1007	CN 1384	\$6,500.00	\$4,420.00	Russell Christo
#1008	CN 1510	\$1,449.50	\$985.66	Paul Gardner
#1009	CN 1513	\$5,587.00	\$3,799.16	Susan Wong
#1010	CN 1551	\$4,996.00	\$3,397.28	Joyce Marsh
#1011	CN 1560	\$2,679.85	\$1,822.30	Sam Witherspoon
#1012	CN 1563	\$5,201.00	\$3,536.68	Theresa Kunec
#1013	CN 1624	\$3,115.00	\$2,118.20	Donna Siaus

FIGURE 28.6

The calculated field has been added to the table.

First, you should drop in a second `TTable` object, setting its `DatabaseName` property to `DBDEMOS` and its `TableName` property to `CUSTOMER`. This is `Table2`. Then you once again select `New Field` from the `Fields Editor` local menu to invoke the `New Field` dialog. This time you'll call the field `CustName`, and the field type will be a `String`. The size of the string is 15 characters. Don't forget to select the `Lookup` button in the `Field Type` radio group. The `Dataset` control in this dialog should be set to `Table2`—the dataset you want to look into. The `Key Fields` and `Lookup Keys` controls should be set to `CustNo`—this is the common field upon which the lookup will be performed. Finally, the `Result field` should be set to `Contact`—this is the field you want displayed. Figure 28.7 shows the `New Field` dialog for the new lookup field. The new field will now display the correct data, as shown in the completed project in Figure 28.8.

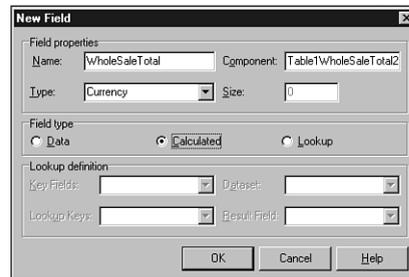
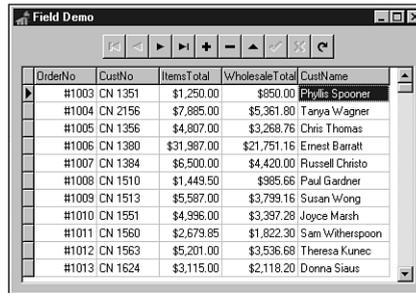


FIGURE 28.7

Adding a lookup field with the `New Field` dialog.



OrderNo	CustNo	ItemsTotal	WholesaleTotal	CustName
#1003	CN 1351	\$1,250.00	\$850.00	Phyllis Spooner
#1004	CN 2156	\$7,885.00	\$5,361.80	Tanya Wagner
#1005	CN 1356	\$4,807.00	\$3,268.76	Chris Thomas
#1006	CN 1380	\$31,987.00	\$21,751.16	Ernest Barratt
#1007	CN 1384	\$6,500.00	\$4,420.00	Russell Christo
#1008	CN 1510	\$1,449.50	\$985.66	Paul Gardner
#1009	CN 1513	\$5,587.00	\$3,799.16	Susan Wong
#1010	CN 1551	\$4,996.00	\$3,397.28	Joyce Marsh
#1011	CN 1560	\$2,679.85	\$1,822.30	Sam Witherspoon
#1012	CN 1563	\$5,201.00	\$3,536.68	Theresa Kunec
#1013	CN 1624	\$3,115.00	\$2,118.20	Donna Slaus

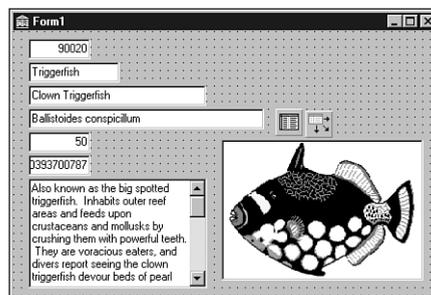
FIGURE 28.8

Viewing the table containing a lookup field.

Drag-and-Drop Fields

Another less obvious feature of the Fields Editor is that it enables you to drag fields from its Fields list box and drop them onto your forms. We can easily demonstrate this feature by starting a new project that contains only a `TTable` on the main form. Assign `Table1.DatabaseName` to `DBDEMOS` and assign `Table1.TableName` to `BIOLIFE.DB`. Invoke the Fields Editor for this table and add all the fields in the table to the Fields Editor list box. You can now drag one or more of the fields at a time from the Fields Editor window and drop them on your main form.

You'll notice a couple of cool things happening here: First, Delphi senses what kind of field you're dropping onto your form and creates the appropriate data-aware control to display the data (that is, a `TDBEdit` is created for a string field, whereas a `TDBImage` is created for a graphic field). Second, Delphi checks to see if you have a `TDataSource` object connected to the dataset; it hooks to an existing one if available or creates one if needed. Figure 28.9 shows the result of dragging and dropping the fields of the `BIOLIFE` table onto a form.

**FIGURE 28.9**

Dragging and dropping fields on a form.

Working with BLOB Fields

A BLOB (Binary Large Object) field is a field that's designed to contain an indeterminate amount of data. A BLOB field in one record of a dataset may contain three bytes of data, whereas the same field in another record of that dataset may contain 3K bytes. Blobs are most useful for holding large amounts of text, graphic images, or raw data streams such as OLE objects.

TBlobField and Field Types

As discussed earlier, VCL includes a `TField` descendant called `TBlobField`, which encapsulates a BLOB field. `TBlobField` has a `BlobType` property of type `TBlobType`, which indicates what type of data is stored in the BLOB field. `TBlobType` is defined in the DB unit as follows:

```
TBlobType = ftBlob..ftOraClob;
```

All these field types and the type of data associated with these field types are listed in Table 28.3.

TABLE 28.3 `TBlobField` Field Types

<i>Field Type</i>	<i>Type of Data</i>
<code>ftBlob</code>	Untyped or user-defined data
<code>ftMemo</code>	Text
<code>ftGraphic</code>	Windows bitmap
<code>ftFmtMemo</code>	Paradox formatted memo
<code>ftParadoxOLE</code>	Paradox OLE object
<code>ftDBaseOLE</code>	dBASE OLE object
<code>ftTypedBinary</code>	Raw data representation of an existing type
<code>ftCursor..ftDataSet</code>	Not valid BLOB types
<code>ftOraBlob</code>	BLOB fields in Oracle8 tables
<code>ftOraClob</code>	CLOB fields in Oracle8 tables

You'll find that most of the work you need to do in getting data in and out of `TBlobField` components can be accomplished by loading or saving the BLOB to a file or by using a `TBlobStream`. `TBlobStream` is a specialized descendant of `TStream` that uses the BLOB field inside the physical table as the stream location. To demonstrate these techniques for interacting with `TBlobField` components, you'll create a sample application.

NOTE

If you ran the Setup program on the CD-ROM accompanying this book, it should have set up a BDE alias that points to the \Data subdirectory of the directory in which you installed the software. In this directory, you can find the tables used in the applications throughout this book. Several of the examples on the CD-ROM expect the DDGData alias.

BLOB Field Example

This project creates an application that enables the user to store WAV files in a database table and play them directly from the table. Start the project by creating a main form with the components shown in Figure 28.10. The TTable component can map to the Wavez table in the DDGUtils alias or your own table of the same structure. The structure of the table is as follows:

<i>Field Name</i>	<i>Field Type</i>	<i>Size</i>
WaveTitle	Character	25
FileName	Character	25
Wave	BLOB	

**FIGURE 28.10**

Main form for Wavez, the BLOB field example.

The Add button is used to load a WAV file from disk and add it to the table. The method assigned to the OnClick event of the Add button is shown here:

```
procedure TMainForm.sbAddClick(Sender: TObject);
begin
  if OpenFileDialog.Execute then
  begin
    tblSounds.Append;
    tblSounds['FileName'] := ExtractFileName(OpenDialog.FileName);
    tblSoundsWave.LoadFromFile(OpenDialog.FileName);
    edTitle.SetFocus;
  end;
end;
```

The code first attempts to execute `OpenDialog`. If it's successful, `tblSounds` is put into Append mode, the `FileName` field is assigned a value, and the Wave BLOB field is loaded from the file specified by `OpenDialog`. Notice that `TBlobField`'s `LoadFromFile` method is very handy here, and the code is very clean for loading a file into a BLOB field.

Similarly, the Save button saves the current WAV sound found in the Wave field to an external file. The code for this button is as follows:

```
procedure TMainForm.sbSaveClick(Sender: TObject);
begin
  with SaveDialog do
  begin
    FileName := tblSounds['FileName']; // initialize file name
    if Execute then // execute dialog
      tblSoundsWave.SaveToFile(FileName); // save blob to file
    end;
  end;
end;
```

There's even less code here. `SaveDialog` is initialized with the value of the `FileName` field. If `SaveDialog`'s execution is successful, `tblSoundsWave`'s `SaveToFile` method is called to save the contents of the BLOB field to the file.

The handler for the Play button does the work of reading the WAV data from the BLOB field and passing it to the `PlaySound()` API function to be played. The code for this handler, shown next, is a bit more complex than the code shown thus far:

```
procedure TMainForm.sbPlayClick(Sender: TObject);
var
  B: TBlobStream;
  M: TMemoryStream;
begin
  B := TBlobStream.Create(tblSoundsWave, bmRead); // create blob stream
  Screen.Cursor := crHourGlass; // wait hourglass
  try
    M := TMemoryStream.Create; // create memory stream
  try
    M.CopyFrom(B, B.Size); // copy from blob to memory stream
    // Attempt to play sound. Raise exception if something goes wrong
    Win32Check(PlaySound(M.Memory, 0, SND_SYNC or SND_MEMORY));
  finally
    M.Free;
  end;
  finally
    Screen.Cursor := crDefault;
    B.Free; // clean up
  end;
end;
```

The first thing this method does is to create an instance of `TBlobStream`, `B`, using the `tblSoundsWave` BLOB field. The first parameter passed to `TBlobStream.Create()` is the BLOB field object, and the second parameter indicates how you want to open the stream. Typically, you'll use `bmRead` for read-only access to the BLOB stream or `bmReadWrite` for read/write access.

TIP

The dataset must be in Edit, Insert, or Append mode to open a `TBlobStream` with `bmReadWrite` privilege.

An instance of `TMemoryStream`, `M`, is then created. At this point, the cursor shape is changed to an hourglass to let the user know that the operation may take a couple of seconds. The stream `B` is then copied to the stream `M`. The function used to play a WAV sound, `PlaySound()`, requires a filename or a memory pointer as its first parameter. `TBlobStream` doesn't provide pointer access to the stream data, but `TMemoryStream` does through its `Memory` property. Given that, you can successfully call `PlaySound()` to play the data pointed at by `M.Memory`. Once the function is called, it cleans up by freeing the streams and restoring the cursor. The complete code for the main unit of this project is shown in Listing 28.2.

LISTING 28.2 The Main Unit for the Wavez Project

```
unit Main;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  ExtCtrls, DBCtrls, DB, DBTables, StdCtrls, Mask, Buttons, ComCtrls;

type
  TMainForm = class(TForm)
    tblSounds: TTable;
    dsSounds: TDataSource;
    tblSoundsWaveTitle: TStringField;
    tblSoundsWave: TBlobField;
    edTitle: TDBEdit;
    edFileName: TDBEdit;
    Label1: TLabel;
    Label2: TLabel;
    OpenFileDialog: TOpenDialog;
    tblSoundsFileName: TStringField;
```

```

SaveDialog: TSaveDialog;
pnlToobar: TPanel;
sbPlay: TSpeedButton;
sbAdd: TSpeedButton;
sbSave: TSpeedButton;
sbExit: TSpeedButton;
Bevel1: TBevel;
dbnNavigator: TDBNavigator;
stbStatus: TStatusBar;
procedure sbPlayClick(Sender: TObject);
procedure sbAddClick(Sender: TObject);
procedure sbSaveClick(Sender: TObject);
procedure sbExitClick(Sender: TObject);
procedure FormCreate(Sender: TObject);
private
  procedure OnAppHint(Sender: TObject);
end;

var
  MainForm: TMainForm;

implementation

{$R *.DFM}

uses MMSystem;

procedure TMainForm.sbPlayClick(Sender: TObject);
var
  B: TBlobStream;
  M: TMemoryStream;
begin
  B := TBlobStream.Create(tblSoundsWave, bmRead); // create blob stream
  Screen.Cursor := crHourGlass; // wait hourglass
  try
    M := TMemoryStream.Create; // create memory stream
    try
      M.CopyFrom(B, B.Size); // copy from blob to memory stream
      // Attempt to play sound. Show error box if something goes wrong
      Win32Check(PlaySound(M.Memory, 0, SND_SYNC or SND_MEMORY));
    finally
      M.Free;
    end;
  end;
finally
  Screen.Cursor := crDefault;
  B.Free; // clean up

```

continues

LISTING 28.2 Continued

```
    end;
end;

procedure TMainForm.sbAddClick(Sender: TObject);
begin
    if OpenFileDialog.Execute then
    begin
        tblSounds.Append;
        tblSounds['FileName'] := ExtractFileName(OpenDialog.FileName);
        tblSoundsWave.LoadFromFile(OpenDialog.FileName);
        edTitle.SetFocus;
    end;
end;

procedure TMainForm.sbSaveClick(Sender: TObject);
begin
    with SaveDialog do
    begin
        FileName := tblSounds['FileName']; // initialize file name
        if Execute then // execute dialog
            tblSoundsWave.SaveToFile(FileName); // save blob to file
    end;
end;

procedure TMainForm.sbExitClick(Sender: TObject);
begin
    Close;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
    Application.OnHint := OnAppHint;
end;

procedure TMainForm.OnAppHint(Sender: TObject);
begin
    stbStatus.SimpleText := Application.Hint;
end;

end.
```

Refreshing the Dataset

If there's one thing you can count on when you create database applications, it's that data contained in a dataset is in a constant state of flux. Records will constantly be added to, removed

from, and modified in your dataset, particularly in a networked environment. Because of this, you may occasionally need to reread the dataset information from disk or memory to update the contents of your dataset.

You can update your dataset using `TDataset`Refresh()` method. It functionally does about the same thing as using `Close()` and then `Open()` on the dataset, but `Refresh()` is a bit faster. The `Refresh()` method works with all local tables; however, some restrictions apply when using `Refresh()` with a database from a SQL database server.

`TTable` components connected to SQL databases must have a unique index before the BDE will attempt a `Refresh()` operation. This is because `Refresh()` tries to preserve the current record, if possible. This means that the BDE has to use `Seek()` to go to the current record at some point, which is practical only on a SQL dataset if a unique index is available. `Refresh()` does not work for `TQuery` components connected to SQL databases.

CAUTION

When `Refresh()` is called, it can create some unexpected side effects for the users of your program. For example, if user 1 is viewing a record on a networked table, and that record has been deleted by user 2, a call to `Refresh()` will cause user 1 to see the record disappear for no apparent reason. The fact that data could be changing beneath the user is something you need to keep in mind when you call this function.

Altered States

At some point, you may need to know whether a table is in Edit mode or Append mode, or even if it's active. You can obtain this information by inspecting `TDataset`State` property. The `State` property is of type `TDataSetState`, and it can have any one of the values shown in Table 28.4.

TABLE 28.4 Values for `TDataSet.State`

<i>Value</i>	<i>Meaning</i>
<code>dsBrowse</code>	The dataset is in Browse (normal) mode.
<code>dsCalcFields</code>	The <code>OnCalcFields</code> event has been called, and a record value calculation is in progress.
<code>dsEdit</code>	The dataset is in Edit mode. This means the <code>Edit()</code> method has been called, but the edited record has not yet been posted.
<code>dsInactive</code>	The dataset is closed.

continues

TABLE 28.4 Continued

<i>Value</i>	<i>Meaning</i>
dsInsert	The dataset is in Insert mode. This typically means that <code>Insert()</code> has been called but changes haven't been posted.
dsSetKey	The dataset is in SetKey mode, meaning that <code>SetKey()</code> has been called but <code>GotoKey()</code> hasn't yet been called.
dsNewValue	The dataset is in a temporary state where the <code>NewValue</code> property is being accessed.
dsOldValue	The dataset is in a temporary state where the <code>OldValue</code> property is being accessed.
dsCurValue	The dataset is in a temporary state where the <code>OldValue</code> property is being accessed.
dsFilter	The dataset is currently processing a record filter, lookup, or some other operation that requires a filter.
dsBlockRead	Data is being buffered en masse, so data-aware controls are not updated and events are not triggered when the cursor moves while this member is set.
dsInternalCalc	A field value is currently being calculated for a field that has a <code>FieldKind</code> of <code>fkInternalCalc</code> .
dsOpening	<code>DataSet</code> is in the process of opening but has not finished. This state occurs when the dataset is opened for asynchronous fetching.

Filters

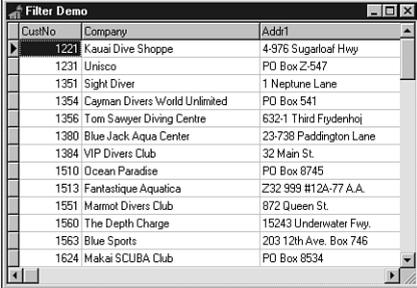
Filters enable you to do simple dataset searching or filtering using only Object Pascal code. The primary advantage of using filters is that they don't require an index or any other preparation on the datasets with which they're used. In many cases, filters can be a bit slower than index-based searching (which is covered later in this chapter), but they're still very usable in almost any type of application.

Filtering a Dataset

One of the more common uses of Delphi's filtering mechanism is to limit a view of a dataset to some specific records only. This is a simple two-step process:

1. Assign a procedure to the dataset's `OnFilterRecord` event. Inside of this procedure, you should write code that accepts records based on the values of one or more fields.
2. Set the dataset's `Filtered` property to `True`.

As an example, Figure 28.11 shows a form containing `TDBGrid`, which displays an unfiltered view of Delphi's `CUSTOMER` table.



CustNo	Company	Addr1
1221	Kauai Dive Shoppe	4-976 Sugarloaf Hwy
1231	Unisco	PO Box Z-547
1351	Sight Diver	1 Neptune Lane
1354	Cayman Divers World Unlimited	PO Box 541
1356	Tom Sawyer Diving Centre	632-1 Third Fydenhoj
1380	Blue Jack Aqua Center	23-738 Paddington Lane
1384	VIP Divers Club	32 Main St.
1510	Ocean Paradise	PO Box 8745
1513	Fantastique Aqualica	Z32 999 #12A-77 A.A.
1951	Marmot Divers Club	872 Queen St.
1960	The Depth Charge	15243 Underwater Fwy.
1963	Blue Sports	203 12th Ave. Box 746
1624	Makai SCUBA Club	PO Box 8534

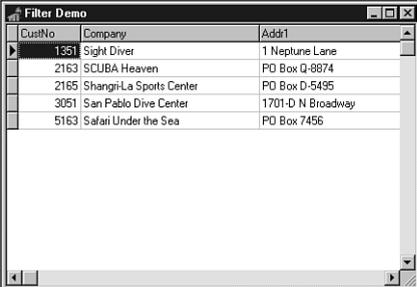
FIGURE 28.11

An unfiltered view of the CUSTOMER table.

In step 1, you write a handler for the table's `OnFilterRecord` event. In this case, we'll accept only records whose `Company` field starts with the letter `S`. The code for this procedure is shown here:

```
procedure TForm1.Table1FilterRecord(DataSet: TDataSet;
  var Accept: Boolean);
var
  FieldVal: String;
begin
  FieldVal := DataSet['Company']; // Get the value of the Company field
  Accept := FieldVal[1] = 'S';    // Accept record if field starts with 'S'
end;
```

After following step 2 and setting the table's `Filtered` property to `True`, you can see in Figure 28.12 that the grid displays only those records that meet the filter criteria.



CustNo	Company	Addr1
1351	Sight Diver	1 Neptune Lane
2163	SCUBA Heaven	PO Box Q-8874
2165	Shangri-La Sports Center	PO Box D-5495
3051	San Pablo Dive Center	1701-D N Broadway
5163	Safari Under the Sea	PO Box 7456

FIGURE 28.12

A filtered view of the CUSTOMER table.

NOTE

The `OnFilterRecord` event should only be used in cases where the filter cannot be expressed in the `Filter` property. The reason for this is that it can provide significant performance benefits. On SQL databases, for example, the `TTable` component will pass the contents of the `FILTER` property in a `WHERE` clause to the database, which is generally much faster than the record-by-record search performed in `OnFilterRecord`.

FindFirst/FindNext

`TDataSet` also provides methods called `FindFirst()`, `FindNext()`, `FindPrior()`, and `FindLast()` that employ filters to find records that match a particular search criteria. All these functions work on unfiltered datasets by calling that dataset's `OnFilterRecord` event handler. Based on the search criteria in the event handler, these functions will find the first, next, previous, or last match, respectively. Each of these functions accepts no parameters and returns a `Boolean`, which indicates whether a match was found.

Locating a Record

Not only are filters useful for defining a subset view of a particular dataset, but they can also be used to search for records within a dataset based on the value of one or more fields. For this purpose, `TDataSet` provides a method called `Locate()`. Once again, because `Locate()` employs filters to do the searching, it will work irrespective of any index applied to the dataset. The `Locate()` method is defined as follows:

```
function Locate(const KeyFields: string; const KeyValues: Variant;  
    Options: TLocateOptions): Boolean;
```

The first parameter, `KeyFields`, contains the name of the field(s) on which you want to search. The second parameter, `KeyValues`, holds the field value(s) you want to locate. The third and last parameter, `Options`, allows you to customize the type of search you want to perform. This parameter is of type `TLocateOptions`, which is a set type defined in the DB unit as follows:

```
type  
    TLocateOption = (loCaseInsensitive, loPartialKey);  
    TLocateOptions = set of TLocateOption;
```

If the set includes the `loCaseInsensitive` member, a case-insensitive search of the data will be performed. If the set includes the `loPartialKey` member, the values contained in `KeyValues` will match even if they're substrings of the field value.

`Locate()` will return `True` if it finds a match. For example, to search for the first occurrence of the value 1356 in the `CustNo` field of `Table1`, use the following syntax:

```
Table1.Locate('CustNo', 1356, []);
```

TIP

You should use `Locate()` whenever possible to search for records, because it will always attempt to use the fastest method possible to find the item, switching indexes temporarily if necessary. This makes your code independent of indexes. Also, if you determine that you no longer need an index on a particular field, or if adding one will make your program faster, you can make that change on the data without having to recode the application.

Using TTable

This section describes the common properties and methods of the `TTable` component and how to use them. In particular, you learn how to search for records, filter records using ranges, and create tables. This section also contains a discussion of `TTable` events.

Searching for Records

When you need to search for records in a table, VCL provides several methods to help you out. When you're working with dBASE and Paradox tables, Delphi assumes that the fields on which you search are indexed. For SQL tables, the performance of your search will suffer if you search on unindexed fields.

Say, for example, you have a table that's keyed on field 1, which is numeric, and on field 2, which is alphanumeric. You can search for a specific record based on those two criteria in one of two ways: using the `FindKey()` technique or the `SetKey().GotoKey()` technique.

FindKey()

`TTable`'s `FindKey()` method enables you to search for a record matching one or more keyed fields in one function call. `FindKey()` accepts an array of `const` (the search criteria) as a parameter and returns `True` when it's successful. For example, the following code causes the dataset to move to the record where the first field in the index has the value 123 and the second field in the index contains the string `Hello`:

```
if not Table1.FindKey([123, 'Hello']) then MessageBeep(0);
```

If a match is not found, `FindKey()` returns `False` and the computer beeps.

SetKey()..GotoKey()

Calling `TTable`'s `SetKey()` method puts the table in a mode that prepares its fields to be loaded with values representing search criteria. Once the search criteria have been established, use the `GotoKey()` method to do a top-down search for a matching record. The previous example can be rewritten with `SetKey()..GotoKey()`, as follows:

```
with Table1 do begin
  SetKey;
  Fields[0].AsInteger := 123;
  Fields[1].AsString := 'Hello';
  if not GotoKey then MessageBeep(0);
end;
```

The Closest Match

Similarly, you can use `FindNearest()` or the `SetKey..GotoNearest` methods to search for a value in the table that's the closest match to the search criteria. To search for the first record where the value of the first indexed field is closest to (greater than or equal to) 123, use the following code:

```
Table1.FindNearest([123]);
```

Once again, `FindNearest()` accepts an array of `const` as a parameter that contains the field values for which you want to search.

To search using the longhand technique provided by `SetKey()..GotoNearest()`, you can use this code:

```
with Table1 do begin
  SetKey;
  Fields[0].AsInteger := 123;
  GotoNearest;
end;
```

If the search is successful and the table's `KeyExclusive` property is set to `False`, the record pointer will be on the first matching record. If `KeyExclusive` is `True`, the current record will be the one immediately following the match.

TIP

If you want to search on the indexed fields of a table, use `FindKey()` and `FindNearest()`—rather than `SetKey()..GotoX()`—whenever possible because you type less code and leave less room for human error.

Which Index?

All these searching methods assume that you're searching under the table's primary index. If you want to search using a secondary index, you need to set the table's `IndexName` parameter to the desired index. For instance, if your table had a secondary index on the `Company` field called `ByCompany`, the following code would enable you to search for the company "Unisco":

```
with Table1 do begin
  IndexName := 'ByCompany';
  SetKey;
  FieldValues['Company'] := 'Unisco';
  GotoKey;
end;
```

NOTE

Keep in mind that some overhead is involved in switching indexes while a table is opened. You should expect a delay of a second or more when you set the `IndexName` property to a new value.

Ranges enable you to filter a table so that it contains only records with field values that fall within a certain scope you define. Ranges work similar to key searches, and as with searches, there are several ways to apply a range to a given table—either using the `SetRange()` method or the manual `SetRangeStart()`, `SetRangeEnd()`, and `ApplyRange()` methods.

CAUTION

If you are working with dBASE or Paradox tables, ranges only work with indexed fields. If you're working with SQL data, performance will suffer greatly if you don't have an index on the ranged field.

SetRange()

Like `FindKey()` and `FindNearest()`, `SetRange()` enables you to perform a fairly complex action on a table with one function call. `SetRange()` accepts two array of `const` variables as parameters: The first represents the field values for the start of the range, and the second represents the field values for the end of the range. As an example, the following code filters through only those records where the value of the first field is greater than or equal to 10 but less than or equal to 15:

```
Table1.SetRange([10], [15]);
```

ApplyRange()

To use the `ApplyRange()` method of setting a range, follow these steps:

1. Call the `SetRangeStart()` method and then modify the `Fields[]` array property of the table to establish the starting value of the keyed field(s).
2. Call the `SetRangeEnd()` method and modify the `Fields[]` array property once again to establish the ending value of the keyed field(s).
3. Call `ApplyRange()` to establish the new range filter.

The preceding range example could be rewritten using this technique:

```
with Table1 do begin
  SetRangeStart;
  Fields[0].AsInteger := 10;      // range starts at 10
  SetRangeEnd;
  Fields[0].AsInteger := 15;      // range ends at 15
  ApplyRange;
end;
```

TIP

Use `SetRange()` whenever possible to filter records—your code will be less prone to error when doing so.

To remove a range filter from a table and restore the table to the state it was in before you called `ApplyRange()` or `SetRange()`, just call `TTable`'s `CancelRange()` method.

```
Table1.CancelRange;
```

Master/Detail Tables

Very often, when programming databases, you'll find situations where the data to be managed lends itself to being broken up into multiple tables that relate to one another. The classic example is a customer table with one record per customer information and an orders table with one record per order. Because every order would have to be made by one of the customers, a natural relationship forms between the two collections of data. This is called a *one-to-many* relationship, because one customer may have many orders (the customer table being the *master* and the orders table being the *detail*).

Delphi makes it easy to create these types of relationships between tables. In fact, it's all handled at design time through the Object Inspector; therefore, it's not even necessary for you to write any code. Start with an empty project and add two each of the `TTable`, `TDataSource`, and

TDBGrid components. DBGrid1 will hook to Table1 via DataSource1, and DBGrid2 hooks to Table2 via DataSource2. Using the DBDEMOS alias as the DatabaseName, Table1 hooks to the CUSTOMER.DB table, and Table2 hooks to the ORDERS.DB table. Your form should look like the one shown in Figure 28.13.

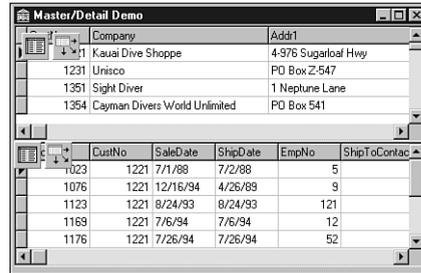


FIGURE 28.13

The master/detail main form in progress.

You now have two unrelated tables sharing the same form. Once you've come this far, the only thing left to do is to create the relationship between the tables using the MasterSource and MasterFields properties of the detail table. Table2's MasterSource property should be set to DataSource1. When you attempt to edit the MasterFields property, you are presented with a property editor called the Field Link Designer. This is shown in Figure 28.14.

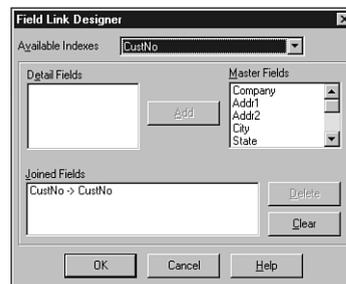


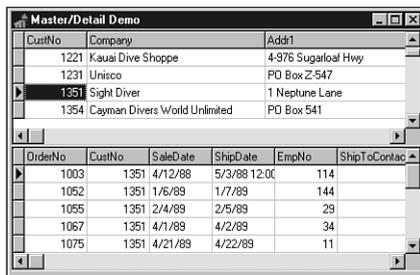
FIGURE 28.14

The Field Link Designer.

In this dialog, you specify which common fields relate the two tables to one another. The field the two tables have in common is CustNo—a numeric identifier that represents a customer. Because the CustNo field is not a part of the ORDERS table's primary index, you'll need to switch to a secondary index that does include the CustNo field. You can do that using the Available Indexes drop-down list in the Field Link Designer. Once you've switched to the

CustNo index, you can then select the CustNo field from both the Detail Fields and Master Fields list boxes and click the Add button to create a link between the tables. Click OK to dismiss the Field Link Designer.

You'll now notice that as you move through the records in Table1, the view of Table2 will be limited to only those records that share the same value in the CustNo field as Table1. The behavior is shown in the finished application in Figure 28.15.



The screenshot shows a window titled "Master/Detail Demo" with two tables. The top table is the master table with columns: CustNo, Company, and Addr1. The bottom table is the detail table with columns: OrderNo, CustNo, SaleDate, ShipDate, EmpNo, and ShipToContact. The detail table shows only records where CustNo matches the selected record in the master table (CustNo 1351).

CustNo	Company	Addr1
1221	Kauai Dive Shoppe	4-976 Sugarloaf Hwy
1231	Unisco	PO Box 2,547
1351	Sight Diver	1 Neptune Lane
1354	Cayman Divers World Unlimited	PO Box 541

OrderNo	CustNo	SaleDate	ShipDate	EmpNo	ShipToContact
1003	1351	4/12/88	5/3/88 12:00	114	
1052	1351	1/6/89	1/7/89	144	
1055	1351	2/4/89	2/5/89	29	
1067	1351	4/1/89	4/2/89	34	
1075	1351	4/21/89	4/22/89	11	

FIGURE 28.15

Master/detail demo program.

TTable Events

TTable provides you with events that occur before and after a record in the table is deleted, edited, and inserted, whenever a modification is posted or canceled, and whenever the table is opened or closed. This is so that you have full control of your database application. The nomenclature for these events is BeforeXXX and AfterXXX, where XXX stands for Delete, Edit, Insert, Open, and so on. These events are fairly self-explanatory, and you'll use them in the database applications in Parts II, "Advanced Techniques," and III, "Component-Based Development," of this book.

TTable's OnNewRecord event fires every time a new record is posted to the table. It's ideal to perform various housekeeping tasks in a handler for this event. An example of this would be to keep a running total of records added to a table.

The OnCalcFields event occurs whenever the table cursor is moved off the current record or the current record changes. Adding a handler for the OnCalcFields event enables you to keep a calculated field current whenever the table is modified.

Creating a Table in Code

Instead of creating all your database tables up front (using the Database Desktop, for example) and deploying them with your application, a time will come when you'll need your program to

have the capability to create local tables for you. When this need arises, once again VCL has you covered. `TTable` contains the `CreateTable()` method, which enables you to create tables on disk. Simply follow these steps to create a table:

1. Create an instance of `TTable`.
2. Set the `DatabaseName` property of the table to a directory or existing alias.
3. Give the table a unique name in the `TableName` property.
4. Set the `TableType` property to indicate what type of table you want to create. If you set this property to `ttDefault`, the table type will correspond to the extension of the name provided in the `TableName` property (for example, `DB` stands for Paradox, and `DBF` stands for `dBASE`).
5. Use `Add()` method for `TTable.FieldDefs` to add fields to the table. The `Add()` method takes four parameters:
 - A string indicating the field name.
 - A `TFieldType` variable indicating the field type.
 - A word parameter that represents the size of the field. Note that this parameter is only valid for types such as `String` and `Memo`, where the size may vary. Fields such as `Integer` and `Date` are always the same size, so this parameter doesn't apply to them.
 - A Boolean parameter that dictates whether this is a required field. All required fields must have a value before a record can be posted to a table.
6. If you want the table to have an index, use the `Add()` method of `TTable.IndexDefs` to add indexed fields. `IndexDefs.Add()` takes the following three parameters:
 - A string that identifies the index.
 - A string that matches the field name to be indexed. Composite key indexes (indexes on multiple fields) can be specified as a semicolon-delimited list of field names.
 - A set of `TIndexOptions` that determines the index type.
7. Call `TTable.CreateTable()`.

The following code creates a table with `Integer`, `String`, and `Float` fields with an index on the `Integer` field. The table is called `F00.DB`, and it will live in the `C:\TEMP` directory:

```
begin
  with TTable.Create(Self) do begin           // create TTable object
    DatabaseName := 'c:\temp';               // point to directory or alias
    TableName := 'F00';                       // give table a name
    TableType := ttParadox;                   // make a Paradox table
    with FieldDefs do begin
```

```
    Add('Age', ftInteger, 0, True);    // add an integer field
    Add('Name', ftString, 25, False);  // add a string field
    Add('Weight', ftFloat, 0, False);  // add a floating-point field
end;
{ create a primary index on the Age field... }
IndexDefs.Add('', 'Age', [ixPrimary, ixUnique]);
CreateTable;                          // create the table
end;
end;
```

NOTE

As mentioned earlier, `TTable.CreateTable()` works only for local tables. For SQL tables, you should use a technique that employs `TQuery` (this is shown in the next chapter).

Data Modules

Data modules enable you to keep all your database rules and relationships in one central location to be shared across projects, groups, or enterprises. Data modules are encapsulated by VCL's `TDataModule` component. Think of `TDataModule` as an invisible form on which you can drop data-access components to be used throughout a project. Creating a `TDataModule` instance is simple: Select File, New from the main menu and then select Data Module from the Object Repository.

The simple justification for using `TDataModule` over just putting data-access components on a form is that it's easier to share the same data across multiple forms and units in your project. In a more complex situation, you would have an arrangement of multiple `TTable`, `TQuery`, and/or `TStoredProc` components. You might have relationships defined between the components and perhaps rules enforced on the field level, such as minimum/maximum values or display formats. Perhaps this assortment of data-access components models the business rules of your enterprise. After taking great pains to set up something so impressive, you wouldn't want to have to do it again for another application, would you? Of course you wouldn't. In such cases, you would want to save your data module to the Object Repository for later use. If you work in a team environment, you might even want to keep the Object Repository on a shared network drive for the use of all the developers on your team.

In the example that follows, you'll create a simple instance of a data module so that many forms have access to the same data. In the database applications shown in several of the later chapters, you'll build more complex relationships into data modules.

The Search, Range, and Filter Demo

Now it's time to create a sample application to help drive home some of the key concepts that were covered in this chapter. In particular, this application will demonstrate the proper use of filters, key searches, and range filters in your applications. This project, called SRF, contains multiple forms. The main form consists mainly of a grid for browsing a table, and other forms demonstrate the different concepts mentioned earlier. Each of these forms will be explained in turn.

The Data Module

Although we're starting a bit out of order, the data module for this project will be covered first. This data module, called DM, contains only a `TTable` and a `TDataSource` component. The `TTable`, called `Table1`, is hooked to the `CUSTOMERS.DB` table in the `DBDEMOS` alias. The `TDataSource`, `DataSource1`, is wired to `Table1`. All the data-aware controls in this project will use `DataSource1` as their `DataSource`. DM is contained in a unit called `DataMod`, and it's shown in its design-time state in Figure 28.16.

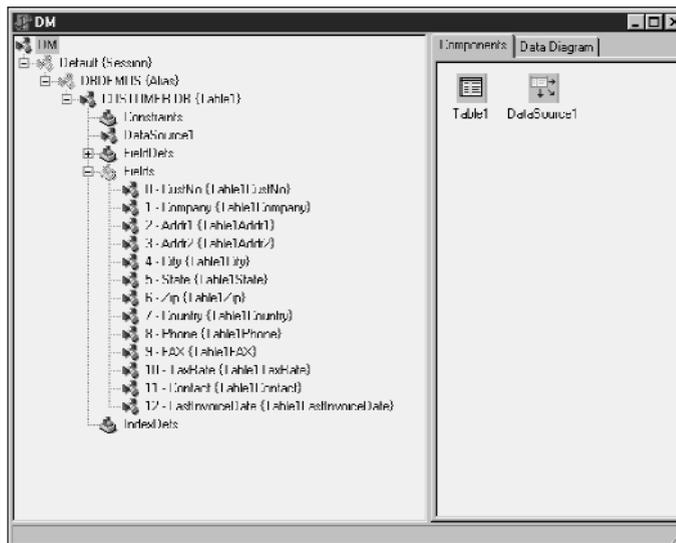


FIGURE 28.16
DM, the data module.

The Main Form

The main form for SRF, appropriately called `MainForm`, is shown in Figure 28.17. This form is contained in a unit called `Main`. As you can see, it contains a `TDBGrid` control, `DBGrid1`, for browsing a table, and it contains a radio button that enables you to switch between different indexes on the table. `DBGrid1`, as explained earlier, is hooked to `DM.DataSource1` as its data source.

NOTE

In order for `DBGrid1` to be able to hook to `DM.DataSource1` at design time, the `DataMod` unit must be in the `uses` clause of the `Main` unit. The easiest way to do this is to bring up the `Main` unit in the Code Editor and select `File, Use Unit` from the main menu. You'll then be presented with a list of units in your project from which you can select `DataMod`. You must do this for each of the units from which you want to access the data contained within `DM`.

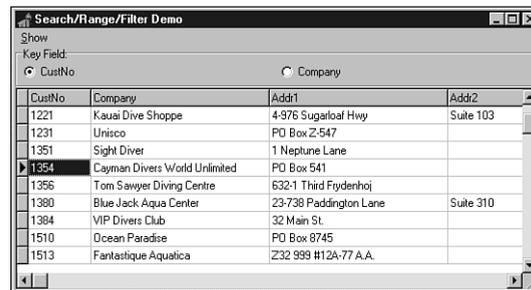


FIGURE 28.17

`MainForm` in the SRF project.

The radio group, called `RGKeyField`, is used to determine which of the table's two indexes is currently active. The code attached to the `OnClick` event for `RGKeyField` is shown here:

```
procedure TMainForm.RGKeyFieldClick(Sender: TObject);
begin
  case RGKeyField.ItemIndex of
    0: DM.Table1.IndexName := '';           // primary index
    1: DM.Table1.IndexName := 'ByCompany'; // secondary, by company
  end;
end;
```

`MainForm` also contains a `TMainMenu` component, `MainMenu1`, which enables you to open and close each of the other forms. The items on this menu are `Key Search`, `Range`, `Filter`, and `Exit`. The `Main` unit, in its entirety, is shown in Listing 28.3.

LISTING 28.3 The Source Code for MAIN.PAS

```
unit Main;

interface

uses
  SysUtils, Windows, Messages, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, ExtCtrls, Grids, DBGrids, DB, DBTables,
  Buttons, Mask, DBCtrls, Menus;

type
  TMainForm = class(TForm)
    DBGrid1: TDBGrid;
    RGKeyField: TRadioGroup;
    MainMenu1: TMainMenu;
    Forms1: TMenuItem;
    KeySearch1: TMenuItem;
    Range1: TMenuItem;
    Filter1: TMenuItem;
    N1: TMenuItem;
    Exit1: TMenuItem;
    procedure RGKeyFieldClick(Sender: TObject);
    procedure KeySearch1Click(Sender: TObject);
    procedure Range1Click(Sender: TObject);
    procedure Filter1Click(Sender: TObject);
    procedure Exit1Click(Sender: TObject);
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  MainForm: TMainForm;

implementation

uses DataMod, KeySrch, Rng, Fltr;

{$R *.DFM}

procedure TMainForm.RGKeyFieldClick(Sender: TObject);
begin
  case RGKeyField.ItemIndex of
    0: DM.Table1.IndexName := '';           // primary index
    1: DM.Table1.IndexName := 'ByCompany'; // secondary, by company
```

continues

LISTING 28.3 Continued

```
    end;
end;

procedure TMainForm.KeySearch1Click(Sender: TObject);
begin
    KeySearch1.Checked := not KeySearch1.Checked;
    KeySearchForm.Visible := KeySearch1.Checked;
end;

procedure TMainForm.Range1Click(Sender: TObject);
begin
    Range1.Checked := not Range1.Checked;
    RangeForm.Visible := Range1.Checked;
end;

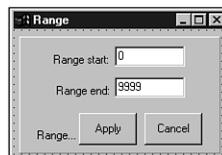
procedure TMainForm.Filter1Click(Sender: TObject);
begin
    Filter1.Checked := not Filter1.Checked;
    FilterForm.Visible := Filter1.Checked;
end;

procedure TMainForm.Exit1Click(Sender: TObject);
begin
    Close;
end;

end.
```

The Range Form

RangeForm is shown in Figure 28.18. RangeForm is located in a unit called Rng. This form enables you to set a range on the data displayed in MainForm to limit the view of the table. Depending on the active index, the items you specify in the Range Start and Range End edit controls can be either numeric (the primary index) or text (the secondary index). Listing 28.4 shows the source code for RNG.PAS.

**FIGURE 28.18**

The RangeForm form.

LISTING 28.4 The Source Code for RNG.PAS

```
unit Rng;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ExtCtrls;

type
  TRangeForm = class(TForm)
    Panel1: TPanel;
    Label2: TLabel;
    StartEdit: TEdit;
    Label1: TLabel;
    EndEdit: TEdit;
    Label7: TLabel;
    ApplyButton: TButton;
    CancelButton: TButton;
    procedure ApplyButtonClick(Sender: TObject);
    procedure CancelButtonClick(Sender: TObject);
  private
    { Private declarations }
    procedure ToggleRangeButtons;
  public
    { Public declarations }
  end;

var
  RangeForm: TRangeForm;

implementation

uses DataMod;

{$R *.DFM}

procedure TRangeForm.ApplyButtonClick(Sender: TObject);
begin
  { Set range of records in dataset from StartEdit's value to EndEdit's }
  { value. Strings are again implicitly converted to numerics.      }
  DM.Table1.SetRange([StartEdit.Text], [EndEdit.Text]);
  ToggleRangeButtons;           // enable proper buttons
end;

procedure TRangeForm.CancelButtonClick(Sender: TObject);
```

continues

LISTING 28.4 Continued

```
begin
  DM.Table1.CancelRange;           // remove set range
  ToggleRangeButtons;             // enable proper buttons
end;

procedure TRangeForm.ToggleRangeButtons;
begin
  { Toggle the enabled property of the range buttons }
  ApplyButton.Enabled := not ApplyButton.Enabled;
  CancelButton.Enabled := not CancelButton.Enabled;
end;

end.
```

NOTE

Pay close attention to the following line of code from the Rng unit:

```
DM.Table1.SetRange([StartEdit.Text], [EndEdit.Text]);
```

You might find it strange that although the keyed field can be of either a `Numeric` type or `Text` type, you're always passing strings to the `SetRange()` method. Delphi allows this because `SetRange()`, `FindKey()`, and `FindNearest()` will perform the conversion from `String` to `Integer`, and vice versa, automatically.

What this means to you is that you should not bother calling `IntToStr()` or `StrToInt()` in these situations—it will be taken care of for you.

The Key Search Form

`KeySearchForm`, contained in the `KeySrch` unit, provides a means for the user of the application to search for a particular key value in the table. The form enables the user to search for a value in one of two ways. First, when the `Normal` radio button is selected, the user can search by typing text into the `Search For` edit control and pressing the `Exact` or `Nearest` button to find an exact match or closest match in the table. Second, when the `Incremental` radio button is selected, the user can perform an incremental search on the table every time he or she changes the text in the `Search For` edit control. The form is shown in Figure 28.19. The code for the `KeySrch` unit is shown in Listing 28.5.

**FIGURE 28.19**

The KeySearchForm form.

LISTING 28.5 The Source Code for KeySrch.PAS

```

unit KeySrch;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, ExtCtrls;

type
  TKeySearchForm = class(TForm)
    Panel1: TPanel;
    Label3: TLabel;
    SearchEdit: TEdit;
    RBNormal: TRadioButton;
    Incremental: TRadioButton;
    Label6: TLabel;
    ExactButton: TButton;
    NearestButton: TButton;
    procedure ExactButtonClick(Sender: TObject);
    procedure NearestButtonClick(Sender: TObject);
    procedure RBNormalClick(Sender: TObject);
    procedure IncrementalClick(Sender: TObject);
  private
    procedure NewSearch(Sender: TObject);
  end;

var
  KeySearchForm: TKeySearchForm;

implementation

uses DataMod;

```

continues

LISTING 28.5 Continued

```
{SR *.DFM}

procedure TKeySearchForm.ExactButtonClick(Sender: TObject);
begin
  { Try to find record where key field matches SearchEdit's Text value. }
  { Notice that Delphi handles the type conversion from the string      }
  { edit control to the numeric key field value.                        }
  if not DM.Table1.FindKey([SearchEdit.Text]) then
    MessageDlg(Format('Match for "%s" not found.', [SearchEdit.Text]),
               mtInformation, [mbOk], 0);
end;

procedure TKeySearchForm.NearestButtonClick(Sender: TObject);
begin
  { Find closest match to SearchEdit's Text value. Note again the }
  { implicit type conversion.                                     }
  DM.Table1.FindNearest([SearchEdit.Text]);
end;

procedure TKeySearchForm.NewSearch(Sender: TObject);
{ This is the method which is wired to the SearchEdit's OnChange }
{ event whenever the Incremental radio is selected. }
begin
  DM.Table1.FindNearest([SearchEdit.Text]); // search for text
end;

procedure TKeySearchForm.RBNormalClick(Sender: TObject);
begin

  ExactButton.Enabled := True; // enable search buttons
  NearestButton.Enabled := True;
  SearchEdit.OnChange := Nil; // unhook the OnChange event
end;

procedure TKeySearchForm.IncrementalClick(Sender: TObject);
begin
  ExactButton.Enabled := False; // disable search buttons
  NearestButton.Enabled := False;
  SearchEdit.OnChange := NewSearch; // hook the OnChange event
  NewSearch(Sender); // search current text
end;

end.
```

The code for the KeySrch unit should be fairly straightforward to you. You might notice that, once again, we can safely pass text strings to the `FindKey()` and `FindNearest()` methods with

the knowledge that they will do the right thing with regard to type conversion. You might also appreciate the small trick that's employed to switch to and from incremental searching on the fly. This is accomplished by either assigning a method to or assigning `Nil` to the `OnChange` event of the `SearchEdit` edit control. When assigned a handler method, the `OnChange` event will fire whenever the text in the control is modified. By calling `FindNearest()` inside that handler, an incremental search can be performed as the user types.

The Filter Form

The purpose of `FilterForm`, found in the `F1tr` unit, is two-fold. First, it enables the user to filter the view of the table to a set where the value of the `State` field matches that of the current record. Second, this form enables the user to search for a record where the value of any field in the table is equal to some value he or she has specified. This form is shown in Figure 28.20.

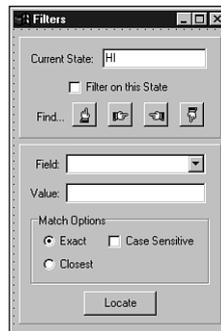


FIGURE 28.20

The `FilterForm` form.

The record-filtering functionality actually involves very little code. First, the state of the check box labeled `Filter on this State` (called `cbFiltered`) determines the setting of `DM.Table1's Filtered` property. This is accomplished with the following line of code attached to `cbFiltered.OnClick`:

```
DM.Table1.Filtered := cbFiltered.Checked;
```

When `DM.Table1.Filtered` is `True`, `Table1` filters records using the following `OnFilterRecord` method, which is actually located in the `DataMod` unit:

```
procedure TDM.Table1FilterRecord(DataSet: TDataSet;
  var Accept: Boolean);
begin
  { Accept record as a part of the filter if the value of the State }
  { field is the same as that of DBEdit1.Text. }
  Accept := Table1State.Value = FilterForm.DBEdit1.Text;
end;
```

To perform the filter-based search, the `Locate()` method of `TTable` is employed:

```
DM.Table1.Locate(CBField.Text, EValue.Text, LO);
```

The field name is taken from a combo box called `CBField`. The contents of this combo box are generated in the `OnCreate` event of this form using the following code to iterate through the fields of `Table1`:

```
procedure TFilterForm.FormCreate(Sender: TObject);
var
  i: integer;
begin
  with DM.Table1 do begin
    for i := 0 to FieldCount - 1 do
      CBField.Items.Add(Fields[i].FieldName);
    end;
  end;
end;
```

TIP

The preceding code will only work when `DM` is created prior to this form. Otherwise, any attempts to access `DM` before it's created will probably result in an Access Violation error. To make sure that the data module, `DM`, is created prior to any of the child forms, we manually adjusted the creation order of the forms in the Autocreate Forms list on the Forms page of the Project Options dialog (found under Options, Project on the main menu).

The main form must, of course, be the first one created, but other than that, this little trick ensures that the data module gets created prior to any other form in the application.

The complete code for the `F1tr` unit is shown in Listing 28.6.

LISTING 28.6 The Source Code for `F1tr.pas`

```
unit F1tr;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, Buttons, Mask, DBCtrls, ExtCtrls;

type
  TFilterForm = class(TForm)
    Panel1: TPanel;
```

```
Label4: TLabel;
DBEdit1: TDBEdit;
cbFiltered: TCheckBox;
Label5: TLabel;
SpeedButton1: TSpeedButton;
SpeedButton2: TSpeedButton;
SpeedButton3: TSpeedButton;
SpeedButton4: TSpeedButton;
Panel2: TPanel;
EValue: TEdit;
LocateBtn: TButton;
Label1: TLabel;
Label2: TLabel;
CBField: TComboBox;
MatchGB: TGroupBox;
RBExact: TRadioButton;
RBClosest: TRadioButton;
CBCaseSens: TCheckBox;
procedure cbFilteredClick(Sender: TObject);
procedure FormCreate(Sender: TObject);
procedure LocateBtnClick(Sender: TObject);
procedure SpeedButton1Click(Sender: TObject);
procedure SpeedButton2Click(Sender: TObject);
procedure SpeedButton3Click(Sender: TObject);
procedure SpeedButton4Click(Sender: TObject);
end;

var
  FilterForm: TFilterForm;

implementation

uses DataMod, DB;

{$R *.DFM}

procedure TFilterForm.cbFilteredClick(Sender: TObject);
begin
  { Filter table if checkbox is checked }
  DM.Table1.Filtered := cbFiltered.Checked;
end;

procedure TFilterForm.FormCreate(Sender: TObject);
var
  i: integer;
begin
```

LISTING 28.6 Continued

```
with DM.Table1 do begin
  for i := 0 to FieldCount - 1 do
    CBField.Items.Add(Fields[i].FieldName);
  end;
end;

procedure TFilterForm.LocateBtnClick(Sender: TObject);
var
  LO: TLocateOptions;
begin
  LO := [];
  if not CBCaseSens.Checked then Include(LO, loCaseInsensitive);
  if RBClosest.Checked then Include(LO, loPartialKey);
  if not DM.Table1.Locate(CBField.Text, EValue.Text, LO) then
    MessageDlg('Unable to locate match', mtInformation, [mbOk], 0);
end;

procedure TFilterForm.SpeedButton1Click(Sender: TObject);
begin
  DM.Table1.FindFirst;
end;

procedure TFilterForm.SpeedButton2Click(Sender: TObject);
begin
  DM.Table1.FindNext;
end;

procedure TFilterForm.SpeedButton3Click(Sender: TObject);
begin
  DM.Table1.FindPrior;
end;

procedure TFilterForm.SpeedButton4Click(Sender: TObject);
begin
  DM.Table1.FindLast;
end;

end.
```

TQuery and TStoredProc: The Other Datasets

Although these components aren't discussed in detail until the next chapter, this section is intended to introduce you to the TQuery and TStoredProc components as TDataSet descendants and siblings of TTable.

TQuery

The TQuery component enables you to use SQL to obtain specific datasets from one or more tables. Delphi enables you to use the TQuery component with both file-oriented server data (that is, Paradox and dBASE) and SQL server data. After assigning the DatabaseName property of TQuery to an alias or directory, you can enter into the SQL property the lines of SQL code you want to execute against the given database. For example, if Query1 were hooked to the DBDEMOS alias, the following code would retrieve all records in the BIOLIFE table where the Length (cm) field is greater than 100:

```
select * from BIOLIFE where BIOLIFE."Length (cm)" > 100
```

Like other datasets, the query will execute when its Active property is set to True or when its Open() method is called. If you want to perform a query that doesn't return a result set (an insert into query, for example), you should use ExecSQL() rather than Open() to invoke the query.

Another important property of TQuery is RequestLive. The RequestLive property indicates whether the result set returned is editable. Set this property to True when you want to edit the data returned by a query.

NOTE

Simply setting the RequestLive property doesn't guarantee a live result set. Depending on the structure of your query, the BDE may not be able to obtain a live result set. For example, queries containing a HAVING clause, using the TO_DATE function, or containing *abstract data type* (ADT) fields are not editable (see the BDE documentation for a complete list of restrictions). To determine whether a query is live, check the value of the CanModify property after opening the query.

In the next chapter, you'll learn more about TQuery features such as parameterized queries and SQL optimization.

TStoredProc

The TStoredProc component provides you with a means to execute stored procedures on a SQL server. Because this is a server-specific feature—and certainly not for database beginners—we'll save the explanation of this component for the next chapter.

Text File Tables

Delphi provides limited support for using text file tables in your applications. Text tables must consist of two files: a data file, which must end in a .TXT extension, and a schema file, which

must end in an .SCH extension. Each file must have the same name (that is, FOO.TXT and FOO.SCH). The data file can be of fixed length or delimited. The schema file tells the BDE how to interpret the data file by providing information such as field names, sizes, and types.

The Schema File

The format of a schema file is similar to that of a Windows INI file. The section name is the same as that of the table (minus the extension). Table 28.5 shows the items and possible item values for a schema file.

TABLE 28.5 Schema File Items and Values

<i>Item</i>	<i>Possible Values</i>	<i>Meaning</i>
FILETYPE	VARYING	Each field in the file can occupy a variable amount of space. Fields are separated with a special character, and strings are delimited with a special character.
	FIXED	Each field can be found at a specific offset from the beginning of the line.
CHARSET	(<i>many</i>)	Specifies which language driver to use. Most commonly, this will be set to ASCII.
DELIMITER	(<i>any char</i>)	Specifies which character is to be used as a delimiter for CHAR fields. Used for VARYING tables only.
SEPARATOR	(<i>any char</i>)	Specifies which character is to be used as a field separator. Used for VARYING tables only.

Using the information shown in Table 28.5, the schema file must have an entry for each field in the table. Each entry will be in the following form:

FieldX = Field Name, Field Type, Size, Decimal Places, Offset

The syntax in the preceding example is explained in the following list:

- *X* represents the field number, from 1 to the total number of fields.
- *Field Name* can be any string identifier. Do not use quotes or string delimiters.
- *Field Type* can be any one of the following values:

<i>Type</i>	<i>Meaning</i>
CHAR	A character or string field
BOOL	A Boolean (T or F)
DATE	A date in the format specified in the BDE Config Tool
FLOAT	A 64-bit floating-point number
LONGINT	A 32-bit integer

<i>Type</i>	<i>Meaning</i>
NUMBER	A 16-bit integer
TIME	A time in the format specified in the BDE Config Tool
TIMESTAMP	A date and time in the format specified in the BDE Config Tool

- *Size* refers to the total number of characters or units. This value must be less than or equal to 20 for numeric fields.
- *Decimal Places* only has meaning for FLOAT fields. It specifies the number of digits after the decimal.
- *Offset* is used only for FIXED tables. It specifies the character position where a particular field begins.

Now, here's a sample schema file for a fixed table called OPTeam:

```
[OPTeam]
FILETYPE = FIXED
CHARSET = ascii
Field1 = EmpNo, LONGINT, 04, 00, 00
Field2 = Name, CHAR, 16, 00, 05
Field3 = OfficeNo, CHAR, 05, 00, 21
Field4 = PhoneExt, LONGINT, 04, 00, 27
Field5 = Height, FLOAT, 05, 02, 32
```

Here's a schema file for a VARYING version of a similar table called OPTeam2:

```
[OPTeam2]
FILETYPE = VARYING
CHARSET = ascii
DELIMITER = "
SEPARATOR = ,
Field1 = EmpNo, LONGINT, 04, 00, 00
Field2 = Name, CHAR, 16, 00, 00
Field3 = OfficeNo, CHAR, 05, 00, 00
Field4 = PhoneExt, LONGINT, 04, 00, 00
Field5 = Height, FLOAT, 05, 02, 00
```

CAUTION

The BDE is very picky about the format of a schema file. If you have one misplaced character or misspelled word, the BDE may not be able to recognize your data at all. If you're having problems getting at your data, scrutinize your schema file.

The Data File

The data file should be a fixed-length (FIXED) or delimited (VARYING) file that contains one record per line. A sample data file for OPTeam can be shown as this:

```
2093 Steve Teixeira C2121 1234 6.5
3265 Xavier Pacheco C0001 3456 5.6
2610 Lino Tadros E2126 5678 5.11
2900 Lance Bullock C2221 9012 6.5
0007 Greg de Vries F3169 7890 5.10
1001 Tillman Dickson C3456 0987 5.9
2611 Rory Bannon E2127 6543 6.0
6908 Karl Santos A1098 5893 5.6
0909 Mr. T B0087 1234 5.9
```

A similar data file for OPTeam2 would look like this:

```
2093,"Steve Teixeira","C2121",1234,6.5
3265,"Xavier Pacheco","C0001",3456,5.6
2610,"Lino Tadros","E2126",5678,5.11
2900,"Lance Bullock","C2221",9012,6.5
0007,"Greg de Vries","F3169",7890,5.10
1001,"Tillman Dickson","C3456",0987,5.9
2611,"Rory Bannon","E2127",6543,6.0
6908,"Karl Santos","A1098",5893,5.6
0909,"Mr. T","B0087",1234,5.9
```

Using the Text Table

You can use text tables with TTable components much like any other database type. Set the table's DatabaseName property to the alias or directory containing the TXT and SCH files. Set the TableType property to ttASCII. Now you should be able to view all available text tables by clicking the drop-down button on the TableName property. Select one of the tables into the property, and you'll be able to view the fields by hooking up a TDataSource and a TDBGrid. Figure 28.21 shows a form browsing the OPTeam table.

NOTE

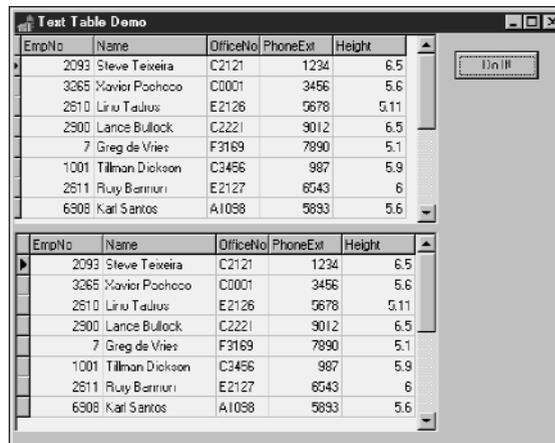
If all the fields in your text table appear to be cramped into one field, the BDE is having problems reading your schema file.

Limitations

Borland never intended for text files to be used in lieu of proper database formats. Because of the limitations inherent in text files, we (the authors) seriously advise against using text file

tables for anything other than importing data to and exporting data from real database formats. Here's a list of limitations to keep in mind when working with text tables:

- Indexes are not supported, so you can't use any `TTable` method that requires an index.
- You cannot use a `TQuery` component with a text table.
- Deleting records is not supported.
- Inserting records is not supported. Attempts to insert a record will cause the new record to be appended to the end of the table.
- Referential integrity is not supported.
- BLOB data types are not supported.
- Editing is not supported on `VARYING` tables.
- Text tables are always opened with exclusive access. You should, therefore, open your text tables in code rather than during design time.



EmpNo	Name	OfficeNo	PhoneExt	Height
2093	Steve Teixeira	C2121	1234	6.5
3265	Mavior Poochoo	C0001	3456	5.6
2510	Liru Tadius	E2126	5678	5.11
2500	Lance Bullock	C2221	9012	6.5
7	Greg de Vries	F3169	7890	5.1
1001	Tillman Dickson	C3456	987	5.9
2511	Ruy Barruri	E2127	6543	6
6508	Karl Santos	A1058	5893	5.6

FIGURE 28.21
Browsing a text table.

Text Table Import

As mentioned earlier, about the only reasonable use for text tables is in converting them to a real database format. With that in mind, what follows is a set of step-by-step instructions for using a `TBatchMove` component to copy a table from text format to a Paradox table. Assume a form containing two `TTable` objects and one `TBatchMove` component. The `TTable` object that represents the text table is called `TextTbl`, and the `TTable` object that represents the target Paradox table is called `PDoxTbl`. The `TBatchMove` component is called `BM`. Here are the steps:

1. Hook `TextTbl1` to the text table you want to import (as described earlier).
2. Set the `DatabaseName` property of `PDoxTbl1` to the target alias or directory. Set the `TableName` property to the desired table name. Set the `TableType` property to `ttParadox`.
3. Set the `Source` property of `BM` to `TextTbl1`. Set the `Destination` property to `PDoxTbl1`. Set the `Mode` property to `batCopy`.
4. Right click `BM` and select `Execute` from the local menu.
5. Voilà! You have just copied your text table to a Paradox table.

Connecting with ODBC

It's a given that the BDE can only provide native support for a limited subset of databases in the world. What happens, then, when your situation requires that you connect to a database type—such as `Btrieve`, for example—that's not directly supported by the BDE? Can you still use Delphi? Of course. The BDE provides an ODBC socket so that you can use an *Open Database Connectivity* (ODBC) driver to access databases not directly supported by the BDE; the capability to take advantage of this feature is built into the Professional and Client/Server Suite editions of Delphi. ODBC is a standard developed by Microsoft for product-independent database driver support.

Where to Find an ODBC Driver

The best place to obtain an ODBC driver is through the vendor who distributes the database format you want to access. When you do venture out to obtain an ODBC driver, bear in mind that there's a difference between 16- and 32-bit ODBC drivers, and that Delphi requires the 32-bit drivers. In addition to the vendor of your particular database, there are a number of vendors who produce ODBC drivers for many different types of databases. In particular, you can obtain ODBC drivers for Access, Excel, SQL Server, and FoxPro from Microsoft. These drivers are available either in the ODBC Driver Pack, or you can often find them on the MS Developer Network CD-ROMs.

CAUTION

Not all ODBC drivers are created equal! Many ODBC drivers are "brain deadened" to work with only one particular software package or to have their functionality otherwise limited. Examples of these types of drivers are ones that have shipped with past versions of Microsoft Office products (which are intended to work only with MS Office). Make sure that the ODBC driver you purchase is certified for application development, not just to work with some existing package.

An ODBC Example: Connecting to MS Access

Assuming you've obtained the necessary 32-bit ODBC driver from Microsoft or another vendor, this section takes you step by step from configuring the driver to making it work with a Delphi `TTable` object. Although Access is directly supported by the BDE, that's beside the point—this section is intended to serve as an example of using the BDE's ODBC socket. This demonstration assumes that you do not yet have an Access database on your hard disk, and it takes you through the steps for creating one:

1. Install the driver using the vendor-provided disk. Once it's installed, run the Windows Control Panel, and you should see an icon for ODBC Data Sources (32bit), as shown in Figure 28.22. Double-click the icon and you'll be presented with the ODBC Data Source Administrator dialog, as shown in Figure 28.23.



FIGURE 28.22

The Windows Control Panel containing the ODBC Data Sources (32 bit) icon.

2. Click the Add button in the Data Source Administrator dialog, and you'll be presented with the Create New Data Source dialog, as shown in Figure 28.24. From this dialog, select "Microsoft Access Driver (*.mdb)" and click Finish.
3. You'll now be presented with a dialog similar to the ODBC Microsoft Access Setup dialog shown in Figure 28.25. You can give the data source any name and description you choose. In this case, we'll call it AccessDB, and the description will read DDG Test for Access.
4. Click the Create button in the ODBC Microsoft Access Setup dialog, and you'll be presented with the New Database dialog, where you can choose a name for your new database and a directory in which to store the database file. Click the OK button after you

choose a file and path. Figure 28.25 shows a picture of the ODBC Microsoft Access Setup dialog with steps 3 and 4 completed. Click OK to dismiss this dialog, and then click Close to dismiss the Data Sources dialog. The data source is now configured, and you're ready to create a BDE alias that maps to this data source.

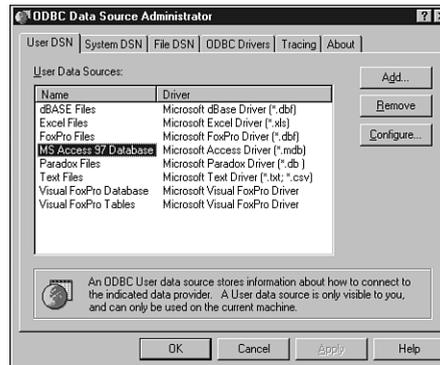


FIGURE 28.23

The ODBC Data Source Administrator dialog.

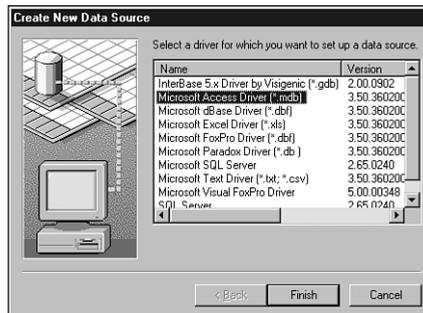
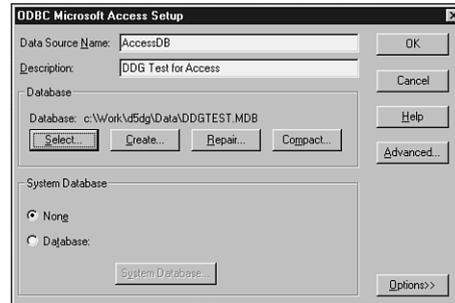


FIGURE 28.24

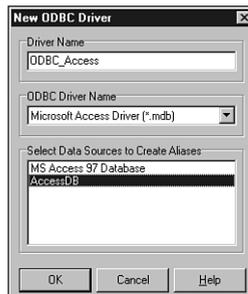
The Create New Data Source dialog.

5. Close all applications that use the BDE. Run the BDE Administrator tool that comes with Delphi and change to the Configuration page on the left pane. Expand the Drivers branch of the tree view, right-click ODBC, and select New from the local menu. This will invoke the New ODBC Driver dialog. Driver Name can be anything you like. For the sake of this example, we'll use ODBC_Access. ODBC Driver Name will be "Microsoft Access Driver (*.mdb)" (the same driver name as step 2). Default Data Source Name should come up automatically as AccessDB (the same name as step 3). The completed

dialog is shown in Figure 28.26. Select OK, and you'll return to the BDE Administrator main window.

**FIGURE 28.25**

The ODBC Microsoft Access Setup dialog.

**FIGURE 28.26**

The completed New ODBC Driver dialog.

- Change to the Databases page in the left pane of the BDE Administrator and select Object, New from the main menu. This will invoke the New Database Alias dialog. In this dialog, select ODBC_Access (from step 5) as the database driver name and click OK. You can then give the alias any name you like—we'll use Access in this case. The completed alias is shown in Figure 28.27. Select OK to dismiss the dialog and then select Object, Apply from the BDE Administrator main window. The alias has now been created, and you may now close the BDE Administrator tool. The next step is to create a table for the database.
- You'll use the Database Desktop application that ships with Delphi to create tables for your Access database. Select File, New, Table from the main menu, and you'll be presented with the Create Table dialog. Choose ODBC_Access (same as steps 5 and 6) as the table type, and the Create ODBC_Access Table dialog will come up.

8. Assuming you're familiar with creating tables in Database Desktop (if you're not, refer to the Delphi documentation), the Create ODBC_Access Table dialog works the same as the "create table" dialogs for other database types. For demonstration purposes, add one field of type CHAR and one of type INTEGER. Figure 28.28 shows the completed dialog.

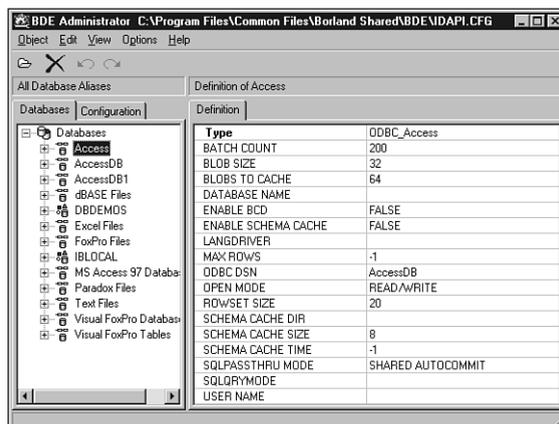


FIGURE 28.27

The new Access alias in BDE Administrator.

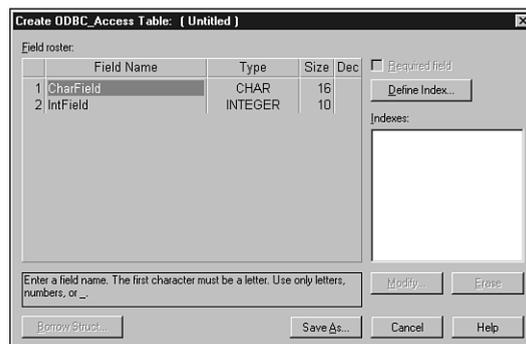


FIGURE 28.28

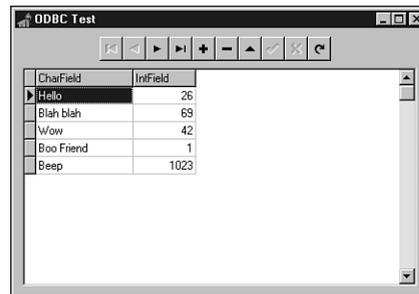
The completed Create ODBC_Access Table dialog.

9. Click the Save As button, and you'll be prompted with the Save Table As dialog. In this dialog, first set Alias to Access (from step 6). At this point, you'll be presented with a database login dialog—just click OK to dismiss the dialog, because no user name or password have been specified. Now give the table a name (do not use an extension) in the File Name edit control. We'll use TestTable in this case. Click OK, and the table will be stored to the database. You're now ready to access this database with Delphi.

NOTE

MS Access tables that comprise a database are stored in one MDB file. Although this is in contrast to Paradox and dBASE, which store each table as a separate file, it is similar to SQL server databases.

10. Create a new project in Delphi. The main form should contain one each of the `TTable`, `TDataSource`, and `TDBGrid` components. `DBGrid1` hooks to `Table1` via `DataSource1`. Select Access (from steps 6 and 9) into `Table1`'s `DatabaseName` property. Click `Table1`'s `TableName` property, and you'll be presented with a login dialog. Simply click the OK button (no password has been configured) and you can choose an available table from the Access database. Because `TestTable` is the only table you created, choose that table. Now set `Table1`'s `Active` property to `True`, and you'll see the field names appear in `DBGrid1`. Run the application, and you'll be able to edit the table. Figure 28.29 shows the completed application.

**FIGURE 28.29**

Browsing an ODBC table in Delphi.

ActiveX Data Objects (ADO)

One of the marquee new features added to Delphi 5 is the ability to access data directly through Microsoft's ADO. This is accomplished via a suite of new components in Delphi Enterprise collectively known as *ADOExpress* and found on the ADO page of the Component Palette. By leveraging the abstract `TDataSet` class mentioned earlier in this chapter, the *ADOExpress* components are able to provide ADO connectivity directly, without having to go through the BDE. This means simplified deployment, fewer dependencies on code you don't have control over, and improved performance.

The Who's Who of Microsoft Data Access

Microsoft has backed a number of data-access strategies over the years, so don't feel bad if the letters *A*, *D*, *O* tend to fall illegibly into an alphabet soup of other acronyms, such as ODBC, DAO, RDS, and UDA. To help put things into perspective, it's worth taking the time to review this collection of terms and acronyms that deal with the various Microsoft data-access strategies. In doing so, you'll hopefully gain a little perspective on how ADO fits into the picture.

- *UDA* (Universal Data Access) is the umbrella term Microsoft gives to its whole data access strategy, including ADO, OLE DB, and ODBC. It's interesting to note that UDA doesn't refer strictly to databases but can be applicable to other data-store technologies, such as directory services, Excel spreadsheet data, and Exchange server data.
- *ODBC* (Open Database Connectivity) is the most well-established Microsoft data-connectivity technology. The ODBC architecture involves a generic SQL-based API, upon which drivers can be developed to access specific databases. Because of the large market presence and proven track record of ODBC, you can still find ODBC drivers for nearly any database. Because of this, ODBC will continue to be used extensively for some time to come, even if it is a bit long in the tooth.
- *RDO* (Remote Data Objects) provides a COM wrapper for ODBC. The goal of RDO is to simplify ODBC development and open ODBC development to Visual Basic and VBA programmers.
- *Jet* is the name of the database engine built into Microsoft Access. Jet supports both Access's native MDB databases and ODBC.
- *DAO* (Data Access Objects) is yet another COM-based API for data access. DAO provides encapsulations for both Jet and ODBC.
- *ODBCDirect* is the technology Microsoft added later to DAO to provide direct access to ODBC, rather than supporting ODBC through Jet.
- *OLE DB* is a generic and simplified COM-based specification and API for data access. OLE DB was designed to be independent of any particular database back end and is the underlying architecture for Microsoft's latest data-connectivity solutions. Drivers, known as *OLE DB providers*, can be written to connect to virtually any data store through OLE DB.
- *ADO* (ActiveX Data Objects) provides a more developer-friendly wrapper for OLE DB.
- *RDS* (Remote Data Services) is an ADO-based technology that enables remote access of ADO data sources in order to build multitier systems. RDS was formerly known as *ADC* (Advanced Data Connector).
- *MDAC* (Microsoft Data Access Components) is the practical implementation and file distribution for UDA. MDAC includes four distinct technologies: ODBC, OLE DB, ADO, and RDS.

ADOExpress Components

Six components make up ADOExpress. Here, we categorize them into three groups: connectivity, ADO access, and compatibility.

Connectivity Components

The `TADOConnection` component is used to establish a connection with an ADO data store. You can hook multiple ADO dataset and command components to a single `TADOConnection` component in order to share the connection for the purposes of executing commands, retrieving data, and operating on metadata. This component is similar to the `TDataBase` component for BDE-based applications, and it's not necessary for simple applications.

The `TRDSConnection` component encapsulates a remote RDS connection by exposing the functionality of RDS's `DataSpace` object. `TRDSConnection` is used by specifying the name of the RDS server machine in the `ComputerName` parameter and the `ProgID` of the RDS server in the `ServerName` property.

ADO Access Components

`TADODataset` and `TADOCommand` make up the group of ADO access components. This group gets its name because the components provide their data-manipulation capability using more of an ADO style than the traditional BDE style with which Delphi developers are generally more familiar.

The `TADODataset` component is the primary component used to retrieve and operate on ADO data. This component has the ability to manipulate tables and execute SQL queries and stored procedures and can connect directly to a data store or connection through a `TADOConnection` component. In VCL terms, `TADODataset` encapsulates the functionality that the `TTable`, `TQuery`, and `TStoredProc` components provide for BDE-based applications.

The `TADOCommand` component is used to execute SQL statements that do not return result sets, much like `TQuery.Execute()` and `TStoredProc.ExecProc()` in BDE-based applications. Like `TADODataset`, this component can connect directly to a data store or connect through a `TADOConnection`. `TADOCommand` can also be used to execute SQL that returns a result set, but the result set must be manipulated using a `TADODataset` component. The following line of code shows how to pipe the result set of a `TADOCommand` query into a `TADODataset`:

```
ADODataset.RecordSet := ADOCommand.Execute;
```

Compatibility Components

We consider `TADOTable`, `TADOQuery`, `TADOStoredProc` to be compatibility components because they provide developers with the separate table, query, and stored procedure components that they may already be familiar with. Developers are free to use these or the ADO access components described previously, although using these components may make it a bit easier to port

BDE-based applications to ADO. Like `TADODataSet` and `TADOCommand`, the compatibility components have the ability to connect directly to a data store or connect through a `TADOConnection` component.

As you might have guessed, `TADOTable` is used to retrieve and operate on a dataset produced by a single table. `TADOQuery` can be used to retrieve and operate on a dataset produced by a SQL statement or execute *Data Definition Language* (DDL) SQL statements, such as `CREATE TABLE`. `TADOStoredProc` is used to execute stored procedures, whether or not they return result sets.

Connecting to an ADO Data Store

The `TADOConnection` component and each of the ADO access and compatibility components contain a property called `ConnectionString` that specifies the connection to an ADO data store and its attributes. The simplest way to provide a value for this property is by using the property editor, which you can invoke by clicking the ellipses next to the property value in the Object Inspector. You'll then be presented with a property editor dialog like the one shown in Figure 28.30.

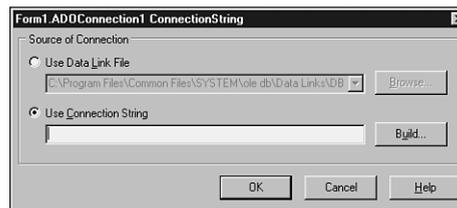


FIGURE 28.30

The ConnectString property editor.

In this dialog, you have the option of choosing a data link file or a connection string for the property value. A data link file is a file on disk, typically with a `.UDL` extension, in which a connection string is stored. Assuming you want to build a new connection string rather than use a UDL file, you should select the `Use Connection String` radio button and click the `Build` button. This will invoke the `Data Link Properties` window shown in Figure 28.31.

Building UDL Files

If you want to build UDL files in order to create connection strings that can be reused many times, you can do so fairly easily in the Windows Explorer, as long as MDAC has been installed on your machine (Delphi 5 installs MDAC). Just open an Explorer window to the folder in which to want to create a new UDL file and then right-click. Then select `New, Microsoft Data Link` from the local menu. This will create

a new UDL file, which you can name. Then right-click the icon for the UDL file and select Properties from the local menu. You'll then be presented with the Data Link Properties window as described in this section.

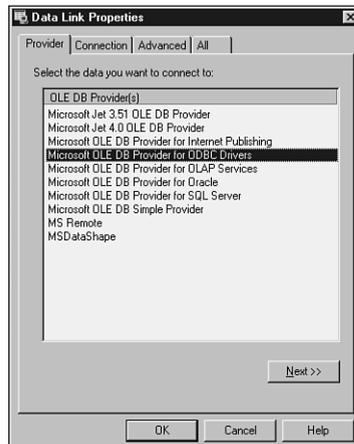


FIGURE 28.31

The Provider page of the Data Link Properties window.

The first page, Provider, of this dialog enables you to choose the OLE DB provider to which you want to connect. For example, you may choose the Microsoft OLE DB provider for ODBC drivers in order to connect to an ODBC driver via OLE DB.

After selecting the provider, you can click the Next button or the Connection tab in order to be taken to the Connection page shown in Figure 28.32. On this page, you'll configure the driver to connect to a particular database. For this example, we want to connect to a dBASE table, so select the dBASE ODBC data source from the Use Data Source Name drop-down list in part 1 of the page. You can skip part 2 of the page because the dBASE table is not password protected. In part 3 of the dialog, we need to set the initial catalog name to the directory containing the dBASE tables. For testing purposes, we set it to the directory containing the Borland sample data.

To ensure that the connection is valid, click the Test Connection button, and you'll receive a confirmation of a valid connection or an error if the directory you entered was invalid.

The Advanced and All pages of the Data Link Properties window enable you to set various properties on the connection, such as Connect Timeout, Access Permissions, Locale ID, and so on. For our purposes, we don't need to edit these pages and can use the defaults. Clicking OK

in this window and then again in the property editor dialog will cause the connection string to be created and placed in the Object Inspector, as shown in Figure 28.33.

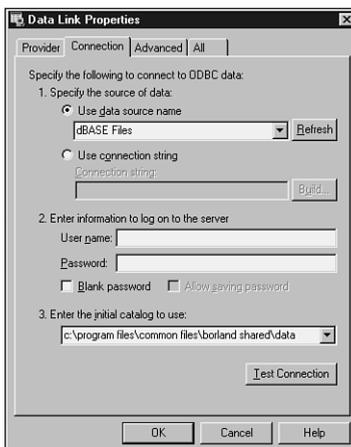


FIGURE 28.32

The Connection page of the Data Link Properties window.

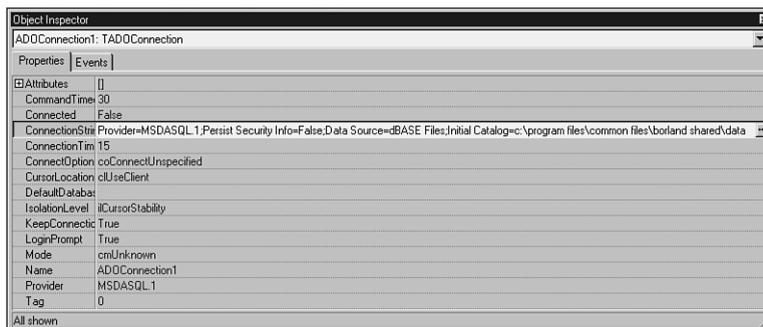


FIGURE 28.33

The completed ConnectString property in the Object Inspector.

Example: Connecting via ADO

Now that you know how to create a new connection string, you already know the hardest part about accessing data via ADO. To take it to the next step in Delphi, you can view the data in the connection you just created. To accomplish this, we'll use only a `TADODataSet` component. Follow the steps outlined previously for setting the `ConnectString` property of the

TADODataset. Then use the property editor for the CommandText property to create a SQL statement that enables you to view the contents of a table, such as that shown in Figure 28.34. Then click OK to close the dialog.

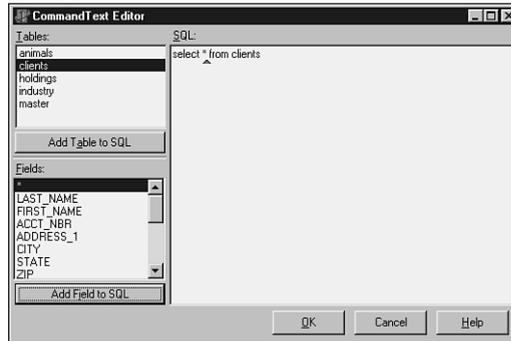


FIGURE 28.34

Editing the CommandText property.

Once you've set the CommandText property, you can set the Active property of the TADODataset to True. The component is now actively viewing the data. In order to see it, you can drop down a TDataSource component, which you'll connect to the TADODataset, and a TDBGrid component, which you'll connect to the TDataSource, as you learned earlier in this chapter. The result is shown in Figure 28.35.

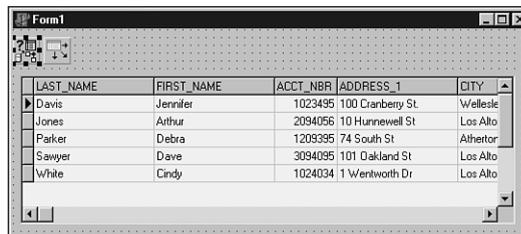


FIGURE 28.35

Accessing data using the TADODataset component.

ADO Deployment

In order to deploy ADO-based solutions on Windows 95, 98, and NT, remember that the MDAC must be installed on the target systems. You'll find the redistributable files in the \MDAC directory of the Delphi 5 CD-ROM. Windows 2000 includes MDAC, so redistribution of MDAC isn't necessary if your application will be running on a Windows 2000 machine.

Summary

After reading this chapter, you should be ready for just about any type of non-SQL database programming with Delphi. You learned the ins and outs of Delphi's `TDataSet` component, which is the ancestor of the `TTable`, `TQuery`, and `TStoredProc` components. You also learned techniques for manipulating `TTable` objects, how to manage fields, and how to work with text tables. Along with all this how-to information, you also learned about the various data-access strategies, including BDE, ODBC, and ADO. As you've seen, VCL offers a pretty tight object-oriented wrapper around the procedural BDE in addition to an extensible framework that can accommodate other engines, such as ADO.

The next chapter, "Developing Client/Server Applications," focuses a bit more on client/server technology and using related VCL classes such as `TQuery` and `TStoredProc` components.

Developing Client/Server Applications

CHAPTER

29

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- **SQL: Its Role in Client/Server Development 1546**
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So what's all this hoopla about "client/server"? It seems that everyone these days is either using or developing some sort of client/server or enterprise system. Unless you've invested the time to understand what client/server is all about, it's easy to become confused over what exactly client/server is and what it offers you that other technologies do not.

If you're a Delphi developer, it wouldn't be a surprise if you've been overwhelmed with all this client/server rhetoric. Delphi 5 is, after all, a client/server development environment. However, that doesn't mean that everything you develop with Delphi is client/server. Nor does it mean that just because an application accesses data from a client/server database, such as Oracle, Microsoft SQL, or InterBase, that it's a client/server application.

This chapter discusses the elements that make up a client/server system. It compares client/server development to traditional desktop and mainframe database development. It also illustrates reasons for using a client/server solution. It discusses how Delphi 5 provides the capability to develop client/server (three-tier) applications. This chapter also points out some pitfalls desktop database developers fall into when moving to client/server.

Why Client/Server?

A typical example of when you might consider a client/server solution would be the following: Imagine that you're responsible for a departmental-level application that accesses data residing on a LAN or file server. Various people within your department may use this application. As this data becomes of greater use to your department, other applications are created to make use of this data.

Suppose this data becomes of interest to other departments within your company. Now, additional applications will have to be built for these departments. This may also require you to move the data to a database server to make it more globally available. As the data becomes of greater interest company-wide, decision-makers must be able to access it through a means that not only gets them the data quickly but also presents the data such that it actually helps in the decision-making process.

The global availability of this data creates several problems inherent in desktop database access across network connections. Two of these problems may be excessive network traffic (creating a bottleneck in data retrieval) and data security.

This is a simplified example, yet it does illustrate a situation in which you might consider the need for a client/server solution. A client/server solution would provide the following features:

- Allow departmental access to the data, enabling departments to process only the part of the business for which they're responsible
- Provide data access to decision-makers efficiently in the way the data should be presented
- Enhance centralized control by MIS of maintaining data integrity while placing less emphasis on centralized control of data analysis and use

- Enforce data integrity rules for the entire database
- Provide better division of labor between the client and the server (each performs the tasks for which it's best suited)
- Be able to use the advanced data integrity capabilities provided by most database servers
- Reduce network traffic because subsets of data are returned to the client, as opposed to entire tables as is the case with desktop databases

Keep in mind that this list is not all-inclusive. As you get into the rest of the chapter, you'll see additional benefits to moving to a client/server-based system.

It's also necessary to mention that making the move to client/server isn't always the right thing to do. As a developer, you must ensure that you've performed a thorough analysis of your user requirements to determine whether client/server is what you need. One consideration you must take into account is that client/server systems are costly. This cost includes network software, the server OS, the database server, and hardware capable of housing such software. Additionally, there will be a significant learning period if users are unfamiliar with the server OS and database server software.

Client/Server Architecture

The typical client/server architecture is one in which the front end (or end user—the *client*) accesses and processes data from a remote machine (the *server*). There is no “true” definition of client/server. However, you can think of it as if the server provides a service and the client requests a service from the server. There may be many clients that request such services from the same server. It's up to the server to decide how to process such requests. Also, there may be more than just the client and server to a client/server system. We'll discuss this further in the section covering three-tier systems.

In a client/server environment, the server handles much more than just data distribution. In fact, the server, more than likely, performs the bulk of the business logic. It also governs how the data is to be accessed and manipulated by the client. The client applications really only serve as a means to present data to or extract data from the end user. The following subsections explain in more detail the responsibilities of the client and the server. Additionally, we'll talk about *business rules*, which are the governing rules for client access to server data.

The Client

The client can be either a GUI or non-GUI application. Delphi 5 allows you to develop both the client and any middle-layer application servers in three-tier models. The database server is most likely developed using an RDBMS such as Oracle or InterBase.

Client applications provide the interface for users needing to manipulate data on the server end. It's through the client that services are requested of the server. A typical service might be, for example, adding a customer, adding an order, or printing a report. Here, the client simply makes the request and provides any necessary data. The server carries the responsibility of processing the request. This doesn't mean that the client is not capable of performing any of the logic. It's entirely possible that the client can carry out most, if not all, of the business logic in the entire application. In this case, this is what we refer to as a *fat client*.

Scalable Applications

You'll often hear the term *scalability* in reference to client/server development with Delphi. What exactly is scalability? Well, to some it means the ability to easily access server databases using Delphi's powerful database features. Also, it can mean to rapidly increase the number of users and demands on a system with minimal or no effect on performance. To others, it means magically turning a desktop application into a client application by simply changing an alias in the application. Unfortunately, the latter is not really true. Sure, you can change an `Alias` property and suddenly access data from a server database. However, this doesn't turn your application into a client application nor does it scale your application. A key advantage to client/server is that you can take advantage of the powerful features offered by the server. It would be impossible to take advantages of these features if your application is designed using desktop database methods.

The Server

The server provides the services to the client. It essentially waits for the client to make a request and then processes that request. A server must be capable of processing multiple requests from multiple clients and also must be capable of prioritizing these requests. More than likely, the server will run continuously to allow constant access to its services.

NOTE

A client doesn't necessarily have to reside on a different machine from the server. Often, the background tasks performed on the data may well reside on the same server machine.

Business Rules

What exactly are business rules? In short, business rules are the governing procedures that dictate how clients access data on the server. These rules are implemented in programming code

on the client, the server, or both. In Delphi 5, business rules are implemented in the form of Object Pascal code. On the server side, business rules are implemented in the form of SQL stored procedures, triggers, and other database objects native to server databases. In three-tier models, business rules can be implemented in the middle tier. We'll discuss these objects later in the chapter.

It's important that you understand that business rules define how the entire system will behave. Without business rules, you have nothing more than data residing on one machine and a GUI application on another and no method for connecting the two.

At some point in the design phase of developing your system, you must decide what processes must exist in your system. Take an inventory system, for example. Here, typical processes would be tasks such as placing an order, printing an invoice, adding a customer, ordering a part, and so on. As stated earlier, these rules are implemented in Object Pascal code on the client or on a middle tier. These rules may also be SQL code on the server or a combination of all three. When the majority of rules are placed on the server, we refer to this as a *fat server*. When most of the rules exist on the client, this is called a *fat client*. When the rules exist on the middle tier, we can still refer to this as a fat server as well. How much and what type of control is required over the data determine what side the business rules should exist on.

NOTE

You'll often see *three-tier* referred to as *n-tier* or *multitier*. The terms *n-tier* and *multitier* are each misnomers. In a three-tier model, you typically have one or more clients, business logic, and the database server. The business logic may very well be distributed into many pieces on several different machines or even application servers. It starts to seem a bit absurd when you start to refer to this as a 10-, 15-, or even 25-tier system. We prefer to think of the business logic (or middle) tier as a single tier regardless of how many boxes and application servers it requires.

Fat Client, Fat Server, or Middle Tier: Where Do Business Rules Belong?

The decision about where you want the business rules to exist, or how you want to separate business rules between the server and clients, depends on several factors. Some of these factors may include data security, data integrity, centralized control, and proper distribution of work.

Data Security Concerns

Security concerns come into play when you want to provide limited access to various parts of the data or to various tasks that may be performed on the data. This is done through user-access privileges to various database objects such as views and stored procedures. We'll

discuss these objects later in this chapter. By using access privileges to database objects, you can restrict a user's access to only those parts of the data that he or she needs. Privileges and stored procedures exist on the server.

One very important concept to remember is that client/server databases are designed so that a wide range of client applications and tools can access them. Although you may have limited access to data as defined in the coding logic of your client application, nothing prevents a user from using another tool to view or edit tables within your database. By making database access accessible only through views and stored procedures, you can prevent unauthorized access to your data. This also plays an important role in maintaining data integrity, as discussed in the next section.

Data Integrity Concerns

Data integrity refers to the correctness and completeness of the data on the server. Unless you take the necessary measures to protect the data, it's possible that this data may get corrupted. Examples of data corruption are placing an order on a nonexistent or depleted product, changing the quantity of a product on an order without adjusting the cost, or deleting a customer with an outstanding balance.

So how do you protect data integrity? One way is to limit the type of operations that can be performed on the data through stored procedures. Another way is by placing the bulk of the business logic on the server or on the middle layer. For example, suppose that in an inventory system, you have a client application that contains most of the business logic. In the client application, the procedure to delete a customer might be smart enough to look at the server data to determine whether a customer has an outstanding balance. This is fine for the client application. However, because this logic exists only with the client and not with the server, there's nothing to prevent a user from loading Database Desktop or some other client tool and deleting a customer directly from the table. To prevent this, you revoke access to the customer table to all users. You then provide a stored procedure on the server that takes care of deleting the user but only after making the necessary checks. Because nobody has access to the tables directly, all users are forced to use the stored procedure.

This is only one way that a business rule existing on the server can protect data integrity. The same thing can be accomplished by placing the necessary checks in triggers or by providing views to only the data the users need access to. It's important to remember that data on the server is there so that many departments through different applications can access it. The more business rules that exist on the server, the more control you have over protecting the data.

Centralized Control of Data

Another benefit to having the business logic on the server, or on another layer in a three-tier setup, is that MIS can implement updates to this business logic without affecting the operation

of the client applications. That means that if additional code were to be added to any stored procedures, this change is transparent to the clients as long as the client interfaces to the server aren't affected by the change. This makes life for MIS much easier and benefits the company overall because MIS can do its job better.

Work Distribution

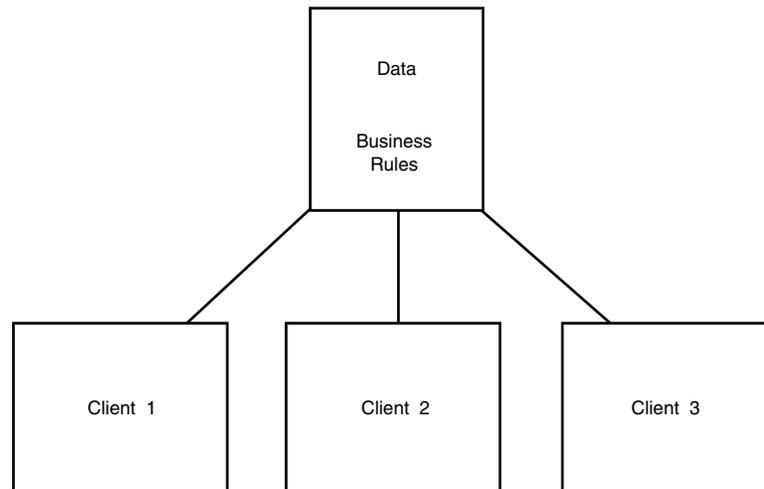
By placing business rules on the server, or by separating them on various middle tiers, MIS can more easily perform the tasks of dividing up responsibilities to specific departments and still maintain the integrity/security of the server data. This allows departments to share the same data yet manipulate only that data necessary to accomplish their particular objectives. This distribution of work is accomplished by granting access to only those stored procedures and other database objects necessary for a particular department.

As an example, we'll use the inventory system again. To be more specific, let's say this is an inventory system for an automotive parts warehouse. Here, several people need to access the same data but for different purposes. A cashier must be able to process invoices, add and remove customers, and change customer information. Warehouse personnel must be able to add new parts to the database as well as order new parts. Accounting personnel must be able to perform their part of the system as well. It's not likely that warehouse personnel will have to run a monthly budget report. Nor is it likely that accounting personnel will have to change customer address information. By creating these business rules on the server, it's possible to grant access based on the needs of a person and/or department. Here, cashier personnel will have access to customer/invoice rules. Warehouse personnel will have access to business rules specific to their needs, whereas accounting personnel can access accounting-related data.

Distribution of work refers not only to dividing up work among various clients but also to determining what work would best be performed on a client as opposed to the server or middle layers. As a developer, you must evaluate various strategies that might allow you to assign CPU-intensive operations to the fast client machines, thus relieving the server so that it can perform less intensive operations. Of course, in deciding which strategies to employ, you must also consider which business rules would be violated as well as whether this approach poses any security risks.

Client/Server Models

You often hear of client/server systems falling under one of two models. These are the two-tiered model and three-tiered model, as shown in Figures 29.1 and 29.2, respectively.

**FIGURE 29.1**

The two-tiered client/server model.

The Two-Tiered Model

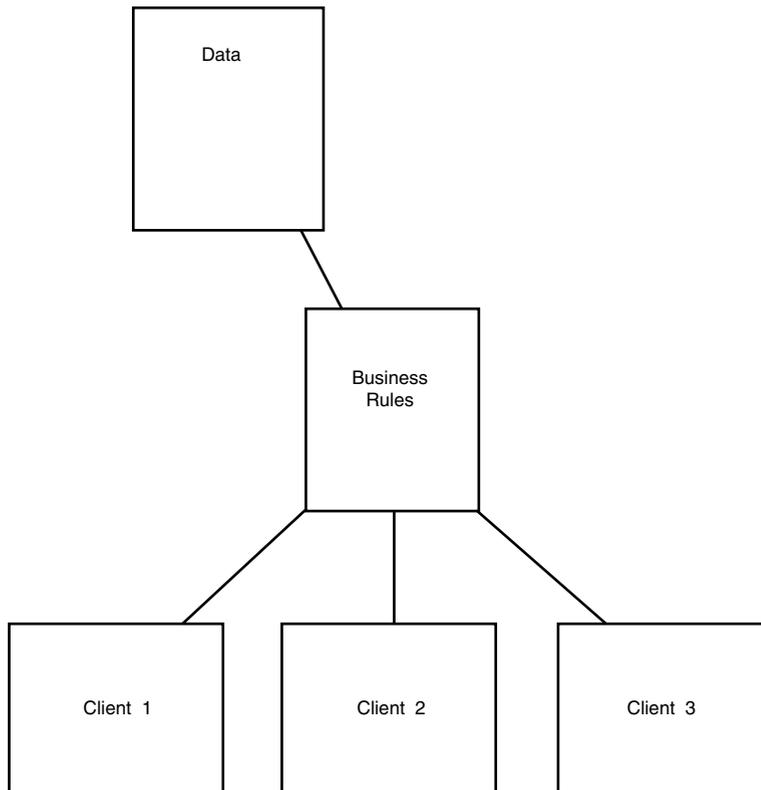
Figure 29.1 illustrates what's referred to as a *two-tiered* client/server model. This model is probably the most common because it follows the same schema as desktop database design. Additionally, many client/server systems being built today have evolved out of existing desktop database applications that stored their data on shared file servers. The migration of systems built around network-shared Paradox or dBASE files up to SQL servers is based on the hope of improved performance, security, and reliability.

Under this model, the data resides on the server, and client applications exist on the client machine. The business logic, or *business rules*, exist on either the client or the server or both.

The Three-Tiered Model

Figure 29.2 shows the *three-tiered* client/server model. Here, the client is the user interface to the data. The remote database server is where the data resides. The client application makes requests to access or modify the data through an applications server or Remote Data Broker. It's typically the Remote Data Broker where the business rules exist.

By distributing the client, server, and business rules on separate machines, designers can more effectively optimize data access and maintain data integrity for other applications in the entire system. Delphi 5 adds powerful capabilities for developing three-tier architectures with the MIDAS technology.

**FIGURE 29.2**

The three-tiered client/server model.

MIDAS: Multitier Distributed Application Services Suite

Borland's MIDAS technology is included with the Delphi 5 Enterprise version only. This technology is a suite of highly advanced components, servers, and core technologies for your three-tier application development. Chapter 32, "MIDAS Development," discusses this technology in more depth.

Client/Server Versus Desktop Database Development

If you're coming from a background of designing desktop databases, it's important that you understand the differences between desktop database and client/server database development. This next section presents some of the key differences between the two.

Set-Oriented Versus Record-Oriented Data Access

One of the most often misunderstood concepts in client/server development has to do with client/server databases being *set oriented* versus *record oriented*. What this means is that client applications do not work with tables directly as do desktop databases. Instead, client applications work with subsets of the data.

The way this works is that the client application requests rows from the server, which are made up of fields from a table or a combination of several tables. These requests are made using Structured Query Language (SQL).

By using SQL, clients are able to limit the number of records that may be returned from the server. Clients use SQL statements to query the server for a result set, which may consist of a subset of the data on a server. This is an important point to note because when you're accessing desktop databases over a network, the entire table is sent to the calling application across the network. The larger the table, the more this weighs on network traffic. This differs from client/server in that only the requested records are transferred across the network, thus placing fewer requirements on the network.

This difference also affects the navigability of SQL data sets. Concepts such as *first*, *last*, *next*, and *previous* record are foreign to SQL-based data sets. This is especially true when you think that result sets may consist of rows made up of several tables. Many SQL servers provide *scrollable cursors*, which are navigable pointers on a SQL result set. However, this is not the same as the desktop navigability, which directly navigates through the actual table. You'll see later in the section titled "TTable or TQuery" how these concepts affect the way you design your client applications with Delphi 5.

Data Security

SQL databases handle security issues differently than do desktop databases. They offer the same password security measures on the overall database access, but they also offer a mechanism to restrict user access to specific database objects such as views, tables, stored procedures, and so on. We'll discuss these objects more later in this chapter. What this means is that user access can be defined on the server based on the user's need to view the data.

Typically, SQL databases allow you to grant or revoke privileges to a user or a group of users. Therefore, it's possible to define a group of users in SQL databases. These privileges may refer to any of the already mentioned database objects.

Record-Locking Methods

Locking is a mechanism used to allow concurrent SQL transactions for many users on the same database. Several locking levels exist, and servers differ as to which level they use.

Table-level locking restricts you from modifying tables that may be involved in an ongoing transaction. Although this method allows for parallel processing, it is slow because users typically need to share the same tables.

An improved locking technique is *page-level* locking. Here, the server locks certain blocks of data on the disk. These are referred to as *pages*. As one transaction is performing an operation on a given page, other transactions are restricted from updating data on that same page. Typically, data is spread over several hundreds of pages, so multiple transactions occurring on the same page are not common.

Some servers offer *record-level* locking, which imposes a lock on a specific row in a database table. However, this results in large overhead in maintaining the locking information.

Desktop databases use what is referred to as *pessimistic* or *deterministic* locking. This means that you're restricted from making changes to table records that are currently being modified by another user. When an attempt to access such a record is made, you'll receive an error message indicating that you cannot access that record until the previous user has freed it.

SQL databases operate on a concept known as *optimistic* locking. With this technique, you aren't restricted from accessing a record that was previously accessed by another user. You can edit and then request the server to save this record. However, before a record is saved, it is compared with the server copy, which may have been updated by another user in the time that you were viewing/editing it on the client end. This will result in an error indicating that the record was modified since you initially received it. As a developer, you must take this into account when designing your client application. Client/server applications must be more reactive to this type of occurrence, which is not the case with their desktop counterparts.

Data Integrity

With SQL databases, you have the opportunity to employ more robust integrity constraints with your server data. Although desktop databases have data integrity constraints built into the database, you must define any business rules in the context of the application's code. In contrast, SQL databases allow you to define these rules on the server end. This gives you the benefit of not only requiring all client applications to use the same set of business rules but also centralizing the maintenance of these rules.

Integrity constraints are defined when you create the tables on the server. We'll show you some samples of this later in the chapter in the section "Creating the Table." Such constraints include validity, uniqueness, and referential constraints.

As stated earlier, integrity constraints can also be defined in the context of the SQL stored procedures. Here, for example, you can check to see if a customer has the proper credit limit before processing an order. You can see how such rules enforce the integrity of the data.

Transaction Orientation

SQL databases are *transaction-oriented*. This means that changes to data aren't made directly to the tables as they are in desktop databases. Instead, the client applications request that the server make these changes, and the server implements this batch of operations in a single transaction.

In order for any changes to the data to be final, the transaction as a whole must be *committed*. If any of the operations within the transaction fails, the entire transaction may be *rolled back* (in other words, aborted).

Transactions preserve the consistency of the data on the server. Let's go back to the inventory example. When an order is made, an `ORDER` table must be updated to reflect the order. Additionally, the `PARTS` table must reflect the reduced number of parts based on the order. If, for some reason, the system fails in between the update to the `ORDERS` table and the update to the `PARTS` table, the data would not correctly reflect the actual number of parts on hand. By encapsulating this entire operation within a transaction, none of the tables affected within the transaction would be updated until the entire transaction is committed.

Transactions can be controlled at the server level or at the client level within your Delphi 5 application. We'll illustrate this later in the chapter in the section "Transaction Control."

NOTE

Some desktop databases, such as Paradox 9, do support transactions.

SQL: Its Role in Client/Server Development

SQL is an industry-standard database-manipulation command set that's used with applications programming environments such as Delphi. SQL is not a language in and of its own. That is, you can't go to the local software store and buy a box of SQL. Instead, SQL is part of the server database.

SQL gained great acceptance as a database query language throughout the '80s and '90s, and today it has become the standard for working with client/server databases across networked environments. Delphi enables you to use SQL through its components. SQL gives you the advantage of viewing your data in the way that only SQL commands will generate, which also gives you much more flexibility than its record-oriented counterpart.

SQL allows you to control the server data by providing the following functionality:

- *Data definition.* SQL lets you define the structures of your tables—the data types of the fields within the tables as well as the referential relationships of certain fields to fields in other tables.
- *Data retrieval.* Client applications use SQL to request from the server whatever data they require. SQL also lets clients define what data to retrieve and how that data is to be retrieved, such as the sorting order, as well as what fields are retrieved.
- *Data integrity.* SQL lets you protect the integrity of the data by using various integrity constraints either defined as part of the table or separately from the table as stored procedures or other database objects.
- *Data processing.* SQL allows clients to update, add, or delete data from the server. This can be as part of a simple SQL statement passed to the server or as a stored procedure that exists on the server.
- *Security.* SQL allows you to protect the data by letting you define user access privileges, views, and restricted access to various database objects.
- *Concurrent access.* SQL manages the concurrent access of data such that users using the system simultaneously don't interfere with each other.

In short, SQL is the primary tool for the development and manipulation of client/server data.

Delphi Client/Server Development

So how does Delphi 5 fit into this client/server environment? Delphi 5 provides you with database object components that encapsulate the functionality of the Borland Database Engine (BDE). This allows you to build database applications without having to know all the functions of the BDE. Additionally, data-aware components communicate with the database-access components. This makes it easy to build user interfaces for database applications. The SQL Links provide native drivers to servers such as Oracle, Sybase, Informix, Microsoft SQL Server, DB2, and InterBase. You can also access data from other databases through ODBC and ADO. In the sections to follow, we'll use both a client/server database—InterBase—and Delphi 5 database components to illustrate various techniques in designing client/server applications.

Delphi 5 includes MIDAS. See the sidebar “MIDAS: Multitier Distributed Application Services Suite” earlier in the chapter or refer to Chapter 34, “Client Tracker: MIDAS Development.” Finally, Delphi also gives you the ability to create distributed applications using the Common Object Request Broker Architecture (CORBA). The CORBA specification was adopted by the Object Management Group. This technology gives you the ability to create object-oriented distributed applications. You'll find information on how Delphi 5 handles CORBA in the online help under “Writing CORBA Applications.” We simply don't have enough space in this book to provide an adequate discussion of the CORBA technology. This is a topic that merits a book of its own.

The Server: Designing the Back End

When you're designing an application to be built around a client/server environment, quite a bit of planning has to happen before you actually begin coding. Part of this planning process involves defining the business rules for the application. That means deciding which tasks are to be performed on the server and which on the client. Then, you have to decide on table structures and relationships between fields, data types, and user security. In order to accomplish all of this, you should be thoroughly familiar with the database objects on the server end.

For illustration purposes, we'll explain these concepts using InterBase. InterBase is a server database that ships with Delphi. It allows you to create standalone client/server applications that adhere to the ANSI entry-level SQL-92 standard. To use InterBase, you must be familiar with the Windows ISQL program, which ships with Delphi.

NOTE

It's beyond the scope of this book to cover InterBase's implementation of SQL, or any aspect of InterBase for that matter. We're merely using InterBase as a means to discuss client/server application development, which is convenient because the local version of InterBase ships with Delphi 5. Much of what we discuss applies to other implementations of SQL in other server databases, except when it relates to server-specific features.

Database Objects

InterBase uses a Data Definition Language (DDL) to define the various database objects that maintain information about the structure of the database and the data. These objects are also referred to as *metadata*. In the following sections, we describe the various objects that make up the metadata and show examples of how such metadata is defined. Keep in mind that most SQL-based databases consist of similar database objects with which you store information about data.

NOTE

Powerful data-modeling tools such as Erwin, xCase, and RoboCase allow you to graphically design your databases using standard data-modeling methodologies. This is something to consider before you start creating your 200-table system by hand.

Defining Tables

As far as table structure and functionality are concerned, InterBase tables are much like the tables described in Chapter 28, “Writing Desktop Database Applications.” That is, they contain an unordered set of rows, each having a certain number of *columns*.

Data Types

Columns can be of any of the available data types, as shown in Table 29.1.

TABLE 29.1 InterBase Data Types

<i>Name</i>	<i>Size</i>	<i>Range/Precision</i>
BLOB	Variable	No limit, 64KB segment size
CHAR(n)	<i>n</i> characters	1 to 32,767 bytes
DATE	64 bits	Jan 1, 100—Dec 11, 5941
DECIMAL (precision, scale)	Variable	prec—1 to 15 scale—1 to 15
DOUBLE PRECISION	64 bits (platform-dependent)	1.7x10 ⁻³⁰⁸ to 1.7x10 ³⁰⁸
FLOAT	32 bits	3.4x10 ⁻³⁸ to 3.4x10 ³⁸
INTEGER	32 bits	-2,147,483,648 to 2,147,483,648
NUMERIC (precision, scale)	Variable	-32,768 to 32,767
SMALLINT	16 bits	1 to 32,767
VARCHAR(n)	<i>n</i> characters	1 to 32,765

Field types may also be defined with domains in InterBase. We’ll discuss this shortly in the section “Using Domains.”

Creating the Table

You use the CREATE TABLE statement to create the table, its columns, and whatever integrity constraints you want applied to each column. Listing 29.1 shows how you would create an InterBase table.

LISTING 29.1 Table Creation in InterBase

```

/* Domain definitions */
CREATE DOMAIN FIRSTNAME AS VARCHAR(15);
CREATE DOMAIN LASTNAME AS VARCHAR(20);
CREATE DOMAIN DEPTNO AS CHAR(3)
    CHECK (VALUE = '000' OR (VALUE > '0' AND VALUE <= '999')
    OR VALUE IS NULL);

```

continues

LISTING 29.1 Continued

```
CREATE DOMAIN JOBCODE AS VARCHAR(5)
    CHECK (VALUE > '99999');
CREATE DOMAIN JOBGRADE AS SMALLINT
    CHECK (VALUE BETWEEN 0 AND 6);
CREATE DOMAIN SALARY AS NUMERIC(15, 2)
    DEFAULT 0 CHECK (VALUE > 0);

/* Table: EMPLOYEE, Owner: SYSDBA */
CREATE TABLE EMPLOYEE (
    EMP_NO EMPNO NOT NULL,
    FIRST_NAME FIRSTNAME NOT NULL,
    LAST_NAME LASTNAME NOT NULL,
    PHONE_EXT VARCHAR(4),
    HIRE_DATE DATE DEFAULT 'NOW' NOT NULL,
    DEPT_NO DEPTNO NOT NULL,
    JOB_CODE JOBCODE NOT NULL,
    JOB_GRADE JOBGRADE NOT NULL,
    JOB_COUNTRY COUNTRYNAME NOT NULL,
    SALARY SALARY NOT NULL,
    FULL_NAME COMPUTED BY (last_name || ', ' || first_name),
    PRIMARY KEY (EMP_NO));
```

The first section of Listing 29.1 shows a series of `CREATE DOMAIN` statements, which we'll explain shortly. The second section of Listing 29.1 creates a table named `EMPLOYEE` with the rows specified. Each row definition is followed by the row type and possibly the `NOT NULL` clause. The `NOT NULL` clause indicates that a value is required for that row. You'll also see that we've specified a primary key on the `EMP_NO` field by using the `PRIMARY KEY` clause. Specifying a primary key not only ensures the uniqueness of the field but also creates an *index* on that field. Indexes speed up data retrieval.

Indexes

Indexes can also be created explicitly by using the `CREATE INDEX` statement. Indexes are based on one or more columns of a table. For example, the following SQL statement would create an index on the last and first names of an employee:

```
CREATE INDEX IDX_EMPNAME ON EMPLOYEE (LAST_NAME, FIRST_NAME);
```

Computed Columns

The `FULL_NAME` field is a computed field. Computed columns are based on a certain expression in the `COMPUTED BY` clause. The example in Listing 29.1 uses the `COMPUTED BY` clause to concatenate the last name and first name, separated by a comma. You can create many variations of computed columns to suit your needs. You should refer to your server documentation to see what capabilities are available for computed columns.

Foreign Keys

You can also specify a foreign key constraint on certain fields. For example, the field `DEPT_NO` is defined as

```
DEPT_NO DEPTNO NOT NULL
```

The type `DEPT NO` is defined by its domain. It's okay if you don't understand this for now. Just assume that the field has been given a valid definition such as `CHAR(3)`. To ensure that this field references another field in another table, add the `FOREIGN KEY` clause to the table definition as shown here, with some of the fields excluded:

```
CREATE TABLE EMPLOYEE (  
    EMP_NO EMPNO NOT NULL,  
    DEPT_NO DEPTNO NOT NULL  
    FIRST_NAME FIRSTNAME NOT NULL,  
    LAST_NAME LASTNAME NOT NULL,  
    PRIMARY KEY (EMP_NO),  
    FOREIGN KEY (DEPT_NO) REFERENCES DEPARTMENT (DEPT_NO));
```

Here, the `FOREIGN KEY` clause ensures that the value in the `DEPT_NO` field of the table `EMPLOYEE` is the same as a value in the `DEPT_NO` column in the table `DEPARTMENT`. Foreign keys also result in an index being created for a column.

Default Values

You can use the `DEFAULT` clause to specify a default value for a certain field. For example, notice the definition for `HIRE_DATE`, which uses the `DEFAULT` clause to specify a default value for this field:

```
HIRE_DATE DATE DEFAULT 'NOW' NOT NULL,
```

Here, the default value to be assigned to this field comes from the result of the `NOW` function, an InterBase function that returns the current date.

Using Domains

Notice the list of domain definitions that appears before the `CREATE TABLE` statement. Domains are customized column definitions. By using domains, you can define table columns with complex characteristics that can be used by other tables in the same database. For example, Listing 29.1 shows the domain definition for `FIRSTNAME` as

```
CREATE DOMAIN FIRSTNAME VARCHAR(15);
```

Any other table that uses `FIRSTNAME` as one of its field definitions will inherit the same data type, `VARCHAR(15)`. If you find the need to redefine `FIRSTNAME` later on, any table defining a field of this type inherits the new definition.

You can add constraints to domain definitions as with column definitions. Take, for example, the domain definition for `JOBCODE`, which ensures that its value is greater than 99999:

```
CREATE DOMAIN JOBCODE AS VARCHAR(5)
    CHECK (VALUE > '99999');
```

You'll also see that the domain `JOBGRADE` ensures that the value is between 0 and 6:

```
CREATE DOMAIN JOBGRADE AS SMALLINT
    CHECK (VALUE BETWEEN 0 AND 6);
```

The examples provided here are just a mere glimpse of what type of integrity constraints you can place on table definitions. This also varies depending on which type of server you intend to use. It would be to your advantage to be thoroughly familiar with the various techniques provided by your server.

Defining the Business Rules with Views, Stored Procedures, and Triggers

Earlier in the chapter, we talked about business rules—the database logic that defines how data is accessed and processed. Three database objects that allow you to define business rules are *views*, *stored procedures*, and *triggers*, which we discuss in the following sections.

Defining Views

A *view* is a valuable database object that allows you to create a customized result set consisting of clusters of columns from one or more tables in a database. This “virtual table” can have operations performed on it as though it were a real table. This allows you to define the subset of data that a particular user or group of users require in addition to restricting their access to the rest of the data.

To create a view, you would use the `CREATE VIEW` statement. In InterBase, there are basically three ways to construct a view:

- *A horizontal subset of a single table's rows.* For example, the following view displays all the fields of the `EMPLOYEE` table with the exception of the `SALARY` column, which may apply only to management personnel:

```
CREATE VIEW EMPLOYEE_LIST AS
    SELECT EMP_NO, FIRST_NAME, LAST_NAME, PHONE_EXT, FULL_NAME
    FROM EMPLOYEE;
```

- *A subset of rows and columns from a single table.* The following example shows a view of employees who are executives based on salaries above \$100,000:

```
CREATE VIEW EXECUTIVE_LIST AS
    SELECT EMP_NO, FIRST_NAME, LAST_NAME, PHONE_EXT, FULL_NAME
    FROM EMPLOYEE WHERE SALARY >= 100,000;
```

- *A subset of rows and columns from more than one table.* The following view shows a subset of the EMPLOYEE table along with two columns from the JOB table. As far as the client application is concerned, the returned rows/columns belong to a single table:

```
CREATE VIEW ENTRY_LEVEL_EMPL AS
  SELECT JOB_CODE, JOB_TITLE, FIRST_NAME, LAST_NAME
  FROM JOB, EMPLOYEE
  WHERE JOB.JOB_CODE = EMPLOYEE.JOB_CODE AND SALARY < 15000;
```

Many operations can be applied to views. Some views are read-only, whereas others can be updated. This depends on certain criteria specific to the server you are using.

Defining Stored Procedures

You can think of a *stored procedure* as a standalone routine that's run on the server and invoked from the client applications. Stored procedures are created with the CREATE PROCEDURE statement. There are essentially two types of stored procedures:

- *Select procedures* return a result set of rows consisting of selected columns from one or more tables or a view.
- *Executable procedures* don't return a result set but perform some type of logic on the server side against the server data.

The syntax for defining each type of procedure is the same and consists of a header and a body.

The stored procedure *header* consists of a procedure name, an optional list of parameters, and an optional list of output parameters. The *body* consists of an optional list of local variables and the block of SQL statements that perform the actual logic. This block is enclosed within a BEGIN..END block. The stored procedure can also nest blocks.

A SELECT Stored Procedure

Listing 29.2 illustrates a simple SELECT stored procedure.

LISTING 29.2 A SELECT Stored Procedure

```
CREATE PROCEDURE CUSTOMER_SELECT (
iCOUNTRY          VARCHAR(15)
)
RETURNS (
CUST_NO           INTEGER,
CUSTOMER          VARCHAR(25),
STATE_PROVINCE   VARCHAR(15),
COUNTRY           VARCHAR(15),
POSTAL_CODE       VARCHAR(12)
)
```

continues

LISTING 29.2 Continued

```
AS
BEGIN
  FOR SELECT
    CUST_NO,
    CUSTOMER,
    STATE_PROVINCE,
    COUNTRY,
    POSTAL_CODE
  FROM customer WHERE COUNTRY = :iCOUNTRY
  INTO
    :CUST_NO,
    :CUSTOMER,
    :STATE_PROVINCE,
    :COUNTRY,
    :POSTAL_CODE
  DO
    SUSPEND;
END
^
```

This procedure takes an `iCOUNTRY` string as a parameter and returns the specified rows of the `CUSTOMER` table where the country matches that of the `iCOUNTRY` parameter. The code that accomplishes this uses a `FOR SELECT . .DO` statement that retrieves multiple rows. This statement functions just like a regular `SELECT` statement except that it retrieves one row at a time and places the specified column values into the variables specified with the `INTO` statement. Therefore, to execute this statement from Windows ISQL, you would enter the following statement:

```
SELECT * FROM CUSTOMER_SELECT("USA");
```

Later, we'll show you how to execute this stored procedure from a Delphi 5 application.

An Executable Stored Procedure

Listing 29.3 illustrates a simple executable stored procedure.

LISTING 29.3 Executable Stored Procedure

```
CREATE PROCEDURE ADD_COUNTRY(
  iCOUNTRY      VARCHAR(15),
  iCURRENCY     VARCHAR(10)
)
AS
BEGIN
  INSERT INTO COUNTRY(COUNTRY, CURRENCY)
  VALUES (:iCOUNTRY, :iCURRENCY);
```

```
SUSPEND;
END
^
```

This procedure adds a new record to the COUNTRY table by issuing an INSERT statement with the data passed into the procedure through parameters. This procedure does not return a result set and would be executed by using the EXECUTE PROCEDURE statement in Windows ISQL as shown here:

```
EXECUTE PROCEDURE ADD_COUNTRY("Mexico", "Peso");
```

Enforcing Data Integrity Through Stored Procedures

Earlier we stated that stored procedures provide a way of enforcing data integrity on the server, rather than the client. With the stored procedure logic, you can test for integrity rules and raise an error if the client is requesting an illegal operation. As an example, Listing 29.4 performs a “ship order” operation and performs the necessary checks to ensure that the operation is valid. If not, the procedure aborts after raising an exception.

LISTING 29.4 A “Ship Order” Stored Procedure

```
CREATE EXCEPTION ORDER_ALREADY_SHIPPED "Order status is 'shipped.'";
CREATE EXCEPTION CUSTOMER_ON_HOLD "This customer is on hold.";
CREATE EXCEPTION CUSTOMER_CHECK "Overdue balance -- can't ship.";

CREATE PROCEDURE SHIP_ORDER (PO_NUM CHAR(8))
AS

    DECLARE VARIABLE ord_stat CHAR(7);
    DECLARE VARIABLE hold_stat CHAR(1);
    DECLARE VARIABLE cust_no INTEGER;
    DECLARE VARIABLE any_po CHAR(8);
BEGIN
/* First retrieve the order status,
   customer hold information and the customer no
   which will be for tests later in the procedure.
   These values are stored in the
   local variables defined above. */

    SELECT s.order_status, c.on_hold, c.cust_no
    FROM sales s, customer c
    WHERE po_number = :po_num
    AND s.cust_no = c.cust_no
    INTO :ord_stat, :hold_stat, :cust_no;

/* Check if the purchase order has been already shipped. If so, raise an
```

continues

LISTING 29.4 Continued

```
        exception and terminate the procedure */

    IF (ord_stat = "shipped") THEN
    BEGIN
        EXCEPTION order_already_shipped;
        SUSPEND;
    END

    /* Check if the Customer is on hold. If so, raise an exception and terminate
       the procedure */

    ELSE IF (hold_stat = "**") THEN
    BEGIN
        EXCEPTION customer_on_hold;
        SUSPEND;
    END

    /* If there is an unpaid balance on orders shipped over 2 months ago,
       put the customer on hold, raise an exception and terminate the procedure
    */

    FOR SELECT po_number
    FROM sales
    WHERE cust_no = :cust_no
    AND order_status = "shipped"
    AND paid = "n"
    AND ship_date < 'NOW' - 60
    INTO :any_po
    DO
    BEGIN
        EXCEPTION customer_check;

        UPDATE customer
        SET on_hold = "**"
        WHERE cust_no = :cust_no;

        SUSPEND;
    END

    /* If we've made it to this point, everything checks out so ship the order.*/
    UPDATE sales
    SET order_status = "shipped", ship_date = 'NOW'
    WHERE po_number = :po_num;

    SUSPEND;
END
^
```

You'll notice in Listing 29.4 that the procedure illustrates another feature of InterBase's DDL—*exceptions*. Exceptions in InterBase are much like exceptions in Delphi 5. They are named error messages that are raised from within the stored procedure when an error occurs. When an exception is raised, it returns the error message to the calling application and terminates the execution of the stored procedure. It is possible, however, to handle the exception within the stored procedure and to allow the procedure to continue processing.

Exceptions are created with the `CREATE EXCEPTION` statement, as shown in Listing 29.4. To raise an exception within a stored procedure, you would use the syntax shown in the example and here:

```
EXCEPTION ExceptionName;
```

In Listing 29.4, we define three exceptions that are raised in the stored procedure under various circumstances. The procedure's commentary explains the process that occurs. The main thing to keep in mind is that these checks are being performed within the stored procedure. Therefore, any client application that executes this procedure would have the same integrity constraints enforced.

Defining Triggers

Triggers are basically stored procedures, except they occur upon a certain event and are not invoked directly from the client application or from within another stored procedure. A trigger event occurs during a table *update*, *insert*, or *delete* operation.

Like stored procedures, triggers can make use of exceptions, thus allowing you to perform various data-integrity checks during any of the previously mentioned operations on a particular table. Triggers offer you the following benefits:

- *Data integrity enforcement.* Only valid data can be inserted into a table.
- *Improved maintenance.* Any changes made to the trigger would be reflected by all applications using the table to which the trigger is applied.
- *Automatic tracking of table modifications.* The trigger can log various events that occur on the tables.
- *Automatic notification of table changes through event alerters.*

Triggers consist of a header and a body, just as stored procedures do. The trigger header contains the trigger name, the table name to which the trigger applies, and a statement indicating when a trigger is invoked. The trigger body contains an optional list of local variables and the block of SQL statements that perform the actual logic enclosed between a `BEGIN..END` block, just like a stored procedure.

Triggers are created with the `CREATE TRIGGER` statement. Listing 29.5 illustrates a trigger in InterBase that stores a history of salary changes for employees.

LISTING 29.5 A Trigger Example

```
CREATE TRIGGER SALARY_CHANGE_HISTORY FOR EMPLOYEE
AFTER UPDATE AS
BEGIN
  IF (old.SALARY <> new.SALARY) THEN
    INSERT INTO SALARY_HISTORY (
      EMP_NO,
      CHANGE_DATE,
      UPDATER_ID,
      OLD_SALARY,
      PERCENT_CHANGE)
    VALUES
      old.EMP_NO,
      "now",
      USER,
      old.SALARY,
      (new.SALARY - old.SALARY) * 100 / old.SALARY);
END
```

Let's examine this example more closely. The header contains the following statement:

```
CREATE TRIGGER SALARY_CHANGE_HISTORY FOR EMPLOYEE
AFTER UPDATE AS
```

First, the `CREATE TRIGGER` statement creates a trigger with the name `SALARY_CHANGE_HISTORY`. Then, the statement `FOR EMPLOYEE` specifies to which table the trigger is to be applied; in this case, this is the `EMPLOYEE` table. The `AFTER UPDATE` statement says that the trigger is to be fired after updates to the `EMPLOYEE` table. This statement could have read `BEFORE UPDATE`, which would specify to fire the trigger before changes are made to the table.

Triggers aren't only for updating tables. The following portions of the trigger header can be used in the definition of triggers:

- `AFTER UPDATE`. Fires the trigger after the table is updated
- `AFTER INSERT`. Fires the trigger after a record has been inserted into the table
- `AFTER DELETE`. Fires the trigger after a record is deleted from the table
- `BEFORE UPDATE`. Fires the trigger before updating a record in the table
- `BEFORE INSERT`. Fires the trigger before inserting a new record into the table
- `BEFORE DELETE`. Fires the trigger before deleting a record from the table

Following the `AS` clause in the trigger definition is the trigger body, which consists of SQL statements that form the trigger logic. In the example in Listing 29.5, a comparison is done between the old and new salary. If a difference exists, a record is added to the `SALARY_HISTORY` table indicating the change.

You'll notice that the example makes reference to the identifiers `Old` and `New`. These context variables refer to the current and previous values of a row being updated. `Old` is not used during a record insert, and `New` is not used during a record delete.

You'll see triggers used more extensively in Chapter 32, "Inventory Manager: Client/Server Development," which covers an InterBase client/server application.

Privileges/Access Rights to Database Objects

In client/server databases, users are granted access to or are restricted from accessing data on the server. These *access privileges* can be applied to tables, stored procedures, and views. Privileges are granted by using the `GRANT` statement, which will be illustrated in a moment. First, Table 29.2 illustrates the various SQL access privileges available to InterBase and most SQL servers.

TABLE 29.2 SQL Access Privileges

<i>Privilege</i>	<i>Access</i>
ALL	The user can select, insert, update, and delete data; see other access rights. ALL also grants execute rights on stored procedures.
SELECT	The user can read data.
DELETE	The user can delete data.
INSERT	The user can write new data.
UPDATE	The user can edit data.
EXECUTE	The user can execute or call a stored procedure.

Granting Access to Tables

To grant user access to a table, you must use the `GRANT` statement, which must include the following information:

- The access privilege
- The table, stored procedure, or view name to which the privilege is applied
- The user's name who is being granted this access

By default, in InterBase only the creator of a table has access to that table and has the ability to grant access to other users. Some examples of granting access follow. You can refer to your InterBase documentation for more information.

The following statement grants `UPDATE` access on the `EMPLOYEE` table to the user with the user name `JOHN`:

```
GRANT UPDATE ON EMPLOYEE TO JOHN;
```

The following statement grants read and edit access on the EMPLOYEE table to the users JOHN and JANE:

```
GRANT SELECT, UPDATE ON EMPLOYEE TO JOHN, JANE;
```

You can see that you can grant access to a list of users as well. If you want to grant all privileges to a user, use the ALL privilege in your GRANT statement:

```
GRANT ALL ON EMPLOYEE TO JANE;
```

Through the preceding statement, the user JANE will have SELECT, UPDATE, and DELETE access on the table EMPLOYEE.

It's also possible to grant privileges to specific columns in a table, as shown here:

```
GRANT SELECT, UPDATE (CONTACT, PHONE) ON CUSTOMERS TO PUBLIC;
```

This statement grants read and edit access on the fields CONTACT and PHONE in the CUSTOMERS table to all users by using the PUBLIC keyword, which specifies all users.

You must also grant privileges to stored procedures that require access to certain tables. For example, the following example grants read and update access on the customer's table to the stored procedure UPDATE_CUSTOMER:

```
GRANT SELECT, UPDATE ON CUSTOMERS TO PROCEDURE UPDATE_CUSTOMER;
```

The variations on the GRANT statement apply to stored procedures as well.

Granting Access to Views

For the most part, when GRANT is used against a view, SQL treats this just as it would when using GRANT against a table. However, you must be sure that the user to whom you're granting UPDATE, INSERT, and/or DELETE privileges also has the same privileges on the underlying tables to which the view refers. A WITH CHECK OPTION statement used when creating a view ensures that the fields to be edited can be seen through the view before the operation is attempted. It's recommended that modifiable views be created with this option.

Granting Access to Stored Procedures

For users or stored procedures to execute other stored procedures, you must grant them EXECUTE access to the stored procedure to be executed. The following example illustrates how you would grant access to a list of users and stored procedures requiring EXECUTE access to another stored procedure:

```
GRANT EXECUTE ON EDIT_CUSTOMER TO MIKE, KIM, SALLY, PROCEDURE ADD_CUSTOMER;
```

Here, the users MIKE, KIM, and SALLY as well as the stored procedure ADD_CUSTOMER can execute the stored procedure EDIT_CUSTOMER.

Revoking Access to Users

To revoke user access to a table or stored procedure, you must use the `REVOKE` statement, which must include the following items:

- The access privilege to revoke
- The table name/stored procedure to which the revocation is applied
- The user's name whose privilege is being revoked

`REVOKE` looks like the `GRANT` statement syntactically. The following example shows how you would revoke access to a table:

```
REVOKE UPDATE, DELETE ON EMPLOYEE TO JANE, TOM;
```

The Client: Designing the Front End

In the following sections, we'll discuss the Delphi 5 database components and how to use them to access a client/server database. We'll discuss various methods on how to perform common tasks efficiently with these components.

Using the TDatabase Component

The `TDatabase` component gives you more control over your database connections. Here's what it includes:

- Creating a persistent database connection
- Overriding the default server logins
- Creating application-level BDE aliases
- Controlling transactions and specifying transaction isolation levels

Tables 29.3 and 29.4 are brief references to `TDatabase`'s properties and methods. For more detailed descriptions, you'll want to refer to the Delphi online help or documentation. We'll show you how to use some of these properties and methods in this and later chapters.

TABLE 29.3 TDatabase Properties

<i>Property</i>	<i>Purpose</i>
AliasName	An existing BDE alias defined with the BDE Configuration utility. This property cannot be used in conjunction with the <code>DriverName</code> property.
Connected	A Boolean property to determine whether the <code>TDatabase</code> component is linked to a database.

continues

TABLE 29.3 Continued

<i>Property</i>	<i>Purpose</i>
DatabaseName	Defines an application-specific alias. Other TDataSet components (TTable, TQuery, and TStoredProc) use this property's value for their AliasName property.
DatasetCount	The number of TDataSet components linked to the TDatabase component.
Datasets	An array referring to all TDataSet components linked to the TDatabase component.
Directory	Working directory for a Paradox or dBase database.
DriverName	Name of a BDE driver such as Oracle, dBASE, InterBase, and so on. This property cannot be used in conjunction with the AliasName property.
Exclusive	Give an application sole access to the database.
Handle	Used to make direct calls to the Borland Database Engine (BDE) API.
InTransaction	Specifies if a transaction is in progress.
IsSQLBased	A Boolean property to determine whether the connected database is SQL based. This value is False if the Driver property holds STANDARD.
KeepConnection	A Boolean property to determine whether the TDatabase maintains a connection to the database when no TDatasets are open. This property is used for efficiency reasons because connecting to some SQL servers can take quite a while.
Locale	Identifies the language driver used with the TDatabase component. This is used primarily for direct BDE calls.
LoginPrompt	Determines how the TDatabase component handles user logins. If this property is set to True, a default login dialog will be displayed. If this property is set to False, the login parameters must be provided in code in the TDatabase.OnLogin event.
Name	The name of the component as referenced by other components.
Owner	The owner of the TDatabase component.
Params	Holds the parameters required to connect to the server database. Default parameters are set using the BDE configuration utility but may be customized here.
Session	Points to the session component with which this database component is associated.
SessionAlias	Specifies whether or not a database component is using a session alias.
Tag	A longint property used to store any integer value.
Temporary	A Boolean property indicating whether the TDatabase component was created as a result of no TDatabase component being present when a TTable, TQuery, or TStoredProc was opened.

<i>Property</i>	<i>Purpose</i>
TraceFlags	Specifies the database operations to track with the SQL Monitor at runtime.
TransIsolation	Determines the transaction isolation level for the server.

Table 29.4 lists TDataBase's methods.

TABLE 29.4 TDataBase Methods

<i>Method</i>	<i>Purpose</i>
ApplyUpdates	Posts pending cached updates for specified datasets to the database server.
Close	Closes the TDatabase connection and all linked TDataset components.
CloseDatasets	Closes all linked TDataset components linked to the TDatabase component. This does not necessarily close the TDatabase connection.
Commit	Commits all changes to the database within a transaction. The transaction must have been established with a call to StartTransaction.
Create	Allocates memory and creates an instances of a TDatabase component.
Destroy	Deallocates memory and destroys the TDatabase instance.
Execute	Executes an SQL statement without the overhead of a TQuery component.
FlushSchemaCache	Flushes the cached schema information for a table.
Free	Performs the same as Destroy except that it first determines whether the TDatabase component is set to nil before calling destroy.
Open	Connects the TDatabase component to the server database. Setting the Connected property to True automatically calls this method.
RollBack	Rolls back or cancels a transaction, thus canceling any changes made to the server since the last call to StartTransaction.
StartTransaction	Begins a transaction with the isolation level specified by the TransIsolation property. Modifications made to the server are not committed until a call to the Commit method is made. To cancel changes, you must call the RollBack method.
ValidateName	Raises an exception if a specified database is already open in the active session.

Application-Level Connections

One reason for using a TDatabase component with your project is to provide an application-level alias for the entire project. This differs from a BDE-level alias in that the alias name provided by the TDatabase component is available only to your project. This application-level alias may be shared among other projects by placing the TDatabase component on a sharable

`TDataModule`. The `TDataModule` can be made sharable by placing it where other developers can add it to their projects or by placing it into the Object Repository.

You specify the application-level alias by assigning a value to the `TDataBase.DatabaseName` property. The BDE alias that specifies the server database to which the `TDatabase` component is connected is specified by the `TDatabase.AliasName` property.

Security Control

The `TDatabase` component allows you to control user access to server data in how it handles the login process. During the login process, a user must provide a valid user name and password to gain access to vital data. By default, a standard login dialog is invoked when the user is connected to a server database.

There are several ways you might want to handle logins. One, you can override the login altogether and allow users to gain access to data without having to log in at all. Second, you can provide a different login dialog so that you can perform your own validity checks if necessary before passing the user name and password to the server for normal checks. Finally, you might want to allow users to log off and log in again without shutting down the application. The following sections illustrate all three techniques.

Automatic Login: Preventing the Login Dialog

To prevent the login dialog from displaying when launching an application, you must set the following `TDataBase` properties:

<i>Property</i>	<i>Description</i>
<code>AliasName</code>	Set to an existing BDE alias that was defined with the BDE Administrator. This is the same value typically used as the <code>Alias</code> property value for <code>TTable</code> and <code>TQuery</code> components.
<code>DatabaseName</code>	Set to an application-level alias that will be seen by <code>TDataSet</code> descendant components (<code>TTable</code> , <code>TQuery</code> , and <code>TStoredProc</code>) within the current application. These components will use this value as their <code>Alias</code> property value.
<code>LoginPrompt</code>	Set to <code>False</code> . This causes the <code>TDatabase</code> component to look to its <code>Params</code> property to find the user name and password.
<code>Params</code>	Specify the user name and password here. To do this, you must invoke the String List Editor for this property to set the values.

After you've set the `TDatabase` properties accordingly, you must link all `TTable`, `TQuery`, and `TStoredProc` components to `TDatabase` by placing the `TDatabase.DatabaseName` property value as their `Alias` property value. This value will appear in the drop-down list of aliases when you select the drop-down list in the Object Inspector.

Now, when you set the `TDatabase.Connected` property to `True`, your application will connect to the server without prompting the user for a user name and password because it will use those values defined in the `Params` property. The same will be true when running the application.

You'll find a small example called `NoLogin.dpr` illustrating this on the accompanying CD-ROM.

Providing a Customized Login Dialog

In certain cases, you might want to present your users with a more customized login dialog. For example, you may want to prompt your users for additional information other than just user name and password from the same dialog. Perhaps you just want a more appealing dialog at program startup than that provided by the default login. Whatever the situation, the process is fairly simple.

Basically, you can disable the default login dialog by setting the `TDatabase.LoginPrompt` property to `True`. However, this time you won't provide the user name and password through the `Params` property. Instead, you create an event handler for the `TDatabase.OnLogin` event. This event handler is called whenever the `TDatabase.Connected` property is set to `True` and the `TDatabase.LoginPrompt` property is set to `True`.

The following function instantiates a custom login form and assigns the user's user name and password back to the calling application:

```
function GetLoginParams(ALoginParams: TStrings): word;
var
  LoginForm: TLoginForm;
begin
  LoginForm := TLoginForm.Create(Application);
  try
    Result := LoginForm.ShowModal;
    if Result = mrOK then
      begin
        ALoginParams.Values['USER NAME'] := LoginForm.edtUserName.Text;
        ALoginParams.Values['PASSWORD'] := LoginForm.edtPassWord.Text;
      end;
  finally
    LoginForm.Free;
  end;
end;
```

The `TDataBase.OnLogin` event handler would invoke the preceding procedure as illustrated here (you'll find this sample project on the accompanying CD-ROM as `LOGIN.DPR`):

```
procedure TMainForm.dbMainLogin(Database: TDatabase;
  LoginParams: TStrings);
begin
  GetLoginParams(LoginParams);
end;
```

Logoff During a Current Session

You can also provide functionality for your users to be able to log off and log in again, perhaps as different users, without having to shut down the application. To do this, again you set up the TDatabase component so that it does not invoke the default login dialog. Therefore, you must override its OnLogin event handler. Also, you must set TDataBase.LoginPrompt to True so that the event handler will be invoked. The process requires the use of some variables to hold the user name and password as well as a Boolean variable to indicate either a successful or unsuccessful login attempt. Also, you must provide two methods—one to perform the login logic and the other to perform the logoff logic. Listing 29.6 illustrates a project that performs this logic.

LISTING 29.6 Login/Logoff Logic Example

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls,
  Forms, Dialogs, StdCtrls, Grids, DBGrids, BDE, DB, DBTables;

type
  TMainForm = class(TForm)
    dbMain: TDatabase;
    tblEmployee: TTable;
    dsEmployee: TDataSource;
    dgbEmployee: TDBGrid;
    btnLogon: TButton;
    btnLogOff: TButton;
    procedure btnLogonClick(Sender: TObject);
    procedure dbMainLogin(Database: TDatabase; LoginParams: TStrings);
    procedure btnLogOffClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
  public
    TempLoginParams: TStringList;
    LoginSuccess: Boolean;
  end;

var
  MainForm: TMainForm;

implementation
uses LoginFrm;

{$R *.DFM}
```

```
procedure TMainForm.btnLogonClick(Sender: TObject);
begin
  // Get the new login params.
  if GetLoginParams(TempLoginParams) = mrOk then
  begin
    // Disconnect the TDatabase component
    dbMain.Connected := False;
  try
    { Attempt to reconnect the TDatabase component. This will invoke
      the DataBase1Login event handler which will set the LoginParams
      with the current user name and password. }
    dbMain.Connected := True;
    tblEmployee.Active := True;
    LoginSuccess := True;
  except
    on EDBEngineError do
    begin
      //If login failed, specify a failed login and reraise the exception
      LoginSuccess := False;
      Raise;
    end;
  end;
end;
end;

procedure TMainForm.dbMainLogin(Database: TDatabase;
  LoginParams: TStrings);
begin
  LoginParams.Assign(TempLoginParams);
end;

procedure TMainForm.btnLogOffClick(Sender: TObject);
begin
  { Disconnect the TDatabase component and set the UserName
    and password variables to empty strings }
  dbMain.Connected := False;
  TempLoginParams.Clear;
end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
  TempLoginParams := TStringList.Create;
end;

procedure TMainForm.FormDestroy(Sender: TObject);
begin
```

continues

LISTING 29.6 Login/Logoff Logic Example

```
    TempLoginParams.Free;  
end;  
  
end.
```

In Listing 29.6, you see that the main form has two fields: `TempLoginParams` and `LoginSuccess`. The `TempLoginParams` field holds the user's user name and password. The `btnLogonClick()` method is the logic for the login process, whereas the `btnLogOffClick()` event handler is the logic for the logoff process. The `dbMainLogin()` method is the `OnLogin` event handler for `dbMain`. The code logic is explained in the code commentary. You should also notice that this project uses the same `TLoginForm` used in the previous example. You'll find this example in the project `LogOnOff.dpr` on the accompanying CD-ROM.

Transaction Control

Earlier in this chapter, we spoke of transactions. We mentioned how transactions allow a series of changes to the database to be committed as a whole to ensure database consistency.

Transaction processing can be handled from Delphi 5 client applications by making use of the `TDatabase` properties and methods specific to transactions. The following section explains how to perform transaction processing from within your Delphi 5 application.

Implicit Versus Explicit Transaction Control

Delphi 5 handles transactions either implicitly or explicitly. By default, transactions are handled implicitly.

Implicit transactions are transactions that are started and committed on a row-by-row basis. This means whenever you call a `Post` method or when `Post` is called automatically in VCL code. Because such transactions occur on a row-by-row basis, this increases network traffic, which may lead to efficiency problems.

Explicit transactions are handled in one of two ways. The first method is whenever you call the `StartTransaction()`, `Commit()`, or `RollBack()` method of `TDataBase`. The other method is by using pass-through SQL statements within a `TQuery` component, which we explain momentarily. Explicit transaction control is the recommended approach to use because it provides for less network traffic and safer code.

Handling Transactions

Back in Table 29.4, you saw three methods of `TDatabase` that deal specifically with transactions: `StartTransaction()`, `Commit()`, and `RollBack()`.

`StartTransaction()` begins a transaction using the isolation level specified by the `TDatabase.TransIsolation` property. Any changes made to the server after `StartTransaction()` is called will fall within the current transaction.

If all changes to the server were successful, a call to `TDatabase.Commit()` is made in order to finalize all changes at once. Otherwise, if an error occurs, `TDatabase.Rollback()` is invoked to cancel any changes made.

The typical example of where transaction processing comes in handy has to do with the inventory example. Given an `ORDER` table and an `INVENTORY` table, whenever an order is made, a new record must be added to the `ORDER` table. Likewise, the `INVENTORY` table must be updated to reflect the new item count on hand for the part or parts just ordered. Now suppose that a user enters an order with a system in which transactions were not present. The `ORDER` table gets its new record, but just before the `INVENTORY` table gets updated, a power failure occurs. The database would be in an inconsistent state because the `INVENTORY` table would not accurately reflect the items on hand. Transaction processing would circumvent this problem by ensuring that both table modifications are successful before finalizing any changes to the database. Listing 29.7 illustrates how this might look in Delphi 5 code.

LISTING 29.7 Transaction Processing

```
dbMain.StartTransaction;
try
  spAddOrder.ParamByName('ORDER_NO').AsInteger := OrderNo;
  { Make other Parameter assignments and then execute the stored
    procedure to add the new order record to the ORDER table.}
  spAddOrder.ExecProc;
  { Iterate through all the parts ordered and update the
    INVENTORY table to reflect the # of parts on hand }
  for i := 0 to PartList.Count - 1 do
  begin
    spReduceParts.ParamByName('PART_NO').AsInteger :=
      PartRec(PartList.Objects[i]).PartNo;
    spReduceParts.ParamByName('NUM_SOLD').AsInteger :=
      PartRec(PartList.Objects[i]).NumSold;
    spReduceParts.ExecProc;
  end;
  // Commit the changes to both the ORDER and INVENTORY tables.
  dbMain.Commit;
except
  // If we get here, an error occurred. Cancel all changes.
  dbMain.Rollback;
  raise;
end;
```

This code is a simplistic example of how to use transaction processing to ensure database consistency. It uses two stored procedures—one to add the new order record and the other to update the `INVENTORY` table with the new data. Keep in mind that this is just a code snippet to illustrate transaction processing with Delphi. This logic could probably be handled better on the server side.

In some cases, the type of transaction processing that must happen might depend on server-specific features. Given this situation, you would have to use a `TQuery` component to pass the server-specific SQL code, which requires that you set the SQL pass-through mode accordingly.

SQL Pass-through Mode

The SQL pass-through mode specifies how Delphi 5 database applications and the Borland Database Engine (BDE) share connections to database servers. The BDE connections are those used in Delphi methods that make BDI API calls. The pass-through mode is set in the BDE Configuration utility. The three settings for the pass-through mode are as follows:

<i>Setting</i>	<i>Description</i>
SHARED AUTOCOMMIT	Transactions are handled on a row-by-row basis. This method is more closely related to that of desktop databases. In the client/server world, this causes heavy network traffic and is not the recommended approach. However, this is the default setting for Delphi 5 applications.
SHARED NOAUTOCOMMIT	Delphi 5 applications must explicitly start, commit, and cancel transactions using the <code>TDatabase</code> . <code>StartTransaction()</code> , <code>Commit()</code> , and <code>RollBack()</code> methods.
NOT SHARED	The BDE and <code>TQuery</code> components issuing pass-through SQL statements do not share the same connections. This means that the SQL code is not restricted to BDE capabilities and may consist of server-specific features.

If you're not using pass-through SQL but want more control over your transaction processing, set the pass-through mode to `SHARED NOAUTOCOMMIT` and handle the transaction processing yourself. In most cases, this should suit your needs. Just keep in mind that in multiuser environments where the same rows get updated often, conflicts may occur.

Isolation Levels

Isolation levels determine how transactions see data that's being accessed from other transactions. The `TDatabase.TransIsolation` property determines what isolation level a particular transaction will use. There are three isolation levels to which you can assign the `TransIsolation` property:

<i>Isolation Level</i>	<i>Description</i>
tiDirtyRead	The lowest isolation level. Transactions using this isolation level can read uncommitted changes from other transactions.
tiReadCommitted	The default isolation level. Transactions using this isolation level can read only committed changes by other transactions.
tiRepeatableRead	This is the highest isolation level. Transactions using this isolation level cannot read changes to previously read data made by other transactions.

The support for the isolation levels listed here may vary on different servers. Delphi 5 will always use the next highest isolation level if a specific isolation level is not supported.

TTable or TQuery

A common misunderstanding is the idea that developing front-end client applications is the same as or similar to developing desktop database applications.

Where you'll see this frame of thinking manifest itself is in how or when one uses TTable versus TQuery components for database access. In the following paragraphs, we'll discuss some of the merits and faults of using a TTable component, when it should be used, and when it should not be used. You'll also see why you're most often better off using a TQuery component.

Can TTable Components Do SQL?

TTable components are great for accessing data in a desktop environment. They are designed to perform the tasks that desktop databases require such as manipulation of the entire table, navigation forward and backward through a table, and even going to a specific record in the table. These concepts, however, are foreign to SQL database servers. Relational databases are designed to be accessed in sets of data. SQL databases do not know the concepts of "next," "previous," and "last" record—something that TTable is good at. Although some SQL databases provide "scrollable cursors," this is not a standard and typically applies only to the result set. Additionally, some servers don't provide bidirectional scrolling.

The key point to make when comparing TTable components against SQL databases is that, ultimately, the commands issued through TTable must be converted to SQL code that the SQL database can understand. Not only does this limit how you can access the server, but it also weighs heavily on efficiency.

To demonstrate the inherent weakness of using TTable to access large datasets, consider the process of opening a TTable just to retrieve a few records. The time it takes for a TTable to open a SQL table is directly proportional to the number of fields and the amount of metadata

(index definitions and so on) attached to the SQL table. When you issue a command such as the following against a SQL table, the BDE sends a series of SQL commands to the server to first retrieve information about the table's columns, indexes, and so on:

```
Table1.Open;
```

Then it issues a `SELECT` statement to build a result set consisting of all the columns and rows from the table. This is where the time it takes to open a table might also be proportional to the size of the SQL table (the number of rows). Even though only the amount of rows necessary to populate the data-aware components are returned to the client, an entire result set is being built in response to the query. This process occurs whenever the `TTable` is opened. On extremely large tables, typical with client/server databases, this single operation can take up to 20 seconds. Keep in mind that some SQL servers such as Sybase and Microsoft SQL don't allow a client to abort the retrieval of a result set. This is where the table's size affects the select duration. Oracle, InterBase, and Informix all enable you to abort a result set without this considerable penalty.

Despite the disadvantages to using `TTables` with a client application, they are typically fine for accessing small tables on the server. You have to test your applications to determine whether the performance hit is unacceptable.

NOTE

MIDAS handles the returning of data packets a bit differently. You'll want to read about this in Chapter 34, "Client Tracker: MIDAS Development."

Issuing FindKey and FindNearest Against SQL Databases

Although `TTable` is capable of looking up records using the `FindKey()` method, it has its limitations when using this against a SQL database. First, `TTable` can only use `FindKey` against an indexed field or fields if you're performing a search based on values from multiple fields. `TQuery` is not faced with this limitation because you perform the record search through SQL. It's true that `TTable.FindKey` results in a `SELECT` statement against the server table. However, the result set will consist of all fields of the table even though you may have only selected certain fields from the `TTable` component's Fields Editor.

To achieve the functionality of `FindNearest()` with SQL code is not as straightforward as using a `TTable`, yet it's not impossible. The following SQL statement almost accomplishes the `TTable.FindNearest()` functionality:

```
SELECT * FROM EMPLOYEES
  WHERE NAME >= "CL"
  ORDER BY NOMENCLATURE
```

Here, the result set returns the record either *at* the position searched for or directly after where it *should be*. The problem here is that this result set returns *all* the records after the position searched on. To be more accurate so that the result set will consist of only one record, you can do the following:

```
SELECT * FROM EMPLOYEES
WHERE NAME = (SELECT MIN(NAME) FROM EMPLOYEES
WHERE NAME >= "CL")
```

Here, you use a nested `SELECT`. In a nested `SELECT` statement, the inner statement returns its result set to the outer `SELECT`. The outer `SELECT` then uses this result set to process its statement. In the inner query in this example, you use the SQL aggregate function `MIN()` to return the lowest value in the column `NAME` on the table `EMPLOYEES`. This single-row single-column result set is then used in the outer query to retrieve the remaining rows.

The point is that you give yourself much more flexibility and efficiency by maximizing SQL capabilities and using the `TQuery` component. By using `TTable`, you only limit what you're able to do against the server data.

Using the TQuery Component

In the previous chapter, you were introduced to the `TQuery` component and shown how you can use it to retrieve result sets of rows in tables. We're going to get a bit more into detail on `TQuery` in the following sections. We'll illustrate how to create dynamic SQL statements at runtime, how to pass parameters to queries, and how to improve `TQuery` performance by setting certain property values.

There are basically two types of queries for which you'll use `TQuery`: those that return result sets and those that don't. For queries returning a result set, you use the `TQuery.Open()` method. The `TQuery.ExecSQL()` method is used when a result set is not returned.

Dynamic SQL

Dynamic SQL means that you can modify your SQL statements at runtime based on various conditions. When you invoke the String List Editor for the `TQuery.SQL` property and enter a statement such as the following, you're entering a static SQL statement:

```
SELECT * FROM EMPLOYEE WHERE COUNTRY = "USA"
```

This statement won't vary unless you completely replace it at runtime.

To make this statement dynamic, you would enter the following into the `SQL` property:

```
SELECT * FROM CUSTOMER WHERE COUNTRY = :iCOUNTRY;
```

In this statement, instead of hard-coding the value on which to search, we've provided a placeholder, a *parameter* whose value can be specified later. This variable is named `iCountry` and

follows the colon in the `SELECT` statement. Its name was chosen at random. Now, you can search on any country by providing the country string to search on.

There are several ways to provide values for a parameterized query. One way is to use the property editor for the `TQuery.Params` property. Another is to provide that value at runtime. You can also provide the value from another dataset through a `TDataSource` component.

Providing TQuery Parameters Through the Params Property Editor

When you invoke the `TQuery.Params` property editor, the Parameter Name list displays the parameters for a given query. For each parameter listed, you must select a type from the Data Type drop-down combo. The value field is where you can specify an initial value for the parameter if you like. You can also select the NULL check box to set the parameter's value to null. When you select OK, the query will prepare its parameters, which binds them to their types (see the sidebar titled "Preparing Queries"). When you invoke `TQuery.Open()`, a result set will be returned to the `TQuery`.

Preparing Queries

When a SQL statement gets sent to the server, the server must parse, validate, compile, and execute the statement. This happens every time you send a SQL statement to the server. You can improve performance by allowing the server to perform the preliminary steps of parsing, validating, and compiling by "preparing" the SQL statement before having the server execute it. This is especially advantageous when using a query repetitively in a loop, by calling `TQuery.Prepare()` before entering the loop as shown in the following code:

```
Query1.Prepare; // First prepare the query.
try
{ Enter a loop to execute a query numerous times }
for i := 1 to 100 do begin
  { provide the parameters for the query }
  Query1.ParamByName('SomeParam').AsInteger := i;
  Query1.ParamByName('SomeOtherParam').AsString := SomeString;
  Query1.Open; // Open the query.
  try
    { Use the result set of Query1 here. }
  finally
    Query1.Close; // Close the query.
  end;
end;
finally
  Query1.Unprepare; // Call unprepare to free up resources
end;
```

`Prepare()` only needs to be called once before its repetitive use. You can also change the values of the query parameters after the first call to `Prepare()` without having to call `Prepare()` again. However, if you change the SQL statement itself, you must call `Prepare()` again before reusing it. A call to `Prepare()` must be matched with a call to `TQuery.UnPrepare()` to release the resources allocated by `Prepare()`.

Queries get prepared when you select the OK button on the Params property editor, or when you call the `TQuery.Prepare()` method, as shown in the preceding code. It's also recommended that you call `Prepare()` once in the form's `OnCreate` event handler and `UnPrepare()` in the form's `OnDestroy` event handler for those queries whose SQL statements won't change. It's not necessary to prepare your SQL queries, but it's certainly beneficial to do so.

Providing TQuery Parameters Using the Params Property

The `TQuery` component has a zero-based array of `TParam` objects, each representing parameters of the SQL statement in the `TQuery.SQL` property. For example, take a look at the following SQL statement:

```
INSERT INTO COUNTRY (
    NAME,
    CAPITAL,
    POPULATION)
VALUES(
    :NAME,
    :CAPITAL,
    :POPULATION)
```

To use the `Params` property to provide values for the parameters `:Name`, `:CAPITAL`, and `:POPULATION`, you would issue the following statement:

```
with Query1 do begin
    Params[0].AsString := 'Peru';
    Params[1].AsString := 'Lima'
    Params[2].AsInteger := 22,000,000;
end;
```

The values provided would be bound to the parameters in the SQL statement. Keep in mind that the order of the parameters in the SQL statement dictates their position in the `Params` property.

Providing TQuery Parameters Using the ParamByName Method

In addition to the `Params` property, the `TQuery` component has the `ParamByName()` method. The `ParamByName()` method enables you to assign values to the SQL parameters by their name rather than by their position in the SQL statement. This enhances code readability but isn't as efficient as the positional method because Delphi must resolve the parameters being references.

To use the `ParamByName()` method to provide value for the preceding `INSERT` query, you would use the following code:

```
with Query1 do begin
  ParamByName('COUNTRY').AsString := 'Peru';
  ParamByName('CAPITAL').AsString := 'Lima';
  ParamByName('POPULATION').AsInteger := 22,000,000;
end;
```

You should see that this code is a bit clearer as to which parameters you're providing values.

Providing TQuery Parameters Using Another Dataset

The parameters provided to a `TQuery` component can also be gotten from another `TDataset` such as `TQuery` or `TTable`. This creates a master-detail relationship between the two datasets. To do this, you must link a `TDataSource` component to the master dataset. The name of this `TDataSource` is assigned to the `DataSource` property of the detail `TQuery` component. When the query is executed, Delphi checks to see whether any value is assigned to the `TQuery.DataSource` property. If so, it will look for column names of the `DataSource` that match parameter names in the SQL statement and will then bind them.

As an example, consider the following SQL statement:

```
SELECT * FROM SALARY_HISTORY
WHERE EMP_NO = :EMP_NO
```

Here, you need a value for the parameter named `EMP_NO`. First, you assign the `TDataSource` that refers to the master `TTable` component to the `TQuery`'s `DataSource` property. Delphi will then search for a field named `EMP_NO` in the table to which the `TTable` refers and will bind the value of that column to the `TQuery`'s parameter for the current row. This is illustrated in the example found in the project `LnkQuery.dpr` on the accompanying CD-ROM.

Using the Format Function to Design Dynamic SQL Statements

Now that we've shown you how to use parameterized queries, it might seem reasonable that either of the following SQL statements would be valid:

```
SELECT * FROM PART ORDER BY :ORDERVAL;
SELECT * FROM :TABLENAME
```

Unfortunately, you cannot replace certain words in a SQL statement such as column names and table names. SQL servers just don't support this capability. So how do you go about putting this type of flexibility into your dynamic SQL statements? You do this by constructing your SQL statements at design time by using the `Format()` function.

If you have any experience programming in C or C++, you'll find that the `Format()` function works much like C's `printf()` function. See the sidebar on the `Format()` function.

Using the Format() Function

Use the `Format()` function to customize strings that vary depending on values provided by *format specifiers*. Format specifiers are placeholders where strings of a specified type will be inserted into a given string. These specifiers consist of a percent symbol (%) and a *type specifier*. The following list illustrates some type specifiers:

<i>Specifier</i>	<i>Description</i>
c	Specifies a char type
d	Specifies an integer type
f	Specifies a float type
p	Specifies a pointer type
s	Specifies a string type

For example, in the string "My name is %s and I'm %d years old.", you see two format specifiers. The %s specifier indicates that a string is to be inserted in its place. The %d specifier indicates that an integer is to be inserted in its place. To construct the string, here's how to use the `Format()` function:

```
S := Format('My name is %s and I'm %d years old.', ['Xavier', 32]);
```

The `Format()` function takes the source string and an open array of arguments to replace the format specifiers. It returns the resulting string. You'll find detailed information on the `Format()` function in Delphi 5's online help.

Therefore, to construct SQL statements with the flexibility to modify field names or table names, you can use the `Format()` function as illustrated in the following code examples.

Listing 29.8 illustrates how you would use the `Format()` function to allow the user to pick the fields by which to sort the result set of a query. The list of fields exists in a list box, and the code is actually the `OnClick` event of that list box. You'll find this demo in the project `OrderBy.dpr` on the accompanying CD-ROM.

LISTING 29.8 Using Format() to Specify Sorting Column

```
procedure TMainForm.lbFieldsClick(Sender: TObject);
{ Define a constant string from which the SQL string will be built }
const
  SQLString = 'SELECT * FROM PARTS ORDER BY %s';
begin
  with qryParts do
  begin
    Close;      // Make sure the query is closed.
```

continues

LISTING 29.8 Continued

```
SQL.Clear; // Clear any previous SQL statement.
{ Now add the new SQL statement constructed with the format
  function }
SQL.Add(Format(SQLString, [lbFields.Items[lbFields.ItemIndex]]));
Open; { Now open Query1 with the new statement }
end;
end;
```

To populate the list box in Listing 29.8 with the field names in the parts table, we used the following code in the form's OnCreate event handler:

```
tblParts.Open;
try
  tblParts.GetFieldNames(lbFields.Items);
finally
  tblParts.Close;
end;
```

tblParts is linked to the PARTS.DB table.

The next example in Listing 29.9 illustrates how to pick a table on which to perform a SELECT statement. The code is practically the same as that presented in Listing 29.8, except that the format string is different and the form's OnCreate event handler retrieves a list of table names in the given session rather than a list of fields for a single table.

First, a list of table names is obtained:

```
procedure TMainForm.FormCreate(Sender: TObject);
begin
{ First, get a list of table names for the user to select }
  Session.GetTableNames(dbMain.DatabaseName, '', False, False, lbTables.Items);
end;
```

Then, the lbTables.OnClick event handler is used to select the table on which to perform a SELECT query, as shown in Listing 29.9.

LISTING 29.9 Using Format() to Specify a Table to Select

```
procedure TMainForm.lbTablesClick(Sender: TObject);
{ Define a constant string from which the SQL string will be built }
const
  SQLString = 'SELECT * FROM %s';
begin
  with qryMain do
  begin
    Close; // Make sure the query is closed.
```

```
SQL.Clear; // Clear any previous SQL statement.
{ Now add the new SQL statement constructed with the format
  function }
SQL.Add(Format(SQLString, [lbTables.Items[lbTables.ItemIndex]]));
Open; { Now open Query1 with the new statement }
end;
end;
```

This demo is provided in the project `Se1Table.dpr` on the accompanying CD-ROM.

Retrieving the Result Set Values of a Query Through TQuery

When a query operation returns a result set, you can access the values of the columns in that result set by using the `TQuery` component as though it were an array whose field names are indexes into this array. For example, suppose you have a `TQuery` whose `SQL` property contains the following SQL statement:

```
SELECT * FROM CUSTOMER
```

You would retrieve the values of the columns as shown in Listing 29.10, which shows the code for the project `Res1tSet.dpr` on the accompanying CD-ROM.

LISTING 29.10 Retrieving the Fields of a TQuery Result Set

```
procedure TMainForm.dsCustomerDataChange(Sender: TObject; Field: TField);
begin
  with lbCustomer.Items do
  begin
    Clear;
    Add(VarToStr(qryCustomer[ 'CustNo' ]));
    Add(VarToStr(qryCustomer[ 'Company' ]));
    Add(VarToStr(qryCustomer[ 'Addr1' ]));
    Add(VarToStr(qryCustomer[ 'City' ]));
    Add(VarToStr(qryCustomer[ 'State' ]));
    Add(VarToStr(qryCustomer[ 'Zip' ]));
    Add(VarToStr(qryCustomer[ 'Country' ]));
    Add(VarToStr(qryCustomer[ 'Phone' ]));
    Add(VarToStr(qryCustomer[ 'Contact' ]));
  end;
end;
```

In the preceding code, you use the default dataset method, `FieldValues()`, to access the field values of `qryCustomer`. Because `FieldValues()` is the default dataset method, it's not necessary to specify the method name explicitly, as shown here:

```
Add(VarToStr(qryCustomer.FieldValues[ 'Contact' ]));
```

CAUTION

The function `FieldValues()` returns a variant field type. If a field were to contain a null value, an attempt to get the field's value with `FieldValue()` would result in an `EVariantError` exception. Therefore, Delphi provides the `VarToStr()` function, which converts null string values to an empty string. Equivalent functions for other data types are not provided. However, you can construct your own as shown here for integer types:

```
function VarToInt(const V: Variant): Integer;
begin
  if TVarData(V).VType <> varNull then
    Result := V
  else
    Result := 0;
end;
```

Be careful, however, when you resave the data. A null value in a SQL database is a valid value. If you were to replace that value with an empty string, which is not the same as null, you could destroy the integrity of the data. You'll have to come up with a runtime solution to this, such as testing for `NULL` and storing some predefined string to represent the null value.

You can also retrieve the field values from a `TQuery` using the `TQuery.Fields` property. The `Fields` property is used in the same way as the `TQuery.Params` property, except it refers to the columns in the result set. Similarly, `TQuery` has the `FieldByName()` method, which functions like the `ParamByName()` method.

The UniDirectional Property

To optimize access to a database, the `TQuery` component has the `UniDirectional` property. This applies to databases that support *bidirectional cursors*. Bidirectional cursors enable you to move forward and backward through the query's result set. By default, this property is `False`. Therefore, when you have components such as the `TDBGrid` component linked to a database that does not support bidirectional movement, Delphi emulates this movement by buffering records on the client side. This can take up a lot of resources on the client end rather quickly. Therefore, if you plan to only move forward through a result set, or if you plan to go through the result set only once, set `UniDirectional` to `True`.

Live Result Sets

By default, `TQuery` returns read-only result sets. You can specify for `TQuery` to return a modifiable result set by changing the `TQuery.RequestLive` property to `True`. However, certain restrictions apply to doing this, as shown in the following lists.

For queries returning result sets from dBASE or Paradox tables, these restrictions apply:

- Uses local SQL Syntax (information provided in online help).
- Uses only a single table.
- SQL statement does not use an ORDER BY clause.
- SQL statement does not use aggregate functions such as SUM and AVG.
- SQL statement does not use calculated fields.
- Comparisons in the WHERE clause may consist only of column names to scalar types.

For queries using pass-through SQL from a server table, these restrictions apply:

- Uses a single table.
- SQL statement does not use an ORDER BY clause.
- SQL statement does not use aggregate functions such as SUM and AVG.

To determine whether a query can be modified, you can check the `TQuery.CanModify` property.

Cached Updates

`TDataSets` contain a `CachedUpdate` property, which allows you to turn any query or stored procedure into an updateable view. This means the changes to the data set are written to a temporary buffer on the client instead of these changes being written to the server. These changes can then be sent to the server by calling the `ApplyUpdates()` method for the `TQuery` or `TStoredProc` component. Cached updates allow optimization of the updates and remove much of the lock contention on the server. You might refer to Chapter 13 of “Delphi 5 Database Application Developer’s Guide,” of the Delphi 5 documentation which is dedicated to working with cached updates.

Executing Stored Procedures

Delphi’s `TStoredProc` and `TQuery` components are both capable of executing stored procedures on the server. The following sections explain how to use both components to perform stored procedure execution.

Using the `TStoredProc` Component

The `TStoredProc` component enables you to execute stored procedures on the server. Depending on the server, it can return either a singleton or multiple result set. `TStoredProc` may also execute stored procedures that return no data at all. To execute server stored procedures, the following `TStoredProc` properties must be set accordingly:

<i>Property</i>	<i>Description</i>
DataBaseName	The name of the database that contains the stored procedure. This is usually the DataBaseName property for the TDatabase component referring to this server database.
StoredProcName	The name of the stored procedure to execute.
Params	This contains the input and output parameters defined by the stored procedure. The order is also based on the definition of the stored procedure on the server.

TStoredProc Input and Output Parameters

You provide input and output parameters through the TStoredProc.Params property. Like TQuery, the parameters must be *prepared* with default data types. This can be done either at design time through the Parameters Editor or at runtime, as will be illustrated.

To prepare parameters using the Parameters Editor, you right-click the TStoredProc component to invoke the Parameters Editor.

The Parameters Name list box shows a list of the input and output parameters for the stored procedure. Note that you must have already selected a StoredProcName from the server for any parameter to display. For each parameter, you specify a data type in the Data Type drop-down combo box. You can also specify an initial value or a null value, as with the TQuery component. When you select the OK button, the parameters will be prepared.

You can also prepare the TStoredProc's parameters at runtime by executing the TStoredProc.Prepare() method. This function is just like the Prepare() method for the TQuery component discussed earlier.

Executing Non-Result Set Stored Procedures

To understand executing a stored procedure that does not return a result set, see Listing 29.11, which shows an InterBase stored procedure that adds a record to a COUNTRY table.

LISTING 29.11 Insert COUNTRY Stored Procedure in InterBase

```
CREATE PROCEDURE ADD_COUNTRY(  
iCOUNTRY      VARCHAR(15),  
iCURRENCY     VARCHAR(10)  
)  
AS  
BEGIN  
    INSERT INTO COUNTRY(COUNTRY, CURRENCY)  
    VALUES (:iCOUNTRY, :iCURRENCY);  
    SUSPEND;  
END  
^
```

To execute this stored procedure from Delphi, you would first set up the `TStoredProc` component with the appropriate values for the properties specified earlier. This includes specifying the parameter types from the Parameters Editor. The Delphi code to run this stored procedure is presented in Listing 29.12.

LISTING 29.12 Executing a Stored Procedure Through `TStoredProc`

```
with spAddCountry do
begin
  ParamByName('iCOUNTRY').AsString := edtCountry.Text;
  ParamByName('iCURRENCY').AsString := edtCurrency.Text;
  ExecProc;
  edtCountry.Text := '';
  edtCurrency.Text := '';
  tblCountries.Refresh;
end;
```

Here, you first assign the values from two `TEdits` to the `TStoredProc` parameters through the `ParamByName()` method. Then you call the `TStoredProc.ExecProc()` function, which executes the stored procedure. You'll find an example that illustrates this code in the project `AddCntry.dpr`.

NOTE

To run the `AddCntry.dpr` project, you must use the `BDEADMIN.EXE` utility to set up a new alias named "DB." This alias must point to the file `\CODE\DATA\DDGIB.GDB`, which can be found on the CD-ROM accompanying this book. Refer to the documentation for the BDE Administrator utility for further information.

Getting a Stored Procedure Result Set from TQuery

It's also possible to execute a stored procedure using a pass-through SQL statement with a `TQuery` component. This is necessary in some cases, as with InterBase, which doesn't support stored procedures that must be called with a `SELECT` statement. For example, a stored procedure that returns result sets can be called just as though it were a table. Take a look at Listing 29.13, which is an InterBase stored procedure that returns a list of employees from an `EMPLOYEE` table belonging to a particular department. The department is specified by the input parameter `iDEPT_NO`.

LISTING 29.13 GET_EMPLOYEES_BY_DEPT Stored Procedure

```
CREATE PROCEDURE GET_EMPLOYEES_IN_DEPT (
iDEPT_NO          CHAR(3))
RETURNS(
EMP_NO           SMALLINT,
FIRST_NAME       VARCHAR(15),
LAST_NAME        VARCHAR(20),
DEPT_NO          CHAR(3),
HIRE_DATE        DATE)
AS
BEGIN
    FOR SELECT
        EMP_NO,
        FIRST_NAME,
        LAST_NAME,
        DEPT_NO,
        HIRE_DATE
    FROM EMPLOYEE
    WHERE DEPT_NO = :iDEPT_NO
    INTO
        :EMP_NO,
        :FIRST_NAME,
        :LAST_NAME,
        :DEPT_NO,
        :HIRE_DATE
    DO
        SUSPEND;
END ^
```

To execute this stored procedure from within Delphi 5, you need to use a TQuery component with the following SQL property:

```
SELECT * FROM GET_EMPLOYEES_IN_DEPT(
:iDEPT_NO)
```

Notice that this statement uses the SELECT statement as though the procedure were a table. The difference, as you can see, is that you must also provide the input parameter `iDEPT_NO`.

We've created a sample project, `Emp_Dept.dpr`, that illustrates executing the preceding stored procedure.

`qryGetEmployees` is the TQuery component that executes the stored procedure shown in Listing 29.13. It gets its parameter from `qryDepartment`, which performs a simple SELECT statement on the DEPARTMENT table in the database. `qryGetEmployees` is linked to `dbgEmployees`, which shows a scrollable list of departments. When the user scrolls through

dbgDepartment, this invokes dsDepartment's OnDataChange event handler. We should mention that dsDepartment is linked to qryDepartment. This event handler executes the code shown in Listing 29.14, which sets the parameter for qryGetEmployees and retrieves its output result set.

LISTING 29.14 DataSource1's OnChange Event Handler

```
procedure TMainForm.dsDepartmentDataChange(Sender: TObject; Field: TField);
begin
  with qryGetEmployees do
  begin
    Close;
    ParamByName('iDEPT_NO').AsString := qryDepartment['DEPT_NO'];
    Open;
  end;
end;
```

So why would you want to retrieve this information through a stored procedure rather than a simple statement on a table? Consider that there may be several people at different levels within a department who need access to the information provided. If these people had direct access to the table, they would be able to see sensitive information such as an employee's salary. By restricting access to a table but providing the "need to know" information through stored procedures and views, you not only establish good security measures but also create a more maintainable set of business rules for the database.

Summary

This chapter presented you with quite a bit of information about client/server development. We first discussed the elements that make up a client/server system. We compared client/server development to traditional desktop database development methodologies. We also introduced you to various techniques using Delphi 5 and InterBase that should set you well on your way to developing client/server projects.

Extending Database VCL

CHAPTER

30

IN THIS CHAPTER

- **Using the BDE 1588**
- **dBASE Tables 1590**
- **Paradox Tables 1595**
- **Extending TDataSet 1613**
- **Summary 1641**

Out of the box, Visual Component Library's (VCL's) database architecture is equipped to communicate primarily by means of the Borland Database Engine (BDE)—feature-rich and reliable database middleware. What's more, VCL serves as a kind of insulator between you and your databases, allowing you to access different types of databases in much the same manner. Although all this adds up to reliability, scalability, and ease of use, there is a downside: database-specific features provided both within and outside the BDE are generally not provided for in the VCL database framework. This chapter provides you with the insight you'll need to extend VCL by communicating directly with the BDE and other data sources to obtain database functionality not otherwise available in Delphi.

Using the BDE

When you're writing applications that make direct calls to the BDE, there are a few rules of thumb to keep in mind. This section presents the general information you need to get into the BDE API from your Delphi applications.

The BDE Unit

All BDE functions, types, and constants are defined in the BDE unit. This unit will need to be in the `uses` clause of any unit from which you want to make BDE calls. Additionally, the interface portion of the BDE unit is available in the `BDE.INT` file, which you'll find in the `.. \Delphi5\Doc` directory. You can use this file as a reference to the functions and records available to you.

TIP

For additional assistance on programming using the BDE API, take a look at the `BDE32.hlp` help file provided in your BDE directory (the default path for this directory is `\Program Files\Borland\Common Files\BDE`). This file contains detailed information on all BDE API functions and very good examples in both Object Pascal and C.

Check()

All BDE functions return a value of type `DBIRESULT`, which indicates the success or failure of the function call. Rather than going through the cumbersome process of checking the result of every BDE function call, Delphi defines a procedure called `Check()`, which accepts a `DBIRESULT` as a parameter. This procedure will raise an exception when the `DBIRESULT` indicates any value except success. The following code shows how to, and how not to, make a BDE function call:

```
// !!Don't do this:  
var
```

```
    Rez: DBIRESULT;
    A: array[0..dbiMaxUserNameLen] of char;
begin
    Rez := dbiGetNetUserName(A); // make BDE call
    if Rez <> DBIERR_NONE then // handle error
        // handle error here
    else begin
        // continue with function
    end;
end;

// !!Do do this:
var
    A: array[0..dbiMaxUserNameLen] of char;
begin
    { Handle error and make BDE call at one time. }
    { Exception will be raised in case of error. }
    Check(dbiGetNetUserName(A));
    // continue with function
end;
```

Cursors and Handles

Many BDE functions accept as parameters handles to cursors or databases. Roughly speaking, a *cursor handle* is a BDE object that represents a particular set of data positioned at some particular row in that data. The data type of a cursor handle is `hDBICur`. Delphi surfaces this concept as the current record in a particular table, query, or stored procedure. The `Handle` properties of `TTable`, `TQuery`, and `TStoredProc` hold this cursor handle. Remember to pass the `Handle` of one of these objects to any BDE function that requires an `hDBICur`.

Some BDE functions also require a handle to a database. A BDE database handle is of type `hDBIDb`, and it represents some particular open database—either a local or networked directory in the case of `dBASE` or `Paradox`, or a server database file in the case of a `SQL` server database. You can obtain this handle from a `TDatabase` through its `Handle` property. If you're not connecting to a database using a `TDatabase` object, the `DBHandle` properties of `TTable`, `TQuery`, and `TStoredProc` also contain this handle.

Syncing Cursors

It's been established that an open Delphi dataset has the concept of a current record, whereas the underlying BDE maintains the concept of a cursor that points to some particular record in a dataset. Because of the way Delphi performs record caching to optimize performance, sometimes the Delphi current record is not in sync with the underlying BDE cursor. Normally, this is not a problem because this behavior is business as usual for VCL's database framework.

However, if you want to make a direct call to a BDE function that expects a cursor as a parameter, you need to ensure that Delphi's current cursor position is synchronized with the underlying BDE cursor. It might sound like a daunting task, but it's actually quite easy to do. Simply call the `UpdateCursorPos()` method of a `TDataSet` descendant to perform this synchronization.

In a similar vein, after making a BDE call that modifies the position of the underlying cursor, you need to inform VCL that it needs to resynchronize its own current record position with that of the BDE. To do this, you must call the `CursorPosChanged()` method of `TDataSet` descendants immediately after calling into the BDE. The following code demonstrates how to use these cursor-synchronization functions:

```
procedure DoSomethingWithTable(T: TTable);
begin
    T.UpdateCursorPos;
    // call BDE function(s) which modifies cursor position
    T.CursorPosChanged;
end;
```

dBASE Tables

dBASE tables have a number of useful capabilities that are not directly supported by Delphi. These features include, among other things, the maintenance of a unique physical record number for each record, the capability to “soft-delete” records (delete records without removing them from the table), the capability to undelete soft-deleted records, and the capability to pack a table to remove soft-deleted records. In this section, you'll learn about the BDE functions involved in performing these actions, and you'll create a `TTable` descendant called `TdBaseTable` that incorporates these features.

Physical Record Number

dBASE tables maintain a unique physical record number for each record in a table. This number represents a record's physical position relative to the beginning of the table (regardless of any index currently applied to the table). To obtain a physical record number, you must call the BDE's `DbiGetRecord()` function, which is defined as follows:

```
function DbiGetRecord(hCursor: hDBICur; eLock: DBILockType;
    pRecBuff: Pointer; precProps: pRECProps): DBIResult stdcall;
```

`hCursor` is the cursor handle. Usually, this is the `Handle` property of the `TDataSet` descendant.

`eLock` is an optional request for the type of lock to place on the record. This parameter is of type `DBILockType`, which is an enumerated type defined as follows:

```
type
    DBILockType = (
```

```

dbiNOLOCK,           // No lock (Default)
dbiWRITELOCK,       // Write lock
dbiREADLOCK);       // Read lock

```

In this case you don't want to place a lock on the record because you're not intending to modify the record content; therefore, `dbiNOLOCK` is the appropriate choice.

`pRecBuff` is a pointer to a record buffer. Because you want to obtain only the record properties and not the data, you should pass `Nil` for this parameter.

`pRecProps` is a pointer to a `RECProps` record. This record is defined as follows:

```

type
  pRECProps = ^RECProps;
  RECProps = packed record
    // Record properties
    iSeqNum      : Longint; // When Seq# supported only
    iPhyRecNum   : Longint; // When Phy Rec#s supported only
    iRecStatus   : Word;    // Delayed Updates Record Status
    bSeqNumChanged : WordBool; // Not used
    bDeleteFlag  : WordBool; // When soft delete supported only
  end;

```

As you can see, you can obtain a variety of information from this record. In this case, you're concerned only with the `iPhyRecNum` field, which is valid only in the case of `dBASE` and `FoxPro` tables.

Putting this all together, the following code shows a method of `TdBaseTable` that returns the physical record number of the current record:

```

function TdBaseTable.GetRecNum: Longint;
{ Returns the physical record number of the current record. }
var
  RP: RECProps;
begin
  UpdateCursorPos;           // update BDE from Delphi
  { Get current record properties }
  Check(DbiGetRecord(Handle, dbiNOLOCK, Nil, @RP));
  Result := RP.iPhyRecNum;   // return value from properties
end;

```

Viewing Deleted Records

Viewing records that have been soft-deleted in a `dBASE` table is as easy as making one BDE API call. The function to call is `DbiSetProp()`, which is a very powerful function that enables you to modify the different properties of multiple types of BDE objects. For a complete description of this function and how it works, your best bet is to check out the “Properties—Getting and Setting” topic in the BDE help. This function is defined as follows:

```
function DbiSetProp(hObj: hDBIObj; iProp: Longint;
  iPropValue: Longint): DBIResult stdcall;
```

The `hObj` parameter holds a handle to some type of BDE object. In this case, it will be a cursor handle.

The `iProp` parameter will contain the identifier of the property to be set. You'll find a complete list of these in the aforementioned topic in the BDE help. For the purposes of enabling or disabling the view of deleted records, use the `curSOFTDELETEON` identifier.

`iPropValue` is the new value for the given property. In this case, it's a Boolean value (0 meaning *off*; 1 meaning *on*).

The following code shows the `SetViewDeleted()` method of `TdBaseTable`:

```
procedure TdBaseTable.SetViewDeleted(Value: Boolean);
{ Allows the user to toggle between viewing and not viewing }
{ deleted records. }
begin
  { Table must be active }
  if Active and (FViewDeleted <> Value) then begin
    DisableControls;    // avoid flicker
    try
      { Magic BDE call to toggle view of soft deleted records }
      Check(DbiSetProp(hDBIObj(Handle), curSOFTDELETEON, Longint(Value)));
    finally
      Refresh;          // update Delphi
      EnableControls;   // flicker avoidance complete
    end;
    FViewDeleted := Value
  end;
end;
```

This method first performs a test to ensure that the table is open and that the value to be set is different than the value the `FViewDeleted` field in the object already contains. It then calls `DisableControls()` to avoid flicker of any data-aware controls attached to the table. The `DbiSetProp()` function is called next (notice the necessary typecast of `hDBICur`'s `Handle` parameter to an `hDBIObj`). Think of `hDBIObj` as an untyped handle to some type of BDE object. After that, the dataset is refreshed and any attached controls are reenabled.

TIP

Whenever you use `DisableControls()` to suspend a dataset's connection to data-aware controls, you should always use a `try..finally` block to ensure that the subsequent call to `EnableControls()` takes place whether or not an error occurs.

Testing for a Deleted Record

When viewing a dataset that includes deleted records, you'll probably need to determine as you navigate through the dataset which records are deleted and which aren't. Actually, you've already learned how to perform this check. You can obtain this information using the `DbiGetRecord()` function that you used to obtain the physical record number. The following code shows this procedure. The only material difference between this procedure and `GetRecNum()` is the checking of the `bDeletedFlag` field rather than the `iPhyRecNo` field of the `RECProps` record. Here's the code:

```
function TdBaseTable.GetIsDeleted: Boolean;
{ Returns a boolean indicating whether or not the current record }
{ has been soft deleted. }
var
  RP: RECProps;
begin
  if not FViewDeleted then      // don't bother if they aren't viewing
    Result := False           // deleted records
  else begin
    UpdateCursorPos;          // update BDE from Delphi
    { Get current record properties }
    Check(DbiGetRecord(Handle, dbiNOLOCK, Nil, @RP));
    Result := RP.bDeleteFlag; // return flag from properties
  end;
end;
```

Undeleting a Record

So far, you've learned how to view deleted records as well as determine whether a record has been deleted, and, of course, you already know how to delete a record. The only other thing you need to learn regarding record deletion is how to undelete a record. Fortunately, the BDE makes this an easy task thanks to the `DbiUndeleteRecord()` function, which is defined as follows:

```
function DbiUndeleteRecord(hCursor: hDBCUR): DBIResult stdcall;
```

The lone parameter is a cursor handle for the current dataset. Using this function, you can create an `UndeleteRecord()` method for `TdBaseTable` as shown here:

```
procedure TdBaseTable.UndeleteRecord;
begin
  if not IsDeleted then
    raise EDatabaseError.Create('Record is not deleted');
  Check(DbiUndeleteRecord(Handle));
  Refresh;
end;
```

Packing a Table

To remove soft-deleted records from a dBASE table, that table must go through a process called *packing*. For this, the BDE provides a function called `DbiPackTable()`, which is defined as follows:

```
function DbiPackTable(hDb: hDBIDb; hCursor: hDBICur;
    pszTableName: PChar; pszDriverType: PChar;
    bRegenIdxs: Bool): DBIResult stdcall;
```

`hDb` is a handle to a database. You should pass the `DBHandle` property of a `TDataSet` descendant or the `Handle` property of a `TDatabase` component in this parameter.

`hCursor` is a cursor handle. You should pass the `Handle` property of a `TDataSet` descendant in this parameter. You may also pass `Nil` if you want to instead use the `pszTableName` and `pszDriverType` parameters to identify the table.

`pszTableName` is a pointer to a string containing the name of the table.

`pszDriverType` is a pointer to a string representing the driver type of the table. If `hCursor` is `Nil`, this parameter must be set to `szDBASE`. As a side note, it's unusual that this parameter is required because this function is supported only for dBASE tables—we don't make the rules, we just play by them.

`bRegenIdxs` indicates whether or not you want to rebuild all out-of-date indexes associated with the table.

Here's the `Pack()` method for the `TdBaseTable` class:

```
procedure TdBaseTable.Pack(RegenIndexes: Boolean);
{ Packs the table in order to removed soft deleted records }
{ from the file. }
const
    SPackError = 'Table must be active and opened exclusively';
begin
    { Table must be active and opened exclusively }
    if not (Active and Exclusive) then
        raise EDatabaseError.Create(SPackError);
    try
        { Pack the table }
        Check(DbiPackTable(DBHandle, Handle, Nil, Nil, RegenIndexes));
    finally
        { update Delphi from BDE }
        CursorPosChanged;
        Refresh;
    end;
end;
```

The complete listing of the `TdBaseTable` object is provided in Listing 30.1, later in this chapter.

Paradox Tables

Paradox tables don't have as many nifty features, such as soft deletion, but they do carry the concept of a record number and table pack. In this section, you'll learn how to extend a `TTable` to perform these Paradox-specific tasks and to create a new `TParadoxTable` class.

Sequence Number

Paradox tables do not have the concept of a physical record number in the dBASE sense. They do, however, maintain the concept of a sequence number for each record in a table. The sequence number differs from the physical record number in that the sequence number is dependent on whatever index is currently applied to the table. The sequence number of a record is the order in which the record appears based on the current index.

The BDE makes it pretty easy to obtain a sequence number using the `DbiGetSeqNo()` function, which is defined as follows:

```
function DbiGetSeqNo(hCursor: hDBICur; var iSeqNo: Longint): DBIResult;
    stdcall;
```

`hCursor` is a cursor handle for a Paradox table, and the `iSeqNo` parameter will be filled in with the sequence number of the current record. The following code shows the `GetRecNum()` function for `TParadoxTable`:

```
cfunction TParadoxTable.GetRecNum: Longint;
{ Returns the sequence number of the current record. }
begin
    UpdateCursorPos;           // update BDE from Delphi
    { Get sequence number of current record into Result }
    Check(DbiGetSeqNo(Handle, Result));
end;
```

Table Packing

Table packing in Paradox has a different meaning than in dBASE because Paradox does not support soft deletion of records. When a record is deleted in Paradox, the record is removed from the table, but a "hole" is left in the database file where the record used to be. To compress these holes left by deleted records and make the table smaller and more efficient, you must pack the table.

Unlike with dBASE tables, there's no obvious BDE function you can use to pack a Paradox table. Instead, you must use `DbiDoRestructure()` to restructure the table and specify that the table should be packed as it's restructured. `DbiDoRestructure()` is defined as follows:

```
function DbiDoRestructure(hDb: hDBIDb; iTblDescCount: Word;
    pTblDesc: pCRTblDesc; pszSaveAs, pszKeyviolName,
    pszProblemsName: PChar; bAnalyzeOnly: Bool): DBIResult stdcall;
```

`hDb` is the handle to a database. However, because this function will not work when Delphi has the table open, you won't be able to use the `DBHandle` property of a `TDataSet`. To overcome this, the sample code (shown a bit later) that uses this function demonstrates how to create a temporary database.

`iTblDescCount` is the number of table descriptors. This parameter must be set to 1 because the current version of the BDE supports only one table descriptor per call.

`pTblDesc` is a pointer to a `CRTblDesc` record. This is the record that identifies the table and specifies how the table is to be restructured. This record is defined as follows:

```

type
  pCRTblDesc = ^CRTblDesc;
  CRTblDesc = packed record
    szTblName      : DBITBLNAME; // Create/Restruct Table descr
    szTblType      : DBINAME;    // TableName incl. optional path & ext
    szErrTblName   : DBIPATH;    // Driver type (optional)
    szTblName      : DBIPATH;    // Error Table name (optional)
    szUserName     : DBINAME;    // User name (if applicable)
    szPassword     : DBINAME;    // Password (optional)
    bProtected     : WordBool;   // Master password supplied in szPassword
    bPack          : WordBool;   // Pack table (restructure only)
    iFldCount      : Word;       // Number of field defs supplied
    pcrFldOp       : pCROpType;  // Array of field ops
    pFldDesc       : pFLDDesc;   // Array of field descriptors
    iIdxCount      : Word;       // Number of index defs supplied
    pcrIdxOp       : pCROpType;  // Array of index ops
    pidxDesc       : PIDXDesc;   // Array of index descriptors
    iSecRecCount   : Word;       // Number of security defs supplied
    pcrSecOp       : pCROpType;  // Array of security ops
    pSecDesc       : pSECDesc;   // Array of security descriptors
    iValChkCount   : Word;       // Number of val checks
    pcrValChkOp    : pCROpType;  // Array of val check ops
    pvchkDesc      : pVCHKDesc;  // Array of val check descscs
    iRintCount     : Word;       // Number of ref int specs
    pcrRintOp      : pCROpType;  // Array of ref int ops
    printDesc      : pPRINTDesc; // Array of ref int specs
    iOptParams     : Word;       // Number of optional parameters
    pFldOptParams  : pFLDDesc;   // Array of field descriptors
    pOptData       : Pointer;    // Optional parameters
  end;

```

For Paradox table packing, it's only necessary to specify values for the `szTblName`, `szTblType`, and `bPack` fields.

`pszSaveAs` is an optional string pointer that identifies the destination table if it is different than the source table.

pszKeyviolName is an optional string pointer that identifies the table to which records that cause key violations during the restructure will be sent.

pszProblemsName is an optional string pointer that identifies the table to which records that cause problems during the restructure will be sent.

bAnalyzeOnly is unused.

The following code shows the Pack() method of TParadoxTable. You can see from the code how the CRTblDesc record is initialized and how the temporary database is created using the DbOpenDatabase() function. Also note the finally block, which ensures that the temporary database is cleaned up after use.

```

procedure TParadoxTable.Pack;
var
  TblDesc: CRTblDesc;
  TempDBHandle: HDBIDb;
  WasActive: Boolean;
begin
  { Initialize TblDesc record }
  FillChar(TblDesc, SizeOf(TblDesc), 0); // fill with 0s
  with TblDesc do begin
    StrPCopy(szTblName, TableName);      // set table name
    StrCopy(szTblType, szPARADOX);      // set table type
    bPack := True;                       // set pack flag
  end;
  { Store table active state. Must close table to pack. }
  WasActive := Active;
  if WasActive then Close;
  try
    { Create a temporary database. Must be read-write/exclusive }
    Check(DbOpenDatabase(PChar(DatabaseName), Nil, dbiREADWRITE,
      dbiOpenExcl, Nil, 0, Nil, Nil, TempDBHandle));
  try
    { Pack the table }
    Check(DbiDoRestructure(TempDBHandle, 1, @TblDesc, Nil, Nil, Nil,
      False));
  finally
    { Close the temporary database }
    DbCloseDatabase(TempDBHandle);
  end;
  finally
    { Reset table active state }
    Active := WasActive;
  end;
end;

```

Listing 30.1 shows the DDGTbls unit in which the TdBaseTable and TParadoxTable objects are defined.

LISTING 30.1 The DDGTbls.pas Unit

```
unit DDGTbls;

interface

uses DB, DBTables, BDE;

type
  TdBaseTable = class(TTable)
  private
    FViewDeleted: Boolean;
    function GetIsDeleted: Boolean;
    function GetRecNum: Longint;
    procedure SetViewDeleted(Value: Boolean);
  protected
    function CreateHandle: HDBICur; override;
  public
    procedure Pack(RegenIndexes: Boolean);
    procedure UndeleteRecord;
    property IsDeleted: Boolean read GetIsDeleted;
    property RecNum: Longint read GetRecNum;
    property ViewDeleted: Boolean read FViewDeleted write SetViewDeleted;
  end;

  TParadoxTable = class(TTable)
  private
  protected
    function CreateHandle: HDBICur; override;
    function GetRecNum: Longint;
  public
    procedure Pack;
    property RecNum: Longint read GetRecNum;
  end;

implementation

uses SysUtils;

{ TdBaseTable }

function TdBaseTable.GetIsDeleted: Boolean;
{ Returns a boolean indicating whether or not the current record }
{ has been soft deleted. }
```

```

var
  RP: RECProps;
begin
  if not FViewDeleted then      // don't bother if they aren't viewing
    Result := False           // deleted records
  else begin
    UpdateCursorPos;          // update BDE from Delphi
    { Get current record properties }
    Check(DbiGetRecord(Handle, dbiNOLOCK, Nil, @RP));
    Result := RP.bDeleteFlag; // return flag from properties
  end;
end;

function TdBaseTable.GetRecNum: Longint;
{ Returns the physical record number of the current record. }
var
  RP: RECProps;
begin
  UpdateCursorPos;           // update BDE from Delphi
  { Get current record properties }
  Check(DbiGetRecord(Handle, dbiNOLOCK, Nil, @RP));
  Result := RP.iPhyRecNum;   // return value from properties
end;

function TdBaseTable.CreateHandle: HDBICur;
{ Overridden from ancestor in order to perform a check to }
{ ensure that this is a dBASE table. }
var
  CP: CURProps;
begin
  Result := inherited CreateHandle;      // do inherited
  if Result <> Nil then begin
    { Get cursor properties, and raise exception if the }
    { table isn't using the dBASE driver. }
    Check(DbiGetCursorProps(Result, CP));
    if not (CP.szTableType = szdBASE) then
      raise EDatabaseError.Create('Not a dBASE table');
  end;
end;

procedure TdBaseTable.Pack(RegenIndexes: Boolean);
{ Packs the table in order to removed soft deleted records }
{ from the file. }
const
  SPackError = 'Table must be active and opened exclusively';
begin

```

continues

LISTING 30.1 Continued

```
{ Table must be active and opened exclusively }
if not (Active and Exclusive) then
  raise EDatabaseError.Create(SPackError);
try
  { Pack the table }
  Check(DbipackTable(DBHandle, Handle, Nil, Nil, RegenIndexes));
finally
  { update Delphi from BDE }
  CursorPosChanged;
  Refresh;
end;
end;

procedure TdBaseTable.SetViewDeleted(Value: Boolean);
{ Allows the user to toggle between viewing and not viewing }
{ deleted records. }
begin
  { Table must be active }
  if Active and (FViewDeleted <> Value) then begin
    DisableControls;    // avoid flicker
    try
      { Magic BDE call to toggle view of soft deleted records }
      Check(DbisetProp(hdbiObj(Handle), curSOFTDELETEON, Longint(Value)));
    finally
      Refresh;          // update Delphi
      EnableControls;   // flicker avoidance complete
    end;
    FViewDeleted := Value
  end;
end;

procedure TdBaseTable.UndeleteRecord;
begin
  if not IsDeleted then
    raise EDatabaseError.Create('Record is not deleted');
  Check(DbiUndeleteRecord(Handle));
  Refresh;
end;

function TParadoxTable.CreateHandle: HDBICur;
{ Overridden from ancestor in order to perform a check to }
{ ensure that this is a Paradox table. }
var
  CP: CURProps;
begin
  Result := inherited CreateHandle;    // do inherited
```

```

if Result <> Nil then begin
  { Get cursor properties, and raise exception if the }
  { table isn't using the Paradox driver. }
  Check(DbGetCursorProps(Result, CP));
  if not (CP.szTableType = szPARADOX) then
    raise EDatabaseError.Create('Not a Paradox table');
end;
end;

function TParadoxTable.GetRecNum: Longint;
{ Returns the sequence number of the current record. }
begin
  UpdateCursorPos;           // update BDE from Delphi
  { Get sequence number of current record into Result }
  Check(DbGetSeqNo(Handle, Result));
end;

procedure TParadoxTable.Pack;
var
  TblDesc: CRTblDesc;
  TempDBHandle: HDBIDb;
  WasActive: Boolean;
begin
  { Initialize TblDesc record }
  FillChar(TblDesc, SizeOf(TblDesc), 0); // fill with 0s
  with TblDesc do begin
    StrPCopy(szTblName, TableName);      // set table name
    szTblType := szPARADOX;              // set table type
    bPack := True;                        // set pack flag
  end;
  { Store table active state. Must close table to pack. }
  WasActive := Active;
  if WasActive then Close;
  try
    { Create a temporary database. Must be read-write/exclusive }
    Check(DbOpenDatabase(PChar(DatabaseName), Nil, dbiREADWRITE,
      dbiOpenExcl, Nil, 0, Nil, Nil, TempDBHandle));
  try
    { Pack the table }
    Check(dbiDoRestructure(TempDBHandle, 1, @TblDesc, Nil, Nil, Nil,
      False));
  finally
    { Close the temporary database }
    DbCloseDatabase(TempDBHandle);
  end;
end;
finally

```

continues

LISTING 30.1 Continued

```
    { Reset table active state }
    Active := WasActive;
end;
end;

end.
```

Limiting TQuery Result Sets

Here's a classic SQL programming *faux pas*: Your application issues a SQL statement to the server that returns a result set consisting of a gazillion rows, thereby making the application user wait forever for the query to return and tying up precious server and network bandwidth. Conventional SQL wisdom dictates that one shouldn't issue queries that are so general that they cause so many records to be fetched. However, this is sometimes unavoidable, and TQuery doesn't seem to help matters much, because it doesn't provide a means for restricting the number of records in a result set to be fetched from the server. Fortunately, the BDE does provide this capability, and it's not very difficult to surface in a TQuery descendant.

The BDE API call that performs this magic is the catchall `DbiSetProp()` function, which was explained earlier in this chapter. In this case, the first parameter to `DbiSetProp()` is the cursor handle for the query, the second parameter must be `curMAXROWS`, and the final parameter should be set to the maximum number of rows to which you want to restrict the result set.

The ideal place to make the call to this function is in the `PrepareCursor()` method of TQuery, which is called immediately after the query is opened. Listing 30.2 shows the `ResQuery` unit, in which the `TRestrictedQuery` component is defined.

LISTING 30.2 The `ResQuery.pas` Unit

```
unit ResQuery;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms,
  Dialogs, DB, DBTables, BDE;

type
  TRestrictedQuery = class(TQuery)
  private
    FMaxRowCount: Longint;
  protected
    procedure PrepareCursor; override;
```

```

published
  property MaxRowCount: Longint read FMaxRowCount write FMaxRowCount;
end;

procedure Register;

implementation

procedure TRestrictedQuery.PrepareCursor;
begin
  inherited PrepareCursor;
  if FMaxRowCount > 0 then
    Check(DbSetProp(hDBIObj(Handle), curMAXROWS, FMaxRowCount));
end;

procedure Register;
begin
  RegisterComponents('DDG', [TRestrictedQuery]);
end;

end.

```

You can limit the result set of a query by simply setting the `MaxRowCount` property to a value greater than zero. To further illustrate the point, Figure 30.1 shows the result of a query restricted to three rows, as shown in SQL Monitor.

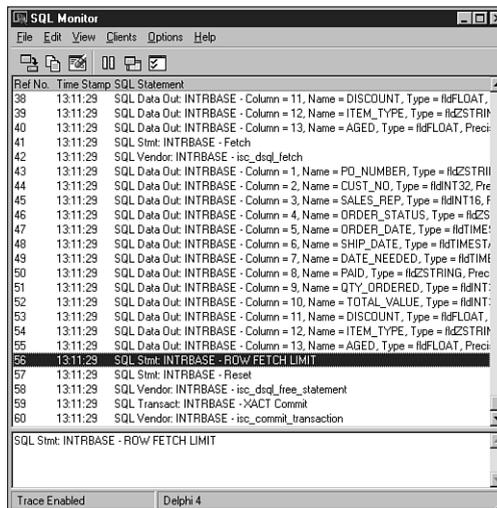


FIGURE 30.1

A restricted query viewed from SQL Monitor.

BDE Miscellany

Through our development of database applications, we've found a few common development tasks that could serve to be automated a bit. Some of these miscellaneous tasks include performing SQL aggregate functions on a table, copying tables, and obtaining a list of Paradox users for a particular session.

SQL Aggregate Functions

Generally speaking, SQL aggregate functions are functions built into the SQL language that perform some arithmetic operation on one or more columns from one or more rows. Some common examples of this are `sum()`, which adds columns from multiple rows, `avg()`, which calculates the average value of columns from multiple rows, `min()`, which finds the minimum value of columns in multiple rows, and `max()`, which (as you might guess) determines the maximum value of columns within multiple rows.

Aggregate functions such as these can sometimes be inconvenient to use in Delphi. For example, if you're working with `TTables` to access data, using these functions involves creating a `TQuery`, formulating the correct SQL statement for the table and column in question, executing the query, and obtaining the result from the query. Clearly this is a process crying out to be automated, and the code in Listing 30.3 does just that.

LISTING 30.3 Automating SQL Aggregate Functions

```
type
    TSQLAggFunc = (safSum, safAvg, safMin, safMax);

const
    // SQL aggregate functions
    SQLAggFuncs: array[TSQLAggFunc] of string = (
        'select sum(%s) from %s',
        'select avg(%s) from %s',
        'select min(%s) from %s',
        'select max(%s) from %s');

function CreateQueryFromTable(T: TTable): TQuery;
// returns a query hooked to the same database and session as table T
begin
    Result := TQuery.Create(nil);
    try
        Result.DatabaseName := T.DatabaseName;
        Result.SessionName := T.SessionName;
    except
        Result.Free;
        Raise;
    end;
end;
```

```
    end;
end;

function DoSQLAggFunc(T: TTable; FieldNames: string;
    Func: TSQLAggFunc): Extended;
begin
    with CreateQueryFromTable(T) do
        begin
            try
                SQL.Add(Format(SQLAggStrs[Func], [FieldNames, T.TableName]));
                Open;
                Result := Fields[0].AsFloat;
            finally
                Free;
            end;
        end;
    end;
end;

function SumField(T: TTable; Field: String): Extended;
begin
    Result := DoSQLAggFunc(T, Field, safSum);
end;

function AvgField(T: TTable; Field: String): Extended;
begin
    Result := DoSQLAggFunc(T, Field, safAvg);
end;

function MinField(T: TTable; Field: String): Extended;
begin
    Result := DoSQLAggFunc(T, Field, safMin);
end;

function MaxField(T: TTable; Field: string): Extended;
begin
    Result := DoSQLAggFunc(T, Field, safMax);
end;
```

As you can see from the listing, each of the individual aggregate function wrappers call into the `DoSQLAggFunc()` function. In this function, the `CreateQueryFromTable()` function creates and returns a `TQuery` component that uses the same database and session as the `TTable` passed in the `T` parameter. The proper SQL string is then formatted from an array of strings, the query is executed, and the query's result is returned from the function.

Quick Table Copy

If you want to make a copy of a table, traditional wisdom might dictate a few different courses of action. The first might be to use the Win32 API's `CopyFile()` function to physically copy the table file(s) from one location to another. Another option is to use a `TBatchMove` component to copy one `TTable` to another. Yet another option is to use `TTable`'s `BatchMove()` method to perform the copy.

However, there are problems with each of these traditional alternatives: A brute-force file copy using the `CopyFile()` API function may not work if the table files are open by another process or user, and it certainly will not work if the table exists within some type of database file on a SQL server. A file copy might become a very complex task if you consider that you may also have to copy associated index, BLOB, or value files. The use of `TBatchMove` would solve these problems, but only if you submit to the disadvantage of the complexity involved in using this component. An additional drawback is the fact that the batch move process is much slower than a direct file copy. Using `TTable.BatchMove()` does help to alleviate the issue of complexity in performing the table copy, but it doesn't overcome the performance shortcomings inherent in the batch move process.

Fortunately, the BDE developers also recognized this issue and made a BDE API function available that provides the best of both worlds: speed and ease of use. The function in question is `DbiCopyTable()`, and it's declared as shown here:

```
function DbiCopyTable (           { Copy one table to another }
    hDb           : hDBIDb;       { Database handle }
    bOverWrite    : Bool;        { True, to overwrite existing file }
    pszSrcTableName : PChar;     { Source table name }
    pszSrcDriverType : PChar;    { Source driver type }
    pszDestTableName : PChar    { Destination table name }
): DBIResult stdcall;
```

Because the BDE API function can't deal directly with VCL `TTable` components, the following procedure wraps `DbiCopyTable()` into a nifty routine to which you can pass a `TTable` and a destination table name:

```
procedure QuickCopyTable(T: TTable; DestTblName: string;
    Overwrite: Boolean);
// Copies TTable T to an identical table with name DestTblName.
// Will overwrite existing table with name DestTblName if Overwrite is
// True.
var
    DBType: DBINAME;
    WasOpen: Boolean;
    NumCopied: Word;
begin
```

```

WasOpen := T.Active;           // save table active state
if not WasOpen then T.Open; // ensure table is open
// Get driver type string
Check(DbGetProp(hDBIObj(T.Handle), drvDRIVERTYPE, @DBType,
  SizeOf(DBINAME), NumCopied));
// Copy the table
Check(DbCopyTable(T.DBHandle, Overwrite, PChar(T.TableName), DBType,
  PChar(DestTblName)));
T.Active := WasOpen;           // restore active state
end;

```

NOTE

For local databases (Paradox, dBASE, Access, and FoxPro), all files associated with the table—index and BLOB files, for example—are copied to the destination table. For tables residing in a SQL database, only the table will be copied, and it's up to you to ensure that the necessary indexes and other elements are applied to the destination table.

Paradox Session Users

If your application uses Paradox tables, you may come across a situation where you need to determine which users are currently using a particular Paradox table. You can accomplish this with the `DbOpenUserList()` BDE API function. This function provides a BDE cursor for a list of users for the current session. The following procedure demonstrates how to use this function effectively:

```

procedure GetPDoxUsersForSession(Sess: TSession; UserList: TStrings);
// Clears UserList and adds each user using the same netfile as session
// Sess to the list. If Sess = nil, then procedure works for default
// net file.
var
  WasActive: Boolean;
  SessHand: hDBISes;
  ListCur: hDBICur;
  User: UserDesc;
begin
  if UserList = nil then Exit;
  UserList.Clear;
  if Assigned(Sess) then
  begin
    WasActive := Sess.Active;
    if not WasActive then Sess.Open;
    Check(DbStartSession(nil, SessHand, PChar(Sess.NetFileDir)));

```

```
end
else
  Check(DbiStartSession(nil, SessHand, nil));
try
  Check(DbiOpenUserList(ListCur));
  try
    while DbiGetNextRecord(ListCur, dbiNOLOCK, @User, nil) =
      DBIERR_NONE do
      UserList.Add(User.szUserName);
    finally
      DbiCloseCursor(ListCur); // close "user list table" cursor
    end;
  finally
    DbiCloseSession(SessHand);
    if Assigned(Sess) then Sess.Active := WasActive;
  end;
end;
```

The interesting thing about the `DbiOpenUserList()` function is that it creates a cursor for a table that's manipulated in the same manner as any other BDE table cursor. In this case, `DbiGetNextRecord()` is called repeatedly until the end of the table is reached. The record buffer for this table follows the format of the `UserDesc` record, which is defined in the BDE unit as follows:

```
type
  pUSERDesc = ^USERDesc;
  USERDesc = packed record
    szUserName : DBIUSERNAME;      { User description }
    iNetSession : Word;            { User Name }
    iProductClass: Word;          { Net level session number }
    szSerialNum : packed array [0..21] of Char; { Product class of user }
  end;
```

Each call to `DbiGetNextRecord()` fills a `UserDesc` record called `User`, and the `szUserName` field of that record is added to the `UserList` string list.

TIP

Note the use of the `try..finally` resource protection blocks in the `GetPDoxUsersForSession()` procedure. These ensure that both the BDE resources associated with the session and cursor are properly released.

Writing Data-Aware VCL Controls

Chapter 21, “Writing Delphi Custom Components,” and Chapter 22, “Advanced Component Techniques,” provided you with thorough coverage of component-building techniques and methodologies. One large topic that wasn’t covered, however, is data-aware controls. Actually, there isn’t much more to creating a data-aware control than there is to creating a regular VCL control, but a typical data-aware component is different in four key respects:

- Data-aware controls maintain an internal data link object. A descendant of `TDataLink`, this object provides the means by which the control communicates with a `TDataSource`. For data-aware controls that connect to a single field of a dataset, this is usually a `TFieldDataLink`. The control should handle the `OnDataChange` event of the data link in order to receive notifications when the field or record data has changed.
- Data-aware controls must handle the `CM_GETDATALINK` message. The typical response to this message is to return the data link object in the message’s `Result` field.
- Data-aware controls should surface a property of type `TDataSource` so the control can be connected to a data source by which it will communicate with a dataset. By convention, this property is called `DataSource`. Controls that connect to a single field should also surface a string property to hold the name of the field to which it is connected. By convention, this property is called `DataField`.
- Data-aware controls should override the `Notification()` method of `TComponent`. By overriding this method, the data-aware control can be notified if the data source component connected to the control has been deleted from the form.

To demonstrate the creation of a simple data-aware control, Listing 30.4 shows the `DBSound` unit. This unit contains the `TDBWavPlayer` component, a component that plays WAV sounds from a BLOB field in a dataset.

LISTING 30.4 The `DBSound.pas` Unit

```
unit DBSound;  
  
interface  
  
uses Windows, Messages, Classes, SysUtils, Controls, Buttons, DB,  
    DBTables, DbCtrls;  
  
type  
    EDBWavError = class(Exception);  
  
    TDBWavPlayer = class(TSpeedButton)  
    private
```

continues

LISTING 30.4 Continued

```
    FAutoPlay: Boolean;
    FDataLink: TFieldDataLink;
    FDataStream: TMemoryStream;
    FExceptOnError: Boolean;
    procedure DataChange(Sender: TObject);
    function GetDataField: string;
    function GetDataSource: TDataSource;
    function GetField: TField;
    procedure SetDataField(const Value: string);
    procedure SetDataSource(Value: TDataSource);
    procedure CMGetDataLink(var Message: TMessage); message
        CM_GETDATALINK;
    procedure CreateDataStream;
    procedure PlaySound;
protected
    procedure Notification(AComponent: TComponent;
        Operation: TOperation); override;
public
    constructor Create(AOwner: TComponent); override;
    destructor Destroy; override;
    procedure Click; override;
    property Field: TField read GetField;
published
    property AutoPlay: Boolean read FAutoPlay write FAutoPlay
        default False;
    property ExceptOnError: Boolean read FExceptOnError
        write FExceptOnError;
    property DataField: string read GetDataField write SetDataField;
    property DataSource: TDataSource read GetDataSource
        write SetDataSource;
end;

implementation

uses MMSystem;

const
    // Error strings
    SNotBlobField = 'Field "%s" is not a blob field';
    SPlaySoundErr = 'Error attempting to play sound';

constructor TDBWavPlayer.Create(AOwner: TComponent);
begin
    inherited Create(AOwner);           // call inherited
    FDataLink := TFieldDataLink.Create; // create field data link
```

```
FDataLink.OnDataChange := DataChange; // get data link notifications
FDataStream := TMemoryStream.Create; // create worker memory stream
end;

destructor TDBWavPlayer.Destroy;
begin
  FDataStream.Free;
  FDataLink.Free;
  FDataLink := Nil;
  inherited Destroy;
end;

procedure TDBWavPlayer.Click;
begin
  inherited Click; // do default behavior
  PlaySound;      // play the sound
end;

procedure TDBWavPlayer.CreateDataStream;
// creates memory stream from wave file in blob field
var
  BS: TBlobStream;
begin
  // make sure it's a blob field
  if not (Field is TBlobField) then
    raise EDBWavError.CreateFmt(SNotBlobField, [DataField]);
  // create a blob stream
  BS := TBlobStream.Create(TBlobField(Field), bmRead);
  try
    // copy from blob stream to memory stream
    FDataStream.SetSize(BS.Size);
    FDataStream.CopyFrom(BS, BS.Size);
  finally
    BS.Free; // free blob stream
  end;
end;

procedure TDBWavPlayer.PlaySound;
// plays wave sound loaded in memory stream
begin
  // make sure we are hooked to a dataset and field
  if (DataSource <> nil) and (DataField <> '') then
    begin
      // make sure data stream is created
      if FDataStream.Size = 0 then CreateDataStream;
      // Play the sound in the memory stream, raise exception on error
```

continues

LISTING 30.4 Continued

```
        if (not MMSystem.PlaySound(FDataStream.Memory, 0, SND_ASYNC or
            SND_MEMORY)) and FExceptOnError then
            raise EDBWavError.Create(SPlaySoundErr);
        end;
    end;

procedure TDBWavPlayer.DataChange(Sender: TObject);
// OnChange handler FFieldDataLink.DataChange
begin
    // deallocate memory occupied by previous wave file
    with FDataStream do if Size <> 0 then SetSize(0);
    // if AutoPlay is on, the play the sound
    if FAutoPlay then PlaySound;
end;

procedure TDBWavPlayer.Notification(AComponent: TComponent;
    Operation: TOperation);
begin
    inherited Notification(AComponent, Operation);
    // do some required housekeeping
    if (Operation = opRemove) and (FDataLink <> nil) and
        (AComponent = DataSource) then DataSource := nil;
end;

function TDBWavPlayer.GetDataSource: TDataSource;
begin
    Result := FDataLink.DataSource;
end;

procedure TDBWavPlayer.SetDataSource(Value: TDataSource);
begin
    FDataLink.DataSource := Value;
    if Value <> nil then Value.FreeNotification(Self);
end;

function TDBWavPlayer.GetDataField: string;
begin
    Result := FDataLink.FieldName;
end;

procedure TDBWavPlayer.SetDataField(const Value: string);
begin
    FDataLink.FieldName := Value;
end;
```

```
function TDBWavPlayer.GetField: TField;
begin
    Result := FDataLink.Field;
end;

procedure TDBWavPlayer.CMGetDataLink(var Message: TMessage);
begin
    Message.Result := Integer(FDataLink);
end;

end.
```

This component is a `TSpeedButton` descendant that, when pressed, can play a WAV sound residing in a database BLOB field. The `AutoPlay` property can also be set to `True`, which will cause the sound to play every time the user navigates to a new record in the table. When this property is set, it might also make sense to set the `Visible` property of the component to `False` so that a button doesn't appear visually on the form.

In the `FDataLink.OnChange` handler, `DataChange()`, the component works by extracting the BLOB field using a `TBlobStream` and copying the BLOB stream to a memory stream, `FDataStream`. When the sound is in a memory stream, you can play it using the `PlaySound()` Win32 API function.

Extending TDataSet

One of the marquee features of the database VCL is the abstract `TDataSet`, which provides the capability to manipulate non-BDE data sources within the database VCL framework.

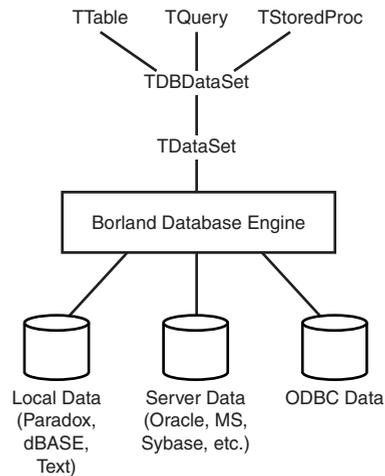
In the Olden Days...

In previous versions of Delphi, the VCL database architecture was closed, making it very difficult to manipulate non-BDE data sources using VCL components. Figure 30.2 illustrates the BDE-centric data set architecture found in Delphi 1 and 2.

As Figure 30.2 shows, `TDataSet` is essentially hard-coded for the BDE, and there's no room in this architecture for non-BDE data sources. Developers wanting to use non-BDE data sources within VCL had two choices:

- Creating a DLL that looks to VCL like the BDE but talks to a different type of data
- Throwing `TDataSet` out the window and writing their own dataset class and data-aware controls

Clearly, either of these options involves a very significant amount of work, and neither is a particularly elegant solution. Something had to be done.

**FIGURE 30.2**

Delphi 1 and 2 VCL dataset architecture.

Modern Times

Recognizing these issues and the strong customer demand for easier access to non-BDE data sources, the Delphi development team made it a priority to extend VCL's data set architecture in Delphi 3. The idea behind the new architecture was to make the `TDataSet` class an abstraction of a VCL dataset and to move the BDE-specific data set code into the new `TBDEDataSet` class. Figure 30.3 provides an illustration of this new architecture.

When you understand how `TDataSet` was uncoupled from the BDE, the challenge becomes how to employ this concept to create a `TDataSet` descendant that manipulates some type of non-BDE data. And we're not using the term *challenge* loosely; creating a functional `TDataSet` descendant is not a task for the faint of heart. This is a fairly demanding task that requires familiarity with VCL database architecture and component writing.

TIP

Delphi provides two examples of creating a `TDataSet` descendant—one very simple and one very complicated. The simple example is the `TTextDataSet` class found in the `TextData` unit in the `\Delphi5\Demos\Db\TextData` directory. This example encapsulates `TStringList` as a one-field dataset. The complex example is the `TBDEDataSet` class found in the `DbTables` unit in the VCL source. As mentioned earlier, this class maps VCL's dataset architecture to the BDE.

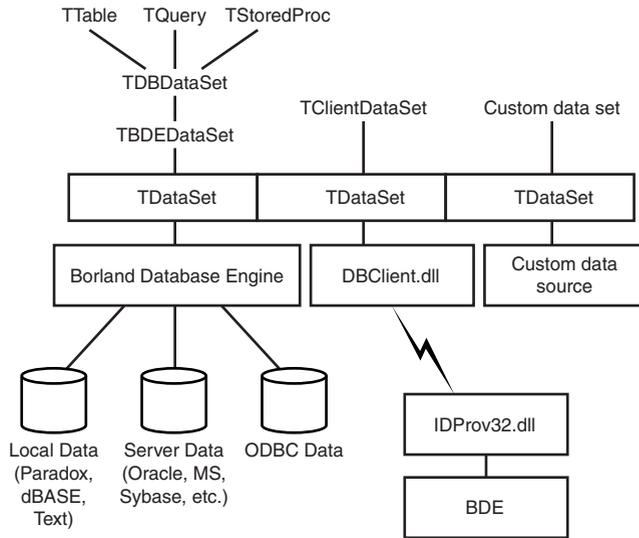


FIGURE 30.3
Delphi 3 and higher VCL dataset architecture.

Creating a TDataSet Descendant

Most dataset implementations will fall in between TTextDataSet and TBDEDataSet in terms of complexity. To provide an example of this, we'll demonstrate how to create a TDataSet descendant that manipulates an Object Pascal file of record (for a description of file of record, see Chapter 12, "Working With Files"). The following record and file type will be used for this example:

```

type
  // arbitrary-length array of char used for name field
  TNameStr = array[0..31] of char;

  // this record info represents the "table" structure:
  PDDGData = ^TDDGData;
  TDDGData = record
    Name: TNameStr;
    Height: Double;
    ShoeSize: Integer;
  end;

  // Pascal file of record which holds "table" data:
  TDDGDataFile = file of TDDGData;
  
```

An Object Pascal `file of record` can provide a convenient and efficient way to store information, but the format is inherently limited by its inability to insert records into or delete records from the middle of the file. For this reason, we'll use a two-file scheme to track the "table" information: the first, *data file*, being the `file of record`; the second, *index file*, maintaining a list of integers that represent seek values into the first file. This means that a record's position in the data file doesn't necessarily coincide with its position in the dataset. A record's position in the dataset is controlled by the order of the index file; the first integer in the index file contains the seek value of the first record into the data file, the second integer in the index file contains the next seek value into the data file, and so on.

In this section we'll discuss what's necessary to create a `TDataSet` descendant called `TDDGDataSet`, which communicates to this `file of record`.

TDataSet Abstract Methods

`TDataSet`, being an abstract class, is useless until you override the methods necessary for manipulation of some particular type of dataset. In particular, you must at least override each of `TDataSet`'s 23 abstract methods and perhaps some optional methods. For the sake of discussion, we've divided them into six logical groupings: record buffer methods, navigational methods, bookmark methods, editing methods, miscellaneous methods, and optional methods.

The following code shows an edited version of `TDataSet` as it is defined in `Db.pas`. For clarity, only the methods mentioned thus far are shown, and the methods are categorized based on the logical groupings we discussed. Here's the code:

```
type
  TDataSet = class(TComponent)
  { ... }
  protected
  { Record buffer methods }
    function AllocRecordBuffer: PChar; virtual; abstract;
    procedure FreeRecordBuffer(var Buffer: PChar); virtual; abstract;
    procedure InternalInitRecord(Buffer: PChar); virtual; abstract;
    function GetRecord(Buffer: PChar; GetMode: TGetMode;
      DoCheck: Boolean):
      TGetResult; virtual; abstract;
    function GetRecordSize: Word; virtual; abstract;
    function GetFieldData(Field: TField; Buffer: Pointer): Boolean;
      override;
    procedure SetFieldData(Field: TField; Buffer: Pointer); virtual;
      abstract;
  { Bookmark methods }
    function GetBookmarkFlag(Buffer: PChar): TBookmarkFlag; override;
    procedure SetBookmarkFlag(Buffer: PChar; Value: TBookmarkFlag);
      override;
```

```

    procedure GetBookmarkData(Buffer: PChar; Data: Pointer); override;
    procedure SetBookmarkData(Buffer: PChar; Data: Pointer); override;
    procedure InternalGotoBookmark(Bookmark: Pointer); override;
    procedure InternalSetToRecord(Buffer: PChar); override;
{ Navigational methods }
    procedure InternalFirst; virtual; abstract;
    procedure InternalLast; virtual; abstract;
{ Editing methods }
    procedure InternalAddRecord(Buffer: Pointer; Append: Boolean);
      virtual; abstract;
    procedure InternalDelete; virtual; abstract;
    procedure InternalPost; virtual; abstract;
{ Miscellaneous methods }
    procedure InternalClose; virtual; abstract;
    procedure InternalHandleException; virtual; abstract;
    procedure InternalInitFieldDefs; virtual; abstract;
    procedure InternalOpen; virtual; abstract;
    function IsCursorOpen: Boolean; virtual; abstract;
{ optional methods }
    function GetRecordCount: Integer; virtual;
    function GetRecNo: Integer; virtual;
    procedure SetRecNo(Value: Integer); virtual;
{ ... }
end;
```

Record Buffer Methods

You must override a number of methods that deal with record buffers. Actually, VCL does a pretty good job of hiding the gory details of its record buffer implementation; `TDataSet` will create and manage groups of buffers, so your job is primarily to decide what goes in the buffers and to move data between different buffers. Because it's a requirement for all `TDataSet` descendants to implement bookmarks, we'll store bookmark information after the record data in the record buffer. The record we'll use to describe bookmark information is as follows:

```

type
  // Bookmark information record to support TDataset bookmarks:
  PDDGBookmarkInfo = ^TDDGBookmarkInfo;
  TDDGBookmarkInfo = record
    BookmarkData: Integer;
    BookmarkFlag: TBookmarkFlag;
end;
```

The `BookmarkData` field will represent a simple seek value into the data file. The `BookmarkFlag` field is used to determine whether the buffer contains a valid bookmark, and it will contain special values when the dataset is positioned on the BOF and EOF cracks.

NOTE

Keep in mind that this implementation of bookmarks and record buffers is specific to this solution. If you were creating a `TDataSet` descendant to manipulate some other type of data, you might choose to implement your record buffer or bookmarks differently. For example, the data source you're trying to encapsulate may natively support bookmarks.

Before examining the record buffer-specific methods, first take a look at the constructor for the `TDDGDataSet` class:

```
constructor TDDGDataSet.Create(AOwner: TComponent);
begin
    FIndexList := TIndexList.Create;
    FRecordSize := SizeOf(TDDGData);
    FBufferSize := FRecordSize + SizeOf(TDDGBookmarkInfo);
    inherited Create(AOwner);
end;
```

This constructor does three important things: First, it creates the `TIndexList` object. This list object is used as the index file described earlier to maintain order in the dataset. Next, the `FRecordSize` and `FBufferSize` fields are initialized. `FRecordSize` holds the size of the data record, and `FBufferSize` represents the total size of the record buffer (the data record size plus the size of the bookmark information record). Finally, this method calls the inherited constructor to perform the default `TDataSet` setup.

The following are `TDataSet` methods that deal with record buffers that must be overridden in a descendant. Except for `GetFieldData()`, all are declared as abstract in the base class:

```
function AllocRecordBuffer: PChar; override;
procedure FreeRecordBuffer(var Buffer: PChar); override;
procedure InternalInitRecord(Buffer: PChar); override;
function GetRecord(Buffer: PChar; GetMode: TGetMode;
    DoCheck: Boolean): TGetResult; override;
function GetRecordSize: Word; override;
function GetFieldData(Field: TField; Buffer: Pointer): Boolean; override;
procedure SetFieldData(Field: TField; Buffer: Pointer); override;
```

AllocRecordBuffer()

The `AllocRecordBuffer()` method is called to allocate memory for a single record buffer. In this implementation of the method, the `AllocMem()` function is used to allocate enough memory to hold both the record data and the bookmark data:

```
function TDDGDataSet.AllocRecordBuffer: PChar;
begin
    Result := AllocMem(FBufferSize);
end;
```

FreeRecordBuffer()

As you might expect, `FreeRecordBuffer()` must free the memory allocated by the `AllocRecordBuffer()` method. It's implemented using the `FreeMem()` procedure, as shown here:

```
procedure TDDGDataSet.FreeRecordBuffer(var Buffer: PChar);
begin
    FreeMem(Buffer);
end;
```

InternalInitRecord()

The `InternalInitRecord()` method is called to initialize a record buffer. In this method, you can do things such as setting default field values and performing some type of initialization of custom record buffer data. In this case, we simply zero-initialize the record buffer:

```
procedure TDDGDataSet.InternalInitRecord(Buffer: PChar);
begin
    FillChar(Buffer^, FBufferSize, 0);
end;
```

GetRecord()

The primary function of the `GetRecord()` method is to retrieve the record data for either the previous, current, or next record in the dataset. The return value of this function is of type `TGetResult`, which is defined in the `Db` unit as follows:

```
TGetResult = (grOK, grBOF, grEOF, grError);
```

The meaning of each of the enumerations is pretty much self-explanatory: `grOk` means success, `grBOF` means the dataset is at the beginning, `grEOF` means the dataset is at the end, and `grError` means an error has occurred.

The implementation of this method is as follows:

```
function TDDGDataSet.GetRecord(Buffer: PChar; GetMode: TGetMode;
    DoCheck: Boolean): TGetResult;
var
    IndexPos: Integer;
begin
    if FIndexList.Count < 1 then
        Result := grEOF
    else begin
```

```
Result := grOk;
case GetMode of
gmPrior:
  if FRecordPos <= 0 then
  begin
    Result := grBOF;
    FRecordPos := -1;
  end
  else
    Dec(FRecordPos);
gmCurrent:
  if (FRecordPos < 0) or (FRecordPos >= RecordCount) then
    Result := grError;
gmNext:
  if FRecordPos >= RecordCount-1 then
    Result := grEOF
  else
    Inc(FRecordPos);
end;
if Result = grOk then
begin
  IndexPos := Integer(FIndexList[FRecordPos]);
  Seek(FDataFile, IndexPos);
  BlockRead(FDataFile, PDDGData(Buffer)^, 1);
  with PDDGBookmarkInfo(Buffer + FRecordSize)^ do
  begin
    BookmarkData := FRecordPos;
    BookmarkFlag := bfCurrent;
  end;
end
else if (Result = grError) and DoCheck then
  DatabaseError('No records');
end;
end;
```

The `FRecordPos` field tracks the current record position in the dataset. You'll notice that `FRecordPos` is incremented or decremented, as appropriate, when `GetRecord()` is called to obtain the next or previous record. If `FRecordPos` contains a valid record number, `FRecordPos` is used as an index into `FIndexList`. The number at that index is a seek value into the data file, and the record data is read from that position in the data file into the buffer specified by the `Buffer` parameter.

`GetRecord()` also has one additional job: When the `DoCheck` parameter is `True` and `grError` is the potential return value, an exception should be raised.

GetRecordSize()

The `GetRecordSize()` method should return the size, in bytes, of the record data portion of the record buffer. Be careful not to return the size of the entire record buffer; just return the size of the data portion. In this implementation, we return the value of the `FRecordSize` field:

```
function TDDGDataSet.GetRecordSize: Word;
begin
    Result := FRecordSize;
end;
```

GetFieldData()

The `GetFieldData()` method is responsible for copying data from the active record buffer (as provided by the `ActiveBuffer` property) into a field buffer. This is often accomplished most expediently using the `Move()` procedure. You can differentiate which field to copy using `Field`'s `Index` or `Name` property. Also, be sure to copy from the correct offset into `ActiveBuffer` because `ActiveBuffer` contains a complete record's data and `Buffer` only holds one field's data. This implementation copies the fields from the internal buffer structure to its respective `TField`:

```
function TDDGDataSet.GetFieldData(Field: TField; Buffer: Pointer):
    Boolean;
begin
    Result := True;
    case Field.Index of
        0:
            begin
                Move(ActiveBuffer^, Buffer^, Field.Size);
                Result := PChar(Buffer)^ <> #0;
            end;
        1: Move(PDDGData(ActiveBuffer)^.Height, Buffer^, Field.DataSize);
        2: Move(PDDGData(ActiveBuffer)^.ShoeSize, Buffer^, Field.DataSize);
    end;
end;
```

Both this method and `SetFieldData()` can become much more complex if you want to support more advanced features such as calculated fields and filters.

SetFieldData()

The purpose of `SetFieldData()` is inverse to that of `GetFieldData()`; `SetFieldData()` copies data from a field buffer into the active record buffer. As you can see from the following code, the implementations of these two methods are very similar:

```
procedure TDDGDataSet.SetFieldData(Field: TField; Buffer: Pointer);
begin
    case Field.Index of
```

```

    0: Move(Buffer^, ActiveBuffer^, Field.Size);
    1: Move(Buffer^, PDDGData(ActiveBuffer)^.Height, Field.DataSize);
    2: Move(Buffer^, PDDGData(ActiveBuffer)^.ShoeSize, Field.DataSize);
end;
DataEvent(deFieldChange, Longint(Field));
end;

```

After the data is copied, the `DataEvent()` method is called to signal that a field has changed and fire the `OnChange` event of the field.

Bookmark Methods

We mentioned earlier that bookmark support is required for `TDataSet` descendants. The following abstract methods of `TDataSet` are overridden to provide this support:

```

function GetBookmarkFlag(Buffer: PChar): TBookmarkFlag; override;
procedure SetBookmarkFlag(Buffer: PChar; Value: TBookmarkFlag); override;
procedure GetBookmarkData(Buffer: PChar; Data: Pointer); override;
procedure SetBookmarkData(Buffer: PChar; Data: Pointer); override;
procedure InternalGotoBookmark(Bookmark: Pointer); override;
procedure InternalSetToRecord(Buffer: PChar); override;

```

For `TDDGDataSet`, you'll see that the implementations of these methods revolve mostly around manipulating the bookmark information tacked onto the end of the record buffer.

GetBookmarkFlag() and SetBookmarkFlag()

Bookmark flags are used internally by `TDataSet` to determine whether a particular record is the first or last in the dataset. For this purpose, you must override the `GetBookmarkFlag()` and `SetBookmarkFlag()` methods. The `TDDGDataSet` implementation of these methods reads from and writes to the record buffer to keep track of this information, as shown here:

```

function TDDGDataSet.GetBookmarkFlag(Buffer: PChar): TBookmarkFlag;
begin
    Result := PDDGBookmarkInfo(Buffer + FRecordSize)^.BookmarkFlag;
end;

procedure TDDGDataSet.SetBookmarkFlag(Buffer: PChar;
    Value: TBookmarkFlag);
begin
    PDDGBookmarkInfo(Buffer + FRecordSize)^.BookmarkFlag := Value;
end;

```

GetBookmarkData() and SetBookmarkData()

The `GetBookmarkData()` and `SetBookmarkData()` methods provide a means for `TDataSet` to manipulate a record's bookmark data without repositioning the current record. As you can see, these methods are implemented in a manner similar to the methods described in the preceding example:

```
procedure TDDGDataSet.GetBookmarkData(Buffer: PChar; Data: Pointer);
begin
  PInteger(Data)^ :=PDDGBookmarkInfo(Buffer + FRecordSize)^.BookmarkData;
end;
```

```
procedure TDDGDataSet.SetBookmarkData(Buffer: PChar; Data: Pointer);
begin
  PDDGBookmarkInfo(Buffer + FRecordSize)^.BookmarkData :=PInteger(Data)^;
end;
```

InternalGotoBookmark()

The `InternalGotoBookmark()` method is called to reposition the current record to that represented by the `Bookmark` parameter. Because a bookmark value is the same as the record number for `TDDGDataSet`, the implementation of this method is straightforward:

```
procedure TDDGDataSet.InternalGotoBookmark(Bookmark: Pointer);
begin
  FRecordPos := Integer(Bookmark);
end;
```

InternalSetToRecord()

`InternalSetToRecord()` is similar to `InternalGotoBookmark()` except that it receives as a parameter a record buffer instead of a bookmark value. The job of this method is to position the dataset to the record provided in the `Buffer` parameter. This implementation of a record buffer contains the bookmark information because the bookmark value is the same as the record position; therefore, the implementation of this method is a one-liner:

```
procedure TDDGDataSet.InternalSetToRecord(Buffer: PChar);
begin
  // bookmark value is the same as an offset into the file
  FRecordPos := PDDGBookmarkInfo(Buffer + FRecordSize)^.Bookmarkdata;
end;
```

Navigational Methods

You must override several abstract navigational methods in `TDataSet` in order to position the dataset on the first or last record:

```
procedure InternalFirst; override;
procedure InternalLast; override;
```

The implementations of these methods are quite simple; `InternalFirst()` sets the `FRecordPos` value to `-1` (the BOF crack value), and `InternalLast()` sets the record position to the record count. Because the record index is zero based, the count is 1 greater than the last index (the EOF crack). Here's an example:

```
procedure TDDGDataSet.InternalFirst;
begin
```

```

    FRecordPos := -1;
end;

procedure TDDGDataSet.InternalLast;
begin
    FRecordPos := FIndexList.Count;
end;

```

Editing Methods

Three abstract TDataSet methods must be overridden in order to allow for the editing, appending, inserting, and deleting of records:

```

procedure InternalAddRecord(Buffer: Pointer; Append: Boolean); override;
procedure InternalDelete; override;
procedure InternalPost; override;

```

InternalAddRecord()

InternalAddRecord() is called when a record is inserted or appended to the dataset. The Buffer parameter points to the record buffer to be added to the dataset, and the Append parameter is True when a record is being appended and False when a record is being inserted. The TDDGDataSet implementation of this method seeks to the end of the data file, writes the record data to the file, and then adds or inserts the data file seek value into the appropriate position in the index list:

```

procedure TDDGDataSet.InternalAddRecord(Buffer: Pointer;
    Append: Boolean);
var
    RecPos: Integer;
begin
    Seek(FDataFile, FileSize(FDataFile));
    BlockWrite(FDataFile, PDDGData(Buffer)^, 1);
    if Append then
    begin
        FIndexList.Add(Pointer(FileSize(FDataFile) - 1));
        InternalLast;
    end
    else begin
        if FRecordPos = -1 then RecPos := 0
        else RecPos := FRecordPos;
        FIndexList.Insert(RecPos, Pointer(FileSize(FDataFile) - 1));
    end;
    FIndexList.SaveToFile(FIdxName);
end;

```

InternalDelete()

The InternalDelete() method deletes the current record from the dataset. Because it's not practical to remove a record from the middle of the data file, the current record is deleted from

the index list. This, in effect, orphans the deleted record in the data file by removing the index entry for a data record. Here's an example:

```
procedure TDDGDataSet.InternalDelete;
begin
  FIndexList.Delete(FRecordPos);
  if FRecordPos >= FIndexList.Count then Dec(FRecordPos);
end;
```

NOTE

This method of deletion means that the data file will not shrink in size even as records are deleted (similar to dBASE files). If you intend to use this type of dataset for commercial work, a good addition would be a file-pack method, which removes orphaned records from the data file.

InternalPost()

The `InternalPost()` method is called by `TDataSet.Post()`. In this method, you should write the data from the active record buffer to the data file. You'll note that the implementation of this method is quite similar to that of `InternalAddRecord()`, as shown here:

```
procedure TDDGDataSet.InternalPost;
var
  RecPos, InsPos: Integer;
begin
  if FRecordPos = -1 then
    RecPos := 0
  else begin
    if State = dsEdit then RecPos := Integer(FIndexList[FRecordPos])
    else RecPos := FileSize(FDataFile);
  end;
  Seek(FDataFile, RecPos);
  BlockWrite(FDataFile, PDDGData(ActiveBuffer)^, 1);
  if State <> dsEdit then
  begin
    if FRecordPos = -1 then InsPos := 0
    else InsPos := FRecordPos;
    FIndexList.Insert(InsPos, Pointer(RecPos));
  end;
  FIndexList.SaveToFile(FIdxName);
end;
```

Miscellaneous Methods

Several other abstract methods must be overridden in order to create a working `TDataSet` descendant. These are general housekeeping methods, and because these methods can't be

pigeonholed into a particular category, we'll call them miscellaneous methods. These methods are as follows:

```
procedure InternalClose; override;
procedure InternalHandleException; override;
procedure InternalInitFieldDefs; override;
procedure InternalOpen; override;
function IsCursorOpen: Boolean; override;
```

InternalClose()

`InternalClose()` is called by `TDataSet.Close()`. In this method, you should deallocate all resources associated with the dataset that were allocated by `InternalOpen()` or that were allocated throughout the course of using the dataset. In this implementation, the data file is closed, and we ensure that the index list has been persisted to disk. Additionally, the `FRecordPos` is set to the BOF crack, and the data file record is zeroed out:

```
procedure TDDGDataSet.InternalClose;
begin
  if TFileRec(FDataFile).Mode <> 0 then
    CloseFile(FDataFile);
  FIndexList.SaveToFile(FIdxName);
  FIndexList.Clear;
  if DefaultFields then
    DestroyFields;
  FRecordPos := -1;
  FillChar(FDataFile, SizeOf(FDataFile), 0);
end;
```

InternalHandleException()

`InternalHandleException()` is called if an exception is raised while this component is being read from or written to a stream. Unless you have a specific need to handle these exceptions, you should implement this method as follows:

```
procedure TDDGDataSet.InternalHandleException;
begin
  // standard implementation for this method:
  Application.HandleException(Self);
end;
```

InternalInitFieldDefs()

In the `InternalInitFieldDefs()` method is where you should define the fields contained in the dataset. This is done by instantiating `TFieldDef` objects, passing the `TDataSet`'s `FieldDefs` property as the `Owner`. In this case, three `TFieldDef` objects are created, representing the three fields in this dataset:

```

procedure TDDGDataSet.InternalInitFieldDefs;
begin
    // create FieldDefs which map to each field in the data record
    FieldDefs.Clear;
    TFieldDef.Create(FieldDefs, 'Name', ftString, SizeOf(TNameStr), False,
        1);
    TFieldDef.Create(FieldDefs, 'Height', ftFloat, 0, False, 2);
    TFieldDef.Create(FieldDefs, 'ShoeSize', ftInteger, 0, False, 3);
end;

```

InternalOpen()

The `InternalOpen()` method is called by `TDataSet.Open()`. In this method, you should open the underlying data source, initialize any internal fields or properties, create the field defs if necessary, and bind the field defs to the data. The following implementation of this method opens the data file, loads the index list from a file, initializes the `FRecordPos` field and the `BookmarkSize` property, and creates and binds the field defs. You'll see from the following code that this method also gives the user a chance to create the database files if they aren't found on disk:

```

procedure TDDGDataSet.InternalOpen;
var
    HFile: THandle;
begin
    // make sure table and index files exist
    FIdxName := ChangeFileExt(FTableName, feDDGIndex);
    if not (FileExists(FTableName) and FileExists(FIdxName)) then
        begin
            if MessageDlg('Table or index file not found. Create new table?',
                mtConfirmation, [mbYes, mbNo], 0) = mrYes then
                begin
                    HFile := FileCreate(FTableName);
                    if HFile = INVALID_HANDLE_VALUE then
                        DatabaseError('Error creating table file');
                    FileClose(HFile);
                    HFile := FileCreate(FIdxName);
                    if HFile = INVALID_HANDLE_VALUE then
                        DatabaseError('Error creating index file');
                    FileClose(HFile);
                end
            else
                DatabaseError('Could not open table');
        end;
    // open data file
    FileMode := fmShareDenyNone or fmOpenReadWrite;
    AssignFile(FDataFile, FTableName);

```

```
Reset(FDataFile);
try
  FIndexList.LoadFromFile(FIdxName); //initialize index TList from file
  FRecordPos := -1; //initial record pos before BOF
  BookmarkSize := SizeOf(Integer); //initialize bookmark size for VCL
  InternalInitFieldDefs; //initialize FieldDef objects
  // Create TField components when no persistent fields have been
  // created
  if DefaultFields then CreateFields;
  BindFields(True); //bind FieldDefs to actual data
except
  CloseFile(FDataFile);
  FillChar(FDataFile, SizeOf(FDataFile), 0);
  raise;
end;
end;
```

NOTE

Any resource allocations made in `InternalOpen()` should be freed in `InternalClose()`.

IsCursorOpen()

The `IsCursorOpen()` method is called internal to `TDataSet` while the dataset is being opened in order to determine whether data is available even though the dataset is inactive. The `TDDGData` implementation of this method returns `True` only if the data file has been opened, as shown here:

```
function TDDGDataSet.IsCursorOpen: Boolean;
begin
  // "Cursor" is open if data file is open. File is open if FDataFile's
  // Mode includes the FileMode in which the file was open.
  Result := TFileRec(FDataFile).Mode <> 0;
end;
```

TIP

The preceding method illustrates an interesting feature of Object Pascal: a *file of record* or untyped file can be typecast to a `TFileRec` in order to obtain low-level information about the file. `TFileRec` is described in Chapter 12, “Working with Files.”

Optional Record Number Methods

If you want to take advantage of TDBGrid's ability to scroll relative to the cursor position in the dataset, you must override three methods:

```
function GetRecordCount: Integer; override;
function GetRecNo: Integer; override;
procedure SetRecNo(Value: Integer); override;
```

Although this feature makes sense for this implementation, in many cases this capability isn't practical or even possible. For example, if you're working with a huge amount of data, it might not be practical to obtain a record count, or if you're communicating with a SQL server, this information might not even be available.

This TDataSet implementation is fairly simple, and these methods are appropriately straightforward to implement:

```
function TDDGDataSet.GetRecordCount: Integer;
begin
    Result := FIndexList.Count;
end;

function TDDGDataSet.GetRecNo: Integer;
begin
    UpdateCursorPos;
    if (FRecordPos = -1) and (RecordCount > 0) then
        Result := 1
    else
        Result := FRecordPos + 1;
end;

procedure TDDGDataSet.SetRecNo(Value: Integer);
begin
    if (Value >= 0) and (Value <= FIndexList.Count-1) then
        begin
            FRecordPos := Value - 1;
            Resync([]);
        end;
end;
```

TDDGDataSet

Listing 30.5 shows the DDG_DS unit, which contains the complete implementation of the TDDGDataSet unit.

LISTING 30.5 The DDG_DS.pas Unit

```
unit DDG_DS;

interface

uses Windows, Db, Classes, DDG_Rec;

type

    // Bookmark information record to support TDataset bookmarks:
    PDDGBookmarkInfo = ^TDDGBookmarkInfo;
    TDDGBookmarkInfo = record
        BookmarkData: Integer;
        BookmarkFlag: TBookmarkFlag;
    end;

    // List used to maintain access to file of record:
    TIndexList = class(TList)
    public
        procedure LoadFromFile(const FileName: string); virtual;
        procedure LoadFromStream(Stream: TStream); virtual;
        procedure SaveToFile(const FileName: string); virtual;
        procedure SaveToStream(Stream: TStream); virtual;
    end;

    // Specialized DDG TDataset descendant for our "table" data:
    TDDGDataSet = class(TDataSet)
    private
        function GetDataFileSize: Integer;
    public
        FDataFile: TDDGDataFile;
        FIdxName: string;
        FIndexList: TIndexList;
        FTableName: string;
        FRecordPos: Integer;
        FRecordSize: Integer;
        FBufferSize: Integer;
        procedure SetTableName(const Value: string);
    protected
        { Mandatory overrides }
        // Record buffer methods:
        function AllocRecordBuffer: PChar; override;
        procedure FreeRecordBuffer(var Buffer: PChar); override;
        procedure InternalInitRecord(Buffer: PChar); override;
        function GetRecord(Buffer: PChar; GetMode: TGetMode;
            DoCheck: Boolean): TGetResult; override;
```

```

function GetRecordSize: Word; override;
procedure SetFieldData(Field: TField; Buffer: Pointer); override;
// Bookmark methods:
procedure GetBookmarkData(Buffer: PChar; Data: Pointer); override;
function GetBookmarkFlag(Buffer: PChar): TBookmarkFlag; override;
procedure InternalGotoBookmark(Bookmark: Pointer); override;
procedure InternalSetToRecord(Buffer: PChar); override;
procedure SetBookmarkFlag(Buffer: PChar; Value: TBookmarkFlag);
    override;
procedure SetBookmarkData(Buffer: PChar; Data: Pointer); override;
// Navigational methods:
procedure InternalFirst; override;
procedure InternalLast; override;
// Editing methods:
procedure InternalAddRecord(Buffer: Pointer; Append: Boolean);
    override;
procedure InternalDelete; override;
procedure InternalPost; override;
// Misc methods:
procedure InternalClose; override;
procedure InternalHandleException; override;
procedure InternalInitFieldDefs; override;
procedure InternalOpen; override;
function IsCursorOpen: Boolean; override;
{ Optional overrides }
function GetRecordCount: Integer; override;
function GetRecNo: Integer; override;
procedure SetRecNo(Value: Integer); override;
public
    constructor Create(AOwner: TComponent); override;
    destructor Destroy; override;
    function GetFieldData(Field: TField; Buffer: Pointer): Boolean;
        override;

// Additional procedures
procedure EmptyTable;
published
    property Active;
    property TableName: string read FTableName write SetTableName;
    property BeforeOpen;
    property AfterOpen;
    property BeforeClose;
    property AfterClose;
    property BeforeInsert;
    property AfterInsert;
    property BeforeEdit;

```

continues

LISTING 30.5 Continued

```
    property AfterEdit;
    property BeforePost;
    property AfterPost;
    property BeforeCancel;
    property AfterCancel;
    property BeforeDelete;
    property AfterDelete;
    property BeforeScroll;
    property AfterScroll;
    property OnDeleteError;
    property OnEditError;

    // Additional Properties
    property DataFileSize: Integer read GetDataFileSize;
end;

procedure Register;

implementation

uses BDE, DBTables, SysUtils, DBConsts, Forms, Controls, Dialogs;

const
    feDDGTable = '.ddg';
    feDDGIndex = '.ddx';
    // note that file is not being locked!

{ TIndexList }

procedure TIndexList.LoadFromFile(const FileName: string);
var
    F: TFileStream;
begin
    F := TFileStream.Create(FileName, fmOpenRead or fmShareDenyWrite);
    try
        LoadFromStream;
    finally
        F.Free;
    end;
end;

procedure TIndexList.LoadFromStream(Stream: TStream);
var
    Value: Integer;
begin
```

```
    while Stream.Position < Stream.Size do
    begin
        Stream.Read(Value, SizeOf(Value));
        Add(Pointer(Value));
    end;
    ShowMessage(IntToStr(Count));
end;

procedure TIndexList.SaveToFile(const FileName: string);
var
    F: TFileStream;
begin
    F := TFileStream.Create(FileName, fmCreate or fmShareExclusive);
    try
        SaveToStream(F);
    finally
        F.Free;
    end;
end;

procedure TIndexList.SaveToStream(Stream: TStream);
var
    i: Integer;
    Value: Integer;
begin
    for i := 0 to Count - 1 do
    begin
        Value := Integer(Items[i]);
        Stream.Write(Value, SizeOf(Value));
    end;
end;

{ TDDGDataSet }

constructor TDDGDataSet.Create(AOwner: TComponent);
begin
    FIndexList := TIndexList.Create;
    FRecordSize := SizeOf(TDDGData);
    FBufferSize := FRecordSize + SizeOf(TDDGBookmarkInfo);
    inherited Create(AOwner);
end;

destructor TDDGDataSet.Destroy;
begin
    inherited Destroy;
    FIndexList.Free;
end;
```

continues

LISTING 30.5 Continued

```
end;

function TDDGDataSet.AllocRecordBuffer: PChar;
begin
    Result := AllocMem(FBufferSize);
end;

procedure TDDGDataSet.FreeRecordBuffer(var Buffer: PChar);
begin
    FreeMem(Buffer);
end;

procedure TDDGDataSet.InternalInitRecord(Buffer: PChar);
begin
    FillChar(Buffer^, FBufferSize, 0);
end;

function TDDGDataSet.GetRecord(Buffer: PChar; GetMode: TGetMode;
    DoCheck: Boolean): TGetResult;
var
    IndexPos: Integer;
begin
    if FIndexList.Count < 1 then
        Result := grEOF
    else begin
        Result := grOk;
        case GetMode of
            gmPrior:
                if FRecordPos <= 0 then
                    begin
                        Result := grBOF;
                        FRecordPos := -1;
                    end
                else
                    Dec(FRecordPos);
            gmCurrent:
                if (FRecordPos < 0) or (FRecordPos >= RecordCount) then
                    Result := grError;
            gmNext:
                if FRecordPos >= RecordCount-1 then
                    Result := grEOF
                else
                    Inc(FRecordPos);
        end;
        if Result = grOk then
```

```

begin
  IndexPos := Integer(FIndexList[FRecordPos]);
  Seek(FDataFile, IndexPos);
  BlockRead(FDataFile, PDDGData(Buffer)^, 1);
  with PDDGBookmarkInfo(Buffer + FRecordSize)^ do
  begin
    BookmarkData := FRecordPos;
    BookmarkFlag := bfCurrent;
  end;
end
else if (Result = grError) and DoCheck then
  DatabaseError('No records');
end;
end;

function TDDGDataSet.GetRecordSize: Word;
begin
  Result := FRecordSize;
end;

function TDDGDataSet.GetFieldData(Field: TField; Buffer: Pointer):
  Boolean;
begin
  Result := True;
  case Field.Index of
    0:
      begin
        Move(ActiveBuffer^, Buffer^, Field.Size);
        Result := PChar(Buffer)^ <> #0;
      end;
    1: Move(PDDGData(ActiveBuffer)^.Height, Buffer^, Field.DataSize);
    2: Move(PDDGData(ActiveBuffer)^.ShoeSize, Buffer^, Field.DataSize);
  end;
end;

procedure TDDGDataSet.SetFieldData(Field: TField; Buffer: Pointer);
begin
  case Field.Index of
    0: Move(Buffer^, ActiveBuffer^, Field.Size);
    1: Move(Buffer^, PDDGData(ActiveBuffer)^.Height, Field.DataSize);
    2: Move(Buffer^, PDDGData(ActiveBuffer)^.ShoeSize, Field.DataSize);
  end;
  DataEvent(deFieldChange, Longint(Field));
end;

procedure TDDGDataSet.GetBookmarkData(Buffer: PChar; Data: Pointer);

```

continues

LISTING 30.5 Continued

```
begin
  PInteger(Data)^ := PDDGBookmarkInfo(Buffer + FRecordSize)^.BookmarkData;
end;

function TDDGDataSet.GetBookmarkFlag(Buffer: PChar): TBookmarkFlag;
begin
  Result := PDDGBookmarkInfo(Buffer + FRecordSize)^.BookmarkFlag;
end;

procedure TDDGDataSet.InternalGotoBookmark(Bookmark: Pointer);
begin
  FRecordPos := Integer(Bookmark);
end;

procedure TDDGDataSet.InternalSetToRecord(Buffer: PChar);
begin
  // bookmark value is the same as an offset into the file
  FRecordPos := PDDGBookmarkInfo(Buffer + FRecordSize)^.Bookmarkdata;
end;

procedure TDDGDataSet.SetBookmarkData(Buffer: PChar; Data: Pointer);
begin
  PDDGBookmarkInfo(Buffer + FRecordSize)^.BookmarkData := PInteger(Data)^;
end;

procedure TDDGDataSet.SetBookmarkFlag(Buffer: PChar;
  Value: TBookmarkFlag);
begin
  PDDGBookmarkInfo(Buffer + FRecordSize)^.BookmarkFlag := Value;
end;

procedure TDDGDataSet.InternalFirst;
begin
  FRecordPos := -1;
end;

procedure TDDGDataSet.InternalInitFieldDefs;
begin
  // create FieldDefs which map to each field in the data record
  FieldDefs.Clear;
  TFieldDef.Create(FieldDefs, 'Name', ftString, SizeOf(TNameStr), False,
    1);
  TFieldDef.Create(FieldDefs, 'Height', ftFloat, 0, False, 2);
  TFieldDef.Create(FieldDefs, 'ShoeSize', ftInteger, 0, False, 3);
end;
```

```
procedure TDDGDataSet.InternalLast;
begin
    FRecordPos := FIndexList.Count;
end;

procedure TDDGDataSet.InternalClose;
begin
    if TFileRec(FDataFile).Mode <> 0 then
        CloseFile(FDataFile);
    FIndexList.SaveToFile(FIdxName);
    FIndexList.Clear;
    if DefaultFields then
        DestroyFields;
    FRecordPos := -1;
    FillChar(FDataFile, SizeOf(FDataFile), 0);
end;

procedure TDDGDataSet.InternalHandleException;
begin
    // standard implementation for this method:
    Application.HandleException(Self);
end;

procedure TDDGDataSet.InternalDelete;
begin
    FIndexList.Delete(FRecordPos);
    if FRecordPos >= FIndexList.Count then Dec(FRecordPos);
end;

procedure TDDGDataSet.InternalAddRecord(Buffer: Pointer;
    Append: Boolean);
var
    RecPos: Integer;
begin
    Seek(FDataFile, FileSize(FDataFile));
    BlockWrite(FDataFile, PDDGData(Buffer)^, 1);
    if Append then
        begin
            FIndexList.Add(Pointer(FileSize(FDataFile) - 1));
            InternalLast;
        end
    else begin
        if FRecordPos = -1 then RecPos := 0
        else RecPos := FRecordPos;
        FIndexList.Insert(RecPos, Pointer(FileSize(FDataFile) - 1));
    end;
end;
```

continues

LISTING 30.5 Continued

```
    end;
    FIndexList.SaveToFile(FIdxName);
end;

procedure TDDGDataSet.InternalOpen;
var
    HFile: THandle;
begin
    // make sure table and index files exist
    FIdxName := ChangeFileExt(FTableName, feDDGIndex);
    if not (FileExists(FTableName) and FileExists(FIdxName)) then
    begin
        if MessageDlg('Table or index file not found. Create new table?',
            mtConfirmation, [mbYes, mbNo], 0) = mrYes then
        begin
            HFile := FileCreate(FTableName);
            if HFile = INVALID_HANDLE_VALUE then
                DatabaseError('Error creating table file');
            FileClose(HFile);
            HFile := FileCreate(FIdxName);
            if HFile = INVALID_HANDLE_VALUE then
                DatabaseError('Error creating index file');
            FileClose(HFile);
        end
        else
            DatabaseError('Could not open table');
    end;
    // open data file
    FileMode := fmShareDenyNone or fmOpenReadWrite;
    AssignFile(FDataFile, FTableName);
    Reset(FDataFile);
    try
        FIndexList.LoadFromFile(FIdxName); //initialize index TList from file
        FRecordPos := -1; //initial record pos before BOF
        BookmarkSize := SizeOf(Integer); //initialize bookmark size for VCL
        InternalInitFieldDefs; //initialize FieldDef objects
        // Create TField components when no persistent fields have been
        // created
        if DefaultFields then CreateFields;
        BindFields(True); //bind FieldDefs to actual data
    except
        CloseFile(FDataFile);
        FillChar(FDataFile, SizeOf(FDataFile), 0);
        raise;
    end;
end;
```

```
procedure TDDGDataSet.InternalPost;
var
  RecPos, InsPos: Integer;
begin
  if FRecordPos = -1 then
    RecPos := 0
  else begin
    if State = dsEdit then RecPos := Integer(FIndexList[FRecordPos])
    else RecPos := FileSize(FDataFile);
  end;
  Seek(FDataFile, RecPos);
  BlockWrite(FDataFile, PDDGData(ActiveBuffer)^, 1);
  if State <> dsEdit then
    begin
      if FRecordPos = -1 then InsPos := 0
      else InsPos := FRecordPos;
      FIndexList.Insert(InsPos, Pointer(RecPos));
    end;
  FIndexList.SaveToFile(FIdxName);
end;

function TDDGDataSet.IsCursorOpen: Boolean;
begin
  // "Cursor" is open if data file is open. File is open if FDataFile's
  // Mode includes the FileMode in which the file was open.
  Result := TFileRec(FDataFile).Mode <> 0;
end;

function TDDGDataSet.GetRecordCount: Integer;
begin
  Result := FIndexList.Count;
end;

function TDDGDataSet.GetRecNo: Integer;
begin
  UpdateCursorPos;
  if (FRecordPos = -1) and (RecordCount > 0) then
    Result := 1
  else
    Result := FRecordPos + 1;
end;

procedure TDDGDataSet.SetRecNo(Value: Integer);
begin
  if (Value >= 0) and (Value <= FIndexList.Count-1) then
    begin
```

continues

LISTING 30.5 Continued

```
    FRecordPos := Value - 1;
    Resync([]);
end;
end;

procedure TDDGDataSet.SetTableName(const Value: string);
begin
    CheckInactive;
    FTableName := Value;
    if ExtractFileExt(FTableName) = '' then
        FTableName := FTableName + feDDGTable;

    FIdxName := ChangeFileExt(FTableName, feDDGIndex);

end;

procedure Register;
begin
    RegisterComponents('DDG', [TDDGDataSet]);
end;

function TDDGDataSet.GetDataFileSize: Integer;
begin
    Result := FileSize(FDataFile);
end;

procedure TDDGDataSet.EmptyTable;
var
    HFile: THandle;
begin
    Close;

    DeleteFile(FTableName);
    HFile := FileCreate(FTableName);
    FileClose(HFile);

    DeleteFile(FIdxName);
    HFile := FileCreate(FIdxName);
    FileClose(HFile);

    Open;
end;

end.
```

Summary

This chapter demonstrated how to extend your Delphi database applications to incorporate features that aren't encapsulated by VCL. Additionally, you learned some of the rules and processes for making direct calls into the BDE from Delphi applications. You also learned the specifics for extending the behavior of `TTable` with regard to dBASE and Paradox tables. Finally, you went step by step through the challenging process of creating a working `TDataSet` descendant. In the next chapter, "Internet-Enabling your Applications with WebBroker," you'll learn how to create server-side applications for the Web and deliver data to Web clients in real time.

Internet-Enabling Your Applications with WebBroker

by Nick Hodges

CHAPTER

31

IN THIS CHAPTER

- **ISAPI, NSAPI, and CGI Web Server Extensions 1645**
- **Creating Web Applications with Delphi 1647**
- **Dynamic HTML Pages with HTML Content Producers 1655**
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The Internet's popularity has exploded, and its use by computer owners has become almost a given. The technology that makes the Internet work is deceptively simple, and as a result, many business organizations are using the technology to create *intranets*—small Web networks accessible only to those within a given organization. Intranets are proving to be an inexpensive and highly effective way to leverage an organization's information systems. As new technologies arrive, some intranets are even being expanded to *extranets*—networks that allow limited access but are not limited to an organization's boundaries.

All of this, of course, makes programming for the Internet/intranet a very important arrow in a programmer's quiver. As you might expect, Delphi makes programming for the Internet/intranet a very straightforward task. Delphi lets you bring its full power to the Web in the following ways:

- By encapsulating the Hypertext Transfer Protocol (HTTP) in easily accessible objects
- By providing an application framework around the application programming interfaces (APIs) of the most popular and powerful Web servers
- By providing a *Rapid Application Development* (RAD) approach to building Web server extensions

With Delphi and its WebBroker components, you can easily build Web server extensions that provide customized, dynamic Hypertext Markup Language (HTML) pages that include access to data from virtually any source.

TIP

The WebBroker components are provided as a part of Delphi Enterprise. If you are a Delphi Professional user, you can purchase the WebBroker components as a separate add-on. Visit the Borland Web site (<http://www.borland.com>) for more information.

The basic technology that makes the Web possible is quite simple. The two agents in the process—the Web client, or client, and the Web server—must establish a communications link and pass information to and from each other. The client requests information and the server provides it. Of course, the client and the server have to agree on how to communicate and what form the information they share will take. They do this across the Web with nothing more than an ASCII byte stream. The client sends a text request and gets a text answer back. The client knows little about what takes place on the server. This simple process allows for cross-platform communication, normally by means of the TCP/IP protocol.

The standard method of communicating used on the Web is the Hypertext Transfer Protocol (HTTP). A *protocol* is simply an agreement about a way of doing business, and HTTP is a protocol designed to pass information from the client to the server in the form of a request, and

from the server to the client in the form of a response. It does so by formatting information as a byte stream of ASCII characters and sending this information between the two agents. The HTTP protocol itself is both flexible and powerful. When used in concert with Hypertext Markup Language (HTML), it can quickly and easily provide Web pages to a browser.

An HTTP request might look like this:

```
GET /mysite/webapp.dll/dataquery?name=CharlieTuna&company=Borland HTTP/1.0
Connection: Keep-Alive
User-Agent: Mozilla/3.0b4Gold (WinNT; I)
Host: www.mysite.com:1024
Accept: image/gif, image/x-xbitmap, image/jpeg, image/pjpeg, */*
```

HTTP is *stateless*, which means that the server has no knowledge of the state of the client and that the communication between the server and the client ends when the request has been satisfied. This makes creating database applications using HTTP somewhat problematic because many database applications rely on the client having access to a live dataset. State information can be stored through the use of *cookies*—pieces of information that are stored on the client as a result of the HTTP response. Cookies are discussed later in the chapter.

ISAPI, NSAPI, and CGI Web Server Extensions

Web servers are the engines that make the Web function. They provide all the content to Web browsers, whether that content is HTML pages, Java applets, or ActiveX controls. Web servers are the tools that provide responses to a client's request. Many different Web servers are available for use on any of the different popular platforms.

The Common Gateway Interface

The first Web servers could merely retrieve and return an existing, static HTML page. Web site managers could provide nothing more in a Web site than the pages that were present on the server at the time of the request. Soon, however, it became clear that a higher level of interaction between client and server was required, and the *Common Gateway Interface* (CGI) was developed as a result. CGI allowed the Web server to launch a separate process based on input from the user, work on that information, and return a dynamically created Web page to the client. A CGI program could do any type of data manipulation that the programmer required, and it could return any sort of page that HTML would allow.

Standard CGI applications work by reading from `STDIN`, writing to `STDOUT`, and reading environmental variables. WinCGI works by storing the request parameters in a file, launching the WinCGI application, reading and processing the data in the file, and then writing an HTML file, which is then returned by the Web server. Suddenly, the Web took a large step forward, because servers could now provide tailored, unique responses to users' requests.

However, CGI and WinCGI applications have some drawbacks. Each request must launch its own process on the server, so multiple requests can easily tie up even a moderately busy server. The task of creating a file, launching a separate process, executing the process, and then writing and returning yet another file is relatively slow.

ISAPI and NSAPI

The major Web server vendors, Microsoft and Netscape, saw the weaknesses inherent in CGI programming, but they also saw the advantages of dynamic Web creation. Therefore, instead of using a separate process for each request, each company wrote APIs for its Web servers that allowed Web server extensions to be run as *dynamic link libraries* (DLLs). DLLs can be loaded once and then respond to any number of requests. They run as part of the Web server process, executing their code in the same memory space as the Web server itself. Instead of having to pass information back and forth as files, Web server extensions can simply pass the information back and forth inside the same memory space. This allows for faster, more efficient, and less resource-intensive Web applications.

Microsoft provides the rather simple and straightforward *Internet Server Application Programming Interface* (ISAPI) with its Internet Information Server (IIS), and Netscape provides the more complex *Netscape Application Programming Interface* (NSAPI) with its family of Web servers.

Delphi provides access to both APIs through the NSAPI.PAS and ISAPI.PAS units. To run the applications in this chapter, you have to be running an IIS server, a Netscape server, or one of a number of shareware or freeware servers that meet the ISAPI specification.

TIP

If you do not currently have a Web server installed, you can download the Microsoft Personal Web Server from Microsoft's Web site (<http://www.microsoft.com>). It is freeware and is ISAPI-compliant. It will run all the examples in this chapter.

Using Web Servers

Whichever Web server you are using, you should bear in mind several things when running Web server applications. First of all, because the extensions are DLLs, they will be loaded into memory and remain in memory while the Web server is running. Therefore, if you are building and testing applications with Delphi, you may have to shut down the Web server to recompile the application because Windows will not allow you to rewrite a file that is being executed. This may vary between Web

servers, but it is true for the Microsoft Personal Web Server. In addition, Web servers generally require that you select a base directory on your system as the root directory for all your HTML files. You can tell Delphi to send your Web applications directly to that directory by entering the full path of the directory into the Project, Options, Directories/Conditionals Output Directory combo box. Finally, you can even debug your Web applications while they are running. Delphi's documentation includes instructions on how to do this. These instructions can be found in the online help under ISAPI, Debugging. The Web server is used as the host application. Each of the major Web servers is configured a bit differently, so check your server's documentation and the Delphi documentation mentioned for further information.

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Creating Web Applications with Delphi

Delphi's WebBroker components make developing Internet/intranet applications easy. The following sections discuss these components and how they allow you to focus on the content of your Web servers without having to worry about the details of HTTP communications protocols.

TWebModule and TWebDispatcher

If you select File, New from the Delphi menu, the New Items dialog box appears. Select the Web Server Application icon to open a wizard that will allow you to select the type of Web server extension. The three choices are ISAPI/NSAPI, CGI, and WinCGI applications. This chapter deals with the ISAPI/NSAPI application type. The construction of the CGI server extensions is done in almost the same manner; however, the ISAPI applications are easier to deal with and run.

NOTE

Delphi also includes a project, `ISAPITER.DPR`, that allows you to run ISAPI modules on an NSAPI-based Web server. The online help has information on how to set up a Netscape Web server to run the ISAPI DLLs created in this chapter.

After you select the application type, Delphi creates a project based on a `TWebModule`. The main project itself is a DLL, and the main unit contains the `TWebModule`. `TWebModule` is a descendant of `TDataModule`, and it contains all the logic needed to receive the HTTP request and respond to it. A `TWebModule` can accept only nonvisual controls, just like its ancestor. You can use all the database controls, as well as the controls on the Internet page of the Component

Palette that produce HTML, to produce content in a `TWebModule`. This allows you to add business rules for your Web-based application in the same manner as you can with `TDataModule` in regular applications.

The `TWebModule` has an `Actions` property, which contains a collection of `TWebActionItem` objects. A `TWebActionItem` allows you to execute code based on a given request. Each `TWebActionItem` has its own name; when a client makes a request based on that name, your code is executed and the appropriate response is given.

NOTE

You can create a Web server application with one of your existing data modules. The `TWebModule` has as one of its fields the `TWebDispatcher` class. This class is included on the Component Palette as the `TWebDispatcher` component. If you replace the default `TWebModule` in your Web server application with an existing data module by using the Project Manager, you can drop a `TWebDispatcher` component on it and it will become a Web server application. The `TWebDispatcher` component on the Internet page of the Component Palette adds all the functionality encapsulated in the `TWebModule`. So if you have all your business rules wrapped up in an existing `TDataModule`, making those rules available to your Web applications is as easy as pointing and clicking. A `TDataModule` with a `TWebDispatcher` component is functionally equivalent to a `TWebModule`. The only difference is that you access the HTTP actions through the `TWebDispatcher` component and not the `TDataModule` itself.

Select the `TWebModule` so that its properties are displayed in the Object Inspector. Select the `Actions` property and either double-click it or select the property editor with the small ellipsis (...) button. This will bring up the `WebModule Actions` dialog. Click the `New` button and select the resulting `WebActionItem` in the property editor that appears. The `Action` item's properties will then be displayed in the Object Inspector. Go to the `PathInfo` property and enter `/test`. Then go to the `Events` page in the Object Inspector and double-click the `OnAction` event to create a new event handler. It will look like this:

```
procedure TWebModule1.WebModule1WebActionItem1Action(Sender: TObject;  
    Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);  
begin  
  
end;
```

This event handler contains all the information about the request that generated this action and the means to respond to it. The client's request information is contained in the `Request` parameter, which is of type `TWebRequest`. The `Response` parameter is of type `TWebResponse`, and it

is used to send the necessary information back to the client. Within this event handler, you can write any code necessary to respond to the request, including file manipulation, database actions, and anything else needed to send an HTML page back to the client.

Before we get into the depths of the `TWebModule`, a simple example will help demonstrate the basics of how a Web server application works. The simplest way to create an HTML page that responds to the client's request is to build the HTML on the fly. You can do this easily by using a `TStringList`. After the HTML is placed into the `TStringList`, it can easily be assigned to the `Content` property of the `Response` parameter. `Content` is a string, and it is used to hold the HTML to be returned to the client. This is the only property of `Response` that must be filled because it contains the data to be displayed. If it is left blank, the client's browser will report that the requested document is empty. Listing 31.1 shows the code that you must add to the `/test` action item event handler.

LISTING 31.1 The `WebModule1WebActionItem1Action` Event Handler

```

procedure TWebModule1.WebModule1WebActionItem1Action(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
var
  Page: TStringList;
begin
  Page := TStringList.Create;
  try
    with Page do
      begin
        Add('<HTML>');
        Add('<HEAD>');
        Add('<TITLE>Web Server Application -- Basic Sample</TITLE>');
        Add('</HEAD>');
        Add('<BODY>');
        Add('<B>This page was created on the fly by Delphi</B><P>');
        Add('<HR>');
        Add('See how easy it was to create a page on the fly with Delphi's
  ➤Web Extensions?');
        Add('</BODY>');
        Add('</HTML>');
      end;
      Response.Content := Page.Text;
    finally
      Page.Free;
    end;
    Handled := True;
  end;

```

Save the project as `SAMPLE1.DLL`, compile it, and place the resulting file in the default directory for your ISAPI- or NSAPI-capable Web server. Then, point your browser to the following location:

```
<web server address>/sample1.dll/test
```

You should see the expected Web page in your browser, as shown in Figure 31.1.

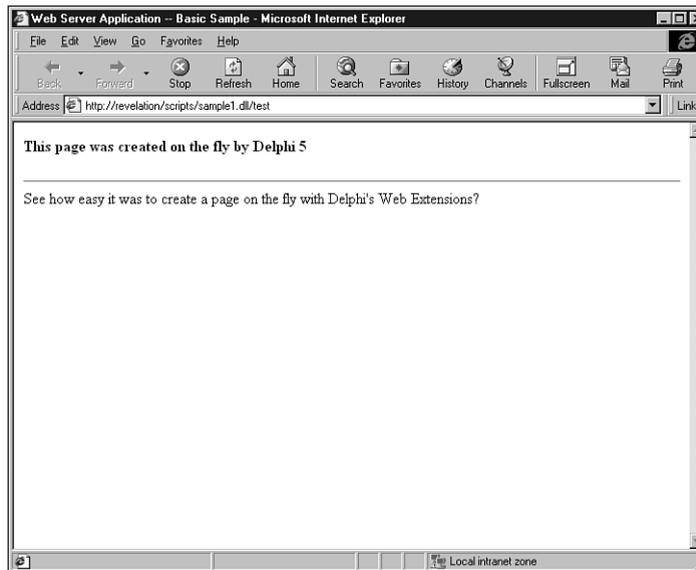


FIGURE 31.1

A sample Web page.

NOTE

If you take Listing 31.1's code from the CD-ROM accompanying this book and place it on your computer, maintaining the same directory structure as on the CD-ROM, you can easily set your Web server up to access the HTML and the DLLs to run all the sample applications from this chapter. Simply create a virtual Web server directory for the root directory and an ISAPI-capable directory that points to the `\bin` directory. Then, you can open up the `INDEX.HTM` file in the root directory, giving you access to all the sample code. Note that if you copy the files from the CD-ROM, they will have the read-only flag set. You will have to remove that flag in Explorer if you want to edit the files copied from the CD-ROM.

Note that the result of the project's compilation is a DLL that conforms to the ISAPI specification. The project's source code reveals the following:

```
library Sample1;
uses
  WebBroker,
  ISAPIApp,
  Unit1 in 'Unit1.pas' {WebModule1: TWebModule};
{$R *.RES}
exports
  GetExtensionVersion,
  HttpExtensionProc,
  TerminateExtension;
begin
  Application.Initialize;
  Application.CreateForm(TWebModule1, WebModule1);
  Application.Run;
end.
```

Note the three exported routines. These three—`GetExtensionVersion`, `HttpExtensionProc`, and `TerminateExtension`—are the only three procedures required by the ISAPI specification.

CAUTION

Like a typical application, your ISAPI application uses a global `Application` object. However, unlike a regular application, this project does not use the `Forms` unit. Instead, the `WebBroker` unit contains an `Application` variable declared as type `TWebApplication`. It handles all the special calls needed to be able to hook into an ISAPI- or NSAPI-capable Web server. As a result, you should never try to add the `Forms` unit to an ISAPI-based Web server extension because this may confuse the compiler into using the wrong `Application` variable.

This simple project illustrates how easy it is to build a Web server application and provide a response to a client's request by using Delphi. This was a relatively simple example, creating HTML dynamically in code. However, as you will soon see, Delphi provides the tools to respond in much more complex and interesting ways. Before looking at what Delphi can do in this regard, we will delve a little deeper into the workings of a `WebBroker` application in the following section.

TWebRequest and TWebResponse

`TWebRequest` and `TWebResponse` are abstract classes that encapsulate the HTTP protocol. `TWebRequest` provides access to all the information passed to the server by the client, and

TWebResponse contains properties and methods that allow you to respond in any of the multiple ways that the HTTP protocol allows. Both of these classes are declared in the HTTPAPP.pas unit, which is used by the WebBroker.pas unit. ISAPI-based Web applications actually use TISAPIResponse and TISAPIRequest, which are descendants of the abstract classes and are declared in ISAPIAPP.PAS. The power of polymorphism allows Delphi to pass the TISAPIxxx classes to the TWebxxx parameters of the OnAction event handler in TWebModule.

TISAPIRequest contains all the information passed by a client when making a request for a Web page. You can gather information about the client from the request. Many of the properties may be blank for any given request, because not all fields are completed for every HTTP request. The RemoteHost and RemoteAddr properties contain the IP address of the requesting machine. The UserAgent property contains information about the browser that the client is using. The Accept property includes a listing of the types of graphics that the user's browser can display. The Referer property contains the URL for the page that the user clicked to create the request. If cookie information is present (cookies are discussed later in the chapter), it is contained in the Cookie property. Multiple cookies can be more easily accessed by the CookieFields array. If any parameters were passed with the request, they will all be contained in a single string inside the Query property. They will also be broken out into an array in the QueryFields property.

NOTE

When you are passing parameters to a URL, they normally follow a question mark (?) after the URL's name. Multiple parameters are separated by ampersands (&), and if the parameters contain spaces, a plus sign (+) is substituted for the spaces. Therefore, a valid set of parameters might look like this inside an HTML page:

```
<A HREF="http://www.someplace.com/ISAPIApp?Param1=This+  
➤Parameter&Param2=That+Parameter">Some Link</A>
```

Most of the information for a TISAPIRequest is revealed in properties, but the class makes public many of the functions used to fill those properties, thus allowing you to access the data directly if you want. TISAPIRequest contains other properties than those discussed here, but these are the main ones you should be interested in. All these properties can be used in your OnAction event handler to determine the type of response your Web server application will provide. If you want to include information about the user's IP address or vary the response based on the type of browser the client is using, you can do that in your OnAction event handler.

You can see what a TISAPIRequest looks like by running the following project in your Web server. Create a new Web server application, bring up the Actions property editor by double-clicking the Actions property in the Object Inspector, and create a new TWebActionItem with

the PathInfo set to http. Go to the Internet page on the Component Palette and drop a TPageProducer (discussed later in this chapter) on the WebModule; then add the code shown in Listing 31.2 to the OnAction event handler for /http.

LISTING 31.2 The OnAction Event Handler

```

procedure TWebModule1.WebModule1Actions0Action(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
var
  Page: TStringList;
begin
  Page := TStringList.Create;
  try
    with Page do
      begin
        Add('<HTML>');
        Add('<HEAD>');
        Add('<TITLE>Web Server Extensions THTTPRequest Demo</TITLE>');
        Add('</HEAD>');
        Add('<BODY>');
        Add('<H3><FONT="RED">This page displays the properties
  ➤of the HTTP request that asked for it.</FONT></H3>');
        Add('<P>');

        Add('Method = ' + Request.Method + '<BR>');
        Add('ProtocolVersion = ' + Request.ProtocolVersion + '<BR>');
        Add('URL = ' + Request.URL + '<BR>');
        Add('Query = ' + Request.Query + '<BR>');
        Add('PathInfo = ' + Request.PathInfo + '<BR>');
        Add('PathTranslated = ' + Request.PathTranslated + '<BR>');
        Add('Authorization = ' + Request.Authorization + '<BR>');
        Add('CacheControl = ' + Request.CacheControl + '<BR>');
        Add('Cookie = ' + Request.Cookie + '<BR>');
        Add('Date = ' + FormatDateTime ('mmm dd, yyyy hh:mm',
          ÂRequest.Date) + '<BR>');
        Add('Accept = ' + Request.Accept + '<BR>');
        Add('From = ' + Request.From + '<BR>');
        Add('Host = ' + Request.Host + '<BR>');
        Add('IfModifiedSince = ' + FormatDateTime ('mmm dd, yyyy hh:mm',
          ÂRequest.IfModifiedSince) + '<BR>');
        Add('Referer = ' + Request.Referer + '<BR>');
        Add('UserAgent = ' + Request.UserAgent + '<BR>');
        Add('ContentEncoding = ' + Request.ContentEncoding + '<BR>');
        Add('ContentType = ' + Request.ContentType + '<BR>');
        Add('ContentLength = ' + IntToStr(Request.ContentLength) + '<BR>');
      end;
    end;
  except
  end;
end;

```

continues

LISTING 31.2 Continued

```
        Add('ContentVersion = ' + Request.ContentVersion + '<BR>');
        Add('Content = ' + Request.Content + '<BR>');
        Add('Connection = ' + Request.Connection + '<BR>');
        Add('DerivedFrom = ' + Request.DerivedFrom + '<BR>');
        Add('Expires = ' + FormatDateTime('mmm dd, yyyy hh:mm',
            Request.Expires) + '<BR>');
Add('Title = ' + Request.Title + '<BR>');
        Add('RemoteAddr = ' + Request.RemoteAddr + '<BR>');
        Add('RemoteHost = ' + Request.RemoteHost + '<BR>');
        Add('ScriptName = ' + Request.ScriptName + '<BR>');
        Add('ServerPort = ' + IntToStr(Request.ServerPort) + '<BR>');

        Add('</BODY>');
        Add('</HTML>');
    end;
    PageProducer1.HTMLDoc := Page;
    Response.Content := PageProducer1.Content;
finally
    Page.Free;
end;
Handled := True;
end;
```

Build the project and copy the resulting `Project1.d11` file in the default directory for your ISAPI- or NSAPI-capable Web server. Point your Web browser to `http://<your server>/project1.d11/http`; when you view this application; it will show you all the values of the HTTP fields passed to the server in the request from your browser.

Of course, every request should have a proper response; therefore, Delphi defines the `TISAPIResponse` class to allow you to return information to the requesting client. The most important property of `TISAPIResponse` is the `Content` property. This is the property that will contain the HTML code that is to be displayed for the client.

`TISAPIResponse` contains a number of additional properties that can be set by your application. You can pass version information in the `Version` property. You can tell the client when the information being passed back was last modified with the `LastModified` property. You can pass information about the content, itself, with the `ContentEncoding`, `ContentType`, and `ContentVersion` properties. The `StatusCode` property allows you to return error codes and other status codes to the client.

TIP

Most browsers react in specific ways to certain status codes. You can check the HTTP specification at the Web site <http://www.w3.org> for the specific status codes.

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The real power of `TISAPIResponse` comes in its methods. Once you have properly formatted your response, use the `SendResponse` method to force your Web application to send the `TWebResponse` information back to the client. You can send any sort of data back to the client using the `SendStream` method. Also, if your application decides to send the client somewhere other than the response provided by the application itself, it can do so using the `SendRedirect` method. `SendRedirect` is discussed later in the chapter.

Dynamic HTML Pages with HTML Content Producers

Of course, building HTML code dynamically is not the most efficient way to provide Web pages, so Delphi provides a number of tools to make building HTML pages much easier, more efficient, and customizable. `TCustomContentProducer` is an abstract class that provides the basic functionality for handling and manipulating HTML pages. `TPageProducer`, `TDataSetTableProducer`, and `TQueryTableProducer` descend from it. When used together, and with either existing or dynamically created HTML, these classes allow you to create a site based on dynamic HTML pages, including data in tables, hyperlinks, and the full range of HTML capabilities. These controls will not actually create HTML for you, but they make the management of HTML and the dynamic creation of Web pages based on parameters and other inputs quite simple.

TPageProducer

`TPageProducer` is used for the manipulation of straight HTML code. It uses customized HTML tags, replacing them with the proper content. You create, either at design time or runtime, an HTML template that contains special tags that are ignored by standard HTML. The `TPageProducer` can then find these tags and replace them with the appropriate information. The tags can contain parameters for passing information. You can even replace one custom tag with text containing other custom tags, thus allowing you to link page producers together, causing a “daisy chain” effect that enables you to define a dynamic Web page based on differing inputs.

These dynamic tags look just like regular HTML tags, but because they are not standard HTML tags, they are ignored by the client's browser. Such a tag looks like this:

```
<#CustomTag Param1=SomeValue "Param2=Some Value with Spaces">
```

The tag should be surrounded by the less-than (<) and greater-than (>) brackets, and the tag's name must begin with a pound sign (#). The tag name must be a valid Pascal identifier. Parameters with spaces must be entirely surrounded by quotes. These custom tags can be placed anywhere inside your HTML document, even inside other HTML tags.

Delphi provides a number of predefined tag names. None of the values have any special action associated with them; rather, they are defined only for convenience and code clarity. For example, you are not required to use the `TgLink` custom tag for a link, but it makes sense (and is clearer in your HTML templates) if you do so. Note that you can define all your custom tags as you want, and they will all become `TgCustom` values. Table 31.1 shows the predefined tag values.

TABLE 31.1 Predefined Tag Values

<i>Name</i>	<i>Value</i>	<i>Tag Conversion Value</i>
Custom	TgCustom	A user-defined or unidentified tag. It can be converted to any user-defined value.
Link	TgLink	This tag should be converted to an anchor value. This is normally a hypertext link or a bookmark value (<A> . .).
Image	TgImage	This tag should be converted to an image tag ().
Table	TgTable	This tag should be replaced with an HTML table (<TABLE> . . </TABLE>).
ImageMap	TgImageMap	This tag should be replaced with an image map. An image map defines links based on hot zones within an image (<MAP> . . </MAP>).
Object	TgObject	This tag should be replaced with code that calls an ActiveX control.
Embed	TgEmbed	This tag should be converted to a tag that refers to a Netscape-compliant add-in DLL.

Using the `TPageProducer` component is rather straightforward. You can assign HTML code to the component in either the `HTMLDoc` or `HTMLFile` property. Whenever the `Content` property is assigned to another variable (usually the `TISAPIResponse.Content` property), it scans the given HTML, calling the `OnHTMLTag` event whenever a custom tag is found in the HTML. The `OnHTMLTag` event handler looks like this:

```
procedure TWebModule1.PageProducer1HTMLTag(Sender: TObject; Tag: TTag;  
  const TagString: String; TagParams: TStrings; var ReplaceText: String);  
begin  
  
end;
```

The `Tag` parameter contains the type of tag found (refer to Table 31.1). The `TagString` parameter holds the value of the whole tag itself. The `TagParams` parameter is an indexed list of each parameter, including the parameter name, the equal sign (=), and the value itself. The `ReplaceText` parameter is a string variable that you will fill with the new value that will replace the tag. The entire tag, including the angle brackets (< and >), is replaced in the HTML code with whatever value is passed back in this parameter.

You can assign an HTML template to the `TPageProducer` in one of two ways. You can create the HTML at runtime as a string and pass it to the `HTMLDoc` property, or you can assign an existing HTML file to the `HTMLFile` property. This allows you to build HTML on the fly or to use existing templates that you have prepared ahead of time.

For example, suppose you have an HTML file called `MYPAGE.HTM` with the following HTML code in it:

```
<HTML>  
<HEAD>  
  <TITLE>My Cool Homepage</TITLE>  
</HEAD>  
<BODY>  
Howdy <#Name>! Thanks for stopping by my web site!  
</BODY>  
</HTML>
```

You can then assign the following code to the `PageProducer.OnHTMLTag` event handler:

```
procedure TWebModule1.PageProducer1HTMLTag(Sender: TObject; Tag: TTag;  
  const TagString: String; TagParams: TStrings; var ReplaceText: String);  
begin  
  case Tag of  
    tgCustom: if TagString = 'Name' then ReplaceText := 'Partner';  
  end;  
end;
```

This results in the following HTML code:

```
<HTML>  
<HEAD>  
  <TITLE>My Cool Homepage</TITLE>  
</HEAD>  
<BODY>
```

```
Howdy Partner! Thanks for stopping by my web site!  
</BODY>  
</HTML>
```

Suppose that you used this code with the `OnAction` event in a `WebModule`, like this:

```
procedure TWebModule1.WebModule1WebActionItem1Action(Sender: TObject;  
    Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);  
begin  
    PageProducer1.HTMLFile := 'MYPAGE.HTM';  
    Response.Content := PageProducer1.Content;  
end;
```

The newly created page would be sent back to the client when requested. When the `PageProducer.Content` property is called, it makes the given replacement of text for every tag it finds, calling the `OnHTMLTag` event handler for each one. More complex pages might have numerous entries in the case statement, replacing various different custom tags with large chunks of HTML, links to other pages, graphics, tables, and so on.

`TCustomPageProducer` objects can also be linked together in a chain. You can use two of them to produce a single page. For example, you might have a basic HTML template that holds standard header and footer code, along with custom tags that define some general values for the page and the location of the main body of the page. You might pass this through one page producer, replacing general data tags with information based on the user's identity. Then, you might replace the main body tag with customized code or more tags based on the information requested by that user. The result could then be passed to yet another `TPageProducer`, which would replace those specific tag values with the appropriate information.

TDataSetTableProducer and TQueryTableProducer

In addition to regular HTML documents, Delphi provides the `TDataSetTableProducer` to allow you to easily and powerfully create HTML tables based on a given dataset.

`TDataSetTableProducer` allows you to fully customize all characteristics of the table, within the limits set by HTML. This class can function to a large degree as a `TDBGrid` because you can format individual cells, rows, and columns. You can access data from any dataset available to your system, whether local or remote. This allows you to build enterprise-level Web sites that access data from virtually any source.

`TDataSetTableProducer` behaves a bit differently than the other database controls in that it accesses data directly from a `TDataSet` descendant rather than through a `TDataSource`. It has a `DataSet` property that can be set at design time to any `TDataSet` descendant found in the same `TWebModule`, or at runtime to any dynamically created value. After the `DataSet` property has been set, you can access and configure the `TDataSetTableProducer` to display any of the columns of the given dataset, as desired. The `TableAttributes` property allows you to set the general characteristics of the table, again within the confines of the HTML specification.

The `Header` and `Footer` properties are of type `TStrings` and allow you to add HTML code before and after the table itself. You can use these properties in conjunction with your own dynamically created HTML or with HTML from a `TPageProducer`. For instance, if the main feature of a page is the table, you might use the `Header` and `Footer` properties to fill in the basic structure of the HTML page. If the table is not the main focus of the page, you might choose to use a custom `TTag` in a `TPageProducer` to place the table in the appropriate place. Either way, you can use the `TDataSetTableProducer` to create data-based Web pages.

The `Columns`, `RowAttributes`, and `TableAttributes` properties are where customizing is done for the table to be produced. The `Columns` property hides a very powerful component editor that you can use to set most of the component's attributes.

TIP

Double-click the component itself or the `Columns` property in the Object Inspector to invoke the `Columns` property editor.

The `Caption` and `CaptionAlign` properties determine how the caption of the table will be shown. The `Caption` is the text displayed either above or below the table, serving to explain the table's contents. The `DataSet` property (Query in the `TQueryTableProducer`) determines the data to be used in the table.

Other than the way they access data, `TDataSetTableProducer` and `TQueryTableProducer` function identically. They have the same properties and are configured the same way. Because of this, you will create a table that is the result of a simple join and use `TQueryTableProducer` in an example to see how they both work.

Start a new Web application and drop a `TQueryTableProducer` from the Internet page of the Component Palette and a `TQuery` and a `TSession` from the Data Access Palette page onto the `TWebModule`. Set the `QueryTableProducer1.Query` property to `Query1` and the `Query1.DatabaseName` property to `DBDEMOS`. Save the project as `TABLEEX.DPR`. Then set the `Query1.SQL` property as follows:

```
SELECT CUSTNO, ORDERNO, COMPANY, AMOUNTPAID, ITEMSTOTAL FROM CUSTOMER,  
↳ORDERS WHERE  
    CUSTOMER.CUSTNO = ORDERS.CUSTNO  
    AND  
    ORDERS.AMOUNTPAID <> ORDERS.ITEMSTOTAL
```

This will produce a small, joined table that has all the customers from the `CUSTOMER.DB` table in the standard `DBDemos` alias who have not yet paid all their orders in full. You can then build a table that shows this data and highlight the amount owed. Set `Query1.Active` to `True` so that the data will be displayed in the `Columns` editor.

NOTE

All Web server applications that will be handling data and using Delphi's data components need to have a `TSession` included in the `WebModule`. Web server applications can be accessed many times concurrently, and Delphi will run each ISAPI or NSAPI server application in a separate thread for each request. As a result, your application needs to have its own, unique session when talking to the BDE. A `TSession` with the `AutoSessionName` property set to `True` in your application ensures that each thread has its own session and does not conflict with other threads trying to access the same data. All you need to do is make sure that there is a `TSession` present in your project—Delphi takes care of the rest.

TIP

When you are building Web extension applications, the `TWebApplication.CacheConnections` property can speed up your application. Each time a client makes a request of your ISAPI or NSAPI application, a new thread is spawned to handle your request, in the process creating a new instance of your `TWebModule`. Normally, each thread is executed for a single connection, and the `TWebModule` is destroyed when that connection is closed. If `CacheConnections` is set to `True`, each thread is preserved and reused as needed. New threads are only created when a cached thread is not available. This will speed performance by saving the execution time for creating a `TWebModule` request every time. However, you have to be really careful, because `TWebModule.OnCreate` is called only once for each cached thread. When a cached thread is finished, it remains in the state it was at completion. This might cause problems the next time the thread is used, depending on what happens in your `OnCreate` event. If you depend on `OnCreate` to initialize variables or perform other initialization actions, you might not want to use cached connections. Instead, you should use an additional method that initializes the data for your Web application and then call that in the `BeforeDispatch` event handler. This way, each time a request is made, the data for your Web module will be initialized.

You can check the current number of unused, cached connections with the `TWebApplication.InactiveCount` property. `TWebApplication.ActiveCount` will tell you the number of active connections. These two properties may help you determine a good value for `TWebApplication.MaxConnections`, which limits the total number of connections that the `TWebModule` can handle at once. An exception will be raised if `ActiveCount` ever exceeds `MaxConnections`.

Double-click `QueryTableProducer1` to invoke the `Columns` component editor. In the upper-left area of the component editor, you can set the general properties for the table as a whole. The lower half of the editor contains an HTML control that will display the table as it is currently configured. The upper-right area contains a collection of `THTMLTableColumn` items that can be configured to determine which fields of the database will be included in the table and how those fields will be displayed. Delphi will automatically import the fields from the `TQuery` and add them to the fields editor. This application will not display the last field, so select the `ItemsTotal` field and delete it. In addition, select the `AMOUNTPAID` field, and set the `BgColor` property to `Lime`.

TIP

It might be a good idea to resize the `Columns` property editor in order to accommodate your table, especially if it will contain a number of columns.

In the upper-left part of the window, set the `Border` value to 1 so that you will be able to see the border of the table in the component editor as it is built. Set the `CellPadding` value to 2 to provide a bit of spacing between the border and the text. If you want to add a little color to the table, set the `BgColor` property to `Aqua`. This will cause the default background color of the table to be aqua. Note that this is the default color—setting the background color for a row or a column will override this value. In addition, `Column` color settings take precedence over `Row` color settings.

When Delphi creates the field columns for the table, it gives the HTML columns headers the names of the fields. However, database field names often do not make nice table column headings, so you can change the default values using the `Title` property. `Title` is a compound property, and one of its subproperties is `Caption`. Set the `Title.Caption` properties of the four columns to `Cust #`, `Order #`, `Company`, and `Amount Owed`, respectively. `Amount Owed` is not quite what the fourth column currently represents, but you will customize the output for this column a little later. The `Title` property also allows you to customize the vertical and horizontal alignment, as well as the color of the column header cell.

NOTE

`THTMLTableColumn`, like other table-related classes, has a `Custom` property. This property lets you enter a string value for the given item in the table. This value will be entered directly in the HTML tag that defines the given table element. `Custom` items might include HTML cell, row, or column modifiers not included in the properties of

continues

the class or proprietary HTML extensions. Microsoft Internet Explorer includes a number of table-formatting extensions that allow you to customize the frames of the table. If you want to add these capabilities, make the entry in the Custom property in the form of *paramname=value*. You can add multiple parameters separated by spaces.

That covers the basic properties for the table that you can set at design time. Now we will discuss the events associated with `TQueryTableProducer` that allow you to customize the table at runtime. `OnCreateContent` occurs prior to any HTML being generated. It contains the `Continue` parameter, a Boolean value that you can set. If your application determines that for some reason the table should not be generated, you can set this parameter to `False`, and no more processing will be done; a call to the `Content` property will return an empty string. It might be used to do such things as prepare the query, set the `TQueryTableProducer.MaxRows` property, or any other processing that you need to do before actually displaying the table.

For instance, in the current example, the application will need to step through each record in the Query as the table is drawn. To ensure that as the table is built the query is pointing to the proper record, the application has to manually increment the cursor in the query each time a new row is started. To do that, the query has to start at the beginning, as does the `TQueryTableProducer`. Therefore, a call to `Query1.First` in the `OnCreateContent` event handler ensures that the query and the HTML table are in sync with each other. Therefore, add the following code to the event handler for `QueryTableProducer1.OnCreateContent`:

```
procedure TWebModule1.QueryTableProducer1CreateContent(Sender: TObject;
  var Continue: Boolean);
begin
  QueryTableProducer1.MaxRows := Query1.RecordCount;
  Query1.First;
  Continue := True;
end;
```

The `OnGetTableCaption` event allows you to format the table's caption however you want. Double-clicking the event in the Object Inspector yields this event handler:

```
procedure TWebModule1.QueryTableProducer1GetTableCaption(Sender: TObject;
  var Caption: String; var Alignment: THTMLCaptionAlignment);
begin
  end;
```

The `Caption` parameter is a variable parameter that will hold the end result of your caption. You can manipulate this parameter as you please, including adding HTML tags to size, color, and format the font of the table's caption. You can use the `Alignment` parameter to determine whether the caption is aligned at the top or the bottom of the table.

Create an `OnGetTableCaption` for the example that you have been working on by double-clicking it in the Object Inspector. Enter the following code to format the table's Caption in order to make it stand out a bit more on the page (this change will not be reflected on the HTML table shown in the Columns property editor):

```
procedure TWebModule1.QueryTableProducer1GetTableCaption(Sender: TObject;
  var Caption: String; var Alignment: THTMLCaptionAlignment);
begin
  Caption := '<B><FONT SIZE="+2" COLOR="RED">Delinquent Accounts</FONT></B>';
  Alignment := caTop;
end;
```

The `OnFormatCell` event can be used to change the appearance of an individual cell. In this example, you can add code to highlight the `Amount Owed` cell of any company that has not paid its bill in full. This gets a little trickier than with the regular grids, because `TQueryTableProducer` only provides you with string values. However, as mentioned earlier, you can use the `CellRow` and `CellColumn` parameters to move the cursor of the `TQuery` along as the table is built, gathering the proper data and making calculations as each row is processed.

The `OnFormatCell` event handler passes you the information about the current cell being formatted in the `CellRow` and `CellColumn` parameters. These are both zero-based. The rest of the parameters are variable parameters to which you can assign values, depending on your application's logic. You can adjust the horizontal and vertical alignment of the data in the cell with the `Align` and `VAlign` parameters. You can pass additional Custom parameters for the cell in the `CustomAttrs` parameter, and of course, you can alter the actual text of the cell with the `CellData` parameter.

The `CellData` parameter is of type `string`, which limits your ability to process it in its native format. If the data were actually stored in the database as an integer, you would have to call `StrToInt` to convert it back to a usable number. The following code illustrates how you might gather the actual `TField` values for the given cell. Perhaps future versions of Delphi will pass the `TField` value into the `OnFormatCell` event handler in addition to or in place of the string value. Add the code in Listing 31.3 to the `OnFormatCell` event handler for `TQueryTableProducer`.

LISTING 31.3 The `OnFormatCell` Event Handler

```
procedure TWebModule1.QueryTableProducer1FormatCell(Sender: TObject;
  CellRow, CellColumn: Integer; var BgColor: THTMLBgColor;
  var Align: THTMLAlign; var VAlign: THTMLVAlign; var CustomAttrs,
  CellData: String);
```

continues

LISTING 31.3 Continued

```
Owed, Paid, Total: Currency;
begin
  if CellRow = 0 then Exit; // Don't process the header row
  if CellColumn = 3 then //if the column is the Amount Owed Column
  begin
    //Calculate the amount that the company owes
    Paid := Query1.FieldByName('AmountPaid').AsCurrency;
    Total := Query1.FieldByName('ItemsTotal').AsCurrency;
    Owed := Total - Paid;
    //Set CellData to amount owed
    CellData := FormatFloat('$0.00', Owed);
    //if it is greater than zero, then highlight the cell.
    if Owed > 0 then
      begin
        BgColor := 'RED';
      end;
    Query1.Next; //Advance the query since we came to the end of a row
  end;
end;
```

This code gathers the data for each unpaid account, subtracts the Amount Owed from the Amount paid, and then highlights in red the accounts that owe money. It illustrates how you can use the current cursor of the TQuery component to access the data being displayed in the HTML table.

Next, add the following strings to the TQueryTableProducer.Header property:

```
<HTML>
<HEAD>
  <TITLE>Delinquent Accounts</TITLE>
</HEAD>
<BODY>
<CENTER><H2>Big Shot Widgets</H2></CENTER>
<P>
The Accounts highlighted in red are late in paying:
<P>
```

Now add this to the TQueryTableProducer.Footer property:

```
<P>
<I>This information is to be kept in the strictest confidence</I><P>
<B><I>Copyright 1999 by BigShotWidgets</I></B><P>
</BODY>
</HTML>
```

This will cause the table to be placed between these two sets of HTML code, thus causing a complete page to be created when the Content property of TQueryTableProducer is called in the following code.

Finally, go back to the main TWebModule of your application and add a single Action, setting its PathInfo to /TestTable. In its OnAction event handler, add the following code:

```
procedure TWebModule1.WebModule1WebActionItem1Action(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
begin
  Response.Content := QueryTableProducer1.Content;
end;
```

Then compile the project and make sure that the resulting DLL is accessible by your Web server. Now, if you call the URL `http://<your server>/tableex.dll/TestTable`, you will see the table with the header and footer text as well as the positive amounts owed highlighted in red, as shown in Figure 31.2.

Customer Number	Order #	Company Name	Amount Owed
1351	1003	Sight Diver	\$1250.00
1510	1008	Ocean Paradise	\$1449.50
1645	1014	Action Club	\$0.00
1984	1017	Adventure Undersea	\$10195.00
2135	1019	Frank's Divers Supply	\$20602.00
2156	1095	Davy Jones' Locker	\$7531.75
3615	1097	Manna SCUBA Center	\$12953.60
1984	1099	Adventure Undersea	\$859.95
2165	1101	Shangri-La Sports Center	\$11629.85
4531	1112	On-Target SCUBA	\$5565.00
4684	1115	Underwater Fantasy	\$4894.95

FIGURE 31.2

A table-based Web page.

Maintaining State with Cookies

The HTTP protocol is a powerful tool, but one of its weaknesses is that it is *stateless*. This means that after an HTTP conversation has been completed, neither the client nor the server

has any memory at all that the conversation even took place, much less what it was about. This can present a number of problems for applications that run across the Web, because the server is not able to remember important items such as passwords, data, record positions, and so on that have been sent to the client. Database applications are particularly affected as they often rely on the client knowing which record is the current record back on the server.

The HTTP protocol provides a basic method for writing information on the client's machine to allow the server to get information about the client from previous HTTP exchanges. Called by the curious name *cookies*, they allow the server to write state information into a file on the client's hard drive and to recall that information at a subsequent HTTP request. This greatly increases a server's capabilities with respect to dynamic Web pages.

Cookies are no more than text values in the form of *CookieName=CookieValue*. A cookie should not include semicolons or commas. The user can refuse to accept cookies, so no application should ever assume that a cookie will be present. Cookies are becoming more and more prevalent as Web sites get more and more sophisticated. If you are a Netscape user, you might be surprised by what you find in your COOKIES.TXT file. Internet Explorer users might peek into the \WINDOWS\COOKIES folder. If you want to track cookies as they are set on your machine, both of these browsers allow you to approve individual cookie settings within their security preference settings.

Managing cookies in Delphi is, pardon the pun, a piece of cake. The `THTTPRequest` and `THTTPResponse` classes encapsulate the handling of cookies quite cleanly, allowing you to easily control how cookie values are set on a client's machine as well as to read what cookies have been previously set.

The work of setting a cookie is all done in the `TWebResponse.SetCookieField` method. Here, you can pass a `TStrings` descendant full of cookie values, along with the restrictions placed on the cookies.

The `SetCookieField` method is declared as follows in the `HTTPAPP` unit:

```
procedure SetCookieField(Values: TStrings; const ADomain, APath: string;  
    AExpires: TDateTime; ASecure: Boolean);
```

The `Values` parameter is a `TStrings` descendant (you will probably use a `TStringList`) that holds the actual string values of the cookies. You can pass multiple cookies in the `Values` parameter.

The `ADomain` parameter allows you to define in which domain the given cookies are relevant. If no domain value is passed, the cookie will be passed to every server to which a client makes a request. Normally, a Web application will set its own domain here so that only the pertinent cookies are returned. The client will examine the existing cookie values and return those cookies that match the given criteria.

For example, if you pass `widgets.com` in the `ADomain` parameter, all future requests to a server in the `widgets.com` domain will pass along the cookie value set with that domain value. The cookie value will not be passed to other domains. If the client requests `big.widgets.com` or `small.widgets.com`, the cookie will be passed. Only hosts within the domain can set cookie values for that domain, thus avoiding all sorts of potential for mischief.

The `APath` parameter allows you to set a subset of URLs within the domain where the cookie is valid. The `APath` parameter is a subset of the `ADomain` parameter. If the server domain matches the `ADomain` parameter, the `APath` parameter is checked against the current path information of the requested domain. If the `APath` parameter matches the pathname information in the client request, the cookie is considered valid.

For example, following the preceding example, if `APath` contained the value `/nuts`, the cookie would be valid for a request to `widgets.com/nuts` and any further paths, such as `widgets.com/nuts/andbolts`.

The `AExpires` parameter determines how long a cookie should remain valid. You can pass any `TDateTime` value in this parameter. Because the client could be anywhere in the world, this value needs to be based on the GMT time zone. If you want a cookie to be valid for 10 days, pass `Now + 10` as a value.

If you want to delete a cookie, pass a date value that is in the past (that is, a negative value) and that will invalidate the cookie. Note that a cookie may become invalid and not be passed, but that does not necessarily mean that the cookie is actually removed from the client's machine.

The final parameter, `ASecure`, is a Boolean value that determines whether the cookie can be passed over nonsecure channels. A `True` value means that the cookie can only be passed over the HTTP-Secure protocol or a Secure Sockets Layer network. For normal use, this parameter should be set to `False`.

Your Web server application receives cookies sent by the client in the `TWebRequest.CookieFields` property. This parameter is a `TStrings` descendant that holds the values in an indexed array. The strings are the complete cookie value in `param=value` form. They can be accessed like any other `TStrings` value. The cookies are also passed as a single string in the `TWebRequest.Cookie` property, but normally you would not want to manipulate them here. You can assign the cookies directly to an existing `TStrings` object with the `TWebRequest.ExtractCookieFields` method.

A simple example can illustrate the ease with which Delphi deals with cookies. First, create a new Web Application and add the `WebUtils` unit to your `uses` clause. The `WebUtils` unit is included on the CD-ROM accompanying this book. Then create a new Web server application

and give it two actions—one named `SetCookie` and the other `GetCookie`. Set the code in the `OnAction` event for `SetCookie` to the following:

```
procedure TWebModule1.WebModule1WebActionItem1Action(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
var
  List: TStringList;
begin
  List := TStringList.Create;
  try
    List.Add('LastVisit=' + FormatDateTime('mm/dd/yyyy hh:mm:ss', Now));
    Response.SetCookieField(List, '', '', Now + 10, False);
    Response.Content := 'Cookie set -- ' + Response.Cookies[0].Name;
  finally
    List.Free;
  end;
  Handled := True;
end;
```

The `OnAction` code for `GetCookie` should be as follows:

```
procedure TWebModule1.WebModule1WebActionItem2Action(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
var
  Params: TParamsList;
begin
  Params := TParamsList.Create;
  try
    Params.AddParameters(Request.CookieFields);
    Response.Content := 'You last set the cookie on ' + Params['LastVisit'];
  finally
    Params.Free;
  end;
end;
```

Set up a Web page that calls the following two URLs:

```
http://<your server>/project1.dll/SetCookie
http://<your server>/project1.dll/GetCookie
```

NOTE

The `TParamsList` class is part of the `WebUtils` unit included on the CD-ROM. It is a class that automatically parses out parameters from a `TStrings` descendant and allows you to index them by the parameter's name. For instance, `TWebResponse` gathers all the cookies passed in an HTTP response and places them in the `CookieFields`

property, which is a `TStrings` descendant. The cookies are in the form `CookieName=CookieValue`. `TParamsList` takes these values, parses them, and indexes them by the parameter name. Therefore, the preceding parameter could be accessed with `MyParams['CookieName']`, which would return `CookieValue`. You can use this class, or you can use the `Values` property found in the `TStrings` class included in the VCL.

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Set the cookie by calling for the first URL from a Web page in the same directory as the DLL. This will set a cookie on the client machine that lasts for 10 days and contains the date and time that the request was made in a cookie called `LastVisit`. If you have your Web browser set to accept cookies, it should ask you to confirm the writing of the cookie. Then call the `GetCookie` action to read the cookie, and you should see the date and time that you last called the `SetCookie` action.

Cookies can contain any information that can be stored in a string. Cookies can be as big as 4KB, and a client can store as many as 300 cookies. Any individual server or domain is limited to 20 cookies. Cookies are powerful but, as you can see, you should try to limit their use. They certainly cannot be used to store large amounts of data on a client's machine.

Very often, you will want to store more information about a user than can be stored in a cookie. Sometimes you will want to keep track of a user's preferences, address, personal information, or even items in a "grocery cart" that are to be purchased from your e-commerce site. This information can easily become rather voluminous. Rather than try to store all this information in the cookie itself, it is often better to encode user information into a cookie rather than storing the information as is. For instance, in order to store a collection of user preferences that are really Boolean values, you might store them in binary format inside the cookie. Therefore, a cookie value of `'1001'` might mean that the user does want further email updates, does not want his or her email address given to other users, does not want to be added to your list server, and does want to join your online discussion groups. You can use characters or numbers to further encode even more data about a user in a cookie.

You can also store a user identification value in a cookie that uniquely identifies a user. You can then retrieve that value from the cookie and use it to look up the user's data in a database. That way, you would be able to minimize the amount of data stored on the user's computer and maximize your control over the information that you maintain about a user.

Cookies can provide a powerful and easy way to maintain data about your users between individual HTTP sessions.

Redirecting to a Different Web Site

Often, a given URL may want to change the destination of a user's request. A Web application may want to process some data based on a request and then serve back a page that may vary depending on the nature of the request or a database entry. Web advertising does this frequently. Often an ad graphic will point to another URL within the domain where it appears, but clicking it takes the user to the advertiser's home page. Along the way, data is gathered about the request and then the client is handed off to the advertiser's page. Frequently, the HTML code for the advertisement's graphic will contain parameters that describe the ad to the server. The server can log that information and then pass the client on to the proper page. This technique is called *redirection*, and it can be very useful for a number of tasks.

Delphi's `TWebResponse` class includes a method called `SendRedirect`. It takes a single string as a parameter that should contain the full address of the site to which the client should be redirected. The method is declared as follows:

```
procedure SendRedirect(const URI: string); virtual; abstract;
```

`SendRedirect` is declared as an abstract method in `HTTPAPP.PAS` and defined in `ISAPIAPP.PAS`.

A Web server could easily process an HTTP request that includes parameters and then pass that request to a site named by one of those parameters. For instance, if a cool GIF file is on a page, and the whole graphic is wrapped up as a hyperlink, the URL assigned to it might look something like this:

```
<A  
  HREF="http://www.somecoolplace.com/transfer?www.borland.com&coolgif.gif&borland">  
  ➤<IMG SRC="coolgif.gif"></A>
```

Given that information, an `OnAction` event in a Web server application named `/transfer` might resemble the following code fragment:

```
procedure TWebModule1.WebModule1WebActionItem3Action(Sender: TObject;  
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);  
begin  
  {Process Request.QueryFields[1] perhaps placing it in a database.  
   It holds the name of the GIF file that caused the user to click on it.  
   You might want to track the GIFs that are the most effective.  
   Then you can keep track of how many hits a particular company is  
   getting from your site by tracking the company name that is getting  
   requested in the Request.QueryFields[2] parameter}  
  //Then, you can call this to send the user on his merry way...  
  Response.SendRedirect(Request.QueryFields[0]);  
end;
```

By using this technique, you can create a generic transfer application that processes every advertisement on a site. Of course, there may be other reasons for calling `SendRedirect` than just advertising. You can use `SendRedirect` whenever you want to keep track of specific URL requests and any data that might be associated with a particular hyperlink. Simply gather the data from the `QueryFields` property and then call `SendRedirect` as needed.

Retrieving Information from HTML Forms

HTML-based forms are growing in use with the growth of the Internet and intranets. It is not a surprise that Delphi makes gathering information from forms easy. This chapter does not cover the details of creating an HTML-based form and the controls that go with it, but rather it deals with how Delphi handles the forms and their data.

On the CD-ROM in the back of this book is a straightforward guest book application that gathers the input from an HTML form and makes entries into a database table. Opening the `INDEX.HTM` file in your browser can access the application. The HTML form for the guest book, `GUEST.HTM`, uses the following line to define the form and the action to take when the user clicks the Submit button:

```
<form method="post" action="guestbk.dll/form">
```

This code causes the form to “post” its data when asked to do so and to call the given DLL `OnAction` event. The form allows the user to enter his or her name, email address, home town, and comments. When the user clicks the Submit button, that information is gathered up and passed to the Web application.

The action with the name `/form` then receives the data in the `Request.ContentFields`, in the form of standard HTTP parameters. `ContentFields` is a `TStrings` descendant that holds the contents of the submitted form. The application contains a `TTable` named `GBTable` that is referenced by the `GBDATA` alias. You will need to create this alias and point it to the `/GBDATA` directory where the Paradox tables reside in order to run the guest book. Listing 31.4 shows the code that receives the content of the form and enters it into the database.

LISTING 31.4 Code for Retrieving Content of a Form

```
var
    MyPage: TStringList;
    ParamsList: TParamsList;
begin
    begin
        ParamsList := TParamsList.Create;
        try try
            ParamsList.AddParameters(Request.ContentFields);
```

continues

LISTING 31.4 Continued

```

        GTable.Open;
        GTable.Append;
        GTable.FieldName('Name').Value := ParamsList['fullnameText'];
        GTable.FieldName('EMail').Value := ParamsList['emailText'];
        GTable.FieldName('WhereFrom').Value :=
            ▶ParamsList['wherefromText'];
GTable.FieldName('Comments').Value := ParamsList['commentsTextArea'];
        GTable.FieldName('FirstTime').Value :=
            ▶(CompareStr(ParamsList['firstVisitCheck'], 'on') = 0);
        GTable.FieldName('DateTime').Value := Now;
        GTable.Post;
    except
        Response.Content := 'An Error occurred in processing your data.';
        Handled := True;
    end;
finally
    ParamsList.Free;
    GTable.Close;
end;
end;

```

The code first inserts the ContentFields property into a TParamsList. It then opens the GTable and inserts the data from the form into the appropriate fields. The code in Listing 31.4 is relatively straightforward.

The next portion of the code, shown in Listing 31.5, creates an HTML response that thanks the user for making an entry. It uses some of the data from the form to address the user by name, and it also confirms the user's email address.

LISTING 31.5 Code for Creating an HTML Response

```

MyPage := TStringList.Create;
ParamsList := TParamsList.Create;
    try
        with MyPage do
            begin
                Add('<HTML>');
                Add('<HEAD><TITLE>Guest Book Demo Page</TITLE></HEAD>');
                Add('<BODY>');
                Add('<H2>Delphi Guest Book Demo</H2><HR>');
                ParamsList.AddParameters(Request.ContentFields);
                Add('<H3>Hello <FONT COLOR="RED">'+ ParamsList['fullnameText']
                    ▶+'</FONT> from '+ParamsList['wherefromText']+'!</H3><P>');
                Add('Thanks for visiting my homepage and making

```

```
    ↪an entry into my Guestbook.<P>');
  Add('If we need to e-mail you, we will use this address -- <B>'
    ↪+ParamsList['emailText']+</B>');
  Add('<HR></BODY>');
  Add('</HTML>');
end;
PageProducer1.HtmlDoc := MyPage;
finally
  MyPage.Free;
  ParamsList.Free;
end;
Response.Content := PageProducer1.Content;
Handled := True;
```

Finally, the application provides a summary of all guest book entries in the /entries action.

Data Streaming

Most of the data you will be providing to clients by HTTP requests will probably be HTML-based pages. However, there may be a time when you want to send other types of data in response to a user's request. Sometimes you might want to provide different graphics or sounds based upon a user's input. You may have a special data format that you want to send down the pipe to a user that can be specially handled by the client's browser. For instance, Netscape provides a plug-in architecture that allows developers to write extensions to the Navigator browser to handle any type of data. RealAudio, Shockwave, and other types of data streaming are examples of Netscape plug-ins that can extend the power of the client's browser.

Whatever the type of data you want to transmit, Delphi makes it easy to stream data back to a client. The `TWebResponse.SendStream` method along with the `TWebResponse.ContentStream` property enable you to send any type of data back to the client by loading it into a Delphi stream class. Of course, you will need to let the client's browser know what type of data is being sent, so you will need to set the `TWebResponse.ContentType` property as well. Setting this string value to an appropriate MIME type will allow the browser to properly handle the incoming data. For instance, if you want to stream a Windows WAV file, you would set the `ContentType` property to 'audio/wav'.

NOTE

MIME stands for *Multipurpose Internet Mail Extensions*. MIME extensions were developed to allow clients and servers to pass data by email that was more complex than the standard text passed in most emails. Browsers and the HTTP protocol have

continues

adapted MIME extensions to allow you to pass almost any sort of data from a Web server to a Web browser. Your Web browser contains a rather large list of these MIME types, and it associates a particular application or plug-in with each MIME type. When the browser gets that type, it looks up which application should be used to handle that particular MIME type and passes the data to it.

Using streams allows you to pass any type of data from virtually any source on your Web server's machine. You can pass data from files that reside on your server or anywhere on your network, from Windows resources built into your ISAPI DLL or other DLLs available to your ISAPI DLL, or you can even construct the data on the fly and send it to the client. There is really no limit to how or what you can send, as long as your client's browser knows what to do with the data.

Now we will construct a simple Web application that illustrates what can be done. You will set up a Web page that displays images from various sources. The application will process the image data as needed and return it to the client as requested. This will be surprisingly easy, because Delphi provides numerous different stream classes that make gathering data into a stream very easy, and the ISAPI extension classes make sending that data a snap as well.

To build the data streaming example, select File, New from the main menu and choose Web Server Application from the resulting dialog. This will give you a `TWebModule`. Go to the Web module, select it, and then go to the Object Inspector. Double-click the Actions property and create three actions called `/file`, `/bitmap`, and `/resource`.

Select the `/file` action, go to the Object Inspector, and select the Events page. Create an `OnAction` event and then add the following code to the event handler:

```
procedure TWebModule1.WebModule1WebActionItem2Action(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
var
  FS: TFileStream;
begin
  FS := TFileStream.Create(JPEGFilename, fmOpenRead);
  try
    Response.ContentType := 'image/jpeg';
    Response.ContentStream := FS;
    Response.SendResponse;
    Handled := True;
  finally
    FS.Free;
  end;
end;
```

The preceding code is pretty straightforward. If you set up the code from the CD-ROM on your computer as described earlier, there should be a JPEG file called `TESTIMG.JPG` in the `\bin` directory. The `OnAction` event handler creates a `TFileStream` that loads that file. It then sets the proper MIME type to tell the client browser that a JPEG file is coming, and it then assigns the `TFileStream` to the `Response.ContentStream` property. The data is then returned to the client by calling the `Response.SendResponse` method. As a result, in the accompanying HTML file, there should be a picture of a rose on the provided HTML page.

NOTE

In the HTML that displays this JPEG file in your browser, you can simply place the reference to the Web application's `Action` property directly in the `IMG` tag, like so:

```
<IMG SRC="../../bin/streamex.dll/file" BORDER=0>
```

The streaming examples can be displayed by means of the `INDEX.HTM` page in the `\STREAMS` directory

The application is able to find the JPEG file because when it was created, it set the `JPEGFilename` variable as follows:

```
procedure TWebModule1.WebModule1Create(Sender: TObject);
var
  Path: array[0..MAX_PATH - 1] of Char;
  PathStr: string;
begin
  SetString(PathStr, Path, GetModuleFileName(HInstance, Path, SizeOf(Path)));
  JPEGFilename := ExtractFilePath(PathStr) + 'TESTIMG.JPG';
end;
```

The `/bitmap` action will load a different image, but in a totally different way. The code for this action is a bit more complicated. It looks like this:

```
procedure TWebModule1.WebModule1WebActionItem3Action(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
var
  BM: TBitmap;
  JPEGImage: TJPEGImage;
begin
  BM := TBitmap.Create;
  JPEGImage := TJPEGImage.Create;
  try
    BM.Handle := LoadBitmap(hInstance, 'ATHENA');
    JPEGImage.Assign(BM);
    Response.ContentStream := TMemoryStream.Create;
```

```
        JPEGImage.SaveToStream(Response.ContentStream);
        Response.ContentStream.Position := 0;
        Response.SendResponse;
        Handled := True;
    finally
        BM.Free;
        JPEGImage.Free;
    end;
end;
```

It takes a bit more work to get a bitmap converted to a JPEG and streamed out to the client. A `TBitmap` is used to grab the bitmap out of the resource file. A `TJPEGImage` from the JPEG unit is created and will convert the bitmap to a JPEG file.

The `TBitmap` class is created and then the Windows API call `LoadBitmap` is used to grab the bitmap from the resource named 'ATHENA'. `LoadBitmap` returns the bitmap's handle, which is assigned to the `Handle` property. The bitmap itself then is assigned immediately to the `TJPEGImage`. The `Assign` method is overloaded and contains the smarts to convert the bitmap to a JPEG.

Next comes a nice example of polymorphism. `Response.ContentStream` is declared as a `TStream`, an abstract class. Because of the power of polymorphism, you can create it as any type of `TStream` descendant you like. In this case, it is created as a `TMemoryStream` and used to hold the JPEG with the `TJPEGImage.SaveToStream` method. Now the JPEG is in a stream and can be sent out. An important but easy-to-forget step is to return the position of the stream to zero after saving the JPEG into it. If this is not done, the stream will be positioned at the end, and no data will be streamed out to the client. After all that is completed, the `Response.SendResponse` method is called to send out the data stored in the stream. The result in this case is the bust of Athena from Delphi's About box.

Another way to load a JPEG is by using a resource entry. You can load a JPEG into an RES file using the following code in an RC file and then compiling it using `BRCC32.EXE`. If you load it as `RCDATA`, you can use the `TResourceStream` class to easily load it and send it to the client browser. `TResourceStream` is a very powerful class that will load a resource from either the EXE file itself or a resource located in an external DLL file. The `/resource` action illustrates how to do this by loading the JPEG from the resource named 'JPEG' that is compiled into the EXE:

```
procedure TWebModule1.WebModule1WebActionItem4Action(Sender: TObject;
    Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
begin
    Response.ContentStream := TResourceStream.Create(hInstance,
        ↪ 'JPEG', RT_RCDATA);
    Response.ContentType := 'image/jpeg';
```

```
    Response.SendResponse;  
    Handled := True;  
end;
```

This code sends the data to the client a little differently. It is much more straightforward and is again a nice example of polymorphism in action. A `TResourceStream` is created and assigned to the `ContentStream` property. Because the `TResourceStream`'s constructor loads the resource into the stream, no further action needs to be taken on the stream, and a simple call to `Response.SendResponse` sends the data down the stream.

The final example streams out a WAV file that is stored as an `RCDATA` resource. This example uses the `Response.SendStream` method to send out a stream created within the method. This illustrates yet another way of sending stream data. You can create a stream, manipulate and modify it as needed, and send it directly back to the client with the `SendStream` method. This action should cause your browser to play a WAV file of a dog barking. Here is the code:

```
procedure TWebModule1.WebModule1WebActionItem1Action(Sender: TObject;  
    Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);  
var  
    RS: TResourceStream;  
begin  
    RS := TResourceStream.Create(hInstance, 'BARK', RT_RCDATA);  
    try  
        Response.ContentType := 'audio/wav';  
        Response.SendStream(RS);  
        Handled := True;  
    finally  
        RS.Free;  
    end;  
end;
```

Summary

This chapter shows you how to build Web server extensions using the ISAPI/NSAPI extensions. This information is easily transferable to the CGI applications that Delphi produces. We discussed the HTTP protocol and how Delphi encapsulates it in its `TWebRequest` and `TWebResponse` classes. We showed you how to build applications using the `TWebModule` and its `OnAction` events with dynamic HTML. We then illustrated custom HTML documents with the `TContentPageProducer` descendants. We also discussed accessing data and building HTML tables using the `TQueryTableProducer`. Then, we discussed how to handle cookies and the content of HTML forms. Finally, we showed you how to stream custom content back to the client. In the next chapter, "MIDAS Development," we will get back to a database-centric way of thinking as you learn about the MIDAS multitier technology.

Midas Development

By Dan Miser

CHAPTER

32

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Multitier applications are being talked about as much as any topic in computer programming today. This is happening for good reason. Multitier applications hold many advantages over the more traditional client/server applications. Borland's Multitier Distributed Application Services Suite (MIDAS) is one way to help you create and deliver a multitier application using Delphi, while building on techniques and skills you've accumulated when using Delphi. This chapter will walk you through some general information about multitier application design, and show you how to apply those principles to create solid MIDAS applications.

Mechanics of Creating a Multitier Application

Because we'll be talking about a multitier application, it might be helpful to first provide a frame of reference to what a tier really is. A *tier*, in this sense, is a layer of an application that provides some specific set of functionality. Here are the three basic tiers used in database applications:

- *Data*. The data tier is responsible for storing your data. Typically, this will be an RDBMS such as Microsoft SQL Server, Oracle, or InterBase.
- *Business*. The business tier is responsible for retrieving data from the data tier in a format appropriate for the application and performing final validation of the data (also known as *enforcing business rules*). This is also the application server layer.
- *Presentation*. Also known as the *GUI tier*, this tier is responsible for displaying the data in an appropriate format in the client application. The presentation tier always talks to the business tier. It never talks directly to the data tier.

In traditional client/server applications, you have an architecture like that shown in Figure 32.1. Notice that the client libraries for data access must be located on every single client machine. This has historically been a trouble spot when deploying client/server applications due to incompatible versions of DLLs. Also, because most of the business tier is located on each client, you need to update all the clients every single time you need to update a business rule.

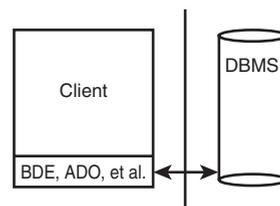


FIGURE 32.1

The traditional client/server architecture.

In multitier applications, the architecture looks more like that shown in Figure 32.2. Using this architecture, you'll find many benefits over the equivalent client/server application.

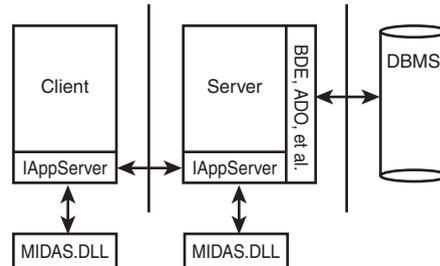


FIGURE 32.2

Multitier architecture.

Benefits of the Multitier Architecture

We list the major benefits of the multitier architecture in the next few sections.

Centralized Business Logic

In most client/server applications, each client application is required to keep track of the individual business rules for a business solution. Not only does this increase the size of the executable, but it also poses a challenge to the software developer to keep strict control over version maintenance. If user A has an older version of the application than user B, the business rules may not be performed consistently, thus resulting in logical data errors. Placing the business rules on the application server requires only one copy of the business rules to be created and maintained. Therefore, everyone using that application server will use the same copy of those business rules. In client/server applications, the RDBMS could address some of the concerns, but not all RDBMS systems provide the same set of features. Also, writing stored procedures makes your application less portable. Using a multitier approach, your business rules are hosted independent of your RDBMS, thus making database independence easier.

Thin-Client Architecture

In addition to the business rules mentioned, the typical client/server application also bears the burden of the majority of the data-access layer. This produces a more sizable executable, more commonly known as a *fat client*. For a Delphi database application accessing a SQL server database, you would need to install the BDE, SQL Links and/or ODBC to access the database,

and the client libraries necessary to talk to the SQL server. After installing these files, you would then need to configure each piece appropriately. This increases the install footprint considerably. Using MIDAS, the data access is controlled by the application server, whereas the data is presented to the user by the client application. This means you only need to distribute the client application and one DLL to help your client talk to your server. This is clearly a thin-client architecture.

Automatic Error Reconciliation

Delphi comes with a built-in mechanism to help with error reconciliation. Error reconciliation is necessary in a multitier application for the same reasons it would be necessary with cached updates. The data is copied to the client machine, where changes are made. Multiple clients can be working on the same record. Error reconciliation helps the user determine what to do with records that have changed since the user last downloaded the record. In the true Delphi spirit, if this dialog does not suit your needs, you can expand on it and create one that does.

Briefcase Model

The briefcase model is based on the metaphor of a physical briefcase. You place your important papers in your briefcase and transport them back and forth, unpacking them when needed. Delphi provides a way to pack up all your data and take it with you on the road without requiring a live connection to the application server or the database server.

Fault Tolerance

If your server machine becomes unavailable due to unforeseen circumstances, it would be nice to dynamically change to a backup server without recompiling your client or server applications. Delphi provides functionality for this out of the box.

Load Balancing

As you deploy your client application to more people, you'll inevitably start to saturate your server's bandwidth. There are two ways to attempt to balance the network traffic: static and dynamic load balancing. For static load balancing, you would add another server machine and have half of your clients use server A, and the other half would access server B. However, what if the clients who use server A put a greater strain on the server than those who use server B? Using dynamic load balancing, you could address this issue by telling each client application

which server to access. There are many different dynamic load-balancing algorithms available, such as random, sequential, least network users, and least network traffic. Delphi 4 and above address this by providing you with a component to implement sequential load balancing.

Classic Mistakes

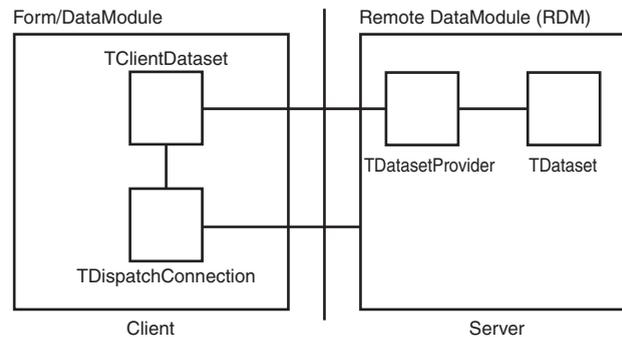
The most common mistake in creating a multitier application is introducing unnecessary knowledge of the data tier into the presentation tier. Some validation is more suitable in the presentation tier, but it's how that validation is performed that determines its suitability in a multitier application.

For example, if you're passing dynamic SQL statements from the client to the server, this introduces a dependency for the client application to always be synchronized with the data tier. Doing things this way introduces more moving parts that need to be coordinated in the overall multitier application. If you change one of the tables' structures on the data tier, you must update all the client applications that send dynamic SQL so that they can now send the proper SQL statement. This clearly limits the benefit that a properly developed thin-client application holds.

Another example is when the client application attempts to control the transaction lifetime, as opposed to allowing the business tier to take care of this on the client's behalf. Most of the time, this is implemented by exposing three methods of the `TDataBase` instance on the server—`BeginTransaction()`, `Commit()`, and `Rollback()`—and calling those methods from the client. Doing things in this manner makes the client code much more complicated to maintain and violates the principle that the presentation tier should be the only tier responsible for communication to the data tier. The presentation tier should never have to rely on such an approach. Instead, you should send your updates to the business tier and let that tier deal with updating the data in a transaction.

Typical MIDAS Architecture

Figure 32.3 shows how a typical MIDAS application looks after it's created. At the heart of this diagram is the Remote Data Module (RDM). The RDM is a descendant of the classic data module available since Delphi 2. This data module is a special form that only allows nonvisual components to be placed on it. The RDM is no different in this respect. In addition, the RDM is actually a COM object—or to be more precise, an *Automation object*. Services that you export from this RDM will be available for use on client machines.

**FIGURE 32.3**

A typical MIDAS application.

Let's look at some of the options available to you when creating an RDM. Figure 32.4 shows the dialog that Delphi presents when you select File, New, Remote Data Module.

**FIGURE 32.4**

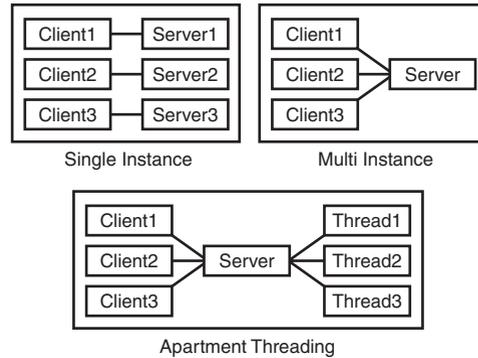
New Remote Data Module dialog.

Server

Now that we've seen how a typical MIDAS application is put together, let's see how to make that happen in Delphi. We'll begin with a look at some of the choices available when setting up the server.

Instancing Choices

Specifying an instancing choice affects how many copies of the server process will be launched. Figure 32.5 shows how the choices made here control how your server behaves.

**FIGURE 32.5**

Server behavior based on instancing options.

Here are the different instancing choices available to a COM server:

- `ciMultiInstance`. Each client that accesses the COM server will use the same server instance. By default, this implies that one client must wait for another before being allowed to operate on the COM server. See the next section, “Threading Choices,” for more detailed information on how the value specified for the Threading Model also affects this behavior. This is equivalent to serial access for the clients. All clients must share one database connection; therefore, the `TDatabase.HandleShared` property must be `True`.
- `ciSingleInstance`. Each client that accesses the COM server will use a separate instance. This implies that each client will consume server resources for each server instance to be loaded. This is equivalent to parallel access for the clients. If you decide to go with this choice, beware of BDE limits that could make this choice less attractive. Specifically, BDE 5.01 has a 48-process limit per machine. Because each client spawns a new server process, you can only have 48 clients connected at one time.
- `ciInternal`. The COM server cannot be created from external applications. This is useful when you want to control access to a COM object through a proxy layer. One example of using this instancing choice can be found in the `<DELPHI>\DEMOS\MIDAS\POOLER` example.

Also note that the configuration of the DCOM object has a direct effect on the object-instancing mode. See the “Deploying MIDAS Applications” section for more information on this topic.

Threading Choices

The threading support in Delphi 5 saw a drastic change for the better. In Delphi 4, selecting the threading model for an EXE server was meaningless. The flag merely marked the Registry to tell COM that a DLL was capable of running under the selected threading model. With Delphi 5, the threading model choice now applies to EXE servers by allowing COM to thread the connections without using any external code. The following is a summary of the threading choices available for an RDM:

- *Single*. Selecting Single means that the server is only capable of handling one request at a time. When using Single, you need not worry about threading issues because the server runs in one thread and COM handles the details of synchronizing the messages for you. However, this is the worst selection you can make if you plan on having a multiuser system because client B would then need to wait for client A to finish its processing before it could even start working. This is obviously not a good situation, because client A could be doing an end-of-day summary report or some other similar time-intensive operation.
- *Apartment*. Selecting the Apartment threading model gives you the best of all possible worlds when combined with `ciMultiInstance` instancing. In this scenario, all the clients share one server process because of `ciMultiInstance`, but the work done on the server from one client does not block another client from doing work due to the Apartment threading choice. When using Apartment threading, you're guaranteed that the instance data of your RDM is safe, but you need to protect access to global variables using some thread synchronization technique, such as `PostMessage()`, critical sections, mutexes, semaphores, or the Delphi wrapper class `TMultiReadExclusiveWriteSynchronizer`. This is the preferred threading model for BDE datasets. Note that if you do use this threading model with BDE datasets, you need to place a `TSession` component on your RDM and set the `AutoSessionName` property to `True` to help the BDE conform to its internal requirements for threading.
- *Free*. This model provides even more flexibility in server processing by allowing multiple calls to be made from the client to the server simultaneously. However, along with that power comes responsibility. You must take care to protect all data from thread conflicts—both instance data and global variables. This is the preferred threading model when using Microsoft Active Data Objects (ADO).
- *Both*. This setting is effectively the same as the Free setting, with one exception—callbacks are serialized automatically.

Data-Access Choices

Delphi 5 client/server comes with many different data-access choices. The BDE continues to be supported, thus allowing you to use `TBDDataset` components, such as `TTable`, `TQuery`, and

TStoredProc. In addition, you now have the choice of supporting ADO and direct InterBase access through new TDataset components.

Advertising Services

The RDM is responsible for communicating which services will be available to clients. If the RDM is going to make a TQuery available for use on the client, you need to place the TQuery on the RDM along with a TDataProvider. The TDataProvider component is then tied to the TQuery via the TDataProvider.Dataset property. Later, when a client comes along and wants to use the data from the TQuery, it can do so by binding to the TDataProvider you just created. You can control which providers are visible to the client by setting the TDataProvider.Exported property to True or False.

If, on the other hand, you don't need an entire dataset exposed from the server and just have a need for the client to make a method call to the server, you can do that, too. Although the RDM has focus, select the Edit, Add To Interface menu option and fill in the dialog with a standard method prototype. After refreshing the type library, you can specify the implementation of this method in code as you always have.

Client

After building the server, we need to create a client to use the services provided by the server. Let's take a look at some of the options available when building your MIDAS client.

Connection Choices

Delphi's architecture for connecting the client to the server starts with the TDispatchConnection. This base object is the parent of all the connection types listed later. When the connection type is irrelevant for a specific section, TDispatchConnection will be used to denote that fact.

TDCOMConnection provides core security and authentication by using the standard Windows implementation of these services. This connection type is especially useful if you're using this application in an intranet/extranet setup (that is, where the people using your application are "known" from the domain's perspective). You can use early binding when using DCOM, and you can use callbacks and ConnectionPoints easily (you can use callbacks when using sockets, too, but you're limited to using late binding to do so). The drawbacks of using this connection are as follows:

- Difficult configuration in many cases
- Not a firewall-friendly connection type
- Requires installation of DCOM95 for Windows 95 machines

TSocketConnection is the easiest connection to configure. In addition, it only uses one port for

MIDAS traffic, so your firewall administrators will be happier than if they had to make DCOM work through the firewall. You must be running `ScktSrvr` (found in the `<DELPHI>\BIN` directory) to make this setup work, so there's one extra file to deploy and run on the server. Delphi 4 also required you to have `WinSock2` installed, which meant another installation for Windows 9x clients. However, if you're using Delphi 5 and not using callbacks, you may want to consider setting `TSocketConnection.SupportCallbacks` to `False`. This allows you to stick with `WinSock 1` on the client machines.

`TOLEnterpriseConnection` provides built-in fault tolerance and load balancing. It also makes it easy to use a Windows 9x machine as a server. Delphi 4 introduced a component that allows for fault tolerance and simple load balancing (`TSimpleObjectBroker`), and it's now known how to use Windows 9x as a server. In addition, the install footprint is quite high.

Starting with Delphi 4, you can also use `TCORBAConnection`. It's the open-standard equivalent of DCOM. You'll end up using CORBA as you migrate your MIDAS applications to allow for cross-platform connections. For example, the Java client for MIDAS (available separately from Borland) allows you to have a JBuilder client talk to a MIDAS server—even if it was built with Delphi.

New to Delphi 5 is the `TWebConnection` component. This connection component allows MIDAS traffic to be transported over HTTP or HTTPS. Some limitations when using this connection type are as follows:

- Callbacks of any type are not supported.
- The client must have `WININET.DLL` installed.
- The server machine must be running MS Internet Information Server (IIS) 4.0 or Netscape 3.6 or greater.

However, these limitations seem well worth it when you have to deliver an application across the Internet or through a firewall that's not under your control.

Note that all these transports assume a valid installation of TCP/IP. The one exception to this is if you're using two Windows NT machines to communicate via DCOM. In that case, you can specify which protocol DCOM will use by running `DCOMCNFG` and moving the desired protocol to the top of the list on the Default Protocols tab. DCOM for Windows 9x only supports TCP/IP.

Connecting the Components

From the diagram in Figure 32.3, you can see how the MIDAS application communicates across tiers. This section will point out the key properties and components that give the client the ability to communicate with the server.

To communicate from the client to the server, you need to use one of the `TDispatchConnection` components listed previously. Each component has properties specific only to that connection type, but all of them allow you to specify where to find the application server. The `TDispatchConnection` is analogous to the `TDatabase` component when used in client/server applications.

Once you have a connection to the server, you need a way to use the services you exposed on the server. This can be accomplished by dropping a `TClientDataset` on your client and hooking it up to the `TDispatchConnection`. Once this connection is made, you can view a list of the exported providers on the server by dropping down the list in the `ProviderNames` property. You'll see a list of exported providers that exist on the server. In this way, the `TClientDataset` component is similar to a `TTable` in client/server applications.

You also have the ability to call custom methods that exist on the server by using the `TDispatchConnection.AppServer` property. For example, the following line of code will call the `Login` function on the server, passing two string parameters and returning a Boolean value:

```
LoginSucceeded := DCOMConnection1.AppServer.Login(UserName, Password);
```

Using MIDAS to Create an Application

Now that we've covered many of the options available when building MIDAS applications, let's use MIDAS to actually create an application to put that theory into practice.

Setting Up the Server

Let's focus on the mechanics of building the application server first. After we have created the server, we will explore how to build the client.

Remote Data Module (RDM)

The RDM is central to creating an application server. To create an RDM for a new application, select the Remote Data Module icon from the Multitier tab of the Object Repository (available by selecting File, New). A dialog will be displayed to allow for initial customization of some options that pertain to the RDM.

The name for the RDM is important because the ProgID for this application server will be built using the project name and RDM name. For example, if the project (DPR) is named `AppServer` and the RDM name is `MyRDM`, the ProgID will be `AppServer.MyRDM`. Be sure to select the appropriate instancing and threading options based on the preceding explanations and the behavior desired for this application server.

One important change for Delphi 5 is the security model for connections made over TCP/IP and HTTP. Because these protocols bypass Windows's default authentication processing, it is

imperative to be sure that the only objects that run on the server are the ones that you specify. This is accomplished by marking the registry with certain values to let MIDAS know that you intend to allow these objects to run. Fortunately, all that is required to do this is to override the `UpdateRegistry` class method. See Listing 32.1 for the implementation provided by Delphi automatically when you create a `Remote DataModule`.

LISTING 32.1 `UpdateRegistry` Class Method from a `Remote DataModule`

```
class procedure TDDGSimple.UpdateRegistry(Register: Boolean;
  const ClassID, ProgID: string);
begin
  if Register then
  begin
    inherited UpdateRegistry(Register, ClassID, ProgID);
    EnableSocketTransport(ClassID);
    EnableWebTransport(ClassID);
  end else
  begin
    DisableSocketTransport(ClassID);
    DisableWebTransport(ClassID);
    inherited UpdateRegistry(Register, ClassID, ProgID);
  end;
end;
```

This method gets called whenever the server gets registered or unregistered. In addition to the COM-specific registry entries that get created in the inherited `UpdateRegistry` call, you can call the `EnableXXXTransport` and `DisableXXXTransport` methods to mark this object as secure.

NOTE

The Delphi 5 version of the `TSocketConnection` component will only show registered, secure objects in the `ServerName` property. If you do not want to enforce security at all, uncheck the `Connections, Registered Objects Only` menu option in the `SCKTSRVR`.

Providers

Because the application server will be responsible for providing data to the client, you must find a way to serve data from the server in a format that's useable on the client. Fortunately, MIDAS provides a `TDatasetProvider` component to make this step easy.

Start by dropping a `TQuery` on the RDM. If you're using a RDBMS, you'll inevitably need a `TDatabase` component set up, too. For now, we'll tie the `TQuery` to the `TDatabase` and specify

a simple query in the SQL property, such as `select * from customer`. Lastly, drop a `TDataSetProvider` component onto the RDM and tie it to the `TQuery` via the `Dataset` property. The `Exported` property on the `DataSetProvider` determines whether this provider will be visible to clients. This property provides the ability to easily control which providers are visible at runtime as well.

NOTE

Although the discussion in this section focuses on using the BDE-based `TDBDataset`, the same principles apply if you want to use any other `TDataSet` descendant for your data access. Two such possibilities exist out of the box: ADO and InterBase Express.

Registering the Server

Once the application server is built, it needs to be registered with COM to make it available for the client applications that will connect with it. The Registry entries discussed Chapter 23, “COM and ActiveX,” are also used for MIDAS servers. You just need to run the server application and the Registry setting will be added. However, before registering the server, be sure to save the project first. This ensures that the ProgID will be correct from this point forward.

If you would rather not run the application, you can pass the parameter `/regserver` on the command line when running the application. This will just perform the registration process and immediately terminate the application. To remove the Registry entries associated with this application, you can use the `/unregserver` parameter.

Creating the Client

Now that we have a working application server, let’s look at how to perform some basic tasks with the client. We will look at how to retrieve the data, how to edit the data, how to update the database with changes made on the client, and how to handle errors during the database update process.

Retrieving Data

Throughout the course of a database application, it’s necessary to bring data from the server to the client to edit that data. By bringing the data to a local cache, you can reduce network traffic and minimize transaction times. In previous versions of Delphi, you would use cached updates to perform this task. However, the same general steps still apply to MIDAS applications.

The client talks to the server via a `TDispatchConnection` component. Providing the `TDispatchConnection` the name of the computer where the application server lives accomplishes this task easily. If you use `TDCOMConnection`, you can specify the fully qualified

domain name (for example, `nt.dmiser.com`), the numeric IP address of the computer (for example, `192.168.0.2`), or the NetBIOS name of the computer (for example, `nt`). However, due to a bug in DCOM, you cannot use the name `localhost` reliably in all cases. If you use `TSocketConnection`, you specify numeric IP addresses in the `Address` property or the `FQDN` in the `Host` property. We'll take a look at the options for `TWebConnection` a little later.

Once you specify where the application server resides, you need to give the `TDispatchConnection` a way to identify that application server. This is done via the `ServerName` property. Assigning the `ServerName` property fills in the `ServerGUID` property for you. The `ServerGUID` property is the most important part. As a matter of fact, if you want to deploy your client application in the most generic manner possible, be sure to delete the `ServerName` property and just use the `ServerGUID`.

Note

If you use `TDCOMConnection`, the `ServerName` list will only display the list of servers that are registered on the current machine. However, `TSocketConnection` is smart enough to display the list of application servers registered on the remote machine.

At this point, setting `TDispatchConnection.Connected` to `True` will connect you to the application server.

Now that you have the client talking to the server, you need a way to use the provider you created on the server. Do this by using the `TClientDataSet` component. A `TClientDataSet` is used to link to a provider (and thus the `TQuery` that is linked to the provider) on the server.

First, you must tie the `TClientDataSet` to the `TDispatchConnection` by assigning the `RemoteServer` property of the `TClientDataSet`. Once you've done that, you can get a list of the available providers on that server by looking at the list in the `ProviderName` property.

At this point, everything is now set up properly to open a `ClientDataSet`.

Because the `TClientDataSet` is a virtual `TDataSet` descendant, you can build on many of the techniques that you've already learned using the `TDBDataSet` components in client/server applications. For example, setting `Active` to `True` opens the `TClientDataSet` and displays the data. The difference between this and setting `TTable.Active` to `True` is that the `TClientDataSet` is actually getting its data from the application server.

Editing Data on the Client

All the records that get passed from the server to the `TClientDataSet` get stored in the `Data` property of the `TClientDataSet`. This property is a variant representation of the MIDAS data

packet. The `TClientDataset` knows how to decode this data packet into a more useful format. The reason the property is defined as a variant is due to the limited types available to the COM subsystem when using type library marshaling.

As you manipulate the records in the `TClientDataset`, a copy of the inserted, modified, or deleted records gets placed in the `Delta` property. This allows MIDAS to be extremely efficient when it comes to applying updates back to the application server, and eventually the database. Only the changed records need to be sent back to the application server.

The format of the `Delta` property is also very efficient. It stores one record for every insert or delete, and it stores two records for every update. The updated records are stored in an efficient manner as well. The unmodified record is provided in the first record, whereas the corresponding modified record is stored next. However, only the changed fields are stored in the modified record to save on storage.

One interesting aspect of the `Delta` property is that it's compatible with the `Data` property. In other words, it can be assigned directly to another `ClientDataset` component's `Data` property. This will allow you to investigate the current contents of the `Delta` property at any given time.

There are several methods available to deal with the editing of data on the `TClientDataset`. We'll refer to these methods as *change control* methods. The change control methods allow you to modify the changes made to the `TClientDataset` in a variety of ways.

NOTE

`TClientDataset` has proven useful in more ways than originally intended. It also serves as an excellent method for storing in-memory tables, which has nothing to do with MIDAS specifically. Additionally, because of the way it exposes data through the `Data` and `Delphi` properties, it has proven useful in a variety of OOP pattern implementations. It is beyond the scope of the chapter to discuss these techniques. However, you will find white papers on these topics at <http://www.xapware.com> or <http://www.xapware.com/ddg>.

Undoing Changes

Most users have used a word-processing application that permits the “Undo” operation. This operation takes your most previous action and rolls it back to the state right before you started. Using `TClientDataset`, you can call `cdsCustomer.UndoLastChange()` to simulate that behavior. The undo stack is unlimited, allowing the user to continue to back up all the way to the beginning of the editing session if so desired. The parameter you pass to this method specifies whether the cursor is positioned to the record being affected.

If the user wanted to get rid of all his updates in one fell swoop, there's an easier way than calling `UndoLastChange()` repeatedly. You can simply call `cdsCustomer.CancelUpdates()` to cancel all changes that have been made in a single editing session.

Reverting to the Original Version

Another possibility is to allow the user to restore a specific record back to the state it was in when the record was first retrieved. Do this by calling `cdsCustomer.RevertRecord()` while the `TClientDataset` is positioned on the record you intend to restore.

Client-Side Transactions: SavePoint

Lastly, a property called `SavePoint` provides the ability to use client-side transactions. This property is ideal for developing “what-if” scenarios for the user. The act of retrieving the value of the `SavePoint` property will store a baseline of the data at that point in time. The user can continue to edit as long as needed. If, at some point, the user decides that the baseline set of data is actually what he or she wants, that saved variable can be assigned back to `SavePoint` and the `TClientDataset` is rolled back to the same state it was at the time when the initial snapshot was taken. It's worth noting that you can have multiple levels of `SavePoint` for a complex scenario as well.

CAUTION

A word of caution about `SavePoint` is in order: You can invalidate a `SavePoint` by calling `UndoLastChange()` past the point that's currently saved. For example, assume the user edits two records and issues a `SavePoint`. At this point, the user edits another record. However, she uses `UndoLastChange()` to revert changes twice in a row. Because the `TClientDataset` state is now in a state prior to the `SavePoint`, the `SavePoint` is in an undefined state.

Reconciling Data

After you've finished making changes to the local copy of data in the `TClientDataset`, you'll need to signal your intent to apply these changes back to the database. This is done by calling `cdsCustomer.ApplyUpdates()`. At this point, MIDAS will take the `Delta` from `cdsCustomer` and pass it to the application server, where MIDAS will apply these changes to the database server using the reconciliation mechanism that you chose for this dataset. All updates are performed inside the context of a transaction. We'll cover how errors are handled during this process shortly.

The parameter you pass into `ApplyUpdates()` specifies the number of errors the update process will allow before considering the update to be bad and subsequently rolls back all the changes that have been made. The word *errors* here refers to key violation errors, referential integrity

errors, or any other database errors. If you specify zero for this parameter, you're telling MIDAS that you won't tolerate any errors. Therefore, if an error does occur, all the changes you made will not be committed to the database. This is the setting that you'll use most often, because it most closely matches solid database guidelines and principles.

However, if you wish, you can specify that a certain number of errors can occur, while still committing all the records that were successful. The ultimate extension of this concept is to pass `-1` as the parameter to `ApplyUpdates()`. This tells MIDAS that it should commit every single record that it can, regardless of the number of errors encountered along the way. In other words, the transaction will always commit when using this parameter.

If you want to take ultimate control over the update process—including changing the SQL that will execute for an insert, update, or delete—you can do so in the `TDataSetProvider.BeforeUpdateRecord()` event. For example, when a user wants to delete a record, you might not want to actually perform a delete operation on the database. Instead, a flag is set to tell applications that this record is not available. Later, an administrator can review these deletions and commit the physical delete operation. The following example shows how to do this:

```
procedure TDataModule1.Provider1BeforeUpdateRecord(Sender: TObject;
  SourceDS: TDataSet; DeltaDS: TClientDataset; UpdateKind: TUpdateKind;
  var Applied: Boolean);
begin
  if UpdateKind=ukDelete then
  begin
    Query1.SQL.Text:='update CUSTOMER set STATUS="DEL" where ID=:ID';
    Query1.Params[0].Value:=SourceDS.FieldByName('ID').Value;
    Query1.ExecSQL;
    Applied:=true;
  end;
end;
```

You can create as many queries as you'd like, controlling the flow and content of the update process based on different factors, such as `UpdateKind` and values in the `DataSet`. When inspecting or modifying records of the `DeltaDS`, be sure to use the `OldValue` and `NewValue` properties of the appropriate `TField`. Using `TField.Value` or `TField.AsXXX` will yield unpredictable results.

In addition, you can enforce business rules here or avoid posting a record to the database altogether. Any exception you raise here will wind its way through MIDAS's error-handling mechanism, which we'll cover next.

Once the transaction is finished, you get an opportunity to deal with errors. The error stops at events on both the server and the client, giving you a chance to take corrective action, log the error, or do anything else you want to with it.

The first stop for the error is the `DataSetProvider.OnUpdateError` event. This is a great place to deal with errors that you're expecting or can resolve without further intervention from the client.

The final destination for the error is back on the client, where you can deal with the error by letting the user help determine what to do with the record. You do this by assigning an event handler to the `TClientDataset.OnReconcileError` event.

This is especially useful because MIDAS is based on an optimistic record-locking strategy. This strategy allows multiple users to work on the same record at the same time. In general, this will cause conflicts when MIDAS tries to reconcile the data back to the database because the record has been modified since it was retrieved. We'll deal with some alternatives to this default identification process later on.

Using Borland's Error-Reconciliation Dialog

Fortunately, Borland provides a standard error-reconciliation dialog that you can use to display the error to the user. Figure 32.6 shows this dialog. The source code is also provided for this unit, so you can modify it if it doesn't suit your needs perfectly. To use this dialog, select File, New in Delphi's main menu and then select Reconcile Error Dialog from the Dialogs page. Remember to remove this unit from the Autocreate Forms list; otherwise, you'll receive compile errors.

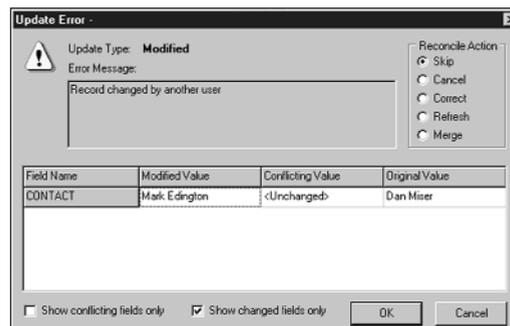


FIGURE 32.6

The Reconcile Error dialog in action.

The main functionality of this unit is wrapped up in the function `HandleReconcileError()`. There is a high degree of correlation between the `OnReconcileError` event and the `HandleReconcileError` function. As a matter of fact, the typical course of action in the `OnReconcileError` event is to call the `HandleReconcileError` function. By doing this, the application allows the end user on the client machine to interact with the error-reconciliation

process on the server machine and specify how these errors should be handled. Here's the code:

```
procedure TMyForm.CDSReconcileError(Dataset: TClientDataset;  
  E: EReconcileError; UpdateKind: TUpdateKind;  
  var Action: TReconcileAction);  
begin  
  Action:=HandleReconcileError(Dataset, UpdateKind, E);  
end;
```

The value of the `Action` parameter determines what MIDAS will do with this record. We'll touch on some other factors that affect which actions are valid at this point a little later. The following list shows the valid actions:

- `raSkip`. Do not update this specific database record. Leave the changed record in the client cache.
- `raMerge`. Merge the fields from this record into the database record. This record will not apply to records that were inserted.
- `raCorrect`. Update the database record with the values you specify. When selecting this action in the Reconcile Error dialog, you can edit the values in the grid. You cannot use this method if another user changed the database record.
- `raCancel`. Don't update the database record. Remove the record from the client cache.
- `raRefresh`. Update the record in the client cache with the current record in the database.
- `raAbort`. Abort the entire update operation.

Not all these options make sense (and therefore will not be displayed) in all cases. One requirement for having the `raMerge` and `raRefresh` actions available is that MIDAS identifies the record via the primary key of the database. This is done automatically using InterBase, but other RDBMSs will require you to manually set the `TField.ProviderFlags.pfInKey` property to `True` on the `TDataset` component for all fields that are in your primary key.

More Options to Make Your Application Robust

After you master these basics, the inevitable question is "What next?" This section is provided to give you some more insight into MIDAS and how you can use these features to make your applications act as you want them to act.

Client Optimization Techniques

The model of retrieving data is fairly elegant. However, because the `TClientDataset` stores all its records in memory, you need to be very careful about the result sets you return to the `TClientDataSet`. The cleanest approach is to ensure that the application server is well

designed and only returns the records the user is interested in. Because the real world seldom follows the utopian solution, you can use the following technique to help throttle the number of records you retrieve at one time to the client.

Limiting the Data Packet

When opening a `TClientDataSet`, the server retrieves the number of records specified in the `TClientDataSet.PacketRecords` property at one time. However, MIDAS will retrieve enough records to fill all available visual controls with data. For example, if you have a `TDBGrid` on a form that can display 10 records at once, and you specify a value of 5 for `PacketRecords`, the initial fetch of data will contain 10 records. After that, the data packet will contain just 5 records per fetch. If you specify `-1` for this property, all records will be transferred. If you specify a value greater than zero for `PacketRecords`, this introduces state to your application. This is due to the requirement that the app server must keep track of each client's cursor position so the app server can return the appropriate packet of records to the client requesting a packet. However, you can keep track of the state on the client, passing the last record position to the server, as appropriate. For a simple example, look at this code, which does exactly that:

Server RDM:

```
procedure TStateless.DataSetProvider1BeforeGetRecords(Sender: TObject;
  var OwnerData: OleVariant);
begin
  with Sender as TDataSetProvider do
  begin
    DataSet.Open;
    if not VarIsEmpty(OwnerData) then
      DataSet.Locate('au_id', OwnerData, []) else
      DataSet.First;
    end;
  end;
end;
```

```
procedure TStateless.DataSetProvider1AfterGetRecords(Sender: TObject;
  var OwnerData: OleVariant);
begin
  with Sender as TDataSetProvider do
  begin
    OwnerData := Dataset.FieldValues['au_id'];
    DataSet.Close;
    end;
  end;
end;
```

Client:

```
procedure TForm1.ClientDataSet1BeforeGetRecords(Sender: TObject;
  var OwnerData: OleVariant);
begin
```

```
// KeyValue is a private OleVariant variable
if not (Sender as TClientDataSet).Active then
  KeyValue := Unassigned;
  OwnerData := KeyValue;
end;

procedure TForm1.ClientDataSet1AfterGetRecords(Sender: TObject;
  var OwnerData: OleVariant);
begin
  KeyValue := OwnerData;
end;
```

One last point when using automatic fetching is that executing `TClientDataSet.Last()` retrieves the rest of the records left in the result set. This can be done innocently by pressing `Ctrl+End` in the `TDBGrid`. To work around this problem, you should set `TClientDataSet.FetchOnDemand` to `False`. This property controls whether a data packet will be retrieved automatically when the user has read through all the existing records on the client. To emulate that behavior in code, you can use the `GetNextPacket()` method, which will return the next data packet for you.

Using the Briefcase Model

Another optimization to reduce network traffic is to use the briefcase model support offered with MIDAS. Do this by assigning a filename to the `TClientDataset.FileName` property. If the file specified in this property exists, the `TClientDataSet` will open up the local copy of the file as opposed to reading the data directly from the application server. This is tremendously useful for items that rarely change, such as lookup tables.

TIP

If you specify a `TClientDataset.FileName` that has an `.XML` extension, the data packet will be stored in XML format, enabling you to use any number of XML tools available to work on the briefcase file.

Sending Dynamic SQL to the Server

Some architectures require modification to the underlying `TDataset`'s core properties, such as the `SQL` property of the `TQuery`, from the client. As long as solid multitier principles are followed, this can actually be a very efficient and elegant solution. Delphi 5 makes this task trivial to accomplish.

There are two steps required to allow for ad hoc queries. First, you simply assign the query statement to the `TClientDataset.CommandText` property. You must also include the

`poAllowCommandText` option in the `DatasetProvider.Options` property. When you open the `TClientDataSet` or call `TClientDataSet.Execute()`, the `CommandText` is passed across to the server. This same technique also works if you want to change the table or stored procedure name on the server.

Application Server Techniques

MIDAS now has many different events for you to customize the behavior of your application. There are `BeforeXXX` and `AfterXXX` events for just about every method imaginable. These events will be especially useful as you migrate your application server to be completely stateless.

Resolving Record Contention

The preceding discussion of the resolving mechanism included a brief mention that two users working on the same record would cause an error when the second user tried to apply the record back to the database. Fortunately, you have full control over detecting this collision.

The `TDataSetProvider.UpdateMode` property is used to generate the SQL statement that will be used to check whether the record has changed since it was last retrieved. Consider the scenario in which two users edit the same record. Here's how `DatasetProvider.UpdateMode` affects what happens to the record for each user:

- `upWhereAll`. This setting is the most restrictive setting but provides the greatest deal of assurance that the record is the same one the user retrieved initially. If the two users edit the same record, the first user will be able to update the record, whereas the second user will receive the infamous "Another user changed the record" error message. If you want to further refine which fields are used to perform this check, you can remove the `pfInWhere` element from the corresponding `TField.ProviderFlags` property.
- `upWhereChanged`. This setting allows the two users to actually edit the same record at the same time; as long as both users edit different fields in the same record, there will be no collision detection. For example, if user A modifies the `Address` field and updates the record, user B can still modify the `BirthDate` field and update the record successfully.
- `upWhereKeyOnly`. This setting is the most forgiving of all. As long as the record exists on the database, every user will have his or her change accepted. This will always overwrite the existing record in the database, so it can be viewed as a way to provide "last in wins" functionality.

Miscellaneous Server Options

There are quite a few more options available in the `TDataSetProvider.Options` property to control how the MIDAS data packet behaves. For example, adding `poReadOnly` will make the dataset read-only on the client. Specifying `poDisableInserts`, `poDisableDeletes`, or

`poDisableEdits` will prevent the client from performing that operation and trigger the corresponding `OnEditError` or `OnDeleteError` event to be fired on the client.

When using nested datasets, you can have updates or deletes cascade from the master record to the detail records if you add `poCascadeUpdates` or `poCascadeDeletes` to the `DatasetProvider.Options` property. Using this property requires your back-end database to support cascading referential integrity.

One shortcoming in previous versions of MIDAS was the inability to easily merge changes made on the server into your `TClientDataset` on the client. One had to resort to using `RefreshRecord` (or possibly `Refresh` to repopulate the entire dataset in some cases) to achieve this.

By setting `DatasetProvider.Options` to include `poPropagateChanges`, all the changes made to your data on the application server (for example, in the `DatasetProvider.BeforeUpdateRecord` event to enforce a business rule) are now automatically brought back into the `TClientDataSet`. Furthermore, setting `TDatasetProvider.Options` to include `poAutoRefresh` will automatically merge `AutoIncrement` and default values back into the `TClientDataSet`.

CAUTION

The `poAutoRefresh` option was non-functional for the initial release of Delphi 5. `poAutoRefresh` will only work with a later version of Delphi 5 that includes the fix for this bug. The workaround in the meantime is to either call `Refresh()` for your `TClientDatasets` or take control of the entire process of applying updates yourself.

The entire discussion of the reconciliation process thus far has revolved around the default SQL-based reconciliation. This means that all the events on the underlying `TDataset` will not be used during the reconciliation process. The `TDatasetProvider.ResolveToDataset` property was created to use these events during reconciliation. For example, if `TDatasetProvider.ResolveToDataset` is true, most of the events on the `TDataset` will be triggered. Be aware that the events that are used are only called when applying updates back to the server. In other words, if you have a `TQuery.BeforeInsert` event defined on the server, it will only fire on the server once you call `TClientDataSet.ApplyUpdates`. The events do not integrate into the corresponding events of the `TClientDataSet`.

Dealing with Master/Detail Relationships

No discussion of database applications would be complete without at least a mention of master/detail relationships. With MIDAS, you have two choices for dealing with master/detail. The original technique involved exporting two providers on the server and creating the

master/detail link on the client side. When doing this, the `cdsDetail.PacketRecords` property defaults to zero. It's important that you do not modify this value because the meaning of zero when used in this context is to retrieve all the detail records for the current master record. The downside to using client-side master/detail linking is that updates to the master and detail datasets are not applied under the context of one transaction. This is certainly problematic, but fortunately, we present an easy-to-use unit later on to work around this limitation.

Nested Datasets

Delphi 4 introduced nested datasets. Nested datasets allow a master table to actually contain detail datasets. In addition to updating master and detail records in one transaction, they allow for storage of all master and detail records to be stored in one briefcase file, and you can use the enhancements to `DBGrid` to pop up detail datasets in their own windows. A word of caution if you do decide to use nested datasets: All the detail records will be retrieved and brought over to the client when selecting a master record. This will become a possible performance bottleneck if you nest several levels of detail datasets. For example, if you retrieve just one master record that has 10 detail records, and each detail record has three detail records linked to the first level detail, you would retrieve 41 records initially. When using client-side linking, you would only retrieve 14 records initially and obtain the other grandchild records as you scrolled through the detail `TClientDataSet`. We'll cover nested datasets in more detail later on.

Real-World Examples

Now that we have the basics out of the way, let's look at how MIDAS can help you by exploring several real-world examples.

Joins

Writing a relational database application depends heavily on walking the relationships between tables. Often, you'll find it convenient to represent your highly normalized data in a view that's more flattened than the underlying data structure. However, updating the data from these joins takes some extra care on your end.

One-Table Update

Applying updates to a joined query is a special case in database programming, and MIDAS is no exception. The problem lies in the join query itself. Although some join queries will produce data that could be automatically updated, there are others that will never conform to rules that will allow automatic retrieval, editing, and updating of the underlying data. To that end, Delphi currently forces you to resolve updates to join queries yourself.

For joins that require only one table to be updated, Delphi can handle most of the updating details for you. Here are the steps required in order to write one table back to the database:

1. Add persistent fields to the joined TQuery.
2. Set TField.ProviderFlags=[] for every field on the TQuery that you won't be updating.
3. Write the following code in the DataSetProvider.OnGetTableName event to tell MIDAS which table you want to update. Keep in mind that this new event makes it easier to specify the table name, although you could do the same thing in Delphi 4 by using the DataSetProvider.OnGetDatasetProperties event:

```
procedure TJoin1Server.prvJoinGetTableName(Sender: TObject;  
    DataSet: TDataSet; var TableName: String);  
begin  
    TableName := 'Emp';  
end;
```

By doing this, you're telling the ClientDataset to keep track of the table name for you. Now when you call ClientDataset1.ApplyUpdates(), MIDAS knows to default to the table name that you specified, as opposed to letting MIDAS try and figure out what the table name is.

An alternate approach would be to use a TUpdateSQL component that only updates the table of interest. This new feature of Delphi 5 allows the TQuery.UpdateObject to be used during the reconciliation process and more closely matches the process used in traditional client/server applications.



You'll find an example on the book's CD-ROM in the directory for this chapter under \Join1.

Multitable Update

For more complex scenarios, such as allowing the editing and updating of multiple tables, you need to write some code yourself. There are two approaches to solving this problem:

- The Delphi 4 method of using DataSetProvider.BeforeUpdateRecord() to break the data packet apart and apply the updates to the underlying tables
- Using the Delphi 5 method of applying updates by using the UpdateObject property

When using cached updates with a multitable join, you need to configure one TUpdateSQL component for each table that will be updated. Because the UpdateObject property can only be assigned to one TUpdateSQL component, you needed to link all the TUpdateSQL.Dataset properties to the joined dataset programmatically in TQuery.OnUpdateRecord and call TUpdateSQL.Apply to bind the parameters and execute the underlying SQL statement. In our case, the dataset we're interested in is the Delta dataset. This dataset is passed as a parameter into the TQuery.OnUpdateRecord event.

However, the problem in using this technique in MIDAS becomes readily apparent when you try to do this for the first time. The TUpdateSQL.Dataset property is declared as a TBDEDataset. Because the Delta dataset is a TDataSet, we cannot make this assignment

legally. Rather than give up and use the `Provider.BeforeUpdateRecord` method of applying updates, we present a `TUpdateSQL` component descendant that will work seamlessly. The key to writing this component is to change the `Dataset` declaration to `TDataset` and perform a static override of the `SetParams` method to bind parameters to the target `TDataset`. Additionally, `SessionName` and `DatabaseName` properties were exposed to allow the update to occur in the same context as other transactions. The resulting code for the `TQuery.OnUpdateRecord` event is shown in Listing 32.2.

LISTING 32.2 Join Using a `TUpdateSQL`

```
procedure TJoin2Server.JoinQueryUpdateRecord(DataSet: TDataSet;
  UpdateKind: TUpdateKind; var UpdateAction: TUpdateAction);
begin
  usqlEmp.SessionName := JoinQuery.SessionName;
  usqlEmp.DatabaseName := JoinQuery.DatabaseName;
  usqlEmp.Dataset := DataSet;
  usqlEmp.Apply(UpdateKind);

  usqlFTEmp.SessionName := JoinQuery.SessionName;
  usqlFTEmp.DatabaseName := JoinQuery.DatabaseName;
  usqlFTEmp.Dataset := DataSet;
  usqlFTEmp.Apply(UpdateKind);

  UpdateAction := uaApplied;
end;
```

Because we've complied with the rules of updating data within the MIDAS architecture, the whole update process is seamlessly triggered as it always is in MIDAS, with a call to `ClientDataset1.ApplyUpdates(0);`.

NOTE

Now that Delphi 5 supports the `UpdateObject` property during reconciliation, it's entirely reasonable to assume that the same method of applying updates to multi-table joins that exist for cached updates will be available for MIDAS. However, at the time of this writing, this functionality was not available.

You'll find an example on the book's CD-ROM in the directory for this chapter under `\Join2`.

MIDAS on the Web

Delphi is tied to the Windows platform; therefore, any clients you write must run on a Windows machine. This is not always desirable. For example, you may want to provide easy access to the data that exists on your database to anyone who has an Internet connection. Because you've already written an application server that acts as a broker for your data—in addition to housing business rules for that data—it would be desirable to reuse the application server as opposed to rewriting the entire data-access and business rule tier in another environment.

Straight HTML

This section focuses on how to leverage your application server while providing a new presentation tier that will use straight HTML. This section assumes you're familiar with the material covered in Chapter 31, "Internet-Enabling Your Applications with WebBroker." Using this method, you're introducing another layer into your architecture. The WebBroker acts as the client to the application server and repackages this data into HTML that will be displayed on the browser. You also lose some of the benefits of working with the Delphi IDE, such as the lack of data-aware controls. However, this is a very viable option for allowing access to your data in a simple HTML format.

After creating a `WebModule`, you simply place a `TDispatchConnection` and `TClientDataset` on the `WebModule`. Once the properties are filled in, you can use a number of different methods to translate this data into HTML that will eventually be seen by the client.

One valid technique would be to add a `TDataSetTableProducer` linked to the `TClientDataset` of interest. From there, the user can click a link and go to an edit page, where she can edit the data and apply the updates. See Listings 32.3 and 32.4 for a sample implementation of this technique.

LISTING 32.3 HTML for Edit and Apply Updates

```
<form action="#"<SCRIPTNAME>/updaterecord" method="post">
<b>EmpNo: <#EMPNO></b>
<input type="hidden" name="EmpNo" value=<#EMPNO>>
<table cellspacing="2" cellpadding="2" border="0">
<tr>
  <td>Last Name:</td>
  <td><input type="text" name="LastName" value=<#LASTNAME>></td>
</tr>
<tr>
  <td>First Name:</td>
  <td><input type="text" name="FirstName" value=<#FIRSTNAME>></td>
</tr>
<tr>
```

continues

LISTING 32.3 Continued

```
<td>Hire Date:</td>
  <td><input type="text" name="HireDate" size="8"
value=<#HIREDATE>></td>
</tr>
<tr>
  <td>Salary:</td>
  <td><input type="text" name="Salary" size="8" value=<#SALARY>></td>
</tr>
<tr>
  <td>Vacation:</td>
  <td><input type="text" name="Vacation" size="4" value=<#VACATION>></td>
</tr>
</table>
<input type="submit" name="Submit" value="Apply Updates">
<input type="Reset">
</form>
```

LISTING 32.4 Code for Edit and Apply Updates

```
unit WebMain;

interface

uses
  Windows, Messages, SysUtils, Classes, HTTPApp, DBWeb, Db, DBClient,
  MConnect, DSProd;

type
  TWebModule1 = class(TWebModule)
    dcJoin: TDCOMConnection;
    cdsJoin: TClientDataSet;
    dstpJoin: TDataSetTableProducer;
    dsppJoin: TDataSetPageProducer;
    ppSuccess: TPageProducer;
    ppError: TPageProducer;
    procedure WebModuleBeforeDispatch(Sender: TObject;
      Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
    procedure WebModule1waListAction(Sender: TObject; Request: TWebRequest;
      Response: TWebResponse; var Handled: Boolean);
    procedure dstpJoinFormatCell(Sender: TObject; CellRow,
      CellColumn: Integer; var BgColor: THTMLBgColor;
      var Align: THTMLAlign; var VAlign: THTMLVAlign; var CustomAttrs,
      CellData: String);
    procedure WebModule1waEditAction(Sender: TObject; Request: TWebRequest;
      Response: TWebResponse; var Handled: Boolean);
```

```

    procedure dsppJoinHTMLTag(Sender: TObject; Tag: TTag;
      const TagString: String; TagParams: TStrings;
      var ReplaceText: String);
    procedure WebModule1waUpdateAction(Sender: TObject;
      Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
private
  { Private declarations }
  DataFields : TStrings;
public
  { Public declarations }
end;

var
  WebModule1: TWebModule1;

implementation

{$R *.DFM}

procedure TWebModule1.WebModuleBeforeDispatch(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
begin
  with Request do
    case MethodType of
      mtPost: DataFields:=ContentFields;
      mtGet: DataFields:=QueryFields;
    end;
end;

function LocalServerPath(sFile : string = '') : string;
var
  FN: array[0..MAX_PATH- 1] of char;
  sPath : shortstring;
begin
  SetString(sPath, FN, GetModuleFileName(hInstance, FN, SizeOf(FN)));
  Result := ExtractFilePath( sPath ) + ExtractFileName( sFile );
end;

procedure TWebModule1.WebModule1waListAction(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
begin
  cdsJoin.Open;
  Response.Content := dstpJoin.Content;
end;

procedure TWebModule1.dstpJoinFormatCell(Sender: TObject; CellRow,

```

LISTING 32.4 Continued

```
    CellColumn: Integer; var BgColor: THTMLBgColor; var Align: THTMLAlign;
    var VAlign: THTMLVAlign; var CustomAttrs, CellData: String);
begin
    if (CellRow > 0) and (CellColumn = 0) then
        CellData := Format('<a href="%s/getrecord?empno=%s">%s</a>',
            [Request.ScriptName, CellData, CellData]);
end;

procedure TWebModule1.WebModule1waEditAction(Sender: TObject;
    Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
begin
    dsppJoin.HTMLFile := LocalServerPath('join.htm');
    cdsJoin.Filter := 'EmpNo = ' + DataFields.Values['empno'];
    cdsJoin.Filtered := true;
    Response.Content := dsppJoin.Content;
end;

procedure TWebModule1.dsppJoinHTMLTag(Sender: TObject; Tag: TTag;
    const TagString: String; TagParams: TStrings; var ReplaceText: String);
begin
    if CompareText(TagString, 'SCRIPTNAME')=0 then
        ReplaceText:=Request.ScriptName;
end;

procedure TWebModule1.WebModule1waUpdateAction(Sender: TObject;
    Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
var
    EmpNo, LastName, FirstName, HireDate, Salary, Vacation: string;
begin
    EmpNo:=DataFields.Values['EmpNo'];
    LastName:=DataFields.Values['LastName'];
    FirstName:=DataFields.Values['FirstName'];
    HireDate:=DataFields.Values['HireDate'];
    Salary:=DataFields.Values['Salary'];
    Vacation:=DataFields.Values['Vacation'];

    cdsJoin.Open;
    if cdsJoin.Locate('EMPNO', EmpNo, []) then
        begin
            cdsJoin.Edit;
            cdsJoin.FieldName('LastName').AsString:=LastName;
            cdsJoin.FieldName('FirstName').AsString:=FirstName;
            cdsJoin.FieldName('HireDate').AsString:=HireDate;
            cdsJoin.FieldName('Salary').AsString:=Salary;
            cdsJoin.FieldName('Vacation').AsString:=Vacation;
```

```
if cdsJoin.ApplyUpdates(0)=0 then
  Response.Content:=ppSuccess.Content else
  Response.Content:=pPErrror.Content;
end;
end;

end.
```

Note that this method requires much custom code to be written, and the full feature set of MIDAS is not implemented in this example—specifically error reconciliation. You can continue to enhance this example to be more robust if you use this technique extensively.

CAUTION

It's imperative that you consider the concept of state when writing your `WebModule` and application server. Because HTTP is a stateless protocol, you cannot rely on the values of properties to be the same as you left them after the call is over.

You'll find an example on the book's CD-ROM in the directory for this chapter under `\WebBrok`.

InternetExpress

With `InternetExpress`, you can enhance the functionality of a straight `WebModule` approach to allow for a richer experience on the client. This is possible due to the use of open standards such as XML and JavaScript in `InternetExpress`. Using `InternetExpress`, you can create a browser-only front-end to your MIDAS application server. No ActiveX controls are downloaded with zero client-side install and configuration requirements; it's nothing but a Web browser hitting a Web server.

In order to use `InternetExpress`, you will need to have some code running on a Web server. For this sample, we will use an ISAPI application, but you could also use CGI or ASP. The purpose of the Web broker is to take requests from the browser and pass those requests on to the app server. Placing `InternetExpress` components in the Web broker application makes this task very easy.

This example will use a standard MIDAS app server that has Customers, Orders, and Employees. Customers and Orders are linked in a nested dataset relationship (for more information on nested datasets, see the next section), whereas the Employees dataset will serve as a lookup table. See the accompanying source code for the app server definition. After the app server has been built and registered, we can focus on building the Web broker application that will communicate with the app server.

Create a new ISAPI application by selecting File, New, Web Server Application from the Object Repository. Place a `TDCOMConnection` component on the `WebModule`. This will act as the link to the app server, so fill in the `ServerName` property with the `ProgID` of the app server.

Next, we will place a `TXMLBroker` component from the `InternetExpress` page of the component palette on the `WebModule` and set the `RemoteServer` and `ProviderName` properties to the `CustomerProvider`. The `TXMLBroker` component acts in a manner similar to the `TClientDataset`. It is responsible for retrieving data packets from the app server and passing those data packets to the browser. The main difference between the data packet in a `TXMLBroker` and a `TClientDataset` is that the `TXMLBroker` translates the `MIDAS` data packets into `XML`. We will also add a `TClientDataset` to the `WebModule` and tie it to the `Employees` provider on the app server. We will use this as a lookup datasource later.

The `TXMLBroker` component is responsible for communication to the application server and also the navigation of `HTML` pages. There are many properties available to customize how your `InternetExpress` application will behave. For example, you can limit the number of records that will be transmitted to the client, or specify the number of errors allowed during an update.

We now need a way to move this data to the browser. Using the `TMidasPageProducer` component, we can use the `WebBroker` technology in `Delphi` to serve an `HTML` page up to the browser. However, the `TMidasPageProducer` also allows for the visual creation of the `Web` page via the `Web Page Editor`.

Double-click on the `TMidasPageProducer` to bring up the `Web Page Editor`. This visual editor helps you customize what elements are present on a given `Web` page. One of the most interesting things about `InternetExpress` is that it is completely extensible. You can create your own components that can be used in the `Web Page Editor` by following some well-defined rules. For examples of custom `InternetExpress` components, see the `<DELPHI>\DEMOS\MIDAS\INTERNET-EXPRESS\INETXCUSTOM` directory.

CAUTION

`TMidasPageProducer` has a property named `IncludePathURL`. It is essential to set this property properly or your `InternetExpress` application will not work. Set the value to the virtual directory that contains the `InternetExpress` `JavaScript` files. For example, if you place the files in `c:\inetpub\wwwroot\jscript`, the value for this property will be `/jscript/`.

With the `Web Page Editor` active, select the `Insert` tool button to display the `Add Web Component` dialog box. This dialog box contains a list of `Web` components that can be added to the `HTML` page. This list is based on which parent component (the section in the upper left) is currently selected. For example, add a `DataForm` `Web` component to the root node to allow end-users to display and edit database information in a form-like layout.

**FIGURE 32.7**

Adding Web Component dialog from the Web Page Editor.

If you then select the DataForm node in the Web Page Editor, you can select the “Insert” tool button again. Notice that the list of components available at this point is different than the list displayed from the previous step. After selecting the FieldGroup component, you will see a warning in the preview pane, telling you that the TXMLBroker property for the FieldGroup is not assigned. By assigning the XMLBroker in the Object Inspector, you will immediately notice the layout of the HTML in the preview pane of the Web Page Editor. As you continue to modify properties or add components, the state of the HTML page will be constantly updated.

The level of customization available with the standard Web components is practically limitless. Properties make it easy to change field captions, alignment, colors; add straight custom HTML code; and even use style sheets. Furthermore, if the component does not suit your needs exactly, you can always create a descendant component and use that in its place. The framework is truly as extensible as your imagination allows.

In order to call the ISAPI DLL, you need to place it in a virtual directory capable of executing a script. You also need to move the JavaScript files found in <DELPHI>\SOURCE\WEBMIDAS to a valid location on your Web server and modify the TMidaspPageProducer.IncludePathURL property to point to the URI of the JavaScript files. After that, the page is ready to be viewed.

To access the page, all you need is a JavaScript-capable browser. Simply point the browser to <http://localhost/inetx/inetxisapi.dll> and the data will display in the browser.

Lastly, you can detect reconciliation errors during the ApplyUpdates process like you are already used to doing in a stand-alone MIDAS application. This capability is made possible when you assign the TXMLBroker.ReconcileProducer property to a TPageProducer. Whenever an error occurs, the Content of the TPageProducer assigned to this property will be returned to the end-user.

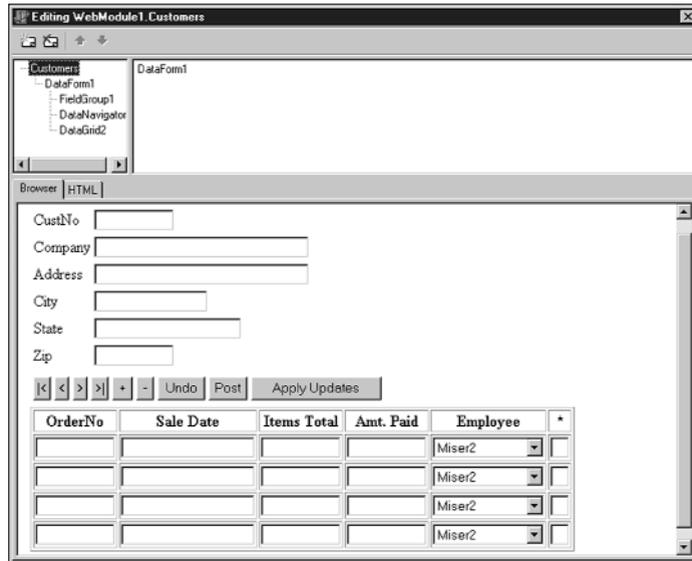


FIGURE 32.8

The Web Page Editor after designing an HTML page.

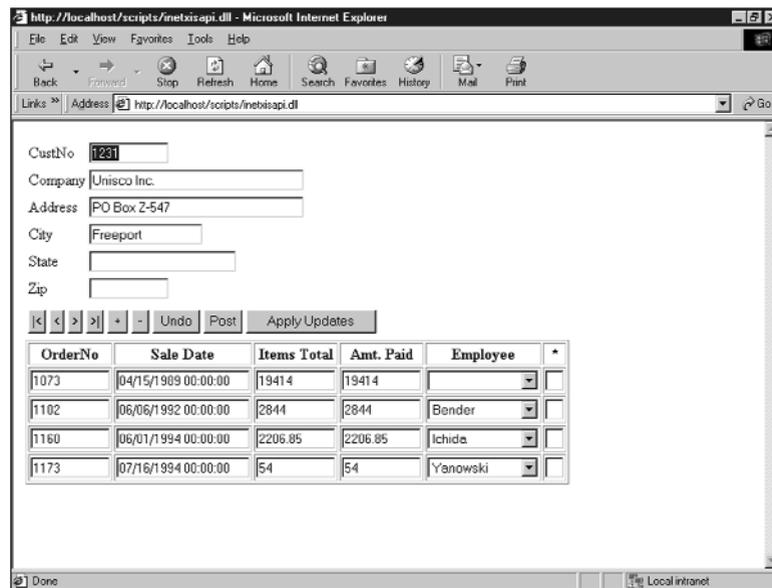


FIGURE 32.9

Internet Explorer accessing the InternetExpress Web page.

A specialized TPageProducer, TReconcilePageProducer, is available by installing the InetXCustom.dpk package found in <DELPHI>\DEMOS\MIDAS\INTERNETEXPRESS\INETXCUSTOM. This PageProducer generates HTML that acts much like the standard MIDAS Reconciliation Error dialog box.



You'll find an example on the book's CD-ROM in the directory for this chapter under \InetX.

More Client Dataset Features

There are many options available to control the TClientDataset component. In this section, we will look at ways to use the TClientDataset to make coding easier in complex applications.

Nested Datasets

We looked at nested datasets from a high-level earlier. Now we'll look at them in more detail.

In order to set up a nested dataset relationship, you need to define the master/detail relationship on the application server. This is done using the same technique you've been using in client/server applications—namely, defining the SQL statement for the detail TQuery, including the link parameter. Here's an example:

```
"select * orders where custno=:custno"
```

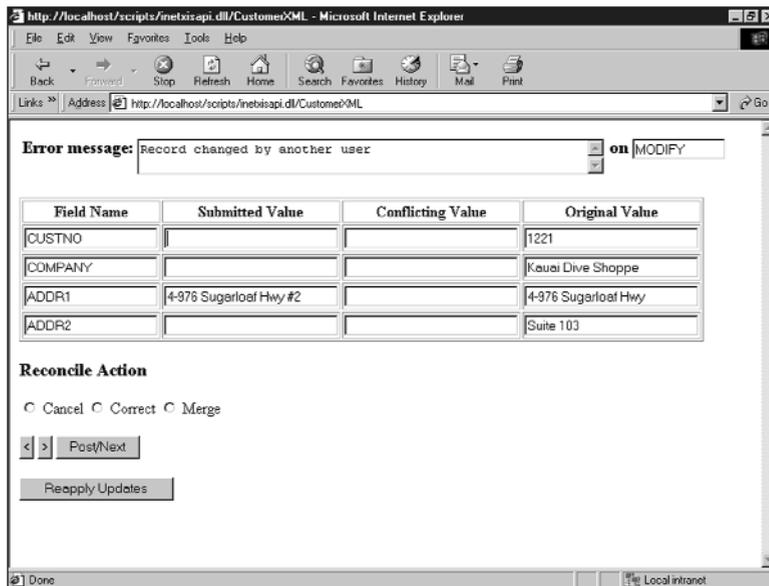


FIGURE 32.10

View of the HTML page generated by TReconcilePageProducer.

You then assign the `TQuery.Datasource` for the detail `TQuery` to point to a `TDataSource` component that's tied to the master `TDataset`. Once this relationship is set up, you only need to export the `TDataSetProvider` that's tied to the master dataset. MIDAS is smart enough to understand that the master dataset has detail datasets linked to it and will therefore send the detail datasets across to the client as a `TDataSetField`.

On the client, you assign the master `TClientDataset.ProviderName` property to the master provider. Then, you add persistent fields to the `TClientDataset`. Notice the last field in the Fields Editor. It contains a field named the same as the detail dataset on the server and is declared as a `TDataSetField` type. At this point, you have enough information to use the nested dataset in code. However, to make things really easy, you can add a detail `TClientDataset` and assign its `DataSetField` property to the appropriate `TDataSetField` from the master. It's important to note here that you did not set any other properties on the detail `TClientDataset`, such as `RemoteServer`, `ProviderName`, `MasterSource`, `MasterFields`, or `PacketRecords`. The only property you set was the `DataSetField` property. At this point, you can bind data-aware controls to the detail `TClientDataset` as well.

After you've finished working with the data in the nested dataset, you need to apply the updates back to the database. This is done by calling the master `TClientDataset`'s `ApplyUpdates` method. MIDAS will apply all the changes in the master `TClientDataset`, which includes the detail datasets, back to the server inside the context of one transaction.

You'll find an example on the book's CD-ROM in the directory for this chapter under `\NestCDS`.

Client-Side Master/Detail Linking

Recall that there were some cautions mentioned earlier when using nested datasets. The alternative to using nested datasets is to create the master/detail relationship on the client side. In order to create a master/detail link using this method, you simply create a `TDataset` and `TDataSetProvider` for the master and the detail on the server.

On the client, you bind two `TClientDataset` components to the datasets that you exported on the server. Then, you create the master/detail relationship by assigning the detail `TClientDataset.MasterSource` property to the `TDataSource` component that points to the master `TClientDataset`.

Setting `MasterSource` on a `TClientDataset` sets the `PacketRecords` property to zero. When `PacketRecords` equals zero, it means MIDAS should just return the metadata information for this `TClientDataset`. However, when `PacketRecords` equals zero in the context of a master/detail relationship, the meaning changes. MIDAS will now retrieve the records for the detail dataset for each master record. In summary, leave the `PacketRecords` property set to the default value.

In order to reconcile the master/detail data back to the database in one transaction, you need to write your own `ApplyUpdates` logic. This is not as simple as most tasks in Delphi, but it does give you full flexible control over the update process.

Applying updates to a single table is usually triggered by a call to `TClientDataset.ApplyUpdates`. This method sends the changed records from the `ClientDataset` to its provider on the middle tier, where the provider will then write the changes to the database. All this is done within the scope of a transaction and is accomplished without any intervention from the programmer. To do the same thing for master/detail tables, you must understand what Delphi is doing for you when you make that call to `TClientDataset.ApplyUpdates`.

Any changes you make to a `TClientDataset` are stored in the `Delta` property. The `Delta` property contains all the information that will eventually be written to the database. The following code illustrates the update process for applying `Delta` properties back to the database. Listings 32.5 and 32.6 show the relevant sections of the client and server for applying updates to a master/detail setup.

CAUTION

The initial release of Delphi 5 had a bug that prevented applying multiple deltas to the server within the context of one transaction. Replace the following method in `DBTABLES.PAS` with the code below if you want to take advantage of this technique.

```
function TDBDataSet.PSInTransaction: Boolean;
var
  InProvider: Boolean;
begin
  InProvider := SetDBFlag(dbfProvider, True);
  try
    Result := Database.InTransaction;
  finally
    SetDBFlag(dbfProvider, InProvider);
  end;
end;
```



You'll find an example on the book's CD-ROM in the directory for this chapter under `\MDCDS`.

LISTING 32.5 Client Updates to Master/Detail

```
procedure TClientDM.ApplyUpdates;
var
  MasterVar, DetailVar: OleVariant;
begin
  Master.CheckBrowseMode;
  Detail_Proj.CheckBrowseMode;
  if Master.ChangeCount > 0 then
    MasterVar := Master.Delta else
    MasterVar := NULL;
  if Detail.ChangeCount > 0 then
    DetailVar := Detail.Delta else
    DetailVar := NULL;
  RemoteServer.AppServer.ApplyUpdates(DetailVar, MasterVar);
  { Reconcile the error datapackets. Since we allow 0 errors, only one error
    packet can contain errors. If neither packet contains errors then we
    refresh the data.}
  if not VarIsNull(DetailVar) then
    Detail.Reconcile(DetailVar) else
  if not VarIsNull(MasterVar) then
    Master.Reconcile(MasterVar) else
  begin
    Detail.Reconcile(DetailVar);
    Master.Reconcile(MasterVar);
    Detail.Refresh;
    Master.Refresh;
  end;
end;
```

LISTING 32.6 Server Updates to Master/Detail

```
procedure TServerRDM.ApplyUpdates(var DetailVar, MasterVar: OleVariant);
var
  ErrCount: Integer;
begin
  Database.StartTransaction;
  try
    if not VarIsNull(MasterVar) then
      begin
        MasterVar := cdsMaster.Provider.ApplyUpdates(MasterVar, 0, ErrCount);
        if ErrCount > 0 then
          SysUtils.Abort; // This will cause Rollback
        end;
      end
    if not VarIsNull(DetailVar) then
```

```

begin
  DetailVar := cdsDetail.Provider.ApplyUpdates(DetailVar, 0, ErrCount);
  if ErrCount > 0 then
    SysUtils.Abort;    // This will cause Rollback
  end;
  Database.Commit;
except
  Database.Rollback
end;
end;
end;

```

Although this method works quite well, it really doesn't provide opportunities for code reuse. This would be a good opportunity to extend Delphi and provide easy reuse. Here are the main steps required to abstract the update process:

1. Place the deltas for each CDS in a variant array.
2. Place the providers for each CDS in a variant array.
3. Apply all the deltas in one transaction.
4. Reconcile the error datapackets returned in the previous step and refresh the data.

The result of this abstraction is provided in the utility unit shown in Listing 32.7.

LISTING 32.7 A Unit Providing Utility Routines and Abstraction

```

unit CDSUtil;

interface

uses
  DbClient, DbTables;

function RetrieveDeltas(const cdsArray : array of TClientDataset): Variant;
function RetrieveProviders(const cdsArray : array of TClientDataset): Variant;
procedure ReconcileDeltas(const cdsArray : array of TClientDataset;
  vDeltaArray: OleVariant);

procedure CDSApplyUpdates(ADatabase : TDatabase; var vDeltaArray: OleVariant;
  const vProviderArray: OleVariant);

implementation

uses
  SysUtils, Provider,
  {$IFDEF VER130}Midas{$ELSE}StdVcl{$ENDIF};

```

continues

LISTING 32.7 Continued

```
type
  PArrayData = ^TArrayData;
  TArrayData = array[0..1000] of Olevariant;

{Delta is the CDS.Delta on input. On return, Delta will contain a data packet}
{containing all of the records that could not be applied to the database.}
{Remember Delphi 5 needs the provider name, so it is passed in the first}
{element of the AProvider variant.}
procedure ApplyDelta(AProvider: OleVariant; var Delta : OleVariant);
var
  ErrCount : integer;
  OwnerData: OleVariant;
begin
  if not VarIsNull(Delta) then
  begin
    // ScktSrvr does not support early-binding
    {$IFDEF VER130}
      Delta := (IDispatch(AProvider[0]) as IAppServer).AS_ApplyUpdates(
        AProvider[1], Delta, 0, ErrCount, OwnerData);
    {$ELSE}
      Delta := OleVariant(IDispatch(AProvider)).ApplyUpdates(Delta, 0, ErrCount);
    {$ENDIF}
    if ErrCount > 0 then
      SysUtils.Abort; // This will cause Rollback in the calling procedure
  end;
end;

{Server call}
procedure CDSApplyUpdates(ADatabase : TDatabase; var vDeltaArray: OleVariant;
  const vProviderArray: OleVariant);
var
  i : integer;
  LowArr, HighArr: integer;
  P: PArrayData;
begin
  {Wrap the updates in a transaction. If any step results in an error, raise}
  {an exception, which will Rollback the transaction.}
  ADatabase.Connected:=true;
  ADatabase.StartTransaction;
  try
    LowArr:=VarArrayLowBound(vDeltaArray,1);
    HighArr:=VarArrayHighBound(vDeltaArray,1);
    P:=VarArrayLock(vDeltaArray);
    try
      for i:=LowArr to HighArr do
```

```

        ApplyDelta(vProviderArray[i], P^[i]);
finally
    VarArrayUnlock(vDeltaArray);
    end;
    ADatabase.Commit;
except
    ADatabase.Rollback;
end;
end;

{Client side calls}
function RetrieveDeltas(const cdsArray : array of TClientDataset): Variant;
var
    i : integer;
    LowCDS, HighCDS : integer;
begin
    Result:=NULL;
    LowCDS:=Low(cdsArray);
    HighCDS:=High(cdsArray);
    for i:=LowCDS to HighCDS do
        cdsArray[i].CheckBrowseMode;

        Result:=VarArrayCreate([LowCDS, HighCDS], varVariant);
        {Setup the variant with the changes (or NULL if there are none)}
        for i:=LowCDS to HighCDS do
            begin
                if cdsArray[i].ChangeCount>0 then
                    Result[i]:=cdsArray[i].Delta else
                        Result[i]:=NULL;
            end;
        end;
    end;

    {If we're using Delphi 5, then we need to return the provider name AND the
    AppServer from this function. We will use ProviderName to call AS_ApplyUpdates
    in the CDSApplyUpdates function later.}
function RetrieveProviders(const cdsArray : array of TClientDataset): Variant;
var
    i: integer;
    LowCDS, HighCDS: integer;
begin
    Result:=NULL;
    LowCDS:=Low(cdsArray);
    HighCDS:=High(cdsArray);

    Result:=VarArrayCreate([LowCDS, HighCDS], varVariant);
    for i:=LowCDS to HighCDS do

```

LISTING 32.7 Continued

```
{$IFDEF VER130}
    Result[i]:=VarArrayOf([cdsArray[i].AppServer, cdsArray[i].ProviderName]);
{$ELSE}
    Result[i]:=cdsArray[i].Provider;
{$ENDIF}
end;

procedure ReconcileDeltas(const cdsArray : array of TClientDataset;
    vDeltaArray: OleVariant);
var
    bReconcile : boolean;
    i: integer;
    LowCDS, HighCDS : integer;
begin
    LowCDS:=Low(cdsArray);
    HighCDS:=High(cdsArray);

    {If the previous step resulted in errors, Reconcile the error datapackets.}
    bReconcile:=false;
    for i:=LowCDS to HighCDS do
        if not VarIsNull(vDeltaArray[i]) then begin
            cdsArray[i].Reconcile(vDeltaArray[i]);
            bReconcile:=true;
            break;
        end;

    {Refresh the Datasets if needed}
    if not bReconcile then
        for i:=HighCDS downto LowCDS do begin
            cdsArray[i].Reconcile(vDeltaArray[i]);
            cdsArray[i].Refresh;
        end;
    end;

end.
```

Listing 32.8 shows a reworking of the previous example using the CDSUtil unit.

LISTING 32.8 A Rework of the Previous Example Using CDSUtil.pas

```
procedure TForm1.btnApplyClick(Sender: TObject);
var
    vDelta: OleVariant;
    vProvider: OleVariant;
```

```
    arrCDS: array[0..1] of TClientDataset;
begin
    arrCDS[0]:=cdsMaster; // Set up ClientDataset array
    arrCDS[1]:=cdsDetail;

    vDelta:=RetrieveDeltas(arrCDS);           // Step 1
    vProvider:=RetrieveProviders(arrCDS);     // Step 2
    DCOMConnection1.ApplyUpdates(vDelta, vProvider); // Step 3
    ReconcileDeltas(arrCDS, vDelta);         // Step 4
end;

procedure TServerRDM.ApplyUpdates(var vDelta, vProvider: OleVariant);
begin
    CDSApplyUpdates(Database1, vDelta, vProvider); // Step 3
end;
```

You can use this unit in either two-tier or three-tier applications. To move from a two-tier to a three-tier approach, you would export a function on the server that calls `CDSApplyUpdates`, instead of calling `CDSApplyUpdates` on the client. Everything else on the client remains the same.

Two-tier Applications

You've seen how to assign the provider—and therefore the data—to the `ClientDataset` in a three-tier application. However, many times a simple two-tier application is all that's needed. So, how do we accomplish this in a two-tier application? There are four possibilities:

- Runtime assignment of data
- Design-time assignment of data
- Runtime assignment of a provider
- Design-time assignment of a provider

The two basic choices when using `ClientDataset` are assigning the `AppServer` property and assigning the data. If you choose to assign the `AppServer`, you have a link between the `TDataSetProvider` and the `ClientDataset` that will allow you to have communication between the `ClientDataset` and `TDataSetProvider`, as needed. If, on the other hand, you choose to assign the data, you have effectively created a local storage mechanism for your data and will not communicate with the `TDataSetProvider` component for more information.

In order to assign the data directly from a `TDataSet` to a `TClientDataset` at runtime, use the code in Listing 32.9.

LISTING 32.9 Code to Assign Data Directly from a TDataSet

```
function GetData(ADataset: TDataSet): OleVariant;
begin
  with TDataSetProvider.Create(nil) do
    try
      Dataset:=ADataset;
      Result:=Data;
    finally
      Free;
    end;
end;

procedure TForm1.Button1Click(Sender: TObject);
begin
  ClientDataset1.Data:=GetData(ADOTable1);
end;
```

This method takes more code and effort than previous versions of Delphi, where you would simply assign the `Table1.Provider.Data` property to the `ClientDataset1.Data` property. However, this function will help make the additional code less noticeable.

You can also use the `TClientDataset` component to retrieve the data from a `TDataSet` at design time by selecting the `Assign Local Data` command from the context menu of the `TClientDataset` component. Then, you specify the `TDataSet` component that contains the data you want, and the data is brought to the `TClientDataset` and stored in the `Data` property.

CAUTION

If you were to save the file in this state and compare the size of the DFM file to the size before executing this command, you would notice an increase in the DFM size. This is because Delphi has stored all the metadata and records associated with the `TDataSet` in the DFM. Delphi will only stream this data to the DFM if the `TClientDataset` is `Active`. You can also trim this space by executing the `Clear Data` command on the `TClientDataset` context menu.

If you want the full flexibility that a provider assignment allows, you need to assign the `AppServer` property. At runtime, you can assign the `AppServer` property in code. This can be as simple as the following statement, found in `FormCreate`:

```
ClientDataset1.AppServer:=TLocalAppServer.Create(Table1);
ClientDataset1.Open;
```

Lastly, you can assign the `AppServer` property at design time. If you leave the `RemoteServer` property blank on a `TClientDataset`, you can assign a `TDataSetProvider` component to the `TClientDataset.ProviderName` property.

The major difference between using `TDataSet` components and `ClientDataset` is that when you're using `ClientDataset`, you're using the `IAppServer` interface to broker your requests for data to the underlying `TDataSet` component. This means that you'll be manipulating the properties, methods, events, and fields of the `TClientDataset` component, not the `TDataSet` component. Think of the `TDataSet` component as if it were in a separate application and therefore can't be manipulated directly by you in code. Place all of your "server" components on a separate `DataModule`. Placing the `TDatabase`, `TDataSet`, and `TCDSProvider` components on a separate `DataModule` effectively prepares your application for an easier transition to a multitier deployment later on. Another benefit of doing this is that it may help you think of the `DataModule` as something that the client cannot touch easily. Again, this is a good preparation for your application, and your own mindset, when it comes time to port this application to a multitier deployment.

NOTE

The `TClientDataset.ProviderName` property cannot be assigned to providers that reside on another form or `DataModule` at design-time. Therefore, you need to set the `TClientDataset.AppServer` property at runtime in code.

Deploying MIDAS Applications

After you've built a complete MIDAS application, the last hurdle left to clear is deploying that application. This section will outline what needs to be done in order to make your MIDAS application deployment painless.

Licensing Issues

Licensing has been a tough subject for many people ever since MIDAS was first introduced in Delphi 3. The myriad of options for deploying this technology has contributed to this confusion. This section will detail the overall requirements of when you need to purchase a MIDAS license. However, the only legally binding document for licensing is in `DEPLOY.TXT`, located in the Delphi 5 directory. Finally, for the ultimate authority to answer this question for a specific situation, you must contact your local Borland sales office. More guidelines and examples are available at

<http://www.borland.com/midas/papers/licensing/>

or our Web site at

<http://www.xapware.com/ddg>

The information from this document was prepared to answer some of the more common scenarios in which MIDAS is used. Pricing information and options are also included in the document.

The key criteria to determine the necessity of a MIDAS license for your application is whether or not the MIDAS data packet crosses a machine boundary. If it does, you need to purchase a license. If it does not (as in the one- and two-tier examples presented earlier), you're using MIDAS technology, but there's no need to purchase a license to use MIDAS in this manner.

DCOM Configuration

DCOM configuration appears to be as much art as it is science. There are many aspects to a complete and secure DCOM configuration, but this section will help you understand some of the basics of this black art.

After registering your application server, your server object is now available for customization in the Microsoft utility DCOMCNFG. This utility is included with NT systems automatically but is a separate download for Win9x machines. As a side note, there are plenty of bugs in DCOMCNFG; the most notable being DCOMCNFG can only be run on Win9x machines that have user-level share enabled. This, of course, requires a domain. This is not always possible or desirable in a peer-to-peer network, such as two Windows 9x machines. This has led many people to incorrectly assume that an NT machine is required in order to run DCOM.

If you can run DCOMCNFG, you can select the registered application server and click the Properties button to reveal custom information about your server. The Identity page is a good place to start in our brief tour of DCOMCNFG. The default setting for a registered server object is Launching User. Microsoft could not have made a worse decision for the default if it tried.

When DCOM creates the server, it uses the security context of the user specified on the Identity page. The "launching user" will spawn one new process of the server object for each and every distinct user login. Many people look at the fact that they select the `ciMultiple` instancing mode and wonder why multiple copies of their server are being created. For example, if user A connects to the server and then user B connects, DCOM will spawn an entirely new process for user B. Additionally, you won't see the GUI portion of the server for users who log in under a different account than that currently in use on the server machine. This is due to the NT concept known as *Windows stations*. The only Windows station capable of writing to the GUI is the Interactive User. This is the user who is currently logged in on the server machine. In summary, never use the Launching User option as your identity for your server.

The next interesting option on this page is the Interactive User. This means that every single client that creates a server will do so under the context of the user who is logged in to the

server at that point in time. This will also allow you to have visual interaction with your application server. Unfortunately, most system administrators do not allow an open login to just sit there idle on an NT machine. In addition, if the logged-in user decides to log out, the application server will not work as desired anymore.

For this discussion, this only leaves the last enabled option on the Identity page: This User. Using this setting, all clients will create one application server and use the login credentials and context of the user specified on the Identity page. This also means that the NT machine does not require a user to be logged in to use the application server. The one downside to this approach is that there will be no GUI display of the server when using this option. However, it is by far and away the best of all available options to get your application server to behave as it should.

Once the server object is configured properly with the right identity, you need to turn your attention to the Security tab. Make sure the user who will be running this object has the appropriate privileges assigned. Also be sure to grant the SYSTEM user access to the server; otherwise, you'll encounter errors along the way.

There are many subtle nuances strewn throughout the DCOM configuration process. For the latest on DCOM configuration issues, especially as they pertain to Windows 9x, Delphi, and MIDAS, visit the DCOM page of our Web site at

<http://www.DistribuCon.com/dcom95.htm>

Files to Deploy

The requirements for deploying a MIDAS application have changed with each new release of Delphi. Delphi 5 makes deployment easier than any other version. With previous versions of Delphi, you needed to deploy the file DBCLIENT.DLL to both the server and the client. This file contained the code to implement the TClientDataset. DBCLIENT.DLL also required registration on the client's system. Other files also have been required over time, such as STDVCL32.DLL, STDVCL40.DLL, and IDPROV32.DLL. If one file was missing or improperly registered, the application would not run properly.

With Delphi 5, the breakdown of minimum files needed for deployment of your MIDAS application is shown in the following lists.

Here are the steps for the server:

1. Copy the application server to a directory with sufficient NTFS privileges.
2. Install your data-access layer to allow the application server to act as a client to the RDBMS (for example, BDE, MDAC, specific client-side database libraries, and so on).
3. Copy MIDAS.DLL to the %SYSTEM% directory. By default, this would be C:\Winnt\System32 for NT machines and C:\Windows\System for 9x machines.

4. Run the application server once to register it with COM.

Here are the steps for the client:

1. Copy the client to a directory, along with any other external dependency files used by your client (for example, runtime packages, DLLs, ActiveX controls, and so on).
2. Copy `MIDAS.DLL` to the `%SYSTEM%` directory.
3. Optional: If you specify the `ServerName` property in your `TDispatchConnection` or if you employ early binding in your client, you need to register the server's type library (TLB) file. This can be done by using a utility such as `<DELPHI>\BIN\TREGSVR.EXE` (or programmatically if you so choose).

Internet Deployment Considerations (Firewalls)

When deploying your application over a LAN, there's nothing to get in your way. You can choose whatever connection type best suits your application's needs. However, if you need to rely on the Internet as your backbone, there are many things that can go wrong—namely, firewalls.

DCOM is not the most firewall-friendly protocol. It requires opening multiple ports on a firewall. Most system administrators are weary of opening an entire range of ports because it invites hackers to come knocking on the door. Using `TSocketConnection`, the story improves somewhat. The firewall only needs one open port. However, the occasional system administrator will even refuse to do that on the grounds that this is a security breach.

`TWebConnection` is a `TSocketConnection` descendant that permits MIDAS traffic to be bundled up into valid HTTP traffic, which uses the most open port in the world—the HTTP port (default port 80). Actually, the component even supports SSL, so you can have secure communications. By doing this, all firewall issues are completely eliminated. After all, if a corporation doesn't allow HTTP traffic in or out, there's nothing that can be done to communicate with them anyway.

This bit of magic is accomplished by using the Borland-provided ISAPI extension that translates HTTP traffic into MIDAS traffic, and vice versa. In this regard, the ISAPI DLL does the same work that `ScktSrvr` does for socket connections. The ISAPI extension `httpsrvr.dll` needs to be placed in a directory capable of executing code. For example, with IIS4, the default location for this file would be in `C:\Inetpub\Scripts`.

One more benefit of using `TWebConnection` is that it supports object pooling. Object pooling is used to spare the server the overhead of object creation every time a client connects to the server. Furthermore, the pooling mechanism in MIDAS allows for a maximum number of objects to be created. After this maximum has been reached, an error will be sent to the client saying that the server is too busy to process this request. This is much more flexible than just

creating an arbitrary number of threads for every single client that wants to connect to the server.

In order to tell MIDAS that this RDM will be pooled, you need to call `RegisterPooled` and `UnregisterPooled` in the `UpdateRegistry` method of the RDM. (See Listing 32.1 for a sample implementation of `UpdateRegistry`.) The following is a sample call to the `RegisterPooled` method:

```
RegisterPooled(ClassID, 16, 30);
```

This call tells MIDAS that 16 objects will be available in the pool, and that MIDAS can free any instances of objects that have been created if there has been no activity for 30 minutes. If you never want to free the objects, you can pass zero as the timeout parameter.

The client does not change that drastically. Simply use a `TWebConnection` as the `TDispatchConnection` for the client and fill in the appropriate properties, and the client will be communicating to the application server over HTTP. The one major difference when using `TWebConnection` is the need to specify the complete URL to the `httpsrvr.dll`, as opposed to just identifying the server computer by name or address. See Figure 32.7 for a screenshot of a typical setup using `TWebConnection`.

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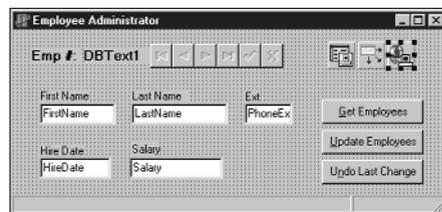
MIDAS
DEVELOPMENT

FIGURE 32.11

TWebConnection setup at design time.

Another benefit of using HTTP for your transport is that an OS such as NT Enterprise allows you to cluster servers. This provides true load balancing and fault tolerance for your application server. For more information about clustering, see

<http://www.microsoft.com/ntserver/ntserverenterprise/exec/overview/clustering>

The limitations of using `TWebConnection` are fairly trivial, and they're well worth any concession in order to have more clients capable of reaching your application server. The limitations are that you must install `wininet.dll` on the client, and no callbacks are available when using `TWebConnection`. In addition, you must register the application server with the utility function `EnableWebTransport` in an overridden `UpdateRegistry` method.

Summary

This chapter has provided quite a bit of information on MIDAS. Still, it has only scratched the surface of what can be done with this technology—something far beyond the scope of a single chapter. Even after you explore all the nooks and crannies of MIDAS, you can still add to your knowledge and capabilities by using MIDAS with C++Builder and JBuilder. Using JBuilder, you can achieve the nirvana of cross-platform access to an application server while using the same technology and concepts you learned here.

MIDAS is a quickly evolving technology that brings the promise of multitier applications to every programmer. Once you experience the true power of creating an application with MIDAS, you may never return to database application development as you know it today.

Rapid Database Application Development

PART V

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Inventory Manager: Client/Server Development

CHAPTER

33

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This chapter illustrates how to design a database application using the concepts discussed in Chapter 29, “Developing Client/Server Applications.” Here, we illustrate techniques for developing a two-tier client/server application. In this application we have divided up the application logic, or *business rules*, between both the client and the server. We also illustrate how to centralize data access in a data module, thus allowing us to completely separate the user interface from the database logic.

Back in Chapter 4, “Application Frameworks and Design Concepts,” we introduced you to a framework for forms that could be created independently or as child windows to another control. In this chapter, we use that framework for our user interface.

The database back end used is Local InterBase. The application is designed around a typical auto-parts business model. This business model requires the application to keep track of three primary sets of data:

- *Product inventory.* This includes the quantities of each item in the inventory and how much each item is worth.
- *Sales.* This set contains information on items sold and to which customer these items were sold.
- *Customer.* This set contains information such as name and address.

This is by no means a full-blown inventory manager application. The purpose of this chapter is to focus on the techniques of client/server development. We have provided a complete working application to illustrate that focus.

The chapter is divided into three parts. The first part, “Designing the Back End,” discusses the design of the back end. This includes the database objects you learned about in Chapter 29. The second part, “Centralizing Database Access: The Business Rules,” discusses how to use Delphi’s `TDataModule` to centralize database access. Finally, the third part, “Designing the User Interface,” discusses the design of the actual user interface for the inventory application.

Designing the Back End

We use the Local InterBase Server by InterBase Software Corporation as the back end for the Inventory Manager application. This gives us the capability to design the database entirely through SQL. It also offers the flexibility of being able to move some of the data processing to the server side of the equation through the use of triggers, generators, and stored procedures—which also helps to ensure better data integrity. Another more tangible benefit of the SQL back end is that it can be scaled to a true client/server environment.

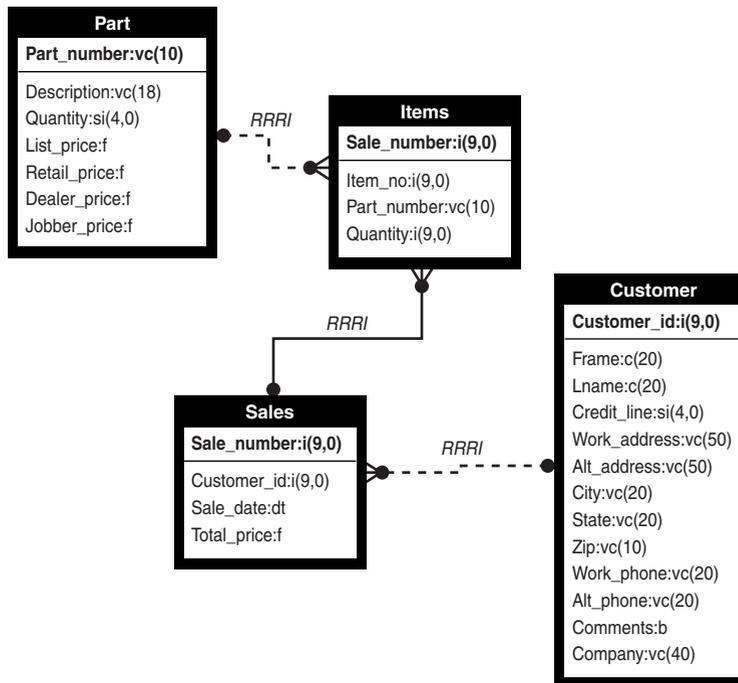
NOTE

Some of the topics in this chapter are specific to InterBase and may not apply to other SQL RDBMSs such as Oracle and Microsoft SQL. The concepts discussed, however, still apply and may just be implemented differently.

As discussed in Chapter 29, we will use SQL to create the various database objects required for the Inventory Manager application. This will include objects such as domains, tables, generators, triggers, stored procedures, and permissions.

There are several ways to create the back end using various *data-modeling* tools. Data-modeling tools such as xCase, RoboCase, Erwin, and SQL-Designer are but a few of the tools that greatly simplify the data-modeling process. All basically allow you to visually model your data without having to type out the SQL code. After you get your basic data-model designed, you can make changes as needed.

Figure 33.1 depicts the data model for our sales application.

**FIGURE 33.1**

Sales application data model.

Defining Domains

Before defining any tables, triggers, and so forth, you define domains that you will use throughout the rest of the SQL code that makes up the *metadata*.

NOTE

Metadata is all the objects (tables, indexes, and so on) contained as part of a database definition.

Think of a *domain* as an entity similar to a user-defined type in Object Pascal. Domains enable you to define special data types with more structure than the built-in data types.

Domains help simplify data and constraint declarations by enabling you to create shorthand names for types that are common throughout your database. Note that you cannot alter a domain after table columns have used it.

The following are some of the domains used in the sales metadata:

- `CREATE DOMAIN DCUSTOMERID AS INTEGER;`

This is a straightforward domain. It defines a new domain called DCUSTOMERID as a type identical to that of a standard, run-of-the-mill integer.

- `CREATE DOMAIN DCREDITLINE AS SMALLINT default 0 CHECK (VALUE BETWEEN 0 AND 3000);`

This defines a new smallint-type domain, but it applies the additional constraint that the value must lie between 0 and 3000.

- `CREATE DOMAIN DNAME AS CHAR(20);`

This defines a domain called DNAME that is a fixed-length string of exactly 20 characters.

- `CREATE DOMAIN DADDRESS AS VARCHAR(50);`
`CREATE DOMAIN DCITY AS VARCHAR(20);`
`CREATE DOMAIN DSTATE AS VARCHAR(20);`
`CREATE DOMAIN DZIP AS VARCHAR(10);`
`CREATE DOMAIN DPHONE AS VARCHAR(20);`

This defines several domains as variable-length strings of up to 50, 20, 20, 10, and 20 characters, respectively.

- `CREATE DOMAIN DPRICE AS NUMERIC(15, 2) default 0.00;`

This creates a domain representing a decimal number. The first number, 15, specifies the digits of precision to store. The second number, 2, specifies the number of decimal places to store. The default value for columns of this domain is 0.00.

NOTE

The CHAR(*n*) data type always stores *n* characters to the database. If the string contained in a particular field is less than *n* characters, unused characters will be padded with spaces.

The VARCHAR(*n*) data type stores the exact size of the string, up to a maximum of *n*. Its advantage over CHAR is that it is more space efficient, but operations on VARCHARs tend to be slightly slower.

You can refer to the InterBase Corp. “InterBase Language Reference Guide” or to the IB32.H1p help file for further information on domains.

Defining the Tables

Using the defined domains, you can create tables. Each table is created by using the CREATE TABLE SQL statement, followed by the enumeration of table fields and data types or domains.

The CUSTOMER Table

The CUSTOMER table represents the customer data object, and it is defined as follows:

```
/* Table: CUSTOMER, Owner: SYSDBA */
CREATE TABLE CUSTOMER (CUSTOMER_ID INTEGER NOT NULL,
    FNAME DNAME NOT NULL,
    LNAME DNAME NOT NULL,
    CREDIT_LINE DCREDITLINE NOT NULL,
    WORK_ADDRESS DADDRESS,
    ALT_ADDRESS DADDRESS,
    CITY DCITY,
    STATE DSTATE,
    ZIP DZIP,
    WORK_PHONE DPHONE,
    ALT_PHONE DPHONE,
    COMMENTS BLOB SUB_TYPE TEXT SEGMENT SIZE 80,
    COMPANY VARCHAR(40),
CONSTRAINT PCUSTOMER_ID PRIMARY KEY (CUSTOMER_ID));
```

The fields defined with the NOT NULL specifier indicate that the user must enter a value for those fields before a record can be posted to the table. In other words, those fields cannot be left blank.

The COMMENTS field requires a bit of explanation. This field is of type BLOB (Binary Large Object), which means that any type of free-form data can be stored there. The SUB TYPE of TEXT, however, means that the data contained within the BLOB is ASCII text and therefore is compatible with the Delphi TDBMemo component.

The `CONSTRAINT` statement creates a primary key on the `CUSTOMER_ID` field, which ensures that each record's value for this field will be unique. This also is the first step to ensuring referential integrity throughout the database; the `PRIMARY KEY` field acts as a lookup field for the `FOREIGN KEY` field defined in another table, as you will see later.

The PART Table

The `PART` table is the shop inventory. This table's definition is fairly straightforward:

```
/* Table: PART, Owner: SYSDBA */
CREATE TABLE PART (PART_NUMBER VARCHAR(10) NOT NULL,
    DESCRIPTION VARCHAR(18),
    QUANTITY SMALLINT NOT NULL,
    LIST_PRICE DPRICE NOT NULL,
    RETAIL_PRICE DPRICE NOT NULL,
    DEALER_PRICE DPRICE NOT NULL,
    JOBBER_PRICE DPRICE NOT NULL,
CONSTRAINT PPART_NUMBER PRIMARY KEY (PART_NUMBER));
```

Each record represents the inventory of one unique part, holding description, quantity, and pricing information. Notice that this table also has a primary key—this time, on the `PART_NUMBER` field.

The SALES Table

The `SALES` table is the table that contains records for every sale to a customer. This table is defined as follows:

```
/* Table: SALES, Owner: SYSDBA */
CREATE TABLE SALES (SALE_NUMBER INTEGER,
    CUSTOMER_ID INTEGER,
    SALE_DATE DATE,
    TOTAL_PRICE DOUBLE PRECISION);

ALTER TABLE SALES ADD FOREIGN KEY (CUSTOMER_ID)
    REFERENCES CUSTOMER(CUSTOMER_ID);
```

Notice the `ALTER TABLE` statement, which adds a foreign key to the `SALES` table. A *foreign key* is a column or set of columns in one table that correspond in exact order to a column or set of columns defined as the primary key in another table. The foreign keys complete the referential integrity with the `SALES` table by ensuring that no entries are made for the `CUSTOMER_ID` field unless an entry with the same customer ID exists in the `CUSTOMER` table.

The ITEMS Table

The `ITEMS` table holds the items, or parts, for a particular sale. The `SALES` table has a one-to-many relationship with the `ITEMS` table and is linked by the `SALE_NUMBER` and `SALE_NO` fields in each table. The `ITEMS` table is defined as follows:

```
/* Table: ITEMS, Owner: SYSDBA */
CREATE TABLE ITEMS (SALE_NUMBER INTEGER,
                    ITEM_NO INTEGER,
                    PART_NO VARCHAR(10),
                    QTY SMALLINT);

ALTER TABLE ITEMS ADD FOREIGN KEY (PART_NO)
REFERENCES PART(PART_NUMBER);
```

Like the SALES table, the ITEMS table has a foreign key that ensures that no record is entered where the part number is nonexistent in the PART table.

Defining Generators

Think of a generator as a mechanism that automatically generates sequential numbers to be inserted into a table. Generators are often used to create unique numbers to be inserted into a table's keyed field. The SALES database will use generators to automatically generate new customer IDs for the CUSTOMER, SALES, and ITEMS tables. These generators are defined as follows:

```
CREATE GENERATOR GEN_CUSTID;
CREATE GENERATOR GEN_ITEMNO;
CREATE GENERATOR GEN_SALENO;
```

NOTE

After you add a generator to a database, it cannot be easily removed. The simplest technique is to remove or modify the trigger or stored procedure so that GEN ID() is not called. You also can remove your generator from the RDB\$GENERATORS systems table.

Defining Triggers

A *trigger* is a routine that automatically performs some action whenever a record in a table is inserted, updated, or deleted. Triggers enable you to let the database perform repetitive tasks as records are committed to tables, thereby freeing the application(s) used to access and modify the data from doing so.

NOTE

Triggers and generators are features specific to InterBase. Although most major SQL vendors also offer these facilities, it is possible that other SQL server vendors use

continues

different syntax and semantics in their implementations. Although they are very nice features, you should keep in mind that using generators and triggers can be a sticky point in migrating the application to a non-InterBase SQL server.

For starters, you need triggers that add new customers and sales numbers to their respective tables using the generators created earlier. The trigger to insert a new, unique customer ID would be as follows:

```
CREATE TRIGGER TCUSTOMER_ID FOR CUSTOMER
ACTIVE BEFORE INSERT POSITION 0
as begin
    new.customer_id = gen_id(gen_custid, 1);
end
```

The following trigger also works on the ITEMS table:

```
CREATE TRIGGER TITEM_NO FOR ITEMS
ACTIVE BEFORE INSERT POSITION 0
as begin
    new.item_no = gen_id(gen_itemno, 1);
end
```

NOTE

There are several additional triggers in this database that convert a two-letter state abbreviation to a full state name. You can find these triggers in `Sales.dd1` on the CD-ROM in the directory for this chapter.

Defining Stored Procedures

A *stored procedure* is a standalone routine that is located on the server as part of a database's metadata.

You can invoke a stored procedure and have it return a dataset just like a normal query. The advantages of stored procedures are that they reduce the amount of processing required at the client end, they reduce the network traffic, and they centralize some particular functionality. Stored procedures also can improve performance because they are precompiled SQL code executed on the server instead of across a network. The general functionality of stored procedures is discussed in greater length in Chapter 29, "Developing Client/Server Applications."

The SALES database employs two stored procedures. The first, `INSERT_SALE`, is used to insert a sale record into the SALES table. This stored procedure takes three input parameters: the

customer ID, the sale data, and the total cost of the sale. This procedure returns the sale identifier generated from within the stored procedure. The client application passes the value returned to another stored procedure where it will be used as a foreign key for the ITEMS table. INSERT_SALE is shown in Listing 33.1.

LISTING 33.1 The INSERT_SALE Stored Procedure

```
CREATE PROCEDURE INSERT_SALE AS BEGIN EXIT; END ^
.
ALTER PROCEDURE INSERT_SALE (
    ICUSTOMER_ID INTEGER,
    ISALE_DATE DATE,
    ITOTAL_PRICE DOUBLE PRECISION)
RETURNS(
    RSALE_NUMBER INTEGER)
AS
BEGIN
    /* First obtain a new Sale identifier from the          */
    /* GEN_SALENO generator. This value is being stored in */
    /* the rSale parameter which is defined as a return   */
    /* value and will therefore be returned to the calling */
    /* client.                                             */
    rSALE_NUMBER = gen_id(GEN_SALENO, 1);
    /* Now insert the record into the SALES table */
    INSERT INTO SALES(
        SALE_NUMBER,
        CUSTOMER_ID,
        SALE_DATE,
        TOTAL_PRICE)
    VALUES(
        :rSALE_NUMBER,
        :iCUSTOMER_ID,
        :iSALE_DATE,
        :iTOTAL_PRICE);
END
```

This stored procedure executes some very basic SQL code. It first retrieves a new ID for the sale record from the GEN_SALENO generator. It then performs a simple INSERT INTO SQL statement to insert the data passed to it through parameters.

The second stored procedure used by the application is slightly more complex. This stored procedure is named INSERT_SALE_ITEM and is used to insert individual items of a sale in the ITEMS table. More than likely, this stored procedure will be called several times for a single sale. Therefore, the client will first call the INSERT_SALE stored procedure to insert a sale record. It would have also gotten a sale ID from the call to INSERT_SALE. Then, the client would call

INSERT_SALE_ITEM for each item being sold. For every call, it must pass the specific item information and the sale ID previously obtained.

INSERT_SALE_ITEM takes three parameters: the sale ID, the part number, and the quantity of the item specified being sold. This stored procedure performs a few data-integrity operations. First, it makes sure that there is at least the number of items requested in the PART table. If not, an exception is raised. If the quantity of parts exists, the value of the Qty parameter is subtracted from the quantity in the PART table for the specified part. Finally, the item is added to the ITEMS table.

INSERT_SALE_ITEM is shown in Listing 33.2.

LISTING 33.2 The INSERT_SALE_ITEM Stored Procedure

```
CREATE PROCEDURE INSERT_SALE_ITEM AS BEGIN EXIT; END ^
.
ALTER PROCEDURE INSERT_SALE_ITEM (
    ISALE_NUMBER INTEGER,
    IPART_NO      VARCHAR(10),
    IQTY          SMALLINT)
AS
    DECLARE VARIABLE Actual_Qty VARCHAR(10);
BEGIN
    /* CHECK IF IQTY ITEMS EXISTS IN THE PARTS TABLE */
    SELECT QUANTITY FROM PART
        WHERE PART_NUMBER = :iPART_NO
        INTO Actual_Qty;
    IF (Actual_Qty < IQTY) THEN
        EXCEPTION EXP_EXCESS_ORDER;
    ELSE BEGIN
        /* First remove the quantity of parts from the PART table */
        UPDATE PART
        SET QUANTITY = (:Actual_Qty - :iQty)
        WHERE PART_NUMBER = :iPART_NO;
        /* Now Insert the new order */
        INSERT INTO ITEMS(
            SALE_NUMBER,
            PART_NO,
            QTY)
        VALUES(
            :iSALE_NUMBER,
            :iPART_NO,
            :iQTY);
    END
END
```

NOTE

If you are using the ISQL tool to enter database metadata, you need to change the terminating character. Because all statements within a procedure must be terminated by a semicolon (;)—which is also the SQL terminating character—you must set the SQL terminating character to some other symbol to avoid conflicts. Do this by using the `SET TERM` command.

In `SALES`, you will use the caret symbol as the terminating character. This line of SQL code will invoke the following change:

```
SET TERM ^ ;
```

Granting Permissions

The final step in defining a database is granting permission to the tables and stored procedures to particular users. For simplicity, you can grant all users `SELECT` and `UPDATE` rights on the `CUSTOMER` table with the following statement:

```
GRANT SELECT, UPDATE ON CUSTOMER TO PUBLIC WITH GRANT OPTION;
```

Alternatively, you can grant all rights to the `SALES` table with the following statement:

```
GRANT ALL ON SALE TO PUBLIC WITH GRANT OPTION;
```

The `GRANT OPTION` clause means that those who are granted access to tables also are allowed to grant others access to the data. The `GRANT` statements used on the Inventory Manager's tables and stored procedures are as follows:

```
/* Grant permissions for this database */  
GRANT SELECT, UPDATE ON CUSTOMER TO PUBLIC WITH GRANT OPTION;  
GRANT ALL ON SALES TO PUBLIC WITH GRANT OPTION;  
GRANT ALL ON PART TO PUBLIC WITH GRANT OPTION;  
GRANT ALL ON ITEMS TO PUBLIC WITH GRANT OPTION;  
GRANT EXECUTE ON PROCEDURE INSERT_SALE TO PUBLIC;  
GRANT EXECUTE ON PROCEDURE INSERT_SALE_ITEM TO PUBLIC;
```

The next section discusses how to connect to the database objects.

Centralizing Database Access: The Business Rules

This section illustrates how to separate database access and business logic from the user interface. This serves several purposes. By placing the business logic within one data module, you make it easier to maintain that same business logic because it is not scattered throughout the

application. This technique also makes it possible to port your two-tier model to a three-tier model by adding the appropriate components to the data module that already contains the business logic. We do not do that here, but we mention this because it is something that merits serious consideration when developing two-tier systems.

You can use `TDataModule` to encompass as much of the database side of things as you see fit. We will show how we do this for the Inventory Manager application.

In our demo application, we use a single `TDataModule` component. For small applications, this approach is sufficient. For larger applications, you might consider separating the disparate pieces among several `TDataModule` components where it logically makes sense.

Listing 33.3 shows the source code for `TDDGSalesDataModule`, which is defined in `SalesDM.pas`.

LISTING 33.3 `TDDGSalesDataModule`

```
unit SalesDM;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  DBTables, Db;

type
  TDDGSalesDataModule = class(TDataModule)
    qryCustomer: TQuery;
    dbSales: TDatabase;
    usqlCustomer: TUpdateSQL;
    qryCustomerCUSTOMER_ID: TIntegerField;
    qryCustomerFNAME: TStringField;
    qryCustomerLNAME: TStringField;
    qryCustomerCREDIT_LINE: TSmallintField;
    qryCustomerWORK_ADDRESS: TStringField;
    qryCustomerALT_ADDRESS: TStringField;
    qryCustomerCITY: TStringField;
    qryCustomerSTATE: TStringField;
    qryCustomerZIP: TStringField;
    qryCustomerWORK_PHONE: TStringField;
    qryCustomerALT_PHONE: TStringField;
    qryCustomerCOMMENTS: TMemoField;
    qryCustomerCOMPANY: TStringField;
    qryParts: TQuery;
    usqlParts: TUpdateSQL;
    qryPartsPART_NUMBER: TStringField;
    qryPartsDESCRIPTION: TStringField;
```

```
qryPartsQUANTITY: TSmallintField;
qryPartsLIST_PRICE: TFloatField;
qryPartsRETAIL_PRICE: TFloatField;
qryPartsDEALER_PRICE: TFloatField;
qryPartsJOBBER_PRICE: TFloatField;
spInsertSaleItem: TStoredProc;
spInsertSale: TStoredProc;
qryTotalPrice: TQuery;
tblTempItems: TTable;
tblTempItemsPART_NUMBER: TStringField;
tblTempItemsDESCRIPTION: TStringField;
tblTempItemsQUANTITY: TSmallintField;
tblTempItemsRETAIL_PRICE: TFloatField;
tblTempItemsTOTAL_PRICE: TFloatField;
qryTotalPricesUMOFTOTAL_PRICE: TFloatField;
qrySale: TQuery;
dsCustomer: TDataSource;
qryItems: TQuery;
dsSale: TDataSource;
qrySalesALE_NUMBER: TIntegerField;
qrySalesALE_DATE: TDateTimeField;
qrySaleTOTAL_PRICE: TFloatField;
qryItemsDESCRIPTION: TStringField;
qryItemsQTY: TSmallintField;
qryCustomerSearch: TQuery;
procedure tblTempItemsBeforePost(DataSet: TDataSet);
procedure dbSalesLogin(Database: TDatabase; LoginParams: TStrings);
protected
  procedure SetAfterTempItemsChange(Value: TDataSetNotifyEvent);
  function GetAfterTempItemsChange: TDataSetNotifyEvent;
public

  // Connection methods

  procedure Logout;
  function Login: Boolean;
  function Connect: Boolean;
  procedure Disconnect;

  // Customer methods
  procedure FirstCustomer;
  procedure LastCustomer;
  procedure NextCustomer;
  procedure PrevCustomer;
  procedure EditCustomer;
  procedure NewCustomer;
```

LISTING 33.3 Continued

```
procedure AcceptCustomer;
procedure CancelCustomer;
procedure DeleteCustomer;
function IsFirstCustomer: Boolean;
function IsLastCustomer: Boolean;
function GetCustomerName: String;
function SearchForCustomer: Boolean;

// Parts methods
procedure FirstPart;
procedure LastPart;
procedure NextPart;
procedure PrevPart;
procedure EditPart;
procedure NewPart;
procedure AcceptPart;
procedure CancelPart;
procedure DeletePart;
function IsFirstPart: Boolean;
function IsLastPart: Boolean;
function SearchForPart: Boolean;

// Sales methods

procedure AddItemToSale;
procedure SaveSale;
procedure CancelSale;
function SaleItemsTotalPrice: double;
procedure OpenTempItems;
procedure CloseTempItems;

// Surfaced properties
property AfterTempItemsChange: TDataSetNotifyEvent
    read GetAfterTempItemsChange
    write SetAfterTempItemsChange;

end;

var
    DDGSalesDataModule: TDDGSalesDataModule;

implementation

uses CustomerSrchFrm, LoginFrm;
```

```
{SR *.DFM}

procedure TDDGSalesDataModule.SetAfterTempItemsChange(Value:
    TDataSetNotifyEvent);
begin
    { This writer method adds the Value parameter to both the AfterPost and
      AfterDelete events of the temporary items table. This ensures that whenever
      the data changes, the event handler will get called. }
    tblTempItems.AfterPost := Value;
    tblTempItems.AfterDelete := Value;
end;

function TDDGSalesDataModule.GetAfterTempItemsChange: TDataSetNotifyEvent;
begin
    Result := tblTempItems.AfterPost;
end;

// Login methods.

procedure TDDGSalesDataModule.dbSalesLogin(Database: TDatabase;
    LoginParams: TStrings);
begin
    { Calls method below to populate the LoginParams strings list
      with the user's login information. GetLoginParams is defined in
      LoginFrm.pas. }
    GetLoginParams(LoginParams);
end;

procedure TDDGSalesDataModule.Logout;
begin
    Disconnect;
end;

function TDDGSalesDataModule.Login: Boolean;
begin
    Result := Connect;
end;

function TDDGSalesDataModule.Connect: Boolean;
begin
    { Connects the user to the database. When dbSales is set to True, its OnLogon
      event handler will be invoked which will invoke our customer login dialog
      defined in LoginFrm.pas. }
    try
        dbSales.Connected := True;
    end;
end;
```

LISTING 33.3 Continued

```
    qryCustomer.Active := True;
    qryParts.Active     := True;
    qrySale.Active      := True;
    qryItems.Active     := True;
    Result := True;
except
    MessageDlg('Invalid Password or login information, cannot login.',
              mtError, [mbok], 0);
    dbSales.Connected := False;
    Result := False;
end;
end;

procedure TDDGSalesDataModule.Disconnect;
begin
    // Disconnect from the database.
    dbSales.Connected := False;
end;

// Customer methods

procedure TDDGSalesDataModule.AcceptCustomer;
begin
    dbSales.ApplyUpdates([qryCustomer]);
end;

procedure TDDGSalesDataModule.CancelCustomer;
begin
    qryCustomer.CancelUpdates;
end;

procedure TDDGSalesDataModule.DeleteCustomer;
begin
    qryCustomer.Delete;
end;

procedure TDDGSalesDataModule.EditCustomer;
begin
    qryCustomer.Edit;
end;

procedure TDDGSalesDataModule.FirstCustomer;
begin
    qryCustomer.First;
end;
```

```
procedure TDDGSalesDataModule.LastCustomer;
begin
  qryCustomer.Last;
end;

procedure TDDGSalesDataModule.NewCustomer;
begin
  qryCustomer.Insert;
end;

procedure TDDGSalesDataModule.NextCustomer;
begin
  qryCustomer.Next;
end;

procedure TDDGSalesDataModule.PrevCustomer;
begin
  qryCustomer.Prior;
end;

function TDDGSalesDataModule.IsFirstCustomer: Boolean;
begin
  Result := qryCustomer.Bof;
end;

function TDDGSalesDataModule.IsLastCustomer: Boolean;
begin
  Result := qryCustomer.Eof;
end;

function TDDGSalesDataModule.GetCustomerName: String;
begin
  { Normally, return the company name. If there is not a company name, return
  the customer's name. }
  if qryCustomerCOMPANY.AsString <> EmptyStr then
    Result := qryCustomerCOMPANY.AsString
  else
    Result := Format('%s %s', [qryCustomerFNAME.AsString,
    qryCustomerLNAME.AsString]);
end;

function TDDGSalesDataModule.SearchForCustomer: Boolean;
var
  CustID: Integer;
  SearchQry: String;
begin
```

LISTING 33.3 Continued

```
// Assume failure.
Result := False;
{ Invoke the SearchCustomer function which is defined in CustomerSrchFrm.pas.
  this function returns the query string that is added to the
  qryCustomerSearch
  TQuery component }
SearchQry := SearchCustomer;
if SearchQry <> EmptyStr then
begin
  Screen.Cursor := crSQLWait;
  try
    qryCustomerSearch.Close;
    qryCustomerSearch.SQL.Clear;
    qryCustomerSearch.SQL.Add(SearchQry);
    qryCustomerSearch.Open;
  try

    // If a record was not found, exit this method.
    if qryCustomerSearch.FieldName('CUSTOMER_ID').IsNull then
    begin
      Screen.Cursor := crDefault;
      Exit;
    end;

    { If a record is found, get the customer's id that is used to
      locate the record in the actual qryCustomer, TQuery component. This
      will position the cursor to the location of the record. }
    CustID := qryCustomerSearch.FieldName('CUSTOMER_ID').AsInteger;

    { If the record is not found in qryCustomer, there is an
    inconsistency
      in the database, raise an error. }
    if not qryCustomer.Locate('CUSTOMER_ID', CustID, []) then
      raise Exception.Create('Inconsistency in database.')
    else
      Result := True;
  finally
    qryCustomerSearch.Close;
  end;
finally
  Screen.Cursor := crDefault;
end;
end
else
  Result := False;
end;
```

```
// Parts Methods

function TDDGSalesDataModule.IsFirstPart: Boolean;
begin
    Result := qryParts.Bof;
end;

function TDDGSalesDataModule.IsLastPart: Boolean;
begin
    Result := qryParts.Eof;
end;

procedure TDDGSalesDataModule.AcceptPart;
begin
    dbSales.ApplyUpdates([qryParts]);
end;

procedure TDDGSalesDataModule.CancelPart;
begin
    qryParts.CancelUpdates;
end;

procedure TDDGSalesDataModule.DeletePart;
begin
    qryParts.Delete;
end;

procedure TDDGSalesDataModule.EditPart;
begin
    qryParts.Edit;
end;

procedure TDDGSalesDataModule.FirstPart;
begin
    qryParts.First;
end;

procedure TDDGSalesDataModule.LastPart;
begin
    qryParts.Last;
end;

procedure TDDGSalesDataModule.NewPart;
begin
    qryParts.Insert;
end;
```

LISTING 33.3 Continued

```
procedure TDDGSalesDataModule.NextPart;
begin
  qryParts.Next;
end;

procedure TDDGSalesDataModule.PrevPart;
begin
  qryParts.Prior;
end;

function TDDGSalesDataModule.SearchForPart: Boolean;
{ This method searches for a part based on the part id specified by the
  user. }
var
  PartNumber: string;
begin
  Result := False;
  PartNumber := '';
  if InputQuery('Part Search', 'Enter a Part Number', PartNumber) then
    if not qryParts.Locate('PART_NUMBER', PartNumber, []) then
      Exit
    else
      Result := True;
end;

// Sales methods

procedure TDDGSalesDataModule.AddItemToSale;
begin
  { The tblTempItems is a temporary table used to hold the
    items that are being added to a sale. If the user saves
    the sale, these records will be used in the stored procedure
    calls that actually store the sale on the database. }
  if not tblTempItems.Locate('PART_NUMBER',
    qryParts.FieldName('PART_NUMBER').AsString, []) then
    begin
      tblTempItems.Insert;
      try
        tblTempItems['PART_NUMBER'] := qryParts['PART_NUMBER'];
        tblTempItems['DESCRIPTION'] := qryParts['DESCRIPTION'];
        tblTempItems['QUANTITY'] := 1;
        tblTempItems['RETAIL_PRICE'] := qryParts['RETAIL_PRICE'];
        tblTempItems.Post;
      except
        tblTempItems.Cancel;
      end;
    end;
```

```

end
else
    MessageDlg('Item already in list', mtWarning, [mbok], 0);
end;

procedure TDDGSalesDataModule.CancelSale;
begin
    { If the user cancels the sale, the items that were added to the tblTempItems
      table will have to be cleared. }
    tblTempItems.Close;
    tblTempItems.EmptyTable;
    tblTempItems.Open;
end;

procedure TDDGSalesDataModule.SaveSale;
var
    SaleNo: Integer;
begin
    { If the user saves the sale, first create a sale record which will return
      a sale key to SaleNo. This is used as the link for sale items which are
      added next. The sale items are gotten from the temporary table
      tblTempItems. }
    dbSales.StartTransaction;
    try
        { First create the sale record. }
        with spInsertSale do
            begin
                ParamByName('iCUSTOMER_ID').AsInteger := qryCustomer['CUSTOMER_ID'];
                ParamByName('iSALE_DATE').AsDateTime := Now;
                ParamByName('iTOTAL_PRICE').AsFloat := SaleItemsTotalPrice;
                ExecProc;
                // Get the key value in SaleNo.
                SaleNo := ParamByName('rSALE_NUMBER').AsInteger;
            end;

            // Now add all records in tblTempItems to the sale specified by SaleNo.
            tblTempItems.First;
            while not tblTempItems.Eof do
                begin
                    with spInsertSaleItem do
                        begin
                            ParamByName('IPART_NO').AsString := tblTempItems['PART_NUMBER'];
                            ParamByName('IQTY').AsInteger := tblTempItems['QUANTITY'];
                            ParamByName('ISALE_NUMBER').AsInteger := SaleNo;
                            ExecProc;
                        end;
                    end;
                end;
            end;
        end;
    end;
end;

```

LISTING 33.3 Continued

```
        tblTempItems.Next;
    end;

    dbSales.Commit;

    // Refresh modified tables.
    qryParts.Close;
    qryParts.Open;

    tblTempItems.Close;
    tblTempItems.EmptyTable;
    tblTempItems.Open;

except
    dbSales.Rollback;
end;
end;

function TDDGSalesDataModule.SaleItemsTotalPrice: double;
begin
    { qryTotalPrice retrieves the total price for all records added to the
      tblTempItems table. This method may be called from any form using this
      data module. }
    qryTotalPrice.Close;
    qryTotalPrice.Open;
    try
        Result := qryTotalPrice.FieldByName('SUM OF TOTAL_PRICE').AsFloat;
    finally
        qryTotalPrice.Close;
    end;
end;

procedure TDDGSalesDataModule.tblTempItemsBeforePost(DataSet: TDataSet);
begin
    { Before posting a record to the temporary table, calculate the total price
      for the TOTAL_PRICE field based on the number of items that the user is
      adding. }
    tblTempItemsTOTAL_PRICE.ReadOnly := False;
    try
        tblTempItems['TOTAL_PRICE'] := tblTempItems['RETAIL_PRICE'] *
            tblTempItems['QUANTITY'];
    finally
        tblTempItemsTOTAL_PRICE.ReadOnly := True;
    end;
end;
end;
```

```

procedure TDDGSalesDataModule.OpenTempItems;
begin
    tblTempItems.Close;
    tblTempItems.EmptyTable;
    tblTempItems.Open;
end;

procedure TDDGSalesDataModule.CloseTempItems;
begin
    tblTempItems.Active := False;
end;

end.

```

TDDGSalesDataModule has a TDatabase component, dbSales, and the various TQuery, TUpdatesSQL, and TStoredProc components necessary for our sales inventory application.

DbSales is the main connection to the SQL back end that exists in Sales.gdb. This connection is made through the alias DDGSALES, which we set up using the DBExplorer program. DBSales establishes the application-level alias DDGSalesDB. Initially, its Connected property is set to False so all tables belonging to it will also be closed when the application is first run. DbSales has an OnLogin event handler that we will discuss momentarily.

You will notice that we functionally grouped the TDDGSalesDataModule's method definitions. These functional groups are as follows:

<i>Method Group</i>	<i>Definition</i>
Connection methods	Methods that allow the user to log on and log off the application
Customer methods	Methods that manipulate customer data specifically
Parts methods	Methods that manipulate the parts data specifically
Sales methods	Methods that create and manage sales

Refer to the listing's commentary for an explanation of the various methods. In particular, examine the SaveSale() method, which is the method that uses the TStoredProc component to create a new sale and adds sale items to that sale. The stored procedures in this method are hooked to the stored procedures shown in Listings 33.1 and 33.2.

Login/Logout Methods

The methods for logging in and logging out are appropriately named Login() and Logout(). Login() invokes the Connect() method, which establishes a connection to the database through dbSales. It does this by setting the dbSales.Connected property to True. When this

happens, the `dbSales.OnLogin` event handler is invoked if one exists. The event handler `dbSalesLogin()` invokes the `GetLoginParams()` method defined in `LoginFrm.pas`, which populates the user's login information by displaying a custom login dialog. This method is shown in Listing 33.4.

LISTING 33.4 TLoginForm: The Custom Login Form

```
unit LoginFrm;

interface

uses WinTypes, WinProcs, Classes, Graphics, Forms, Controls, StdCtrls,
    Buttons, ExtCtrls;

type
    TLoginForm = class(TForm)
        lblEnterPassword: TLabel;
        lblEnterName: TLabel;
        edtName: TEdit;
        edtPassword: TEdit;
        btnOK: TButton;
        btnCancel: TButton;
    public
    end;

function GetLoginParams(ALoginParams: TStrings): Boolean;

implementation

{$R *.DFM}

function GetLoginParams(ALoginParams: TStrings): Boolean;
var
    LoginForm: TLoginForm;
begin
    Result := False;
    LoginForm := TLoginForm.Create(Application);
    try
        if LoginForm.ShowModal = mrOk then
            begin
                ALoginParams.Values['USER NAME'] := LoginForm.edtName.Text;
                ALoginParams.Values['PASSWORD'] := LoginForm.edtPassWord.Text;
                Result := True;
            end;
    finally
    end;
end;
```

```
    LoginForm.Free;  
end;  
end;  
  
end.
```

The `Logout()` method simply closes `dbSales`, which in turn closes all the `TQuery/TTable` connections.

Customer Table Methods

`DDGSalesDataModule` contains several methods to manipulate the `CUSTOMER` table: `NewCustomer()`, `AcceptCustomer()`, `EditCustomer()`, `DeleteCustomer()`, and `CancelCustomer()`. All are straightforward in that they just call the appropriate `TQuery` methods to invoke the action. The remaining methods require a bit more explanation.

`GetCustomerName()` is a function that retrieves the company name of a customer. If a company name does not exist, the method returns the first and last name of a customer whose customer ID is that specified by the `CustID` parameter.

`SearchForCustomer()` allows the user to perform a search on the customer table for a certain customer. The search is based on the fields specified by the user from a customer search form. This form builds a query string that gets passed to the server. We will discuss the functionality of this form later. For now, just assume that it builds a query string that gets assigned to `qryCustomerSearch.SQL`. If the customer specified is found, that customer record is made the active one.

Part Table Methods

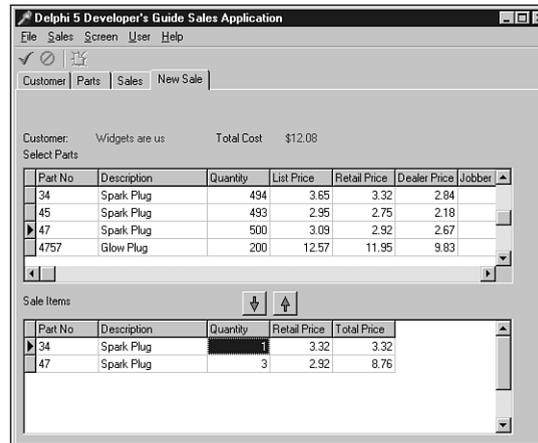
The part methods are similar to the customer methods. The `NewPart()`, `EditPart()`, `AcceptPart()`, `DeletePart()`, and `CancelPart()` methods are simple methods that call the appropriate `TQuery` methods to perform the specific operation.

`SearchForPart()` is not quite as complex as `SearchForCustomer()`. It retrieves a part number by using the `InputQuery()` function and then performs a `Locate()` operation to find the part.

Sales Methods

The sales methods are where things get a bit more interesting. These methods represent more what you would be doing to perform various operations against a client/server database—in particular, the `SaveSale()` method.

`AddItemToSale()` allows the user to specify the items to add to a new sale (see Figure 33.2).

**FIGURE 33.2**

Adding items to a sale.

`CancelSale()` terminates an “insert sale” operation.

`SaveSale()` is `DDGSalesDataModule`'s most complex method. This method uses the transaction capabilities of `dbSales` to add a sale to the database. This involves starting the transaction, adding the sale record, adding x number of items being sold, and then committing or rolling back the entire process (transaction).

The sale record is added by using the `spInsertSale` stored procedure. Notice how the sale number that is generated inside the actual stored procedure is returned to the client with the following statement:

```
SaleNo := ParamByName('rSALE_NUMBER').AsInteger;
```

This value is then used for each record added to the `ITEMS` table through the `TStoredProc` component `spInsertSaleItems`. This is how you link the items being sold with a sale.

Temporary Table Methods

The `TempPartsTable` methods perform operations on the temporary table used to hold items for a sale. Table 33.1 shows the definition of this table.

TABLE 33.1 TEMPPART.DB Table Fields

<i>Field Name</i>	<i>Type</i>	<i>Size</i>	<i>Meaning</i>
PART_NO	A	10	Part number for this item
DESCRIPTION	A	18	Description of this part
QUANTITY	S		Number of parts being sold
RETAIL_PRICE	N	50	Retail price for the item being sold
RETAIL_PRICE	N	50	Total price for the number of parts being sold

The `AddItemToSale()` method is responsible for adding parts to the sale.

The `SaleItemsTotalPrice()` method returns the total price in items existing in `tblTempItems`. This method uses the `qryTotalPrice` component to run a query against the Paradox table to calculate the total price. The SQL statement that is executed is

```
select SUM(RETAIL_PRICE) from temppart.db
```

This statement returns the sum of the numeric values for the specified column—in this case the `RETAIL_PRICE` column.

The `tblTempItemsBeforePost()` method is the event handler for the `tblTempParts.BeforePost` event. This event handler ensures that the record being posted reflects the correct price based on the quantity of items being sold. This is possible because the `BeforePost` event occurs before the record is actually posted to the table.

Surfacing Data-Access Component Events to Users of the TDataModule

One of the problems with centralizing database access is that the data-access components each have their own event that you might want the user interface to know about. Usually, you do this because you want something to happen on the UI side as a result of a data-access component's event. Because the components reside on the `TDataModule`, there is no automatic way for forms using the `TDataModule` to hook into these events. Keep in mind that the `TDataModule` may be made accessible in the form of a compiled unit.

One way of surfacing certain events is to give the `TDataModule` its own event to which any forms using it can attach an event handler. This `TDataModule` event can be invoked as a result of a specific component's event. This is how you surface the `AfterPost` and `AfterDelete` events for the `tblTempParts` table through one property—`AfterTempItemsChange`. This property has both reader and writer methods that directly access the `tblTempParts` actual properties.

Designing the User Interface

With the centralized data access defined, you can build the user interface around the methods, properties, and events of the `TDataModule` object. In the next few sections, we are going to talk about the various forms in the application.

This application uses the framework discussed in Chapter 4, “Application Frameworks and Design Concepts,” where a form can become a child window of another window.

Our application uses the model shown in Figure 33.3.

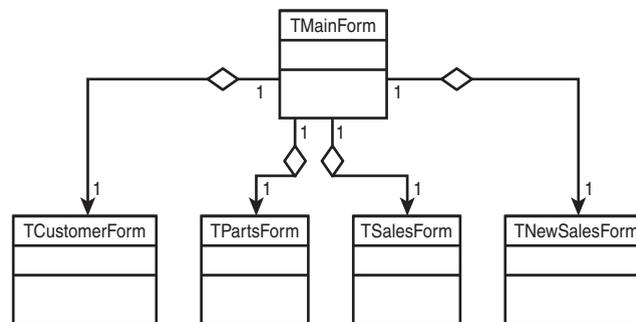


FIGURE 33.3

Inventory application layout.

This main form can contain four child forms:

- *Customer form.* Used to add, edit, and browse customers in the system
- *Parts form.* Used to add, edit, and browse the inventory of parts
- *Sales form.* Used to browse sales
- *New Sales form.* Used to add a new sale

There are some other supportive forms that are not invoked as child forms of the main form. We will discuss these forms momentarily. For now, we will focus primarily on the main form and each of the child forms.

TMainForm: The Application’s Main Form

The main form of the application contains a `TTabControl` component, which serves as the parent component to the child forms. The user changes the child form by selecting the desired screen either from the main menu or by selecting a tab of `tcMain`. The coding logic ensures that the menu items and tab controls remain in sync. Most of the main form logic focuses on ensuring that only one child form is created and visible and that others are properly freed.

Listing 33.5 shows the source code for the main form, TMainForm.

LISTING 33.5 The Inventory Application's Main Form: TMainForm

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  Menus, StdCtrls, ComCtrls, ExtCtrls, ChildFrm;

type

  { There are four types of child forms that can be displayed in this
    application. The TActiveScreenType is declared to allow us to know
    which of the four types of forms are active. }

  TActiveScreenType = (acCustomer, acParts, acSales, acNewSales);

  TMainForm = class(TForm)
    mmSales: TMainMenu;
    mmiScreen: TMenuItem;
    mmiCustomer: TMenuItem;
    mmiParts: TMenuItem;
    mmiNewSale: TMenuItem;
    mmiSales: TMenuItem;
    mmiFile: TMenuItem;
    mmiExit: TMenuItem;
    mmiHelp: TMenuItem;
    tcMain: TTabControl;
    mmiUser: TMenuItem;
    mmiLogon: TMenuItem;
    mmiLogoff: TMenuItem;
    imgCar: TImage;
    procedure ScreenClick(Sender: TObject);
    procedure mmiExitClick(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure tcMainChange(Sender: TObject);
    procedure tcMainChanging(Sender: TObject; var AllowChange: Boolean);
    procedure mmiLogonClick(Sender: TObject);
    procedure mmiLogoffClick(Sender: TObject);
  private
    // ActiveScreenType stores the type of form that is active.
    ActiveScreenType: TActiveScreenType;
    // ActiveScreen is a reference to the active child form.
```

LISTING 33.5 Continued

```
    ActiveScreen: TChildForm;
    procedure SetActiveScreen;
public
    { Public declarations }
end;

var
    MainForm: TMainForm;

implementation

uses CustomerFrm, PartsFrm, NewSalesFrm, SalesFrm, SalesDM;

{$R *.DFM}

procedure TMainForm.FormCreate(Sender: TObject);
begin
    // Set the alignment for the main tab control.
    tcMain.Align := alClient;
end;

procedure TMainForm.mmiExitClick(Sender: TObject);
begin
    Close;
end;

procedure TMainForm.ScreenClick(Sender: TObject);
begin
    { This method is invoked when the user has chosen to change the screen via
      the main menu.
      This method determines if it is possible to change to another child form. It
      does this by making sure that each child form's CanChange() method returns
      True. If so, it changes the global ActiveScreenType value and invokes the
      SetActiveScreen() method to actually perform the change logic. }
    if Sender is TMenuItem then
    begin
        if ActiveScreen <> nil then
        begin
            if ActiveScreen.CanChange then
            begin

                TMenuItem(Sender).Checked := True;
                if Sender = mmiCustomer then
                    ActiveScreenType := acCustomer
                else if Sender = mmiParts then
```

```

        ActiveScreenType := acParts
    else if Sender = mmiSales then
        ActiveScreenType := acSales
    else if Sender = mmiNewSale then
        ActiveScreenType := acNewSales;

    // Ensure the TTabControl is in-sync with the clicked item on the menu.
    tcMain.TabIndex := ord(ActiveScreenType);
    SetActiveScreen;
    end
end;
end;
end;

procedure TMainForm.tcMainChange(Sender: TObject);
begin
{ This method changes the screen when the user has switched tabs. It
synchronizes the settings for the main menu and the tab control. This method
also calls the SetActiveScreen() method to actually change the active
screen.}
    if ActiveScreen <> nil then
    begin
        case tcMain.TabIndex of
            0: mmiCustomer.Checked := True;
            1: mmiParts.Checked := True;
            2: mmiSales.Checked := True;
            3: mmiNewSale.Checked := True;
        end;
        ActiveScreenType := TActiveScreenType(tcMain.TabIndex);
        SetActiveScreen;
    end;
end;

procedure TMainForm.SetActiveScreen;
{ This method changes the active screen to one of the four child forms. Each
child form becomes a child of the TTabControl tcMain. }
var
    TempScreen: TChildForm;
begin
{ Determine if we have an instantiated child form yet. If so, unmerge its
menu and free the child form. }

    TempScreen := ActiveScreen;

    // Unmerge the menu.
    if Assigned(ActiveScreen) then

```

LISTING 33.5 Continued

```
begin
  if ActiveScreen.GetFormMenu <> nil then
    mmSales.UnMerge(ActiveScreen.GetFormMenu);

end;

{ Determine which active screen (child form) to create and set its toolbar
  to have the main form as the parent if appropriate. }
case ActiveScreenType of
  acCustomer:
    begin
      ActiveScreen := TCustomerForm.Create(Application, tcMain);
      TCustomerForm(ActiveScreen).SetToolBarParent(self);
    end;
  acParts:
    begin
      ActiveScreen := TPartsForm.Create(Application, tcMain);
      TPartsForm(ActiveScreen).SetToolBarParent(self);
    end;
  acSales:
    ActiveScreen := TSalesForm.Create(Application, tcMain);
  acNewSales:
    begin
      ActiveScreen := TNewSalesForm.Create(Application, tcMain);
      TPartsForm(ActiveScreen).SetToolBarParent(self);
    end;
end;

// Merge the menu of the child form with the menu of the main form.
if ActiveScreen <> nil then
begin
  if ActiveScreen.GetFormMenu <> nil then
    mmSales.Merge(ActiveScreen.GetFormMenu);
  ActiveScreen.Show;

end;

if Assigned(TempScreen) then
  TempScreen.Free;
end;

procedure TMainForm.tcMainChanging(Sender: TObject;
  var AllowChange: Boolean);
begin
```

```
// Change only if the child form is in the mode that allows changing.
AllowChange := ActiveScreen.CanChange;
end;

procedure TMainForm.mmiLogonClick(Sender: TObject);
begin
  // Log the user onto the system
  if DDGSalesDataModule.Login then
    begin
      tcMain.Align := alClient;
      tcMain.Visible := True;
      ActiveScreenType := acCustomer;
      SetActiveScreen;
      mmiScreen.Enabled := True;
      mmiLogon.Enabled := False;
      mmiLogoff.Enabled := True;
    end;
end;

procedure TMainForm.mmiLogoffClick(Sender: TObject);
begin
  // Log the user off the system.
  if Assigned(ActiveScreen) then
    begin
      if ActiveScreen.GetFormMenu <> nil then
        mmSales.UnMerge(ActiveScreen.GetFormMenu);
      ActiveScreen.Free;
      ActiveScreen := nil;
    end;

    tcMain.Visible := False;
    DDGSalesDataModule.Logout;

    mmiScreen.Enabled := False;
    mmiLogon.Enabled := True;
    mmiLogoff.Enabled := False;

end;

end.
```

Refer to the commentary within the main form's listing (see Listing 33.5) for specifics of each method. The bulk of this application's code exists in `DDGSalesDataModule` (already discussed). The child forms contain most of the logic in regards to the user interface. We will discuss these next.

TCustomerForm: Customer Entry

TCustomerForm is where the user can add, edit, and delete customers from the database. This form is shown in Figure 33.4. Because much of the user interface logic exists in TCustomerForm's ancestor classes, this form's source code is pleasingly thin and simple to understand. Listing 33.6 is the source for TCustomerForm.

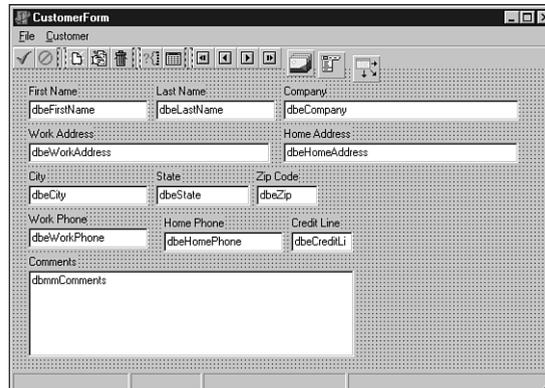


FIGURE 33.4

The customer data-entry form.

LISTING 33.6 Customer Entry Form: TCustomerForm

```
unit CustomerFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  DBNAVSTATFRM, StdCtrls, DBCtrls, Mask, Menus, ImgList, ComCtrls, ToolWin,
  Db, DBModeFrm;

type
  TCustomerForm = class(TDBNavStatForm)
    lblFirstName: TLabel;
    dbfFirstName: TDBEdit;
    lblLastName: TLabel;
    dbfLastName: TDBEdit;
    lblCreditLine: TLabel;
    dbfCreditLine: TDBEdit;
    lblWorkAddress: TLabel;
```

```
    dbeWorkAddress: TDBEdit;
    lblHomeAddress: TLabel;
    dbeHomeAddress: TDBEdit;
    lblCity: TLabel;
    dbeCity: TDBEdit;
    lblState: TLabel;
    dbeState: TDBEdit;
    lblZipCode: TLabel;
    dbeZip: TDBEdit;
    lblWorkPhone: TLabel;
    dbeWorkPhone: TDBEdit;
    lblHomePhone: TLabel;
    dbeHomePhone: TDBEdit;
    lblComments: TLabel;
    dbmmComments: TDBMemo;
    lblCompany: TLabel;
    dbeCompany: TDBEdit;
    dsCustomer: TDataSource;
    EXit1: TMenuItem;
    procedure sbFirstClick(Sender: TObject);
    procedure sbPrevClick(Sender: TObject);
    procedure sbNextClick(Sender: TObject);
    procedure sbLastClick(Sender: TObject);
    procedure sbInsertClick(Sender: TObject);
    procedure sbEditClick(Sender: TObject);
    procedure sbDeleteClick(Sender: TObject);
    procedure sbCancelClick(Sender: TObject);
    procedure sbAcceptClick(Sender: TObject);
    procedure FormShow(Sender: TObject);
    procedure sbFindClick(Sender: TObject);
    procedure sbBrowseClick(Sender: TObject);
private
    procedure SetNavButtons;
public
    function GetFormMenu: TMainMenu; override;
    function CanChange: Boolean; override;
end;

var
    CustomerForm: TCustomerForm;

implementation

uses SalesDM;
```

continues

LISTING 33.6 Continued

```
{SR *.DFM}

procedure TCustomerForm.SetNavButtons;
begin
    // Ensure that the navigational buttons are set according to the form's mode.
    sbFirst.Enabled := not DDGSalesDataModule.IsFirstCustomer;
    sbLast.Enabled  := not DDGSalesDataModule.IsLastCustomer;
    sbPrev.Enabled  := not DDGSalesDataModule.IsFirstCustomer;
    sbNext.Enabled  := not DDGSalesDataModule.IsLastCustomer;

    // synchronize the navigational menu items with the speedbuttons.
    mmiFirst.Enabled := sbFirst.Enabled;
    mmiLast.Enabled  := sbLast.Enabled;
    mmiPrevious.Enabled := sbPrev.Enabled;
    mmiNext.Enabled  := sbNext.Enabled;
end;

procedure TCustomerForm.sbFirstClick(Sender: TObject);
begin
    // Go to the first record in the result set.
    inherited;
    DDGSalesDataModule.FirstCustomer;
    SetNavButtons;
end;

procedure TCustomerForm.sbPrevClick(Sender: TObject);
begin
    // Go to the previous record in the result set.
    inherited;
    DDGSalesDataModule.PrevCustomer;
    SetNavButtons;
end;

procedure TCustomerForm.sbNextClick(Sender: TObject);
begin
    // Go to the next record in the result set.
    inherited;
    DDGSalesDataModule.NextCustomer;
    SetNavButtons;
end;

procedure TCustomerForm.sbLastClick(Sender: TObject);
begin
    // Go to the last record in the result set.
```

```
    inherited;
    DDGSalesDataModule.LastCustomer;
    SetNavButtons;
end;

procedure TCustomerForm.sbInsertClick(Sender: TObject);
begin
    // Insert a new customer.
    inherited;
    DDGSalesDataModule.NewCustomer;
end;

procedure TCustomerForm.sbEditClick(Sender: TObject);
begin
    // Edit the current customer.
    inherited;
    DDGSalesDataModule.EditCustomer;
end;

procedure TCustomerForm.sbDeleteClick(Sender: TObject);
begin
    // Delete the current customer.
    inherited;
    DDGSalesDataModule.DeleteCustomer;
end;

procedure TCustomerForm.sbCancelClick(Sender: TObject);
begin
    // Cancel the Edit or Add operation.
    inherited;
    DDGSalesDataModule.CancelCustomer;
end;

procedure TCustomerForm.sbAcceptClick(Sender: TObject);
begin
    // Accept Add or Edit changes.
    inherited;
    DDGSalesDataModule.AcceptCustomer;
end;

procedure TCustomerForm.FormShow(Sender: TObject);
begin
    // Initialize menus and buttons accordingly.
    inherited;
    SetNavButtons;
end;
```

LISTING 33.6 Continued

```
function TCustomerForm.CanChange: Boolean;
begin
    // Allow the user to change forms only when browsing record.
    Result := FormMode = fmBrowse;
end;

function TCustomerForm.GetFormMenu: TMainMenu;
begin
    { Return the main menu. This is required by the main form for
      menu merging. }
    Result := mmFormMenu;
end;

procedure TCustomerForm.sbFindClick(Sender: TObject);
begin
    // Search for a specific customer by invoking the customer search form.
    inherited;
    DDGSalesDataModule.SearchForCustomer;
end;

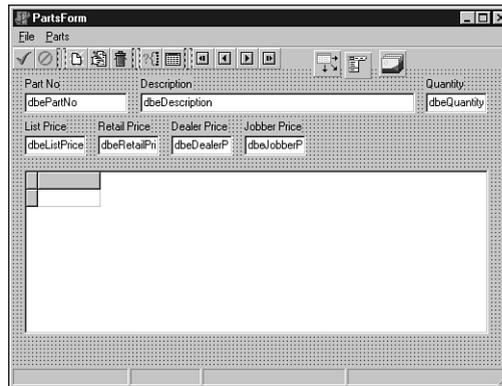
procedure TCustomerForm.sbBrowseClick(Sender: TObject);
begin
    // Set the form to browse mode. This will cancel an edit or add operation.
    inherited;
    if not (FormMode = fmBrowse) then
        DDGSalesDataModule.CancelCustomer;
end;

end.
```

Refer to the listing commentary for explanations of the specific methods. The small amount of code required for this form is possible because most of the database logic exists in `TDDGSalesDataModule`, not to mention how much is handled for you by the VCL. The remaining forms are equally lean.

TPartsForm: Inventory Entry

The parts entry form, `TPartsForm`, is shown in Figure 33.5. Listing 33.7 shows its source code.

**FIGURE 33.5**

The parts data-entry form.

LISTING 33.7 Parts Entry Form: TPartsForm

```
unit PartsFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  DBNAVSTATFRM, Menus, ImgList, ComCtrls, ToolWin, Grids, DBGrids, Db,
  StdCtrls, Mask, DBCtrls, DBModeFrm;

type
  TPartsForm = class(TDBNavStatForm)
    lblPartNo: TLabel;
    dbPartNo: TDBEdit;
    dsParts: TDataSource;
    lblDescription: TLabel;
    dbDescription: TDBEdit;
    lblQuantity: TLabel;
    dbQuantity: TDBEdit;
    lblListPrice: TLabel;
    dbListPrice: TDBEdit;
    lblRetailPrice: TLabel;
    dbRetailPrice: TDBEdit;
    lblDealerPrice: TLabel;
    dbDealerPrice: TDBEdit;
    lblJobberPrice: TLabel;
```

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continues

LISTING 33.7 Continued

```
    dbeJobberPrice: TDBEdit;
    dbgParts: TDBGrid;
    procedure sbAcceptClick(Sender: TObject);
    procedure sbCancelClick(Sender: TObject);
    procedure sbInsertClick(Sender: TObject);
    procedure sbEditClick(Sender: TObject);
    procedure sbDeleteClick(Sender: TObject);
    procedure sbFirstClick(Sender: TObject);
    procedure sbPrevClick(Sender: TObject);
    procedure sbNextClick(Sender: TObject);
    procedure sbLastClick(Sender: TObject);
    procedure FormShow(Sender: TObject);
    procedure sbFindClick(Sender: TObject);
    procedure sbBrowseClick(Sender: TObject);
private
    procedure SetNavButtons;
public
    function GetFormMenu: TMainMenu; override;
    function CanChange: Boolean; override;
end;

var
    PartsForm: TPartsForm;

implementation

uses SalesDM;

{$R *.DFM}

procedure TPartsForm.SetNavButtons;
begin
    // Ensure that the navigational buttons are set according to the form's mode.
    sbFirst.Enabled := not DDGSalesDataModule.IsFirstPart;
    sbLast.Enabled := not DDGSalesDataModule.IsLastPart;
    sbPrev.Enabled := not DDGSalesDataModule.IsFirstPart;
    sbNext.Enabled := not DDGSalesDataModule.IsLastPart;

    // synchronize the navigational menu items with the speedbuttons.
    mmiFirst.Enabled := sbFirst.Enabled;
    mmiLast.Enabled := sbLast.Enabled;
    mmiPrevious.Enabled := sbPrev.Enabled;
    mmiNext.Enabled := sbNext.Enabled;

end;
```

```
procedure TPartsForm.sbAcceptClick(Sender: TObject);
begin
    // Accept add/edit changes to this part.
    inherited;
    DDGSalesDataModule.AcceptPart;
end;

procedure TPartsForm.sbCancelClick(Sender: TObject);
begin
    // Cancel add/Edit operation.
    inherited;
    DDGSalesDataModule.CancelPart;
end;

procedure TPartsForm.sbInsertClick(Sender: TObject);
begin
    // Insert a new part.
    inherited;
    DDGSalesDataModule.NewPart;
end;

procedure TPartsForm.sbEditClick(Sender: TObject);
begin
    // Edit the current part.
    inherited;
    DDGSalesDataModule.EditPart;
end;

procedure TPartsForm.sbDeleteClick(Sender: TObject);
begin
    // Delete the current part.
    inherited;
    DDGSalesDataModule.DeletePart;
end;

procedure TPartsForm.sbFirstClick(Sender: TObject);
begin
    // Go to the first record in the result set.
    inherited;
    DDGSalesDataModule.FirstPart;
    SetNavButtons;
end;

procedure TPartsForm.sbPrevClick(Sender: TObject);
begin
    // Go to the previous record in the result set.
```

LISTING 33.7 Continued

```
    inherited;
    DDGSalesDataModule.PrevPart;
    SetNavButtons;
end;

procedure TPartsForm.sbNextClick(Sender: TObject);
begin
    // Go to the next record in the result set.
    inherited;
    DDGSalesDataModule.NextPart;
    SetNavButtons;
end;

procedure TPartsForm.sbLastClick(Sender: TObject);
begin
    // Go to the last record in the result set.
    inherited;
    DDGSalesDataModule.LastPart;
    SetNavButtons;
end;

procedure TPartsForm.FormShow(Sender: TObject);
begin
    // Initialize the speedbuttons and menu items accordingly.
    inherited;
    SetNavButtons;
end;

function TPartsForm.CanChange: Boolean;
begin
    // Allow the user to change forms, only if not adding or editing a record.
    Result := FormMode = fmBrowse;
end;

function TPartsForm.GetFormMenu: TMainMenu;
begin
    // Return the main menu. This is used by the main form for menu merging of
    // child forms.
    Result := mmFormMenu;
end;

procedure TPartsForm.sbFindClick(Sender: TObject);
begin
    // Search for a part by the part number.
    inherited;
```

```

DDGSalesDataModule.SearchForPart;
end;

procedure TPartsForm.sbBrowseClick(Sender: TObject);
begin
    // Go into browse mode but only after canceling any changes made to the
    // current record.
    inherited;
    if not (FormMode = fmBrowse) then
        DDGSalesDataModule.CancelPart;
end;

end.

```

You will see from the listing that this is almost identical to `TCustomerForm`. This type of consistency is a desired attribute and one that makes code easier to understand.

TSalesForm: Sales Browsing

The sales form is used to browse existing sales (see Figure 33.6). Its source code contains only one method, `GetFormMenu()`, which had to be overridden to return `nil` so that the main form would not attempt to perform a menu-merging operation. We will not show the listing for this form because there is no specific code that we wrote. You will find its unit, `SalesFrm.pas`, on the CD-ROM in the directory for this chapter.

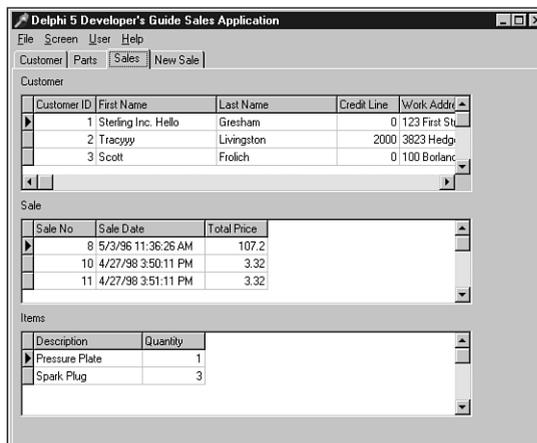


FIGURE 33.6

The sales-browsing form.

TNewSalesForm: Sales Entry

TNewSalesForm is the most complex of the four child forms. Its source is shown in Listing 33.8. Nevertheless, it is still a very simple form. The code commentary discusses the coding logic. In particular, note that we had to create a method to return its TToolBar component. This method already exists in the TDBNavStatForm component of which the other child forms were descendants. This form, however, is a descendant of TChildForm only. Therefore, we needed to create the method for it. Figure 33.7 shows TNewSalesForm.

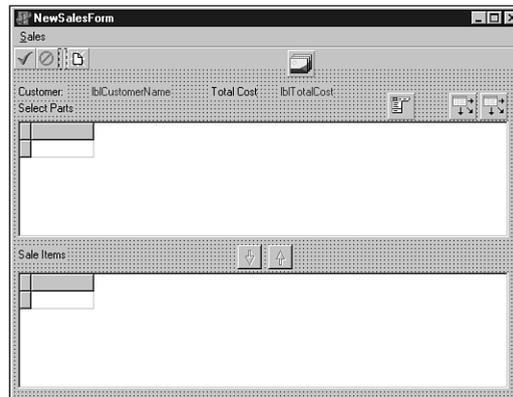


FIGURE 33.7

The new sales data-entry form.

LISTING 33.8 New Sales Entry Form: TNewSalesForm

```
unit NewSalesFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  CHILDFRM, Grids, DBGrids, Buttons, StdCtrls, Db, Menus, ToolWin, ComCtrls,
  ImgList;

type
  TNewSalesForm = class(TChildForm)
    dsParts: TDataSource;
    dsTempItems: TDataSource;
    lblCustomer1: TLabel;
    lblCustomerName: TLabel;
    lblTotCost: TLabel;
```

```
    lblTotalCost: TLabel;
    lblSelectParts: TLabel;
    sbAddPart: TSpeedButton;
    sbRemovePart: TSpeedButton;
    lblSaleItems: TLabel;
    dbgParts: TDBGrid;
    dbgSaleItems: TDBGrid;
    mmFormMenu: TMainMenu;
    mmiSales: TMenuItem;
    mmiNew: TMenuItem;
    mmiCancel: TMenuItem;
    mmiSave: TMenuItem;
    tbSales: TToolBar;
    sbAccept: TToolButton;
    sbCancel: TToolButton;
    tb1: TToolButton;
    sbInsert: TToolButton;
    ilNavigationBar: TImageList;
    procedure FormCreate(Sender: TObject);
    procedure FormDestroy(Sender: TObject);
    procedure FormShow(Sender: TObject);
    procedure sbAddPartClick(Sender: TObject);
    procedure mmiNewClick(Sender: TObject);
    procedure mmiCancelClick(Sender: TObject);
    procedure mmiSaveClick(Sender: TObject);
private
    AddingSale: Boolean;

    procedure SetSaleMenus;
    procedure TempItemsAfterChange(DataSet: TDataSet);
public
    function CanChange: Boolean; override;
    function GetFormMenu: TMainMenu; override;
    procedure SetToolBarParent(AParent: TWinControl);
end;

var
    NewSalesForm: TNewSalesForm;

implementation

uses SalesDM;

{$R *.DFM}

function TNewSalesForm.CanChange: Boolean;
```

LISTING 33.8 Continued

```
begin
    Result := not AddingSale;
end;

procedure TNewSalesForm.FormCreate(Sender: TObject);
begin
    inherited;
    // The tblTempItems table on DDGSalesDataModule is required for this form.
    DDGSalesDataModule.OpenTempItems;
    AddingSale := False; // Initially we're not adding a sale.

    { Assign the TempItemsAfterChange event handler to the event handlers
      surfaced by DDGSalesDataModule. }
    DDGSalesDataModule.AfterTempItemsChange := TempItemsAfterChange;
    SetSaleMenus;
end;

procedure TNewSalesForm.FormDestroy(Sender: TObject);
begin
    // Close the DDGSalesDataModule.tblTempItems table.
    inherited;
    DDGSalesDataModule.CloseTempItems;
end;

procedure TNewSalesForm.FormShow(Sender: TObject);
begin
    // Retrieve the customer name for the current customer.
    inherited;
    lblCustomerName.Caption := DDGSalesDataModule.GetCustomerName;
    { The total should show a balance of zero since the form has just been
      invoked. }
    lblTotalCost.Caption := '$ 0.00';
end;

procedure TNewSalesForm.TempItemsAfterChange(DataSet: TDataSet);
begin
    // This is required in the AfterPost event of the
    // tblTempItems on the datamodule
    // because we must recalculate this everytime the user makes a change.
    lblTotalCost.Caption := FormatFloat('$#,##0.00',
        DDGSalesDataModule.SaleItemsTotalPrice);
end;

procedure TNewSalesForm.sbAddPartClick(Sender: TObject);
begin
```

```
// Add the selected item to the sale.
inherited;
DDGSalesDataModule.AddItemToSale;
end;

procedure TNewSalesForm.mmiNewClick(Sender: TObject);
begin
    // Set the form into a mode to represent adding a sale.
    inherited;
    AddingSale := True;
    SetSaleMenus;
end;

procedure TNewSalesForm.mmiCancelClick(Sender: TObject);
begin
    // Cancel the current sale.
    inherited;
    AddingSale := False;
    DDGSalesDataModule.CancelSale;
    SetSaleMenus;
end;

procedure TNewSalesForm.mmiSaveClick(Sender: TObject);
begin
    // Save the current sale.
    inherited;
    DDGSalesDataModule.SaveSale;
    AddingSale := False;
    SetSaleMenus;
    { Invoke the TempItemsAfterChange event handler to ensure that the form
      updates its controls accordingly. }
    TempItemsAfterChange(nil);
end;

procedure TNewSalesForm.SetSaleMenus;
begin
    // Set menu items and speed buttons to reflect the form's mode.
    mmiNew.Enabled      := not AddingSale;
    mmiCancel.Enabled   := AddingSale;
    mmiSave.Enabled     := AddingSale;
    sbAddPart.Enabled   := AddingSale;
    sbRemovePart.Enabled := AddingSale;

    sbAccept.Enabled    := mmiSave.Enabled;
    sbCancel.Enabled    := mmiCancel.Enabled;
    sbInsert.Enabled    := mmiNew.Enabled;
```

LISTING 33.8 Continued

```
end;

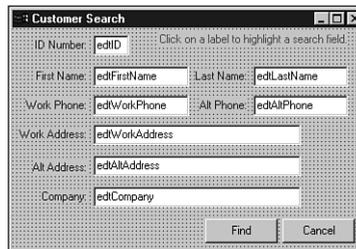
function TNewSalesForm.GetFormMenu: TMainMenu;
begin
    // Return the main menu to be used by the main form for menu merging.
    Result := mmFormMenu;
end;

procedure TNewSalesForm.SetToolBarParent(AParent: TWinControl);
begin
    { This form uses a toolbar, return its parent. We were required to
      create this method for this form as it is a descendant of TChildForm,
      not TDBNavStatForm which already contains this method. }
    tbSales.Parent := AParent;
end;

end.
```

The CustomerSearch Dialog

TCustomerSearchForm is used by DDGSalesDataModule to retrieve a query statement to be used to perform a search on the CUSTOMER table. This form is responsible for obtaining the field values from the user and building the query statement in SQL code. TCustomerSearchForm is shown in Figure 33.8.

**FIGURE 33.8**

The customer search form.

TCustomerSearchForm is not a child form like the previously mentioned forms. TCustomerSearchForm contains no data-aware controls. The user places values into the fields on which a search is to be performed. The user must then click the labels for the fields on which to search. This turns the label's color to c1Red. The logic of TCustomerSearchForm uses the values entered by the user and the TLabel colors to build a SQL query statement.

Listing 33.9 shows the source code for TCustomerSearchForm.

LISTING 33.9 Customer Search Form: TCustomerSearchForm

```
unit CustomerSrchFrm;

interface

uses WinTypes, WinProcs, Classes, Graphics, Forms, Controls, Buttons,
    StdCtrls, SysUtils;

type
    TCustomerSearchForm = class(TForm)
        lblIDNumber: TLabel;
        edtIDNumber: TEdit;
        lblFirstName: TLabel;
        lblLastName: TLabel;
        lblAltPhone: TLabel;
        lblWorkPhone: TLabel;
        lblWorkAddress: TLabel;
        lblAltAddress: TLabel;
        lblCompany: TLabel;
        edtFirstName: TEdit;
        edtLastName: TEdit;
        edtWorkPhone: TEdit;
        edtAltPhone: TEdit;
        edtWorkAddress: TEdit;
        edtAltAddress: TEdit;
        edtCompany: TEdit;
        btnCancel: TButton;
        btnFind: TButton;
        lblInstruction: TLabel;
        procedure FormCreate(Sender: TObject);
        procedure FindCustBtnClick(Sender: TObject);
        procedure CancelBtnClick(Sender: TObject);
        procedure lblIDNumberClick(Sender: TObject);
        procedure FormClose(Sender: TObject; var Action: TCloseAction);
    private
        FindPressed: Boolean;
        procedure ClearEditFields;
        function BuildSQLStatement: string;
    public
        QueryString: String;
    end;

function SearchCustomer: String;
```

LISTING 33.9 Continued

```
implementation

{$R *.DFM}

uses Dialogs;

function SearchCustomer: String;
var
    CustomerSearchForm: TCustomerSearchForm;
begin
    Result := EmptyStr;
    CustomerSearchForm := TCustomerSearchForm.Create(Application);
    try
        if CustomerSearchForm.ShowModal = mrOk then
            Result := CustomerSearchForm.QueryString;
    finally
        CustomerSearchForm.Free;
    end;
end;

function TCustomerSearchForm.BuildSQLStatement: string;
{ This function builds an SQL query statement based on the search
  fields of a customer record as specified by the user. The search
  fields are indicated by the labels whose color is clRed. The user
  can select these labels by clicking on them. The user must enter a
  value into the edit field to which the labels refer. }
var
    Sep: String[3]; // Used as a separator.
begin
    Sep := '';
    Result := '';

    if lblIDNumber.Font.Color = clRed then
        begin
            Result := Format('(CUSTOMER_ID = %s)', [edtIDNumber.Text]);
            Sep := 'AND';
        end;

    if lblLastName.Font.Color = clRed then
        begin
            Result := Format('%s %s (UPPER(LNAME) = "%s")',
                [Result, Sep, UpperCase(edtLastName.Text)]);
            Sep := 'AND';
        end;
end;
```

```
end;

if lblFirstName.Font.Color = clRed then
begin
  Result := Format('%s %s (UPPER(FNAME) = "%s")',
                  [Result, Sep, UpperCase(edtFirstName.Text)]);
  Sep := 'AND';
end;

if lblWorkPhone.Font.Color = clRed then
begin
  Result := Format('%s %s (UPPER(WORK_PHONE) = "%s")',
                  [Result, Sep, UpperCase(edtWorkPhone.Text)]);
  Sep := 'AND';
end;

if lblAltPhone.Font.Color = clRed then
begin
  Result := Format('%s %s (UPPER(ALT_PHONE) = "%s")',
                  [Result, Sep, UpperCase(edtAltPhone.Text)]);
  Sep := 'AND';
end;

if lblWorkAddress.Font.Color = clRed then
begin
  Result := Format('%s %s (UPPER(WORK_ADDRESS) = "%s")',
                  [Result, Sep, UpperCase(edtWorkAddress.Text)]);
  Sep := 'AND';
end;

if lblAltAddress.Font.Color = clRed then
begin
  Result := Format('%s %s (UPPER(ALT_ADDRESS) = "%s")',
                  [Result, Sep, UpperCase(edtAltAddress.Text)]);
  Sep := 'AND';
end;

if lblCompany.Font.Color = clRed then
begin
  Result := Format('%s %s (UPPER(COMPANY) = "%s")',
                  [Result, Sep, UpperCase(edtCompany.Text)]);
end;

if Length(Result) > 0 then
  Result := Format('SELECT CUSTOMER_ID FROM CUSTOMER WHERE (%s)',
                  [Result]);
```

continues

LISTING 33.9 Continued

```
end;

procedure TCustomerSearchForm.ClearEditFields;
{ This method clears all of the edit fields and sets their labels
  to clNavy in color. }
var
  i: word;
begin
  for i := 0 to ComponentCount - 1 do
  begin
    if Components[i] is TEdit then
      TEdit(Components[i]).Text := '';

    if Components[i] is TLabel then
      TLabel(Components[i]).Font.Color := clNavy;
  end;
end;

procedure TCustomerSearchForm.FormCreate(Sender: TObject);
begin
  FindPressed := False;
  // Clear the edit fields.
  ClearEditFields;
end;

procedure TCustomerSearchForm.FindCustBtnClick(Sender: TObject);
begin
  FindPressed := True;
  // Make the QueryString available to the caller of this dialog.
  QueryString := BuildSQLStatement;
end;

procedure TCustomerSearchForm.CancelBtnClick(Sender: TObject);
begin
  ClearEditFields;
end;

procedure TCustomerSearchForm.lblIDNumberClick(Sender: TObject);
{ All labels are hooked to this OnClick event handler which changes
  the color of the labels. The clRed color is used to specify a label on
  which to perform a search operation. }
begin
```

```
with (Sender as TLabel) do
  if Font.Color = clNavy then
    Font.Color := clRed
  else
    Font.Color := clNavy;
end;

procedure TCustomerSearchForm.FormClose(Sender: TObject;
  var Action: TCloseAction);
begin
  { Before closing the form to perform a search operation, make sure
    the user has specified on which fields to perform the search. }
  if (QueryString = '') and FindPressed then
    begin
      MessageDlg('You must highlight a search field by'+
        ' clicking on a label.', mtInformation, [mbOk], 0);
      Action := caNone;
    end
  else begin
      Action := caHide;
      ClearEditFields;
    end;
end;

end.
```

The main method to examine here is the `BuildSQLStatement()` function, which returns a string representing the SQL query statement. This method looks at each of the labels and, if its color is `clRed`, uses its corresponding edit control to build a query statement by using a series of `Format()` statements.

`ClearEditFields()` is a simple method used to set all labels to `clNavy` and to clear the contents of the edit controls. This method is used when the form is created in the `FormCreate()` event handler.

The `FormClose()` event handler ensures that the user has specified fields on which to perform the search by ensuring that `QueryString` is not empty. Only if a field was selected will `QueryString` contain a valid SQL statement. Additionally, this method allows the form to close regardless of the user's specified fields if the user clicked the Cancel button. This is determined by the value of the `FindPressed` Boolean variable, which is set to `True` when the Find button is clicked.

If Find is clicked, the SQL statement is returned to the calling form.

Summary

This concludes the Inventory Application. This chapter illustrates how you would design a client/server, two-tier application. The two-tier model probably makes up the majority of client/server systems. Nevertheless, with the Internet and related technologies, the three-tiered model is becoming more popular and is the topic of later chapters.

Client Tracker: MIDAS Development

CHAPTER

34

IN THIS CHAPTER

- **Designing the Server Application 1786**
- **Designing the Client Application 1789**
- **Summary 1807**

In the previous chapter, “Inventory Manager: Client/Server Development,” we discussed techniques for developing two-tier applications. In this chapter, we will create a three-tier application using the MIDAS technology presented in Chapter 32, “MIDAS Development.” The focus of this chapter is to illustrate the simplicity of using the MIDAS components as well as the briefcase model for offsite work.

The application we will develop lends itself to the briefcase model. This application is a client tracker or manager. Often, sales reps perform much of their work offsite, possibly travelling to several different locations. The client list that these sales reps work with might be critical to both the reps and their parent company. Therefore, this client information should probably reside at the company site. How then, can the sales rep make use of this data without having to rely on a network connection? Also, how can the sales rep update the company data with newer information that he or she is likely to get at the client’s site?

TClientDataSet makes it possible to create briefcase applications with its implementation of *internal caching*, which allows the sales reps to download the data or even a subset of the data with which they can work offsite. Later, when they return to home base, they can upload any changes made to the database. In this chapter, we will build a simple client management tool that illustrates this approach to building briefcase applications.

Designing the Server Application

The server application is designed using the same procedure discussed back in Chapter 32. Here, you will see our TRemoteDataModule, called CustomerRemoteDataModule, containing TSession, TDataBase, TQuery, and TDataSetProvider components. The TSession component, ssnCust, is provided to handle multi-instancing issues (its AutoSessionName property is set to True). DbCust, the TDataBase component, provides the client connection to the database and prevents the login dialog from displaying. QryCust, the TQuery component, returns the result set to the client table. PrvCust is bound to qryCust through its DataSet property. We use the same Customer table presented in the last chapter.

Listing 34.1 shows the source code for the remote data module.

LISTING 34.1 Customer Remote Data Module Source Code

```
unit CustRDM;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  ComServ, ComObj, VCLCom, StdVcl, DataBkr, DBClient, CustServ_TLB,
  Db, DBTables, Provider;
```

```

type

  TFilterType = (ftNone, ftCity, ftState);

  TCustomerRemoteDataModule = class(TRemoteDataModule,
    ICustomerRemoteDataModule)
    ssnCust: TSession;
    dbCust: TDatabase;
    qryCust: TQuery;
    prvCust: TDataSetProvider;
  private
    FFilterStr: String;
    FFilterType: TFilterType;
  public
    { Public declarations }
  protected
    procedure FilterByCity(const ACity: WideString; out Data: OleVariant);
      safecall;
    procedure FilterByState(const AStateStr: WideString; out Data: OleVariant);
      safecall;
    procedure NoFilter(out Data: OleVariant); safecall;
  end;

var
  CustomerRemoteDataModule: TCustomerRemoteDataModule;

implementation

{$R *.DFM}

procedure TCustomerRemoteDataModule.FilterByCity(const ACity: WideString;
  out Data: OleVariant);
begin
  FFilterType := ftCity;
  FFilterStr := ACity;
  qryCust.Close;
  qryCust.SQL.Clear;
  qryCust.SQL.Add(Format('select * from CUSTOMER where CITY = "%s"', [ACity]));
  qryCust.Open;
  Data := prvCust.Data;
end;

procedure TCustomerRemoteDataModule.FilterByState(
  const AStateStr: WideString; out Data: OleVariant);
begin
  FFilterType := ftState;

```

continues

LISTING 34.1 Customer Remote Data Module Source Code

```
FFilterStr := AStateStr;
qryCust.Close;
qryCust.SQL.Clear;
qryCust.SQL.Add(Format('select * from CUSTOMER where STATE = "%s"',
  [AStateStr]));
qryCust.Open;
Data := prvCust.Data;
end;

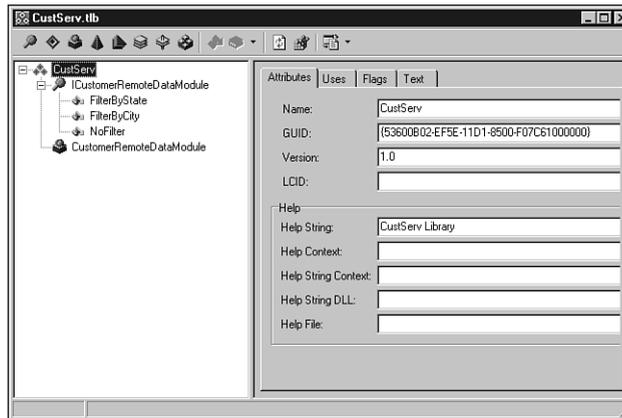
procedure TCustomerRemoteDataModule.NoFilter(out Data: OleVariant);
begin
  FFilterType := ftNone;
  qryCust.Close;
  qryCust.SQL.Clear;
  qryCust.SQL.Add('select * from CUSTOMER');
  qryCust.Open;
  Data := prvCust.Data;
end;

initialization
  TComponentFactory.Create(ComServer, TCustomerRemoteDataModule,
    Class_CustomerRemoteDataModule, ciMultiInstance, tmSingle);
end.
```

Listing 34.1 shows three methods that were added to `TCustomerDataModule`. These methods were actually added to the interface `ICustomerRemoteDateModule` through the Type Library Editor, which in turn created the implementation methods for the `TCustomerRemoteDataModule` class (see Figure 34.1). In the Type Library Editor, we defined the methods and their parameters and then added the code to each implementation method created by Delphi. You can examine the source code for the type library in the file `CustServ_TLB.pas`.

NOTE

This demo is a conversion of a demo written for Delphi 4. To port Delphi 4 MIDAS servers to Delphi 5, you must perform a few steps. These steps are detailed in the online help under "Converting MIDAS Applications."

**FIGURE 34.1**

The Type Library Editor.

The methods `FilterByCity()` and `FilterByState()` are used to allow the client to download a subset of the entire table. This makes sense, because it might not be necessary to download the entire client list when the sales rep is traveling to a single location. Both of these methods take a string parameter that is used to specify the filter value. `NoFilter()` removes any filtering applied to the table.

These methods cause server-side filtering in that they provide a way to limit the records returned to the client. Alternatively, the user may want to perform filtering on the client side. That is, the sales rep may want to access the entire result set but have the ability to filter out desired records as needed. We will illustrate both techniques.

Designing the Client Application

The client application contains a data module and a main form. We will discuss the data module first.

Client Data Module

The data module for the Client Tracker application illustrates several techniques. First, it illustrates how to implement the briefcase model. Second, it shows how to make its mode (online/offline) persistent. In other words, when the user shuts down the application, it will recall its state when executed again. This prevents the application from attempting to attach to the server when the client is running it offline. We also illustrate how to perform client-side filtering. When the user is online, the application will perform server-side filtering. When the user is offline, filtering is performed on the client end. Listing 34.2 shows the source code for `CustomerDataModule`.

LISTING 34.2 Customer Data Module Source Code

```
unit CustDM;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  DBClient, MConnect, Db;

const
  cFileName          = 'CustData.cds';

  cRegIniFile        = 'Software\DDG Client App';
  cRegSection        = 'Startup Config';
  cRegOnlineIdent    = 'Run Online';

type

  TFilterType = (ftNone, ftByCity, ftByState);

  TAddErrorToClientEvent = procedure(const AFieldName, OldStr, NewStr,
    CurStr, ErrMsg: String) of Object;

  TCustomerDataModule = class(TDataModule)
    cdsCust: TClientDataSet;
    dcomCust: TDCOMConnection;
    cdsCustCUSTOMER_ID: TIntegerField;
    cdsCustFNAME: TStringField;
    cdsCustLNAME: TStringField;
    cdsCustCREDIT_LINE: TSmallintField;
    cdsCustWORK_ADDRESS: TStringField;
    cdsCustALT_ADDRESS: TStringField;
    cdsCustCITY: TStringField;
    cdsCustSTATE: TStringField;
    cdsCustZIP: TStringField;
    cdsCustWORK_PHONE: TStringField;
    cdsCustALT_PHONE: TStringField;
    cdsCustCOMMENTS: TMemoField;
    cdsCustCOMPANY: TStringField;
    procedure CustomerDataModuleCreate(Sender: TObject);
    procedure cdsCustReconcileError(DataSet: TClientDataSet;
      E: EReconcileError; UpdateKind: TUpdateKind;
      var Action: TReconcileAction);
    procedure CustomerDataModuleDestroy(Sender: TObject);
    procedure cdsCustFilterRecord(DataSet: TDataSet; var Accept: Boolean);
  private
```

```
FFilterType: TFilterType;
FFilterStr: String;
FOnAddErrorToClient: TAddErrorToClientEvent;

function GetOnline: Boolean;
procedure SetOnline(const Value: Boolean);
{ Private declarations }
protected
function GetChangeCount: Integer;

public
procedure EditClient;
procedure AddClient;
procedure SaveClient;
procedure CancelClient;
procedure DeleteClient;
procedure ApplyUpdates;
procedure CancelUpdates;
procedure First;
procedure Previous;
procedure Next;
procedure Last;
function IsBOF: Boolean;
function IsEOF: Boolean;

procedure FilterByState;
procedure FilterByCity;
procedure NoFilter;

property ChangeCount: Integer read GetChangeCount;
property Online: Boolean read GetOnline write SetOnline;

property OnAddErrorToClient: TAddErrorToClientEvent
  read FOnAddErrorToClient
  write FOnAddErrorToClient;

end;

var
  CustomerDataModule: TCustomerDataModule;

implementation
uses MainCustFrm, Registry;

{$R *.DFM}
```

LISTING 34.2 Continued

```
procedure TCustomerDataModule.AddClient;
begin
    cdsCust.Insert;
end;

procedure TCustomerDataModule.ApplyUpdates;
begin
    cdsCust.ApplyUpdates(-1);
end;

procedure TCustomerDataModule.CancelClient;
begin
    cdsCust.Cancel;
end;

procedure TCustomerDataModule.CancelUpdates;
begin
    cdsCust.CancelUpdates;
end;

procedure TCustomerDataModule.DeleteClient;
begin
    if MessageDlg('Are you sure you want to delete the current record?',
        mtConfirmation, [mbYes, mbNo], 0) = mrYes then
        cdsCust.Delete;
end;

procedure TCustomerDataModule.EditClient;
begin
    cdsCust.Edit;
end;

function TCustomerDataModule.IsBOF: Boolean;
begin
    Result := cdsCust.Bof;
end;

function TCustomerDataModule.IsEOF: Boolean;
begin
    Result := cdsCust.Eof;
end;

procedure TCustomerDataModule.First;
begin
    cdsCust.First;
```

```
end;

procedure TCustomerDataModule.Last;
begin
  cdsCust.Last;
end;

procedure TCustomerDataModule.Next;
begin
  cdsCust.Next;
end;

procedure TCustomerDataModule.Previous;
begin
  cdsCust.Prior;
end;

procedure TCustomerDataModule.SaveClient;
begin
  cdsCust.Post;
end;

procedure TCustomerDataModule.cdsCustReconcileError(
  DataSet: TClientDataSet; E: EReconcileError; UpdateKind: TUpdateKind;
  var Action: TReconcileAction);
{ If an error occurs, update the appropriate TListView on the main form with
  the error data. }
var
  CurStr, NewStr, OldStr: String;
  i: integer;
  V: Variant;

procedure SetString(V: Variant; var S: String);
{ We must test for a null value on V which would be returned if the
  table field was null. This is necessary because we can't typecast null
  as a string. }
begin
  if VarIsNull(V) then
    S := EmptyStr
  else
    S := String(V);
end;

begin
  for i := 0 to DataSet.FieldCount - 1 do
```

continues

LISTING 34.2 Continued

```
begin

    V := DataSet.Fields[i].NewValue;
    SetString(V, NewStr);

    V := DataSet.Fields[i].CurValue;
    SetString(V, CurStr);

    V := DataSet.Fields[i].OldValue;
    SetString(V, OldStr);

    if NewStr <> CurStr then
        if Assigned(FOnAddErrorToClient) then
            FOnAddErrorToClient(DataSet.Fields[i].FieldName, OldStr, NewStr,
                CurStr, E.Message)
        end;
        //Update record and removes changes from the change log.
        Action := raRefresh;
    end;

function TCustomerDataModule.GetChangeCount: Integer;
begin
    Result := cdsCust.ChangeCount;
end;

function TCustomerDataModule.GetOnline: Boolean;
begin
    Result := dcomCust.Connected;
end;

procedure TCustomerDataModule.SetOnline(const Value: Boolean);
begin

    if Value = True then
        begin
            dcomCust.Connected := True;

            if cdsCust.ChangeCount > 0 then begin
                ShowMessage('Your changes must be applied before going online');
                cdsCust.ApplyUpdates(-1);
            end;
            cdsCust.Refresh;

        end
    else begin
```

```
    cdsCust.FileName := cFileName;
    dcomCust.Connected := False;
end;
end;

procedure TCustomerDataModule.CustomerDataModuleCreate(Sender: TObject);
{ Determine if the user last left the application online or offline and
  re-launch the application in that same mode. }
var
  RegIniFile: TRegIniFile;
  IsOnline: Boolean;
begin
  RegIniFile := TRegIniFile.Create(cRegIniFile);
  try
    IsOnline := RegIniFile.ReadBool(cRegSection, cRegOnlineIdent, True);
  finally
    RegIniFile.Free;
  end;

  if IsOnline then
  begin
    dcomCust.Connected := True;
    cdsCust.Open;
  end
  else begin
    cdsCust.FileName := cFileName;
    cdsCust.Open;
  end;
end;

end;

procedure TCustomerDataModule.CustomerDataModuleDestroy(Sender: TObject);
{ Save the online/offline status of the application to the registry. When
  the user runs the application again, it will launch as it was last
  brought down. }
var
  RegIniFile: TRegIniFile;
begin
  RegIniFile := TRegIniFile.Create(cRegIniFile);
  try
    RegIniFile.WriteBool(cRegSection, cRegOnlineIdent, Online);
  finally
    RegIniFile.Free;
  end;
end;
end;
```

LISTING 34.2 Continued

```
procedure TCustomerDataModule.FilterByCity;
{ If we're online, let the server apply the filter so that we only retrieve
  the records we want. Otherwise, apply the filter to the in-memory result
  set of cdsCust. }
var
  CityStr: String;
  Data: OleVariant;
begin
  InputQuery('Filter on City', 'Enter City: ', CityStr);
  FFilterStr := CityStr;

  if Online then
  begin
    dcomCust.AppServer.FilterByCity(CityStr, Data);
    cdsCust.Refresh;
  end
  else begin
    FFilterType := ftByCity;
    cdsCust.Filtered := True;
    cdsCust.Refresh;
  end;
end;

procedure TCustomerDataModule.FilterByState;
{ If we're online, let the server apply the filter so that we only retrieve
  the records we want. Otherwise, apply the filter to the in-memory result
  set of cdsCust. }
var
  StateStr: String;
  Data: OleVariant;
begin
  InputQuery('Filter on State', 'Enter State: ', StateStr);
  FFilterStr := StateStr;

  if Online then
  begin
    dcomCust.AppServer.FilterByState(StateStr, Data);
    cdsCust.Refresh;
  end
  else begin
    FFilterType := ftByState;
    cdsCust.Filtered := True;
    cdsCust.Refresh;
  end;
end;
```

```
end;

procedure TCustomerDataModule.NoFilter;
{ If we're online, let the server apply the filter so that we only retrieve
  the records we want. Otherwise, apply the filter to the in-memory result
  set of cdsCust. }
var
  Data: OleVariant;
begin
  if Online then
  begin
    dcomCust.AppServer.NoFilter(Data);
    cdsCust.Refresh;
  end
  else begin
    FFilterType      := ftNone;
    cdsCust.Filtered := False;
    cdsCust.Refresh;
  end;
end;

procedure TCustomerDataModule.cdsCustFilterRecord(DataSet: TDataSet;
  var Accept: Boolean);
begin
  case FFilterType of
    ftByCity: Accept := DataSet.FieldByName('CITY').AsString = FFilterStr;
    ftByState: Accept := DataSet.FieldByName('STATE').AsString = FFilterStr;
    ftNone: Accept := True;
  end;
end;

end.
```

Initial Wiring

Most of the methods you see in Listing 34.2 are simple methods that perform navigation or manipulation on the client dataset, `cdsCust`. Notice that we provide a method on the data module to expose an operation on `cdsCust` rather than to allow any forms to access it directly. Here, we are just adhering to strict OOP methodologies. Although this is not necessary in Delphi, we do so for consistency and to enforce centralization of database logic.

`CustomerDataModule` contains a `TDCOMConnection` object, `dcomCust`, and the `TClientDataSet` object, `cdsCust`. `dcomCust` is connected to the server application through its `ServerName` property, which is set to `CustServ.CustomerRemoteDataModule`.

CdsCust is linked to qryCust on the remote data module in its `ProviderName` property. That takes care of the wiring necessary to get a MIDAS application's server and client up and running. However, to get the most out of this technology, some code needs to be written.

Error Reconciliation

After the client application passes changes back to the server, errors may occur (especially in the briefcase model, where it is possible that another user has modified a given record). The error can be handled on the server or on the client. If it is handled on the client, the server passes error information back to the client through the `OnReconcileError` handler of `TClientDataSet`. In this event handler, several options are available that we will discuss momentarily. The `OnReconcileError` property refers to a `TReconcileErrorEvent` method, which is defined as follows:

```
TReconcileErrorEvent = procedure(DataSet: TClientDataSet; E:
  EReconcileError; UpdateKind: TUpdateKind; var Action: TReconcileAction)
  of object;
```

The `DataSet` parameter refers to the data set on which the error occurred. `EReconcileError` is an exception class for client dataset errors. You can use this class as you would any exception class. `UpdateKind` can be any of the values specified in Table 34.1. This information comes from Delphi's online help.

TABLE 34.1 The `TUpdateKind` Values

<i>TUpdateKind Value</i>	<i>Meaning</i>
<code>ukModify</code>	The cached update to the record is a modification to the record's contents.
<code>ukInsert</code>	The cached update is the insertion of a new record.
<code>ukDelete</code>	The cached update is the deletion of a record.

The `Action` parameter is of type `TReconcileAction`. By setting the `Action` parameter to `raRefresh`, the client application cancels any changes made by the user and refreshes its copy of the result so that it is the same as the server's copy. This is what is done in the example. Other options for the `Action` property may be set to those values shown in Table 34.2, which comes from Delphi's online help (where you can also look for further information on error reconciliation).

TABLE 34.2 The `TReconcileAction` Values

<i>TReconcileAction Value</i>	<i>Meaning</i>
<code>raSkip</code>	Skips updating the record that raised the error condition and leaves the unapplied changes in the change log
<code>raAbort</code>	Aborts the entire reconcile operation

<i>TReconcileAction Value</i>	<i>Meaning</i>
<code>raMerge</code>	Merges the updated record with the record on the server
<code>raCorrect</code>	Replaces the current updated record with the value of the record in the event handler
<code>raCancel</code>	Backs out all changes for this record, reverting to the original field values
<code>raRefresh</code>	Backs out all changes for this record, replacing it with the current values from the server

Within the `OnReconcileError` handler, you can refer to the `OldValue`, `NewValue`, and `CurValue` properties for each field of the client data set. These are discussed in Chapter 32, “MIDAS Development.”

The `OnReconcileError` event handler for `cdsCust`, `cdsCustReconcileError()`, takes care of retrieving the new, old, and current values of any field for which an error has been passed back to the client upon an update. It then invokes the method referred to by `FOnAddErrorToClient`. `FOnAddErrorToClient` is a method pointer of type `TAddErrorToClientEvent` that is defined at the top of Listing 34.2. You will see in our discussion of the application’s main form, `MainCustForm`, how we implement a `TAddErrorToClientEvent` method and assign it to `FOnAddErrorToClient`. Again, this is another example of how we try to keep the data module independent of the user interface elements.

Online and Offline Data Manipulation

We have provided a Boolean property, `Online`, whose reader and writer methods take care of putting the client in either its online or offline state. The method that does this is `SetOnline()`.

`SetOnline()` sets `dcomCust.Connected` to `True` if the user is going online (that is, connecting to the server). If the user was previously offline, any pending changes are applied to the server database. Errors will result in the `cdsCust.OnReconcileError` event handler that is executed. If the user is going offline, `dcomCust.Connected` is set to `False`. `CdsCust` will still work with its in-memory copy of the data. In fact, because a filename is specified in `cdsCust.FileName`, the data can be stored locally to a flat file.

`GetOnline()` just returns `True` if the user is online.

NOTE

`TClientDataSet.FileName` is specific to Delphi 4 and 5. If you are running Delphi 3, you can accomplish the same thing by invoking the `SaveToFile()` and `LoadFromFile()` methods of `TClientDataSet`.

Online and Offline Persistence

The `OnCreate` and `OnDestroy` event handlers for `CustomerDataModule` ensure that the client application is run in the same mode (online or offline) as when it was last closed. This is done by storing its state in the System Registry, which is checked every time the application runs. The constants defined at the top of Listing 34.2 specify the Registry section and keys.

Filtering Records

`CustomerDataModule` allows the user to filter out certain records based on the client's city or state of residence. Client-side filtering occurs when the status of the application is offline. When the client is online, the server is allowed to perform the filtering. One thing to note is that when the client issues a filter while online, when he or she goes offline, only those records that were part of the filter are saved locally to the client's machine.

The `FilterByCity()` and `FilterByState()` methods call the `FilterbyCity()` and `FilterbyState()` methods of the application server discussed earlier. These methods are called only if the user is online. If the user is offline, filtering is done via the `Filter` property and the `OnFilterRecord` event handler of `TClientDataSet`.

Client Main Form

The main form for the client application is very straightforward. It is shown in Listing 34.3.

LISTING 34.3 MainCustFrm.pas—TMainCustForm

```
unit MainCustFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  DBNAVSTATFRM, Db, StdCtrls, DBCtrls, Mask, ComCtrls, Menus, ImgList,
  ToolWin, DBMODEFRM, Grids, DBGrids;

type

  TMainCustForm = class(TDBNavStatForm)
    pcClients: TPageControl;
    dsClientDetail: TTabSheet;
    lblFirstName: TLabel;
    lblLastName: TLabel;
    lblCreditLine: TLabel;
    lblWorkAddress: TLabel;
    lblAltAddress: TLabel;
    lblCity: TLabel;
    lblState: TLabel;
```

```
lblZipCode: TLabel;  
lblWorkPhone: TLabel;  
lblAltPhone: TLabel;  
lblCompany: TLabel;  
dbeFirstName: TDBEdit;  
dbeLastName: TDBEdit;  
dbeCreditLine: TDBEdit;  
dbeWorkAddress: TDBEdit;  
dbeAltAddress: TDBEdit;  
dbeCity: TDBEdit;  
dbeState: TDBEdit;  
dbeZipCode: TDBEdit;  
dbeWorkPhone: TDBEdit;  
dbeAltPhone: TDBEdit;  
dbeCompany: TDBEdit;  
tsComments: TTabSheet;  
dbmComments: TDBMemo;  
dsClients: TDataSource;  
SaveDialog1: TSaveDialog;  
OpenDialog1: TOpenDialog;  
mmiSave: TMenuItem;  
N3: TMenuItem;  
mmiApplyUpdates: TMenuItem;  
mmiCancelUpdates: TMenuItem;  
mmiMode: TMenuItem;  
mmiOffline: TMenuItem;  
mmiOnline: TMenuItem;  
tsErrors: TTabSheet;  
lvClient: TListView;  
mmiExit: TMenuItem;  
mmiFilter: TMenuItem;  
mmiByState: TMenuItem;  
mmiByCity: TMenuItem;  
mmiNoFilter: TMenuItem;  
tsClientList: TTabSheet;  
DBGrid1: TDBGrid;  
procedure sbAcceptClick(Sender: TObject);  
procedure sbCancelClick(Sender: TObject);  
procedure sbInsertClick(Sender: TObject);  
procedure sbEditClick(Sender: TObject);  
procedure sbDeleteClick(Sender: TObject);  
procedure sbFirstClick(Sender: TObject);  
procedure sbPrevClick(Sender: TObject);  
procedure sbNextClick(Sender: TObject);  
procedure sbLastClick(Sender: TObject);  
procedure FormCreate(Sender: TObject);
```

LISTING 34.3 Continued

```
    procedure mmiOnlineClick(Sender: TObject);
    procedure mmiApplyUpdatesClick(Sender: TObject);
    procedure mmiCancelUpdatesClick(Sender: TObject);
    procedure dsClientsDataChange(Sender: TObject; Field: TField);
    procedure Exit1Click(Sender: TObject);
    procedure mmiExitClick(Sender: TObject);
    procedure mmiByStateClick(Sender: TObject);
    procedure mmiByCityClick(Sender: TObject);
    procedure mmiNoFilterClick(Sender: TObject);
private
    procedure SetControls;
    procedure GoToOnlineMode;
    procedure GoToOfflineMode;

public
    procedure AddErrorToClient(const aFieldName, aOldValue, aNewValue,
        aCurValue, aErrorStr: String);
end;

var
    MainCustForm: TMainCustForm;

implementation

uses CustDM;

{$R *.DFM}

procedure TMainCustForm.AddErrorToClient(const aFieldName, aOldValue,
    aNewValue,
    aCurValue, aErrorStr: String);
{ This method is used to add a TListItem to the TListView, aLV. The items
  added here give an indication of the errors that occur when performing
  updates to the server data. }
var
   NewItem: TListItem;
begin
    NewItem := lvClient.Items.Add;
    NewItem.Caption := aFieldName;
    NewItem.SubItems.Add(aOldValue);
    NewItem.SubItems.Add(aNewValue);
    NewItem.SubItems.Add(aCurValue);
    NewItem.SubItems.Add(aErrorStr);
end;
```

```
procedure TMainCustForm.SetControls;
begin
  // Ensure that the navigational buttons are set according to the form's mode.
  sbFirst.Enabled := not CustomerDataModule.IsBof;
  sbLast.Enabled  := not CustomerDataModule.IsEof;
  sbPrev.Enabled  := not CustomerDataModule.IsBof;
  sbNext.Enabled  := not CustomerDataModule.IsEof;

  // synchronize the navigational menu items with the speedbuttons.
  mmiFirst.Enabled := sbFirst.Enabled;
  mmiLast.Enabled  := sbLast.Enabled;
  mmiPrevious.Enabled := sbPrev.Enabled;
  mmiNext.Enabled  := sbNext.Enabled;

  // Set other menus accordingly

  mmiApplyUpdates.Enabled := mmiOnline.Checked and (FormMode = fmBrowse) and
    (CustomerDataModule.ChangeCount > 0);
  mmiCancelUpdates.Enabled := mmiOnline.Checked and (FormMode = fmBrowse) and
    (CustomerDataModule.ChangeCount > 0);

  mmiOnline.Checked := CustomerDataModule.Online;
  mmiOffline.Checked := not mmiOnline.Checked;

  stbStatusBar.Panels[0].Text := Format('Changed Records: %d',
    [CustomerDataModule.ChangeCount]);

  if CustomerDataModule.Online then
    stbStatusBar.Panels[2].Text := 'Working Online'
  else
    stbStatusBar.Panels[2].Text := 'Working Offline'

end;

procedure TMainCustForm.sbAcceptClick(Sender: TObject);
begin
  inherited;
  CustomerDataModule.SaveClient;
  SetControls;
end;

procedure TMainCustForm.sbCancelClick(Sender: TObject);
begin
  inherited;
```

continues

LISTING 34.3 Continued

```
    CustomerDataModule.CancelClient;
    SetControls;
end;

procedure TMainCustForm.sbInsertClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.AddClient;
    SetControls;
end;

procedure TMainCustForm.sbEditClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.EditClient;
    SetControls;
end;

procedure TMainCustForm.sbDeleteClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.DeleteClient;
    SetControls;
end;

procedure TMainCustForm.sbFirstClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.First;
    SetControls;
end;

procedure TMainCustForm.sbPrevClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.Previous;
    SetControls;
end;

procedure TMainCustForm.sbNextClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.Next;
    SetControls;
end;
```

```
procedure TMainCustForm.sbLastClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.Last;
    SetControls;
end;

procedure TMainCustForm.FormCreate(Sender: TObject);
begin
    inherited;
    CustomerDataModule.OnAddErrorToClient := AddErrorToClient;
    SetControls;

    // Make these guys refer to each other so that they reset the other
    mmiOnline.Tag := Longint(mmiOffline);
    mmiOffline.Tag := Longint(mmiOnline);
end;

procedure TMainCustForm.GoToOnlineMode;
begin
    CustomerDataModule.Online := True;
    SetControls;
end;

procedure TMainCustForm.GoToOfflineMode;
begin
    CustomerDataModule.Online := False;
    SetControls;
end;

procedure TMainCustForm.mmiOnlineClick(Sender: TObject);
var
    mi: TMenuItem;
begin
    inherited;
    mi := Sender as TMenuItem;

    if not mi.Checked then
    begin
        mi.Checked := not mi.Checked;
        TMenuItem(mi.Tag).Checked := not mi.Checked;

        if mi = mmiOnline then
        begin
            if mi.Checked then
```

LISTING 34.3 Continued

```
        GoToOnlineMode
    else
        GoToOfflineMode
    end

    else begin
        if mi.Checked then
            GoToOfflineMode
        else
            GoToOnlineMode
        end;
    end;
end;

procedure TMainCustForm.mmiApplyUpdatesClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.ApplyUpdates;
    SetControls;
end;

procedure TMainCustForm.mmiCancelUpdatesClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.CancelUpdates;
    SetControls;
end;

procedure TMainCustForm.dsClientsDataChange(Sender: TObject;
    Field: TField);
begin
    inherited;
    SetControls;
end;

procedure TMainCustForm.Exit1Click(Sender: TObject);
begin
    inherited;
    Close;
end;

procedure TMainCustForm.mmiExitClick(Sender: TObject);
begin
    inherited;
```

```
    Close;
end;

procedure TMainCustForm.mmiByStateClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.FilterByState;
end;

procedure TMainCustForm.mmiByCityClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.FilterByCity;
end;

procedure TMainCustForm.mmiNoFilterClick(Sender: TObject);
begin
    inherited;
    CustomerDataModule.NoFilter;
end;

end.
```

Most of the methods for `TMainCustForm` call the methods of `CustomerDataModule`.

Notice the `AddErrorToClient()` method. This method serves as the `OnAddErrorToClient` property of `CustomerDataModule`. The `OnCreate` event handler of `TMainCustForm` assigns this method to the data module's property. `AddErrorToClient()` adds any events to the `TListView` control on the main form for the user to examine. This `TListView` control displays the field name, old value, new value, and current values for the error. It also displays the error string.

The simple `SetControls()` method handles setting up various controls on the form. It ensures that controls are enabled or disabled when appropriate. The rest of the methods are discussed in the commentary in the source code.

Summary

Although the Client Tracker is a simple application, most of the wiring necessary for creating three-tier applications is shown in this example. You might also find that you need to implement some other specifics such as callbacks or connection pooling, as discussed in Chapter 32, "MIDAS Development." The point is this: Developing three-tier applications using MIDAS is not harder than developing two-tier or even desktop database applications.

DDG Bug-Reporting Tool: Desktop Application Development

CHAPTER

35

IN THIS CHAPTER

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- **The Data Model 1811**
- **Developing the Data Module 1811**
- **Developing the User Interface 1829**
- **Enabling the Application for
the Web 1837**
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This chapter discusses techniques for developing desktop database applications. The DDG bug-reporting application illustrates several methods to take into consideration, in particular, how to design an application that may be deployed to the Internet. In this demo, we also illustrate several techniques and tricks to get around some sticky issues when separating the user interface from the data-manipulation routines.

Because of Delphi's ease of use, developing database applications is simple. However, it is also easy to overlook issues that may end up biting you later when you want to extend the application's basic functionality. In this chapter, we will show you how to take this into account when creating your database applications.

General Application Requirements

The general requirements for the DDG bug-reporting application are discussed in this section. Be aware that our intentions were not to actually design a deployable bug-reporting tool. Rather, we use a real-world need to illustrate the techniques discussed in this chapter. Therefore, we left out functionality that you might expect from this application so as not to cloud our techniques with application logic.

World Wide Web-Ready

The bug-reporting application must be designed in such a manner as to minimize the development effort to make its functionality available on the World Wide Web. This means that the user interface must be completely—not almost completely—separated from the database logic. In essence, you should be able to attach different user interfaces to the database logic. In fact, you will see this in Chapter 36, “DDG Bug-Reporting Tool: Using WebBroker,” when we make our application available through Web pages.

User Data Entry and Logon

The bug-reporting application contains a table of users who can log on to the system. These users can report the existence of bugs by using this application. Users can also add other users to the bug-reporting application. For this version of the application, it is not required that the users be able to edit or delete user information.

A user logs on to the bug-reporting tool by providing a user name, which is stored in the `Users.db` table. This logon is only for the process of obtaining the user ID, which is needed to manipulate reported bugs—this is not a security measure.

Bug Manipulation, Browsing, and Filtering

Users can add, edit, and delete bug information. Users can also provide the necessary field information for each bug. For example, a user can enter the date the bug is reported; assign it

to another user; and specify a status, a summary, details, and the affected source. The user entering the bug is added automatically.

Bug Actions

Users can add actions (notes) to an existing bug report. Users can also browse actions previously entered by themselves or by other users. This is a handy way to track the bug-correction progress and for interested parties to pass notes back and forth about a bug.

Other UI Functionality

The application must make use of techniques necessary to make the user interface easy to understand and use. Features such as lookup fields and “friendly” display labels will be used where necessary.

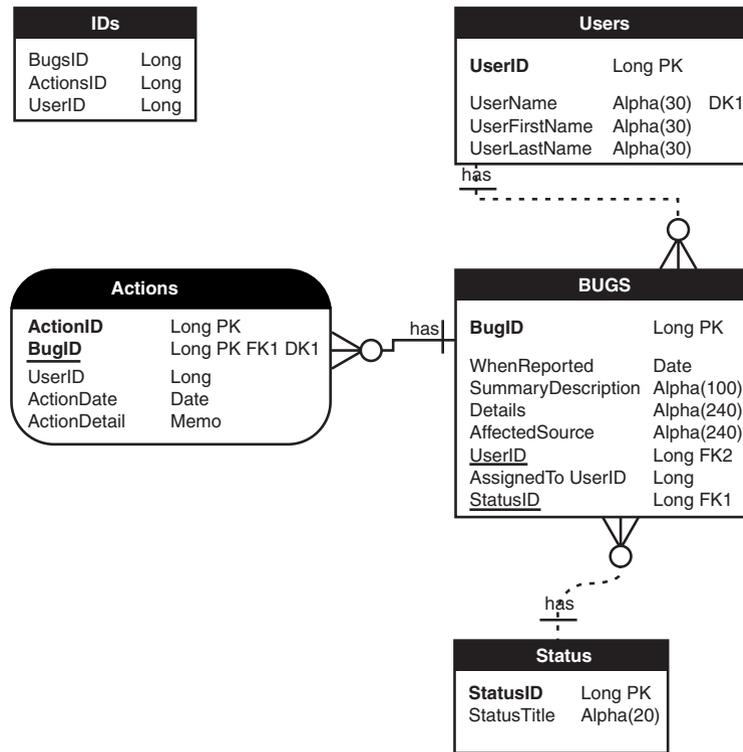
The Data Model

The data model for the bug-reporting application is shown in Figure 35.1. Here is what the tables in the model consist of:

- **IDs.** The IDs table serves as the key generation table and keeps track of the next available key for the Users, Bugs, and Actions tables.
- **Users.** The Users table stores users who are added to the bug-reporting system.
- **Bugs.** The Bugs table stores the general information about bugs.
- **Actions.** The Actions table stores notes on bugs. Each bug may have several notes.
- **Status.** The Status table is a lookup table for assigning a specific status to each bug.

Developing the Data Module

The data module is the central piece to the bug-reporting application. It is through the data module that all database manipulation is handled. The user interface uses the data module’s functionality through public methods and properties. No direct reference to data-access components is made from any user interface element except where necessary from the Object Inspector. An example of directly accessing a data-access component would be in the DataSet property for the TDataSource component that resides on UI forms. Likewise, and even more important, the data module should never access elements that reside in the user interface.

**FIGURE 35.1**

The bug-reporting application data model.

NOTE

When developing applications in which you want to separate data logic from the user interface, the placement of the TDataSource component is not of grave concern. We chose to place it on the UI forms rather than in the data module because we feel it has more to do with user interface than data access. This, however, is a preference, and you may choose to do otherwise for whatever reason.

Listing 35.1 shows the source code for the bug application's data module.

LISTING 35.1 Data Module for the DDGBugs Application

```
unit DDGBugsDM;

interface
```

uses

Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
Db, DBTables, HTTPApp, DBWeb;

type

```
EUnableToObtainID = class(Exception);

TDDGBugsDataModule = class(TDataModule)
  dbDDGBugs: TDatabase;
  tblBugs: TTable;
  tblUsers: TTable;
  tblStatus: TTable;
  tblActions: TTable;
  tblBugsBugID: TIntegerField;
  tblBugsWhenReported: TDateField;
  tblBugsSummaryDescription: TStringField;
  tblBugsDetails: TStringField;
  tblBugsAffectedSource: TStringField;
  tblBugsUserID: TIntegerField;
  tblBugsStatusID: TIntegerField;
  dsUsers: TDataSource;
  dsStatus: TDataSource;
  tblIDs: TTable;
  tblBugsUserNameLookup: TStringField;
  tblBugsAssignedToLookup: TStringField;
  tblUsersUserID: TIntegerField;
  tblUsersUserName: TStringField;
  tblUsersUserFirstName: TStringField;
  tblUsersUserLastName: TStringField;
  tblBugsAssignedToUserID: TIntegerField;
  dsBugs: TDataSource;
  wbdpBugs: TWebDispatcher;
  dstpBugs: TDataSetTableProducer;
  procedure DDGBugsDataModuleCreate(Sender: TObject);
  procedure tblBugsBeforePost(DataSet: TDataSet);
  procedure tblBugsFilterRecord(DataSet: TDataSet; var Accept: Boolean);
  procedure tblUsersBeforePost(DataSet: TDataSet);
  procedure tblBugsAfterInsert(DataSet: TDataSet);
  procedure wbdpBugswaShowAllBugsAction(Sender: TObject;
    Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
  procedure wbdpBugswaIntroAction(Sender: TObject; Request: TWebRequest;
    Response: TWebResponse; var Handled: Boolean);
  procedure wbdpBugswaUserNameAction(Sender: TObject;
    Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
  procedure wbdpBugswaVerifyUserNameAction(Sender: TObject;
```

continues

LISTING 35.1 Continued

```
    Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
private
    FLoginUserID: Integer;
    FLoginUserName: String;

    function GetFilterOnUser: Boolean;
    procedure SetFilterOnUser(const Value: Boolean);
    function GetNumBugs: Integer;
protected
    procedure PostAction(Sender: TObject; Action: TStrings);
public

    // Bugs Methods
    procedure FirstBug;
    procedure LastBug;
    procedure NextBug;
    procedure PreviousBug;
    function IsLastBug: Boolean;
    function IsFirstBug: Boolean;
    function IsBugsTblEmpty: Boolean;
    procedure InsertBug;
    procedure DeleteBug;
    procedure EditBug;
    procedure SaveBug;
    procedure CancelBug;
    procedure SearchForBug;

    // User Functions
    {$IFDEF DDGWEBBUGS}
    procedure AddUser;
    {$ENDIF}

    procedure PostUser(Sender: TObject);
    function GetUserFLName(AUserID: Integer): String;

    // Action Methods

    {$IFDEF DDGWEBBUGS}
    procedure AddAction;
    {$ENDIF}

    procedure GetActions(AActions: TStrings);

    // Id Generation
    function GetDataSetID(const AFieldName: String): Integer;
```

```
function GetNewBugID: Integer;
function GetNewUserID: Integer;
function GetNewActionID: Integer;

// Login Function
function Login: Boolean;

// Exposed properties

property LoginUserID: Integer read FLoginUserID;
property FilterOnUser: Boolean read GetFilterOnUser write SetFilterOnUser;
property NumBugs: Integer read GetNumBugs;
end;

var
  DDGBugsDataModule: TDDGBugsDataModule;

implementation

{$IFDEF DDGWEBBUGS}
uses UserFrm, ActionFrm;
{$ENDIF}

{$R *.DFM}

// Helper functions.

function IsInteger(IntVal: String): Boolean;
var
  v, code: Integer;
begin
  val(IntVal, v, code);
  Result := code = 0;
end;

procedure MemoFromStrings(AMemoField: TMemoField; AStrings: TStrings);
var
  Stream: TMemoryStream;
begin
  Stream := TMemoryStream.Create;
  try
    AStrings.SaveToStream(Stream);
    Stream.Seek(0, soFromBeginning);
    AMemoField.LoadFromStream(Stream);
  finally
    Stream.Free;
  end;
end;
```

continues

LISTING 35.1 Continued

```
    end;
end;

procedure StringsFromMemo(AStrings: TStrings; AMemoField: TMemoField);
var
    Stream: TMemoryStream;
begin
    Stream := TMemoryStream.Create;
    try
        AMemoField.SaveToStream(Stream);
        Stream.Seek(0, soFromBeginning);
        AStrings.LoadFromStream(Stream);
    finally
        Stream.Free;
    end;
end;

// Internal methods

function TDDGBugsDataModule.GetFilterOnUser: Boolean;
begin
    Result := tblBugs.Filtered;
end;

procedure TDDGBugsDataModule.SetFilterOnUser(const Value: Boolean);
begin
    tblBugs.Filtered := Value;
end;

function TDDGBugsDataModule.GetNumBugs: Integer;
begin
    Result := tblBugs.RecordCount;
end;

// Identifier methods

function TDDGBugsDataModule.GetDataSetID(const AFieldName: String): Integer;
const
    MaxAttempts = 50;
var
    Attempts: Integer;
    NextID: Integer;
begin
    tblIDs.Active := True;
    // Try fifty times if until this works or raise an exception
```

```
Attempts := 0;
while Attempts <= MaxAttempts do
begin
  try
    Inc(Attempts);
    // If another user has the table in edit mode, an error occurs here.
    tblIDs.Edit;
    // If we reach the Break statement, we are successful. Break out of loop.
    Break;
  except
    on EDBEngineError do
    begin
      // Do some delay
      Continue;
    end;
  end;
end;

if tblIDs.State = dsEdit then
begin
  // Increment the value obtained from the table and restore the new value
  // to the table for the next record.
  NextID := tblIDs.FieldByName(AFieldName).AsInteger;
  tblIDs.FieldByName(AFieldName).AsInteger := NextID + 1;
  TblIDs.Post;
  Result := NextID;
end
else
  Raise EUnableToObtainID.Create('Cannot create unique ID');
end;

function TDDGBugsDataModule.GetNewActionID: Integer;
begin
  Result := GetDataSetID('ActionsID');
end;

function TDDGBugsDataModule.GetNewBugID: Integer;
begin
  Result := GetDataSetID('BugsID');
end;

function TDDGBugsDataModule.GetNewUserID: Integer;
begin
  Result := GetDataSetID('UsersID');
end;
```

continues

LISTING 35.1 Continued

```
// Initialization/Login methods.

procedure TDDGBugsDataModule.DDGBugsDataModuleCreate(Sender: TObject);
begin
  { These tables are opened in the proper order so the master-detail
    relationship does not fail.}
  dbDDGBugs.Connected := True;
  tblUsers.Active := True;
  tblStatus.Active := True;
  tblBugs.Active := True;
  tblActions.Active := True;
end;

function TDDGBugsDataModule.Login: Boolean;
var
  UserName: String;
begin
  InputQuery('Login', 'Enter User Name: ', UserName);
  Result := tblUsers.Locate('UserName', UserName, []);
  if Result then
  begin
    FLoginUserID := tblUsers.FieldByName('UserID').AsInteger;
    FLoginUserName := tblUsers.FieldByName('UserName').AsString;
  end;
end;

// Bug methods.

procedure TDDGBugsDataModule.FirstBug;
begin
  tblBugs.First;
end;

procedure TDDGBugsDataModule.LastBug;
begin
  tblBugs.Last;
end;

procedure TDDGBugsDataModule.NextBug;
begin
  tblBugs.Next;
end;

procedure TDDGBugsDataModule.PreviousBug;
begin
```

```
tblBugs.Prior;
end;

function TDDGBugsDataModule.IsLastBug: Boolean;
begin
    Result := tblBugs.Eof;
end;

function TDDGBugsDataModule.IsFirstBug: Boolean;
begin
    Result := tblBugs.Bof;
end;

function TDDGBugsDataModule.IsBugsTblEmpty: Boolean;
begin
    // If RecordCount is zero, there are not bugs in the table.
    Result := tblBugs.RecordCount = 0;
end;

procedure TDDGBugsDataModule.InsertBug;
begin
    tblBugs.Insert;
end;

procedure TDDGBugsDataModule.DeleteBug;
var
    Qry: TQuery;
    BugID: Integer;
begin
    if MessageDlg('Delete Action?', mtConfirmation,
        [mbYes, mbNo], 0) = mrYes then
    begin
        BugID := tblBugs.FieldByName('BugID').AsInteger;
        // Use a dynamically created TQuery component to perform these operations.
        Qry := TQuery.Create(self);
        try
            dbDDGBugs.StartTransaction;
            try
                // First delete any action belonging to this bug.
                Qry.DatabaseName := dbDDGBugs.DatabaseName;
                Qry.SQL.Add(Format('DELETE FROM ACTIONS WHERE BugID = %d', [BugID]));
                Qry.ExecSQL;

                // Now delete bug from the bugs table.
                Qry.SQL.Clear;
                Qry.SQL.Add(Format('DELETE FROM BUGS WHERE BugID = %d', [BugID]));
```

continues

LISTING 35.1 Continued

```
        Qry.ExecSQL;

        tblBugs.Refresh;
        tblActions.Refresh;

        dbDDGBugs.Commit;
    except
        dbDDGBugs.Rollback;
        raise;
    end;
finally
    Qry.Free;
end;
end;
end;

procedure TDDGBugsDataModule.EditBug;
begin
    tblBugs.Edit;
end;

procedure TDDGBugsDataModule.SaveBug;
begin
    tblBugs.Post;
end;

procedure TDDGBugsDataModule.CancelBug;
begin
    tblBugs.Cancel;
end;

procedure TDDGBugsDataModule.SearchForBug;
var
    BugStr: String;
begin
    InputQuery('Search for bug', 'Enter bug ID: ', BugStr);
    if IsInteger(BugStr) then
        if not tblBugs.Locate('BugID', StrToInt(BugStr), []) then
            MessageDlg('Bug not found.', mtInformation, [mbOK], 0);
        end;
    end;

    // User methods.

{$IFDEF DDGWEBBUGS}
procedure TDDGBugsDataModule.AddUser;
```

```
begin
  tblUsers.Insert;
  try
    if NewUserForm(PostUser) = mrCancel then
      tblUsers.Cancel;
    except
      { An error occurred. Put the table to browse mode
        and reraise the exception }
      tblUsers.Cancel;
      raise;
    end;
  end;
end;
{$ENDIF}

procedure TDDGBugsDataModule.PostUser(Sender: TObject);
begin
  if tblUsers.State = dsInsert then
    tblUsers.FieldName('UserID').AsInteger := GetNewUserID;
    tblUsers.Post;
  end;
end;

function TDDGBugsDataModule.GetUserFLName(AUserID: Integer): String;
begin
  // Returns the first and last name concatenated.
  if tblUsers.Locate('UserID', AUserID, []) then
    Result := Format('%s %s', [tblUsers.FieldName('UserFirstName').AsString,
      tblUsers.FieldName('UserLastName').AsString])
  else
    Result := EmptyStr;
  end;
end;

{$IFDEF DDGWEBBUGS}
procedure TDDGBugsDataModule.AddAction;
begin
  NewActionForm(PostAction);
end;
{$ENDIF}

procedure TDDGBugsDataModule.GetActions(AActions: TStrings);
var
  Action: TStringList;
  ActionUserId: Integer;

begin
  Action := TStringList.Create;
  try
```

continues

LISTING 35.1 Continued

```
with tblActions do
begin
  tblActions.First;
  while not Eof do
  begin
    Action.Clear;
    ActionUserID := FieldByName('UserID').AsInteger;
    StringsFromMemo(Action, TMemoField(FieldByName('ActionDetail')));
    AActions.Add(Format('Action Added on: %s',
      [FormatDateTime('mmm dd, yyyy',
        FieldByName('ActionDate').AsDateTime)]));
    AActions.Add(Format('Action Added by: %s',
      [GetUserFLName(ActionUserID)]));
    AActions.Add(EmptyStr);
    AActions.AddStrings(Action);
    AActions.Add('=====');
    AActions.Add(EmptyStr);
    tblActions.Next;
  end; // while
end; // with
finally
  Action.Free;
end;
end;

procedure TDDGBugsDataModule.PostAction(Sender: TObject; Action: TStrings);
var
  BugID: Integer;
begin
  tblActions.Insert;
  try
    BugID := tblBugs.FieldByName('BugID').AsInteger;
    tblActions.FieldByName('ActionID').AsInteger := GetNewActionID;
    tblActions.FieldByName('BugID').AsInteger := BugID;
    tblActions.FieldByName('UserID').AsInteger := LoginUserID;
    tblActions.FieldByName('ActionDate').AsDateTime := Date;
    MemoFromStrings(TMemoField(tblActions.FieldByName('ActionDetail')),
      Action);
    tblActions.Post;
  except
    tblActions.Cancel;
    raise;
  end;
end;
```

```
// Event Handlers

procedure TDDGBugsDataModule.tblBugsBeforePost(DataSet: TDataSet);
begin
    if tblBugs.State = dsInsert then
        tblBugs.FieldByName('BugID').AsInteger := GetNewBugID;
end;

procedure TDDGBugsDataModule.tblBugsFilterRecord(DataSet: TDataSet;
    var Accept: Boolean);
begin
    Accept := tblBugs.FieldByName('UserID').AsInteger = FLoginUserID;
end;

procedure TDDGBugsDataModule.tblUsersBeforePost(DataSet: TDataSet);
begin
    if tblUsers.State = dsInsert then
        tblUsers.FieldByName('UserID').AsInteger := GetNewUserID;
end;

procedure TDDGBugsDataModule.tblBugsAfterInsert(DataSet: TDataSet);
begin
    tblBugs.FieldByName('UserID').AsInteger := FLoginUserID;
    tblBugs.FieldByName('UserNameLookup').AsString := FLoginUserName;
end;

end.
```

Application Initialization and Login

You will see in Listing 35.2 that we moved the `TDDGBugsDataModule` so that it is created first. Then we call its `Login()` method, which determines whether the application execution continues. It makes this determination based on whether the username entered actually exists in the `Users.db` table, as shown in the `TDDGBugsDataModule.Login()` method in Listing 35.1.

In order to support user logins, we had to modify the project file as shown in Listing 35.2.

LISTING 35.2 Project File for the Bug-Reporting Application

```
program DDGBugs;

uses
    Forms,
    Dialogs,
    ChildFrm in '..\ObjRepos\CHILDFRM.pas' {ChildForm},
```

continues

LISTING 35.2 Continued

```
DBModeFrm in '..\ObjRepos\DBMODEFRM.pas' {DBModeForm},
DBNavStatFrm in '..\ObjRepos\DBNAVSTATFRM.pas' {DBNavStatForm},
MainFrm in 'MainFrm.pas' {MainForm},
UserFrm in 'UserFrm.pas' {UserForm},
ActionFrm in 'ActionFrm.pas' {ActionForm},
DDGBugsDM in '..\Shared\DDGBugsDM.pas' {DDGBugsDataModule: TDataModule};

{$R *.RES}

begin
  Application.Initialize;
  Application.CreateForm(TDDGBugsDataModule, DDGBugsDataModule);
  if DDGBugsDataModule.Login then
  begin
    Application.CreateForm(TMainForm, MainForm);
    Application.Run;
  end
  else
    MessageDlg('Invalid Login', mtError, [mbOk], 0);
end.
```

Generating Paradox Keys

Because the bug-reporting application uses the Paradox database as the back end, we acquire a slight anomaly that we must get around. This anomaly has to do with the Paradox autoincrement fields. Although Paradox's autoincrement fields can supposedly allow you to use them as key fields, they are highly unreliable. Our experience has been that they can easily become out of sync with foreign keys. We opted to avoid their use and create our own keys based on the values contained in the `IDs.db` table.

The `IDs.db` table stores the next available integer value for the Bugs, Users, and Action keys. The `TDDGBugsDataModule.GetDataSetID()` method ensures that only one user is able to put the specific key field of the `tblIDs` table into Edit mode. This will ensure that no two users get identical key values when inserting records. `GetDataSetID()` is made generic for the three types of keys by passing in the field name for the key value desired. Therefore, this method can be used to obtain keys for bugs, users, and actions. In fact, this method is called by the `GetNewActionID()`, `GetNewBugID()`, and `GetNewUserID()` methods. These three methods may be called whenever posting a record to one of these tables. You do so in the `BeforePost` event handlers for the `tblBugs` and `tblUsers` tables and in the `PostAction()` method for the `tblActions` table.

Bug-Manipulation Routines

The bug-manipulation routines are those methods declared under the comment `// Bug Methods`. Most of these functions are self-explanatory—especially the navigation method, which we will not go into. The method `DeleteBug()` contains most of the code for the bug manipulation routines. This method ensures that any actions belonging to a bug get deleted before the bug record is deleted. We will discuss actions shortly. Here, we are using the transaction functionality of `TDatabase` to wrap this operation in a transaction. This will ensure that no data is lost if an error occurs. Note that to perform transaction processing against a local database such as `Paradox`, you must set the `TransIsolation` property of the `TDatabase` component to `tiDirtyRead`, as we have done.

Browsing/Filtering Bugs

The user is able to browse all bugs in the database or just those bugs belonging to him or her. This is made possible through the use of the `Filtered` property of the `tblBugs` component. When `tblBugs.Filtered` is `True`, the `tblBugs.OnFilterRecord` property is invoked for each record. Here, you display a record only if its `UserID` field is that of the user logged on, as indicated by the global field `FLoginUserID`. Notice how you surface the `Filtered` property of the `tblBugs` table to the user interface. Instead of allowing the user interface to directly access the `tblBugs.Filtered` property, you surface this property through the `TDDGBugsDataModule.FilterOnUser` property. This property's writer method, `SetFilterOnUser()`, performs the assignment to the `tblBugs.Filtered` property. Now, you cannot actually enforce the rule that forms cannot directly access properties of components that reside on a `TDataModule` because the VCL is not using strict OOP visibility rules.

Adding Users

Adding users is done through the `TDDGBugsDataModule.AddUser()` and `TDDGBugsDataModule.PostUser()` methods. The `AddUser()` method invokes a simple dialog with which you add the user data. Note how the `PostUser()` method is passed to the `NewUserForm()` function, which invokes the user form. This illustrates how you can avoid having to make a form invoked by a data module refer right back to that data module. The reason this problem presented itself is because we are protecting the data module components from external access. There are probably a number of ways we could have accomplished this—this just happens to be the one we chose. `NewUserForm()` invokes the form defined in the `UserFrm.pas` unit shown in Listing 35.3.

LISTING 35.3 UserFrm.pas: The User F30orm

```
unit UserFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls, Mask, DBCtrls;

type

  TUserForm = class(TForm)
    lblUserName: TLabel;
    dbeUserName: TDBEdit;
    lblFirstName: TLabel;
    dbeFirstName: TDBEdit;
    lblLastName: TLabel;
    dbeLastName: TDBEdit;
    btnOK: TButton;
    btnCancel: TButton;
    procedure btnOKClick(Sender: TObject);
  private
    FPostUser: TNotifyEvent;
  public
    { Public declarations }
  end;

function NewUserForm(APostUser: TNotifyEvent): Word;

implementation
uses dbTables;
{$R *.DFM}

function NewUserForm(APostUser: TNotifyEvent): Word;
var
  UserForm: TUserForm;
begin
  UserForm := TUserForm.Create(Application);
  try
    UserForm.FPostUser := APostUser;
    Result := UserForm.ShowModal;
  finally
    UserForm.Free;
  end;
end;

procedure TUserForm.btnOKClick(Sender: TObject);
```

```
begin
  if dbeUserName.Text = EmptyStr then begin
    MessageDlg('A user name is required.', mtWarning, [mbOK], 0);
    dbeUserName.SetFocus;
    ModalResult := mrNone;
  end
  else begin
    try
      FPostUser(self);
    except
      on EDBEngineError do
        begin
          MessageDlg('User name already exists.', mtWarning, [mbOK], 0);
          dbeUserName.SetFocus;
          ModalResult := mrNone;
        end;
      end;
    end;
  end;
end;
end.
```

As shown in Listing 35.3, `NewUserForm()` creates the `TUserForm` and displays it. Notice that you assign the `APostUser` parameter to the `FPostUser` field that is of the type `TNotifyEvent`. By declaring `FPostUser` as a method pointer (`TNotifyEvent`), you can assign the `PostUser()` method from `TDDGBugDataModule` to `FPostUser` because `PostUser()` matches the definition of `TNotifyEvent`. This concept was covered in Chapters 20, “Key Elements of the VCL and Runtime Type Information,” and 21, “Writing Delphi Custom Components.”

When the user clicks the OK button, `btnOkClick()` is invoked. Provided a user name was entered, the `TDDGBugDataModule.PostUser()` method (referred to by `FPostUser`) is invoked, which should save the user record (see `PostUser()` in Listing 35.1). If an error occurs in `PostUser()`, the user name already exists in the database. This illustrates another advantage to passing the `PostUser()` method to the `TUserForm`. The `TUserForm` can handle an error raised in the data module. This concept is not that different from developing components. You develop the data module such that it is completely self-contained. You also allow users of the data module to handle any errors raised within the data module.

Adding Actions

Actions are basically notes that are optionally attached to each bug. Anybody can add an action to a bug. The `TDDGBugsDataModule.AddAction()` method calls `NewActionForm()`, which obtains the action data from the user and adds it to the database. `NewActionForm()` is defined in `ActionFrm.pas`, which is shown in Listing 35.4.

LISTING 35.4 ActionFrm.pas: The Action Form

```
unit ActionFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls;

type

  TPostActionEvent = procedure (Sender: TObject; Action: TStrings) of Object;

  TActionForm = class(TForm)
    memAction: TMemo;
    lblAction: TLabel;
    btnOK: TButton;
    btnCancel: TButton;
    procedure btnOKClick(Sender: TObject);
  private
    FPostAction: TPostActionEvent;
  public
    { Public declarations }
  end;

procedure NewActionForm(APostAction: TPostActionEvent);

implementation
{$R *.DFM}

procedure NewActionForm(APostAction: TPostActionEvent);
var
  ActionForm: TActionForm;
begin
  ActionForm := TActionForm.Create(Application);
  try
    ActionForm.FPostAction := APostAction;
    ActionForm.ShowModal;
  finally
```

```
        ActionForm.Free;  
    end;  
end;  
  
procedure TActionForm.btnOKClick(Sender: TObject);  
begin  
    if Assigned(FPostAction) then  
        FPostAction(Self, memAction.Lines);  
end;  
  
end.
```

Much like `NewUserForm()`, the `NewActionForm()` method takes a method pointer as a parameter. This time, we defined our own method type of `TPostActionEvent`, which takes a `TObject` and the `TStrings` object containing the action text. When the user clicks the OK button, the `btnOKClick()` event is invoked, which in turn invokes `TDDGBugsDataSource.PostAction()` to add the action to the database (`FPostAction` refers to `PostAction()`).

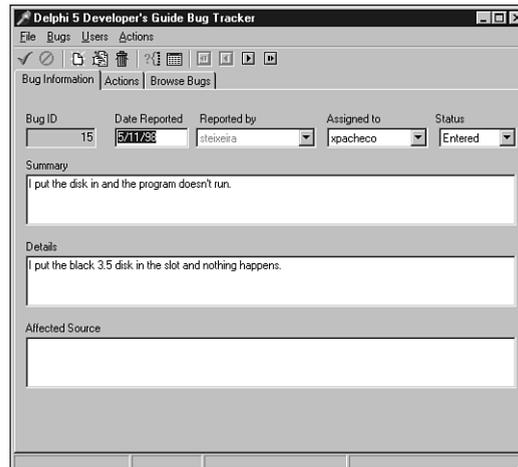
You can refer to the source commentary for additional information on the data module. Later, you will see how to add code to this data module to share it with another application—an ISAPI server that Web-enables the bug program.

Developing the User Interface

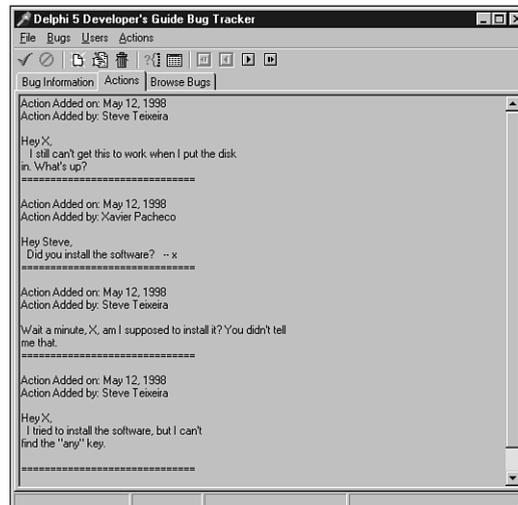
In this section, we will discuss the development of the user interface for this application. We will also point out some preparations you can make for Web deployment of this application.

The Main Form

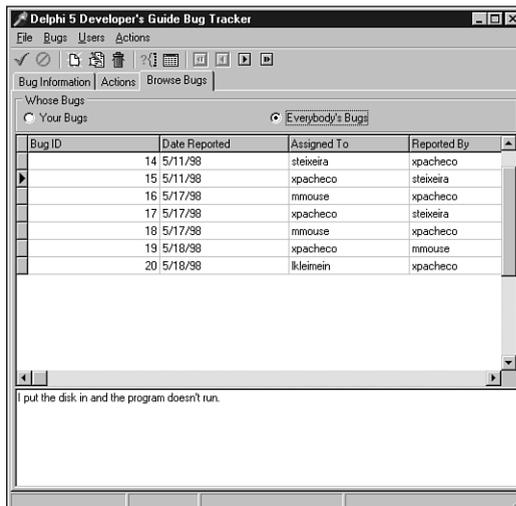
The user interface basically refers to the methods of the data module. We have a single form interface consisting of three pages. The first page allows the user to add, edit, and view the bug information. The second page is for browsing actions. The third page allows the user to view a grid that contains either all the bugs or only the currently logged-in user's bugs. Figures 35.2, 35.3, and 35.4 show the three pages for the main form.

**FIGURE 35.2**

The Bug Information page.

**FIGURE 35.3**

The Actions page.

**FIGURE 35.4**

The Browse Bugs page.

TMainForm is defined in MainFrm.pas, which is shown in Listing 35.5.

LISTING 35.5 The Main Form for the DDGBugs Application

```
unit MainFrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  DBNAVSTATFRM, Menus, ImgList, ComCtrls, ToolWin, StdCtrls, DBCtrls, Db,
  Mask, dbModeFrm, ActnList, Grids, DBGrids, ExtCtrls;

type

  TMainForm = class(TDBNavStatForm)
    pcMain: TPageControl;
    tsBugInformation: TTabSheet;
    tsActions: TTabSheet;
    lblBugID: TLabel;
    dbeBugID: TDBEdit;
    dsBugs: TDataSource;
    lblDateReported: TLabel;
    lblSummary: TLabel;
```

continues

LISTING 35.5 Continued

```
    lblDetails: TLabel;  
    lblAffectedSource: TLabel;  
    lblReportedBy: TLabel;  
    lblAssignedTo: TLabel;  
    lblStatus: TLabel;  
    dbmSummary: TDBMemo;  
    dbmDetails: TDBMemo;  
    dbmAffectedSource: TDBMemo;  
    tsBrowseBugs: TTabSheet;  
    rgWhoseBugs: TRadioGroup;  
    dbgBugs: TDBGrid;  
    dbmSummary2: TDBMemo;  
    memAction: TMemo;  
    dblcAssignedTo: TDBLookupComboBox;  
    dblcStatus: TDBLookupComboBox;  
    dbeDateReported: TDBEdit;  
    mmiFile: TMenuItem;  
    mmiExit: TMenuItem;  
    mmiUsers: TMenuItem;  
    mmiAddUser: TMenuItem;  
    mmiActions: TMenuItem;  
    mmiAddActionToBug: TMenuItem;  
    dblcReportedBy: TDBLookupComboBox;  
    procedure FormCreate(Sender: TObject);  
    procedure sbFirstClick(Sender: TObject);  
    procedure sbPreviousClick(Sender: TObject);  
    procedure sbNextClick(Sender: TObject);  
    procedure sbLastClick(Sender: TObject);  
    procedure sbSearchClick(Sender: TObject);  
    procedure FormCloseQuery(Sender: TObject; var CanClose: Boolean);  
    procedure sbAcceptClick(Sender: TObject);  
    procedure sbCancelClick(Sender: TObject);  
    procedure sbInsertClick(Sender: TObject);  
    procedure sbEditClick(Sender: TObject);  
    procedure sbDeleteClick(Sender: TObject);  
    procedure sbBrowseClick(Sender: TObject);  
    procedure rgWhoseBugsClick(Sender: TObject);  
    procedure mmiExitClick(Sender: TObject);  
    procedure mmiAddUserClick(Sender: TObject);  
    procedure mmiAddActionToBugClick(Sender: TObject);  
    procedure dsBugsDataChange(Sender: TObject; Field: TField);  
private  
    procedure SetActionStatus;  
  
protected
```

```
public
  { Public declarations }
end;

var
  MainForm: TMainForm;

implementation

uses DDGBugsDM;

{$R *.DFM}

{ TMainForm }

procedure TMainForm.SetActionStatus;
begin
  mmiFirst.Enabled := not DDGBugsDataModule.IsFirstBug;
  mmiLast.Enabled  := not DDGBugsDataModule.IsLastBug;
  mmiNext.Enabled  := not DDGBugsDataModule.IsLastBug;
  mmiPrevious.Enabled := not DDGBugsDataModule.IsFirstBug;
  mmiDelete.Enabled := not DDGBugsDataModule.IsBugTblEmpty;

  sbFirst.Enabled := mmiFirst.Enabled;
  sbLast.Enabled  := mmiLast.Enabled;
  sbNext.Enabled  := mmiNext.Enabled;
  sbPrev.Enabled  := mmiPrevious.Enabled;
  sbDelete.Enabled := mmiDelete.Enabled;

  // User cannot add users or actions when adding/editing a bug.
  mmiUsers.Enabled := FormMode = fmBrowse;
  mmiActions.Enabled := (FormMode = fmBrowse) and
    (DDGBugsDataModule.NumBugs <> 0);

  { disable the browsing of bug records when the user is editing or adding
    a new bug. }
  dbgBugs.Enabled      := FormMode = fmBrowse;
  rgWhoseBugs.Enabled := FormMode = fmBrowse;

end;

procedure TMainForm.FormCreate(Sender: TObject);
begin
  inherited;
  SetActionStatus;
end;
```

continues

LISTING 35.5 Continued

```
procedure TMainForm.sbFirstClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.FirstBug;
    SetActionStatus;
end;

procedure TMainForm.sbPreviousClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.PreviousBug;
    SetActionStatus;
end;

procedure TMainForm.sbNextClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.NextBug;
    SetActionStatus;
end;

procedure TMainForm.sbLastClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.LastBug;
    SetActionStatus;
end;

procedure TMainForm.sbSearchClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.SearchForBug;
end;

procedure TMainForm.FormCloseQuery(Sender: TObject; var CanClose: Boolean);
var
    Rslt: word;
begin
    inherited;
    if not (FormMode = fmBrowse) then
    begin
        rslt := MessageDlg('Save changes?', mtConfirmation, mbYesNoCancel, 0);
        case rslt of
            mrYes:
                begin
                    DDGBugsDataModule.SaveBug;
                end;
        end;
    end;
end;
```

```
        FormMode := fmBrowse;
        CanClose := True;
    end;
mrNo:
    begin
        DDGBugsDataModule.CancelBug;
        FormMode := fmBrowse;
        CanClose := True;
    end;
mrCancel:
    CanClose := False;
end;
end;
end;

procedure TMainForm.sbAcceptClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.SaveBug;
    SetActionStatus;
end;

procedure TMainForm.sbCancelClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.CancelBug;
    SetActionStatus;
end;

procedure TMainForm.sbInsertClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.InsertBug;
    SetActionStatus;
end;

procedure TMainForm.sbEditClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.EditBug;
    SetActionStatus;
end;

procedure TMainForm.sbDeleteClick(Sender: TObject);
begin
    inherited;
```

continues

LISTING 35.5 Continued

```
    DDGBugsDataModule.DeleteBug;
    SetActionStatus;
end;

procedure TMainForm.sbBrowseClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.CancelBug;
    SetActionStatus;
end;

procedure TMainForm.rgWhoseBugsClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.FilterOnUser := rgWhoseBugs.ItemIndex = 0;
end;

procedure TMainForm.mmiExitClick(Sender: TObject);
begin
    inherited;
    Close;
end;

procedure TMainForm.mmiAddUserClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.AddUser;
end;

procedure TMainForm.mmiAddActionToBugClick(Sender: TObject);
begin
    inherited;
    DDGBugsDataModule.AddAction;
    dsBugsDataChange(nil, nil);
end;

procedure TMainForm.dsBugsDataChange(Sender: TObject; Field: TField);
begin
    inherited;
    // A new bug is being displayed so clear the action list and
    // retrieve the actions for the newly displayed bug.
    memAction.Lines.Clear;
    DDGBugsDataModule.GetActions(memAction.Lines);
end;

end.
```

TMainForm descends from TDBNavStatForm, which was presented back in Chapter 4, “Application Frameworks and Design Concepts.” It should exist in your Object Repository. TDBNavStatForm contains the functionality to update the speedbuttons and status bar based on the form’s mode (Add, Edit, or Browse). Most of the methods simply call the corresponding data module methods.

Note that you set the dsBugs.AutoEdit property to False, thus preventing the user from inadvertently placing the table into Edit mode. You want to have the user explicitly set the Bugs table to Edit or Insert mode by clicking the appropriate buttons or menu items.

This form is uncomplicated. SetActionStatus() simply enables/disables buttons and menus based on various conditions. FormCloseQuery() ensures that the user saves or cancels any pending edit or insert.

Other User Interface Issues

From the data module, we have controlled how field labels are displayed by adding the fields to the TTable object and specifying a friendlier label in the Object Inspector. The same can be done for TDBGrid objects by modifying the Title property of the TDBGrid.Columns property. We have used both methods to control the labels displayed to the user.

Enabling the Application for the Web

We stated earlier that a Web-enabled version of the application is required. To make this possible, we need to remove any references to any forms from within TDDGBugsDataModule. Using the conditional compilation directives you will see in the DDGBugsDM.pas unit does this. For example, examine the following code:

```
{IFDEF DDGWEBBUGS}
  procedure AddUser;
{ENDIF}
```

The {IFDEF} condition ensures that the AddUser() method is compiled into the application only if the DDGWEBBUGS conditional directive is not defined, which is the case for this application.

Summary

In this chapter we discussed techniques for developing a desktop database application. We also emphasized separating the user interface from the data manipulation routines. This will make converting the application to a Web-enabled version easier. The next chapter, “DDG Bug-Reporting Tool: Using WebBroker,” illustrates how to do just that.

DDG Bug-Reporting Tool: Using WebBroker

CHAPTER

36

IN THIS CHAPTER

- **The Page Layout 1840**
- **Changes to the Data Module 1841**
- **Setting Up the TDataSetTableProducer
Component: dstpBugs 1841**
- **Setting Up the TWebDispatcher
Component: wbdpBugs 1842**
- **Setting Up the TPageProducer
Component: pprdBugs 1843**
- **Coding the DDGWebBugs ISAPI Server:
Adding TActionItem Instances 1843**
- **Browsing Bugs 1850**
- **Adding a New Bug 1856**
- **Summary 1861**

The last chapter, “DDG Bug Reporting Tool: Desktop Application Development,” demonstrated various techniques for designing desktop database applications. One consideration we discussed was how to develop an application that you plan to deploy to the World Wide Web. In this chapter, we are going to deploy the last chapter’s application, a simple bug-reporting tool, to the World Wide Web as an ISAPI server. As stated in the previous chapter, this effort should require minimal modifications to the code already written. We will use the techniques covered in Chapter 31, “Internet-Enabling Your Applications with WebBroker.” Therefore, we will not go into any detail here on topics covered in that chapter. If you feel you need to review Chapter 31, you might do so before reading on.

The Page Layout

The layout (flow) of this Web-based bug-reporting tool is illustrated in Figure 36.1.

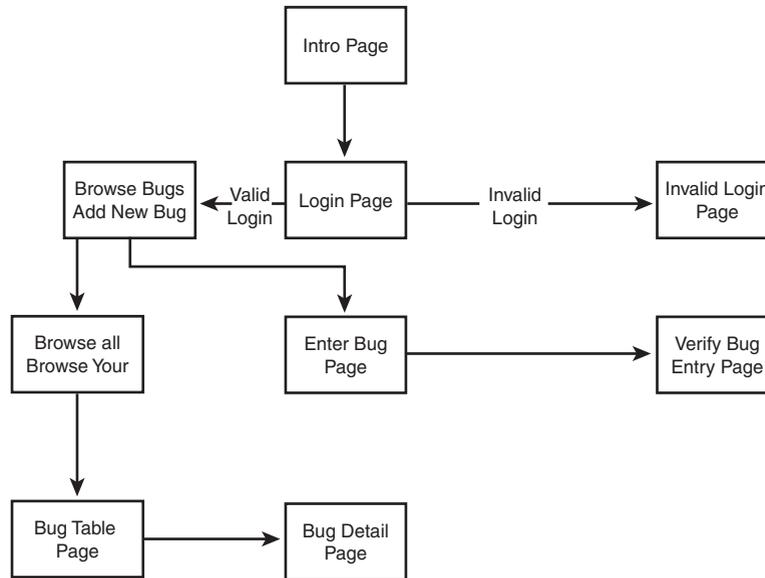


FIGURE 36.1

The flow for the Web-based bug-reporting tool.

You can see from the page layout that this application is really a subset of the functionality presented in Chapter 35. As an exercise, feel free to expand on the techniques demonstrated in this chapter to provide the full functionality presented in the previous chapter.

The following sections explain the code used to develop the pages. You will notice in this example that all pages are created at runtime—that is, no predefined HTML documents are

loaded. There weren't any compelling reasons why we chose this method instead of writing some HTML documents that are loaded by the WebBroker components. You can certainly use the latter approach for your applications.

Changes to the Data Module

Our intent here is to use much of the functionality and components we used in designing `TDDGBugsDataModule` from the last chapter. We mainly want to add functionality to that data module and minimize any changes that could potentially break its use in the original non-Web-based application. We accomplish this by avoiding making changes to already existing methods. We also recompile and test the original application to further verify that the previous application is left intact.

Note that we did not have to create a separate Web module; rather, we just added the `TWebDispatcher` component to the existing `TDataModule`. This allows us to use `TDataModule` as we had already designed it.

For this Web-based version of the bug-reporting tool, we have added four more components to `TDDGBugsDataModule`: `TWebDispatcher`, `TDataSetTableProducer`, `TPageProducer`, and `TSession`. We will use these components throughout the code.

We should also mention the purpose of the `TSession` component. The ISAPI server DLL can potentially be accessed by multiple clients, meaning that multiple people might be trying to hit the database simultaneously through this single DLL instance. This DLL will operate within a single process space. Therefore, each client that attempts to hit the server requires a separate, dedicated Web module. These separate Web modules are created at runtime and are handled in their own unique thread. This also necessitates each database connection getting its own `TSession` component in order to prevent database connections from conflicting with each other when multiple clients hit the database. By setting the `TSession.AutoSessionName` property of the `TSession` component to `True`, we ensure that each `TSession` instance is also given its own unique name. Actually, it is the thread that requires its own BDE session.

Note that adding a `TSession` component to the Web module or to `TDataModule` is not required when writing a WinCGI or CGI server application, because these are compiled to separate applications that operate in their own process spaces.

Setting Up the `TDataSetTableProducer` Component: `dstpBugs`

The data module's `TDataSetTableProducer` component, `dstpBugs`, is attached to the `TTable` component, `tblBugs`. Much like configuring a `TDBGrid`, we have modified the

`dstpBugs.Columns` property to specify titles other than the default (see Figure 36.2). These are the titles that will show up in the Web page table. We have also modified the `dstpBugs.TableAttributes` property to allow for a one-pixel wide border that will give the table a three-dimensional appearance on most Web browsers.

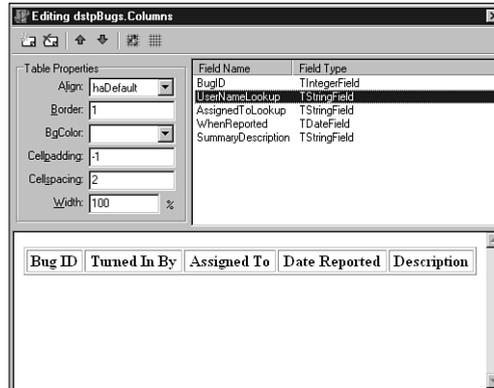


FIGURE 36.2

Editing the Columns property for dstpBugs.

Setting Up the TWebDispatcher Component: wbdpBugs

Figure 36.3 shows the Actions editor used to add several `TWebActionItem` instances to `wbdpBugs`. We will get into the details of each of these actions as well as how they present the user with access to the bug application through the Web.

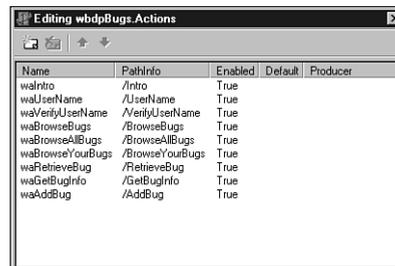


FIGURE 36.3

Editing the Actions property for wbdpBugs.

Setting Up the TPageProducer Component: pprdBugs

If you bring up the `pprdBugs.HTMLDoc` property, you will notice that it is empty. This property is manipulated at runtime programmatically. We will use this same instance of `TPageProducer` in two different situations, as you will see when we discuss the code.

Coding the DDGWebBugs ISAPI Server: Adding TActionItem Instances

All the functionality of the Web bug-reporting tool is provided through the `TWebDispatcher` component's `TActionItem` instances. Table 36.1 shows the purpose of each `TActionItem` instance. We will discuss each of these separately.

TABLE 36.1 The Purpose of the `TActionItem` Instances

<code>TActionItem</code>	<i>Purpose</i>
<code>waIntro</code>	Displays an initial introductory page to the user.
<code>waUserName</code>	Prompts the user to enter a username.
<code>waVerifyUserName</code>	Invoked from <code>waUserName.OnAction</code> . Verifies the username entered by the user.
<code>waBrowseBugs</code>	Displays two selections to the user: Browse All Bugs and Browse User's Bugs Only.
<code>waBrowseAllBugs</code>	Displays a table containing all the bugs in the database.
<code>waBrowseYourBugs</code>	Displays a table containing bugs belonging to the user.
<code>waRetrieveBug</code>	Displays detail information on the bugs.
<code>waGetBugInfo</code>	Provides the input page to which the user enters new bug information.
<code>waAddBug</code>	Adds the new bug to the table and displays a verification screen.

In the following sections, we will show the individual listing for each method added to the `DDBBugsDM.pas` unit instead of showing the entire listing.

Helper Routines

The `AddHeader()` procedure, shown in Listing 36.1, is used to add a standard header to the Web bug pages consisting of the page title and header. Also, the background image to use is specified here. Note that the location of this background image is dependant on the Web server. You will most likely have to modify this statement, depending on your system, to be able to

find the image. `AddFooter()`, shown in Listing 36.2, is used to add the standard footer information, including the copyright statement.

LISTING 36.1 `TDDGBugsDataModule.AddHeader()` Is Used to Add the Standard Header Information

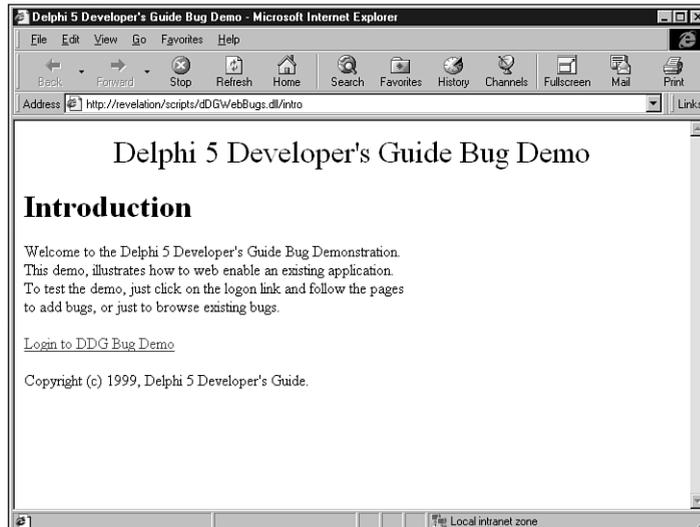
```
procedure AddHeader(AWebPage: TStringList);
// Adds a standard header to each web page.
begin
  with AWebPage do
  begin
    Add('<HTML>');
    Add('<HEAD>');
    Add('<BODY BACKGROUND=''/samples/images/backgrnd.gif''>');
    Add('<TITLE>Delphi 5 Developer's Guide Bug Demo</Title>');
    Add('<CENTER>');
    Add('<P>');
    Add('<FONT SIZE=6>Delphi 5 Developer's Guide Bug Demo</font>');
    Add('</CENTER>');
    Add('</HEAD>');
  end;
end;
```

LISTING 36.2 `TDDGBugsDataModule.AddFooter()` Is Used to Add the Standard Footer Information

```
procedure AddFooter(AWebPage: TStringList);
// Adds the standard footer information to each web page.
begin
  with AWebPage do
  begin
    Add('<BR><BR>Copyright (c) 1998, Delphi 5 Developer's Guide. ');
    Add('</BODY>');
    Add('</HTML>');
  end;
end;
```

The Introduction Page

The introduction page is shown in Figure 36.4. It is created by the `waIntro.OnAction` event handler, `wbdpBugswaIntroAction()`, which is shown in Listing 36.3.

**FIGURE 36.4**

The Introduction page.

LISTING 36.3 TDDGBugsDataModule.wbdpBugswaIntroAction() Displays an Initial Introductory Page

```

procedure TDDGBugsDataModule.wbdpBugswaIntroAction(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
// Introductory page for the web demo.
var
  WebPage: TStringList;
begin
  WebPage := TStringList.Create;
  try
    AddHeader(WebPage);
    with WebPage do
      begin
        Add('<BODY>');
        Add('<H1>Introduction</H1>');
        Add('<P>Welcome to the Delphi 5 Developer's Guide Bug Demonstration. ');
        Add('<BR>This demo, illustrates how to web enable an existing
↳application. ');
        Add('<BR>To test the demo, just click on the logon
↳link and follow the pages ');
        Add('<BR>to add bugs, or just to browse existing bugs. ');
        Add('</P>');
      end;
    end;
end;

```

continues

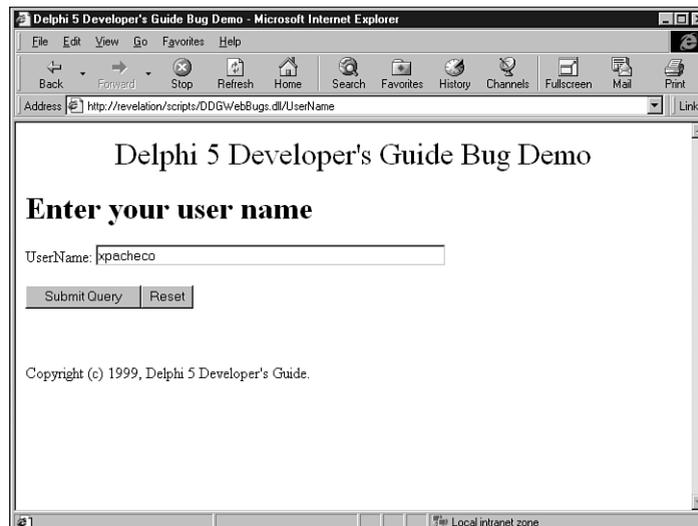
LISTING 36.3 Continued

```
Add(' <A href=" ../DDGWebBugs.dll/UserName">Login to DDG Bug Demo</A>');
AddFooter(WebPage);
Response.Content := WebPage.Text;
Handled := True;
end;
finally
  WebPage.Free;
end;
end;
```

You will notice that in each instance where a Web page is generated, we pass WebPage to the AddHeader() and AddFooter() procedures. The introduction page is straightforward enough. It simply contains a link to the TWebAction, waUserName. For information on TWebAction, see Chapter 31.

Obtaining and Verifying the User Login Name

Figure 36.5 shows the page generated by TDDGBugsDataModule.wbdpBugswaUserNameAction() (see Listing 36.4). This is basically an HTML form used to obtain the username. This page invokes the TDDGBugsDataModule.wbdpBugswaVerifyUserNameAction() event handler (see Listing 36.5).

**FIGURE 36.5**

Obtaining the username.

LISTING 36.4 TDDGBugsDataModule.wbdpBugswaUserNameAction() Displays the Username Retrieval Page

```

procedure TDDGBugsDataModule.wbdpBugswaUserNameAction(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
// This page prompts the user for the username.
var
  WebPage: TStringList;
begin
  WebPage := TStringList.Create;
  try
    AddHeader(WebPage);
    with WebPage do
      begin
        Add('<BODY>');
        Add('<H1>Enter your user name</H1>');
        Add('<FORM action="..\\DDGWebBugs.dll\\VerifyUserName" method="GET">');
        Add('<p>UserName: <INPUT type="text" name="UserName" maxlength="30"
  size="50"></P>');
        Add('<p><INPUT type="SUBMIT"><INPUT type="RESET"></p>');
        Add('</FORM>');
        AddFooter(WebPage);
        Response.Content := WebPage.Text;
        Handled := True;
      end;
    finally
      WebPage.Free;
    end;
end;

```

LISTING 36.5 TDDGBugsDataModule.wbdpBugswaVerifyUserNameAction() Verifies the Username

```

procedure TDDGBugsDataModule.wbdpBugswaVerifyUserNameAction(
  Sender: TObject; Request: TWebRequest; Response: TWebResponse;
  var Handled: Boolean);
{ This page takes the name entered by the user. The information is saved
  and passed back to the client as a cookie. Additional information is also
  passed back as a cookie that will be used later for adding bugs from
  the Web. }
var
  WebPage: TStringList;
  CookieList: TStringList;
  UserName: String;

```

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continues

LISTING 36.5 Continued

```
UserFName,
UserLName: String;
UserID: Integer;
ValidLogin: Boolean;

procedure BuildValidLoginPage;
begin
  AddHeader(WebPage);
  with WebPage do
  begin
    Add('<BODY>');
    Add(Format('<H1>User name, %s verified. User ID is: %d</H1>',
      [Request.QueryFields.Values['UserName'], UserID]));
    Add('<BR><BR><A href=" ../DDGWebBugs.dll/BrowseBugs">Browse Bug List</A>');
    Add('<BR><A href=" ../DDGWebBugs.dll/GetBugInfo">Add a New Bug</A>');
    AddFooter(WebPage);
  end;
end;

procedure BuildInvalidLoginPage;
begin
  AddHeader(WebPage);
  with WebPage do
  begin
    Add('<BODY>');
    Add(Format('<H1>User name, %s is not a valid user.</H1>',
      [Request.QueryFields.Values['UserName']]));
    AddFooter(WebPage);
  end;
end;

begin

  UserName := Request.QueryFields.Values['UserName'];

  // The login will be valid if the username exists in the Users.db.
  ValidLogin := tblUsers.Locate('UserName', UserName, []);

  WebPage := TStringList.Create;
  try

    if ValidLogin then
    begin

      // Retrieve the UserID and the user's first and last name
      UserID := tblUsers.FieldByName('UserID').AsInteger;
```

```
UserFName := tblUsers.FieldByName('UserFirstName').AsString;
UserLName := tblUsers.FieldByName('UserLastName').AsString;

CookieList := TStringList.Create;
try

    // Store the user's information as cookies.
    CookieList.Add('UserID='+IntToStr(UserID));
    CookieList.Add('UserName='+UserName);
    CookieList.Add('UserFirstName='+UserFName);
    CookieList.Add('UserLastName='+UserLName);

    Response.SetCookieField(CookieList, '', '', Now + 1, False);
finally
    CookieList.Free;
end;
BuildValidLoginPage;
end
else begin
    UserID := -1;
    BuildInvalidLoginPage;
end;

Response.Content := WebPage.Text;
Handled := True;

finally
    WebPage.Free;
end;

end;
```

`WbdpBugswaVerifyUserNameAction()` performs several actions. First, it verifies that the username entered represents a valid user in the `tblUsers` table. If the username is valid, the `BuildValidLoginPage()` procedure is called; otherwise, `BuildInvalidLoginPage()` is called.

If the logon is valid, the user's first and last names and user ID is retrieved from `tblUsers`. Then, these items are returned as cookies back to the client. Future requests to the Web bug server will pass these values back to the server. We will use these values in generating other pages. Finally, `BuildValidLoginPage()` is called. It constructs a page containing links for browsing bugs or adding new bugs. If the login is invalid, `BrowseInvalidLoginPage()` is called. It simply presents a message indicating the invalid login.

Assuming the user has entered a valid login, he or she has the option to browse bugs or enter a new bug.

Browsing Bugs

If the user chooses to browse bugs, he or she is presented with a page that provides the options for browsing all bugs in the database or just browsing those bugs he or she has entered. This page is constructed in `TDDGBugsDataModule.wbdpBugswaBrowseBugsAction()` and is shown in Listing 36.6.

LISTING 36.6 `TDDGBugsDataModule.wbdpBugswaBrowseBugsAction()` Displays Browsing Options for the User

```
procedure TDDGBugsDataModule.wbdpBugswaBrowseBugsAction(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
{ This page gives the user the option of browsing all bugs or just bugs
  entered by him/her. }
var
  WebPage: TStringList;
begin
  WebPage := TStringList.Create;
  try
    AddHeader(WebPage);
    with WebPage do
      begin
        Add('<BODY>');
        Add('<H1>Browse Option</H1>');
        Add('<BR><BR><A href=" ../DDGWebBugs.dll/BrowseAllBugs">
↳Browse All Bugs</A>');
        Add('<BR><BR><A href=" ../DDGWebBugs.dll/BrowseYourBugs">
↳Browse Your Bugs</A>');
        AddFooter(WebPage);
        Response.Content := WebPage.Text;
        Handled := True;
      end;
    finally
      WebPage.Free;
    end;
end;
```

Browsing All Bugs

The option to browse all bugs invokes the `TDDGBugsDataModule.wbdpBugswaBrowseAllBugsAction()` event handler, as shown in Listing 36.7.

LISTING 36.7 TDDGBugsDataModule.wbdpBugswaBrowseAllBugsAction() Displays All Bugs in the System

```

procedure TDDGBugsDataModule.wbdpBugswaBrowseAllBugsAction(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
{ This page prepares the TPageProducer component for browsing all bugs.
  The standard header and footer is applied to this page, but a tag is
  used to add the table to the page.  }
var
  WebPage: TStringList;
begin
  WebPage := TStringList.Create;
  try
    AddHeader(WebPage);
    WebPage.Add('<BODY>');
    WebPage.Add('<H1>Browsing all Bugs</H1>');
    WebPage.Add('<#TABLE>');
    AddFooter(WebPage);

    pprdBugs.HTMLDoc.Clear;
    pprdBugs.HTMLDoc.AddStrings(WebPage);

    { As a result of the line below, the OnHTMLTag event handle for
      pprdBugs will be invoked. }
    Response.Content := pprdBugs.Content;

    Handled := True;
  finally
    WebPage.Free;
  end;
end;

```

This event handler makes use of the TPageProducer component pprdBugs. The functionality needed from this component is its capability to use tags within the HTML content. In particular, we want to use the #TABLE tag. We have added the standard header and footer to the Web page. However, instead of assigning WebPage to Response.Content, we assign WebPage to the pprdBugs.HTMLDoc property. Then, we assign pprdBugs.Content to Response.Content. This causes the pprdBugs.OnHTMLTag event to be invoked. This event, TDDGBugsDataModule.pprdBugsHTMLTag(), is shown in Listing 36.8.

LISTING 36.8 TDDGBugsDataModule.pprdBugsHTMLTag() Assigns the Table to the Tag

```

procedure TDDGBugsDataModule.pprdBugsHTMLTag(Sender: TObject; Tag: TTag;
  const TagString: String; TagParams: TStrings; var ReplaceText: String);
begin

```

continues

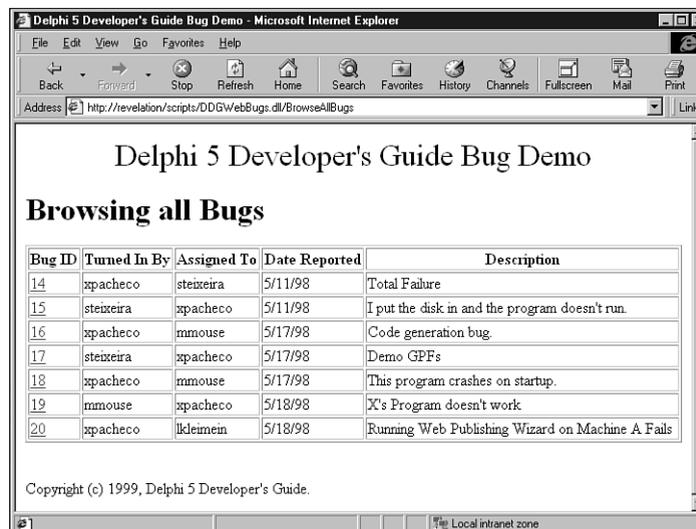
LISTING 36.8 Continued

```

if Tag = tgTable then begin
  with dstpBugs do
  begin
    DataSet.Close;
    DataSet.Open;
    ReplaceText := dstpBugs.Content;
  end;
end;
end;

```

This simple event handler assigns the `dstpBugs.Content` property, which refers to the table, to the `pprdBugs.ReplaceText` property, which will replace the `#TABLE` tag with the table contents. The resulting page is shown in Figure 36.6. It displays the bugs entered by all users.

**FIGURE 36.6**

A list of bugs entered by all users.

Browsing User-Entered Bugs

If the user chooses to browse his or her own bugs, a page containing a table with only the bugs he or she has entered is presented to the user. The `TDDGBugsDataModule.wbdpBugswaBrowseYourBugsAction()` event handler constructs this page (see Listing 36.9).

LISTING 36.9 TDDGBugsDataModule.wbdpBugswaBrowseYourBugsAction() Displays Only the User's Bugs

```
procedure TDDGBugsDataModule.wbdpBugswaBrowseYourBugsAction(  
    Sender: TObject; Request: TWebRequest; Response: TWebResponse;  
    var Handled: Boolean);  
{ This page prepares the TPageProducer component for browsing bugs which  
  belong to the user. The standard header and footer is applied to this page,  
  but a tag is used to add the table to the page. }  
var  
    WebPage: TStringList;  
    UserID: Integer;  
    UserFName,  
    UserLName: String;  
begin  
    WebPage := TStringList.Create;  
    try  
        AddHeader(WebPage);  
        WebPage.Add('<BODY>');  
  
        // Retrieve the user ID which is stored in the cookie.  
        UserID := StrToInt(Request.CookieFields.Values['UserID']);  
        UserFName := Request.CookieFields.Values['UserFirstName'];  
        UserLName := Request.CookieFields.Values['UserLastName'];  
  
        WebPage.Add(Format('<H1>Browsing Bugs Entered by %s %s</H1>',  
            [UserFName, UserLName]));  
        WebPage.Add('<#TABLE>');  
        pprdBugs.HTMLDoc.Clear;  
        pprdBugs.HTMLDoc.AddStrings(WebPage);  
  
        AddFooter(WebPage);  
  
        // Make sure the table is now filtered by the UserID  
        FLoginUserID := UserID;  
        FilterOnUser := True;  
  
        Response.Content := pprdBugs.Content;  
  
        Handled := True;  
    finally  
        WebPage.Free;  
    end;  
end;
```

As was the case with the event handler for browsing all bugs, the standard header and footer need to be added to this page. Also, the `UserID`, `UserFirstName`, and `UserLastName` cookies are retrieved from the `Request.CookieFields` property. `UserFirstName` and `UserLastName` are used to display the user's name on the Web page. `UserID` is assigned `FLoginUserID`. Then the `FilterOnUser` property is set to `True`. If you recall from the previous chapter, by setting the `FilterOnUser` property to `True`, its `SetFilterOnUser()` writer method is invoked, which in turn sets `tblBugs.Filtered` to `True`. This causes the `OnFilterRecord` event handler for `tblBugs`, `tblBugsFilterRecord()`, to be called for each record in the data set. This event executes the following line of code:

```
Accept := tblBugs.FieldName('UserID').AsInteger = FLoginUserID;
```

You can see that the filter applied depends on the value contained in the `FLoginUserID` field. This explains why the value of `UserID` from the cookie field needs to be assigned to `FLoginUserID`.

Finally, the `pprdBugs.Content` property is assigned to `Response.Content`. Again, this will cause the `pprdBugs.OnHTMLTag` event to be invoked.

Formatting Table Cells and Displaying Bug Detail

`dstpBugs` contains the `OnFormatCell` event handler

`TDDGBugsDataModule.dstpBugsFormatCell()`. This event handler converts the displayed bug ID to an HTML link, which displays the detail information for that bug.

`TDDGBugsDataModule.wbdpBugswaRetrieveBugAction()` is the event handler that actually displays this bug information. Both these event handlers are shown in Listing 36.10.

LISTING 36.10 The Event Handlers for Displaying Bug Detail

```
procedure TDDGBugsDataModule.dstpBugsFormatCell(Sender: TObject; CellRow,
  CellColumn: Integer; var BgColor: THTMLBgColor; var Align: THTMLAlign;
  var VAlign: THTMLVAlign; var CustomAttrs, CellData: String);
{ Convert the BugID cell of the table to a link which invokes the page to
  display the bug detail. }
begin
  if (CellColumn = 0) and not (CellRow = 0) then
    CellData := Format('<A href=" ../DDGWebBugs.dll/RetrieveBug?
↳BugID=%s">%s</A>',
      [CellData, CellData]);
end;

procedure TDDGBugsDataModule.wbdpBugswaRetrieveBugAction(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
{ View the bug detail information. }
var
  BugID: Integer;
```

```
WebPage: TStringList;

procedure GetBug;
begin
  if tblBugs.Locate('BugID', BugID, []) then
    with tblBugs do
      begin
        WebPage.Add(Format('Bug ID:      %d', [BugID]));
        WebPage.Add(Format('<BR>Reported By:  %s',
          [FieldName('UserNameLookup').AsString]));
        WebPage.Add(FormatDate(' "<BR>Reported On:"   mmm dd, yyyy',
          FieldName('WhenReported').AsDateTime));
        WebPage.Add(Format('<BR>Assigned To:  %s',
          [FieldName('AssignedToLookup').AsString]));
        WebPage.Add(Format('<BR>Status:      %s',
          [FieldName('StatusTitle').AsString]));
        WebPage.Add(Format('<BR>Summary:     %s',
          [FieldName('SummaryDescription').AsString]));
        WebPage.Add(Format('<BR>Details:    %s',
          [FieldName('Details').AsString]));
        WebPage.Add('<BR>');
        WebPage.Add('<BR>');

        GetActions(WebPage);
      end;
    end;

begin
  BugID := StrToInt(Request.QueryFields.Values['BugID']);

  WebPage := TStringList.Create;
  try
    AddHeader(WebPage);
    with WebPage do
      begin
        Add('<BODY>');
        Add('<H1>Bug Detail</H1>');
        GetBug;
        AddFooter(WebPage);
        Response.Content := WebPage.Text;
        Handled := True;
      end;
  finally
    WebPage.Free;
  end;

end;
```

Adding a New Bug

The user has the option of adding a new bug to the database. The following sections discuss the pages that retrieve the bug data from the user and display the bug information back to the user once the bug has been entered.

Retrieving the Bug Data

The event handler `TDDGBugsDataModule.wbdpBugswaGetBugInfoAction()`, shown in Listing 36.11, generates the page used to retrieve the new bug information from the user. This page basically creates an HTML form that contains the appropriate controls to allow the user to enter the proper bug information. Figure 36.7 shows the resulting page from this event handler.

LISTING 36.11 `TDDGBugsDataModule.wbdpBugswaGetBugInfoAction()` Displays the Bug Detail Entry Page to the User

```
procedure TDDGBugsDataModule.wbdpBugswaGetBugInfoAction(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
{ Prepares the page to retrieve new bug information from the user. }
var
  WebPage: TStringList;

procedure AddAssignToNames;
{ Adds a drop down list to the HTML Page of Assign to users }
begin

  WebPage.Add('<BR>Assign To:');
  WebPage.Add('<BR><SELECT name="AssignTo"><BR>');

  with tblUsers do
  begin
    First;
    while not Eof do
    begin
      WebPage.Add(Format('<OPTION>%s %s - %s',
        [FieldName('UserFirstName').AsString,
          FieldName('UserLastName').AsString,
          FieldName('UserName').AsString]));
      tblUsers.Next;
    end;
    WebPage.Add('</SELECT>');
  end;
end;

procedure AddStatusTitles;
```

```

{ Adds a drop down list to the HTML Page of bug status items }
begin
  WebPage.Add('<BR>Status:');
  WebPage.Add('<BR><SELECT name="Status"><BR>');

  with tblStatus do
  begin
    First;
    while not Eof do
    begin
      WebPage.Add(Format('<OPTION>%s', [FieldByName('StatusTitle').AsString]));
      tblStatus.Next;
    end;
    WebPage.Add('</SELECT>');
  end;
end;

begin
  WebPage := TStringList.Create;
  try
    AddHeader(WebPage);
    with WebPage do
    begin
      Add('<BODY>');
      Add('<H1>Add New Bug</H1>');
      Add('<FORM action="..\\DDGWebBugs.dll/AddBug"
method="GET">');
      Add('<BR>Summary Description:<BR><INPUT type="text"
name="Summary" maxlength="100" size="50">');
      Add('<BR>Details:<BR><TEXTAREA name="Details"
rows=5 cols=50> </TEXTAREA>');

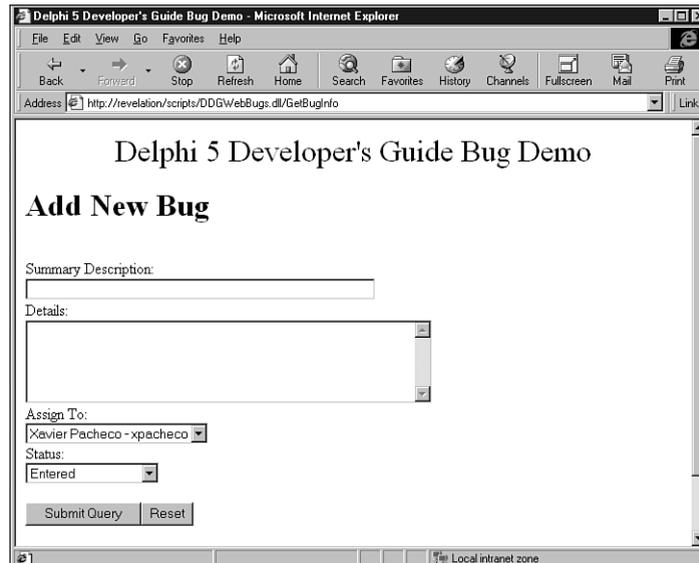
      AddAssignToNames;
      AddStatusTitles;

      Add('<p><INPUT type="SUBMIT"><INPUT type="RESET"></p>');
      Add('</FORM>');
      AddFooter(WebPage);
      Response.Content := WebPage.Text;
      Handled := True;
    end;
  finally
    WebPage.Free;
  end;
end;
end;

```

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**FIGURE 36.7**

The bug-entry page.

The two helper functions, `AddAssignToNames()` and `AddStatusTitle()`, create combo boxes from which the user can select values for the bug. Unlike using Delphi data-aware controls that can automatically assign the selected lookup values to the new record, this assignment has to be made manually, as you will see in the event handler that adds the new bug to the database.

Verifying Bug Insertion

The event handler `TDDGBugsDataModule.wbdpBugswaAddBugAction()` is shown in Listing 36.12.

LISTING 36.12 `TDDGBugsDataModule.wbdpBugswaAddBugAction()` Adds a New Bug to the Table

```

procedure TDDGBugsDataModule.wbdpBugswaAddBugAction(Sender: TObject;
  Request: TWebRequest; Response: TWebResponse; var Handled: Boolean);
{ Adds the Bug to the database. Uses the cookies returned by the client
  to display information about the user. }
var
  SummaryStr,
  DetailsStr,
  AssignToStr,
  StatusStr: String;
  WebPage: TStringList;
  UserID: Integer;

```

```

    UserName: String;
    UserFName,
    UserLName: String;
    AssignedToUserName: String;
    PostSucceeded: boolean;

function GetAssignedToID: Integer;
var
    PosIdx: Integer;
begin
    PosIdx := Pos('-', AssignToStr);
    AssignedToUserName := Copy(AssignToStr, PosIdx+2, 100);
    tblUsers.Locate('UserName', AssignedToUserName, []);
    Result := tblUsers.FieldByName('UserID').AsInteger;
end;

function GetStatusID: Integer;
begin
    tblStatus.Locate('StatusTitle', StatusStr, []);
    Result := tblStatus.FieldByName('StatusID').AsInteger;
end;

procedure DoPostSuccessPage;
begin
    with WebPage do
        begin
            Add(Format('<H1>Thank you %s %s, your bug has been added.</H1>',
                [UserFName, UserLName]));
            Add(Format('"<BR><BR>Bug Entered on:" mmm dd, yyyy', Date));
            Add(Format('<BR>Bug Assigned to: %s', [AssignedToUserName]));
            Add(Format('<BR>Details: %s', [DetailsStr]));
            Add(Format('<BR>Status: %s', [StatusStr]));
        end;
    end;

procedure DoPostFailPage;
begin
    WebPage.Add('<BR>Bug Entry failed. ');
end;

begin
    // Retrieve the fields inserted.
    SummaryStr := Request.QueryFields.Values['Summary'];
    DetailsStr := Request.QueryFields.Values['Details'];
    AssignToStr := Request.QueryFields.Values['AssignTo'];

```

continues

LISTING 36.12 Continued

```
StatusStr := Request.QueryFields.Values['Status'];

// Retrieve the cookie fields.
UserID := StrToInt(Request.CookieFields.Values['UserID']);
UserName := Request.CookieFields.Values['UserName'];
UserFName := Request.CookieFields.Values['UserFirstName'];
UserLName := Request.CookieFields.Values['UserLastName'];

// Necessary for the AfterInsert event handler.
FLoginUserID := UserID;
FLoginUserName := UserName;

InsertBug;
try
    tblBugs.FieldByName('SummaryDescription').AsString := SummaryStr;
    tblBugs.FieldByName('WhenReported').AsDateTime := Date;
    tblBugs.FieldByName('Details').AsString := DetailsStr;
    tblBugs.FieldByName('AssignedToUserID').AsInteger := GetAssignedToID;
    tblBugs.FieldByName('StatusID').AsInteger := GetStatusID;
    tblBugs.Post;
    PostSucceeded := True;

except
    tblBugs.Cancel;
    PostSucceeded := False;
end;

WebPage := TStringList.Create;
try
    AddHeader(WebPage);
    with WebPage do
        begin
            Add('<BODY>');

            if PostSucceeded then
                DoPostSuccessPage
            else
                DoPostFailPage;

            AddFooter(WebPage);
            Response.Content := WebPage.Text;
            Handled := True;
        end;
end;
```

```
finally
    WebPage.Free;
end;

end;
```

This event handler first retrieves all the values entered by the user from the bug-entry page shown in Figure 36.7. It also retrieves the cookie fields entered previously. The three lines of code

```
// Necessary for the AfterInsert event handler.
FLoginUserID := UserID;
FLoginUserName := UserName;
```

are required for the `AfterInsert` event handler for `tblBugs`, which performs as follows:

```
tblBugs.FieldByName('UserID').AsInteger := FLoginUserID;
tblBugs.FieldByName('UserNameLookup').AsString := FLoginUserName;
```

Finally, the new bug is inserted into `tblBugs`. If the insertion succeeds, the Web page is constructed by calling `DoPostSuccessPage()`; otherwise, `DoPostFailPage()` is called.

`DoPostSuccessPage()` simply presents the bug data back to the user, whereas `DoPostFailPage()` displays a failure notification.

Recall that data-aware lookup controls are not used to obtain valid entries for the `AssignToUserID` and `StatusID` fields for `tblBugs`. Our bug-entry page provides the user with the strings that represent these items in the drop-down combo boxes. In order to add the proper lookup index values to `tblBugs`, a search is performed on the strings selected by the user against both `tblUsers` and `tblStatus`. Note that a bit of string manipulation is required for the `AssignToUserID` field in order to extract the proper string with which to perform the search (see the `GetAssignToID()` method).

Summary

This chapter covered deploying Web database applications. In this chapter, we demonstrated how, if properly designed, an existing application can be deployed to the Web with few modifications to the existing code (with the exception of adding code specific to the Web). In fact, most of what we presented here has more to do with the construction of HTML documents than with database manipulation. You might consider modifying this demo to extend its functionality as well as moving the HTML construction code to actual HTML files.

Appendixes

PART VI

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Error Messages and Exceptions

APPENDIX

A

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- **Layers of Handlers, Layers of Severity** 1866
- **Runtime Errors** 1867

One difference between good software and great software is that whereas good software runs well, great software runs well and *fails* well. In Delphi programs, errors that are detected at runtime usually are reported and handled as exceptions. This allows your code the opportunity to respond to problems and recover (by backing up and trying another approach) or at least to “degrade gracefully” (free allocated resources, close files, and display an error message), instead of just crashing and making a mess of your system. Most exceptions in Delphi programs are raised and handled completely within the program; very few runtime errors actually will bring a Delphi program to a screeching halt.

This appendix lists the most common error messages that a Delphi application can report and provides field notes to help you find the cause of the error condition. Because each component you add to your Delphi environment often has its own set of error messages, this list can never be complete, so we’ll focus on the most common or most insidious error messages you’re likely to face while developing and debugging your Delphi applications.

Layers of Handlers, Layers of Severity

Every Delphi program has two default exception handlers, one below the other. VCL provides the default exception handler you’ll see most of the time. VCL wraps an exception handler around the window procedure entry points of every VCL object. If an exception occurs while your program is responding to a Windows message (which is what your program spends 99 percent of its lifetime doing) and the exception is not handled by your code or a VCL component, the exception eventually will wind up stopping at the VCL default exception handler in the window procedure. That exception handler calls `Application.HandleException`, which will show the exception instance’s text message to the user in a pop-up message box. After that, your program continues running and processing additional window messages.

The lowest-level exception handler lives at the heart of the Delphi RTL, several subbasements below the default VCL exception handler. If an exception occurs outside the context of message processing—such as during program startup or shutdown or during the execution of the VCL default exception handler—and the exception goes unhandled, it eventually will wind up stopping at the RTL default exception handler. At this level, there’s no recourse for recovery—no message loop to keep things going. When activated, the RTL default exception handler displays a detailed error message to the user and then terminates the application.

In addition to the exception message text, the RTL default exception handler also reports the address of the code that raised the exception, in the form of a hexadecimal address. Use the Search, Find Error option in the Delphi IDE and enter this address in the dialog box. Delphi will move the cursor to the place in your source code that corresponds to this address, if it can locate the address and the source code.

If Delphi responds with “Address Not Found,” this could mean that the error occurred in another module (for example, a “wild” pointer overwrote memory in use by some other application). More often, however, “Address Not Found” indicates that you have disabled line-number information in the unit that the address corresponds to (`{D-}`) or that you don’t have source code for that unit. Double-check that you’re compiling your project with compiler debug info enabled, in the Project, Options dialog box, Compiler page, Debugging section. While you have the Project, Options dialog box open, check to see that the search path on the Directories/Conditionals page contains all the source code directories you want to use during debugging. If the Delphi IDE can’t find a source file, it can’t show you the source code line that corresponds to the exception error address. Use Project, Build All to recompile all your units with the new compiler settings.

Runtime Errors

This section will give you some pointers on what you should do when you experience errors in the form of exceptions or Win32 API function failures. These types of errors are rarely fatal, but you should know how to tackle them when the need arises.

Exceptions

Here we describe additional exceptions that Delphi’s VCL components can raise. Keep in mind that custom components and your own code can (and often should) define additional exception classes specific to the task at hand.

Several of the exception classes listed here describe related error conditions: families of errors. The relationship of the exception classes to each other is captured by creating a general-purpose exception class to represent the entire family and specific exception classes that inherit from the general-purpose class. When you want to handle all errors in that family the same way, use the general-purpose exception class in the `on` clause of your `except` block. When you want to handle only certain specific errors from that family, use the specific exception classes in `on` clauses in your `except` block.

In the following list, we use indentation to group related exception classes together beneath their common generic ancestor class:

- **Exception.** This is the ancestor of all exception classes. There is nothing wrong with using this class to raise exceptions in quick-and-dirty code, but in production code, you’ll want to be able to distinguish between the multitude of families of errors that your application can encounter. The best way to distinguish a family of related error conditions from the rest of the pack is to use a custom exception class to report those related errors.

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AND EXCEPTIONS**

- **EAbort**. Referred to as Delphi's "silent" exception, this exception is trapped by the VCL default exception handler, but VCL does not inform the user that the exception occurred. Use **EAbort** when you want to take advantage of the exception's capability to abort and unwind out of a complicated process, but you don't want the user to see an error message. Remember, the terms *exception* and *error* are *not* equivalent: exceptions are a means of changing program flow to facilitate error handling (among other things).
- **EAccessViolation**. An access violation has occurred in the operating system. Usually caused by a `Nil` or "wild" pointer.
- **EAssertionFailed**. The statement passed to the `Assert()` procedure evaluated to `False`.
- **EBitsError**. Raised when the `Bits` or `Size` property of a `TBits` object is out of bounds.
- **EComponentError**. This exception is raised in two situations. The first situation is when you use `RegisterClasses()` to attempt to register a component outside the `Register()` procedure. The second is when the name of your component is invalid or not unique.
- **EControlC**. The user has interrupted with the `Ctrl+C` key combination. This exception only occurs within console-mode applications.
- **EDbEditError**. The user entered text into a `TMaskEdit` or `TDbEdit` component that's incompatible with the current edit mask.
- **EDdeError**. An error occurred during a DDE operation with any of the `TDdeClientConv`, `TDdeClientItem`, `TDdeServerConv`, and `TDdeServerItem` components.
- **EExternalException**. This exception occurs when an unrecognized exception is raised by the operating system.
- **EInOutError**. This exception is raised when any I/O error occurs in your program. This exception will only occur when I/O checking is enabled using `{SI+}` in code or by enabling I/O Checking on the Compiler page of the Project Options dialog in IDE.
- **EIntError**. This is the ancestor of all integer math exceptions. Here are the descendants of this class:
 - **EDivByZero**. This exception is raised when you divide an integral number by zero. This exception is raised as a result of runtime error 200. This code example will cause an **EDivByZero** exception:

```
var
  I: integer;
begin
  I := 0;
  I := 10 div I;  { exception raised here }
end;
```
 - **EIntOverflow**. This exception is raised when you attempt to perform an operation that overflows an integral variable beyond that variable type's capacity. This excep-

tion is raised as a result of runtime error 215. This exception will only be raised if overflow checking is enabled using {\$Q+} in code or by enabling Overflow Checking on the Compiler page of the Project Options dialog in the IDE. The following code will cause this exception to be raised:

```
var
  l: longint;
begin
  l := MaxLongint;
  l := l * l;  { exception raised here }
end;
```

- **ERangeError.** This exception is raised when you attempt to index an array beyond its declared bounds or when you attempt to store a value that's too large in an integral type variable. This exception is raised as a result of runtime error 201. Range checking must be enabled with {\$R+} in code or by enabling Range Checking on the Compiler page of the Project Options dialog in the IDE for this error to occur. The following example will cause Delphi to raise this exception:

```
var
  a: array[1..16] of integer;
  i: integer;
begin
  i := 17;
  a[i] := 1;  { exception raised here }
end;
```

- **EIntfCastError.** An attempt was made to cast an object or interface to an unsupported interface.
- **EInvalidCast.** This exception is raised when you attempt to use the as operator to type-cast a class to an incompatible class. This exception is raised as a result of runtime error 219. The following code will cause this exception to be raised:

```
var
  B: TObject;
begin
  B := TButton.Create(nil);
  { exception raised here - TMemo is not an ancestor of TButton }
  with B as TMemo do
    ...
end;
```

- **EInvalidGraphic.** This exception is raised when you attempt to use LoadFromFile() on a file that's not a compatible graphics format in a class expecting a graphics file.
- **EInvalidGraphicOperation.** This exception is raised when you attempt to perform an illegal operation on a graphic object. For example, resizing a TIcon is illegal.

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AND EXCEPTIONS**

- **EInvalidOperation**. This exception occurs when you try to display or perform any other operation that requires a window handle on a control without a parent. Here's an example:

```
var
  b: TBitBtn;
begin
  b := TBitBtn.Create(Self);
  b.SetFocus; { exception raised here }
end;
```

- **EInvalidPointer**. This exception is raised usually when you attempt to free an invalid or already-freed portion of memory in a call to `Dispose()`, `FreeMem()`, or a class destructor. This example causes an `EInvalidPointer` exception to be raised:

```
var
  p: pointer;
begin
  GetMem(p, 8);
  FreeMem(p, 8);
  FreeMem(p, 8); { exception raised here }
end;
```

- **EListError**. This exception will be raised if you try to index past the end of a `TList` descendant. Here's an example:

```
var
  S: TStringList;
  Strng: String;
begin
  S := TStringList.Create;
  S.Add('One String');
  Strng := S.Strings[2]; { exception raised here }
end;
```

- **EMathError**. This is the ancestor object from which the following floating-point exceptions are derived:
 - **EInvalidOp**. This exception is raised when an invalid instruction is sent to the numeric coprocessor. This exception is uncommon unless you control the coprocessor directly with `BASM` code.
 - **EOverflow**. This exception is raised as a result of floating-point overflow (that is, when a value becomes too large to hold in a floating point variable). This exception corresponds to runtime error 205.
 - **EUnderflow**. Raised as a result of floating-point underflow (that is, when a value becomes too small to hold in a floating point variable). This exception corresponds to runtime error 206.
 - **EZeroDivide**. Raised when a floating point number is divided by zero.

- **EMCIDeviceError**. This exception indicates that an error occurred in the **TMediaPlayer** component. Most commonly, this exception is raised when the user attempts to play some media whose type is unsupported by the hardware.
- **EMenuError**. This is a generic exception that occurs in almost any error condition involving a **TMenu**, **TMenuItem**, or **TPopupMenu** component.
- **EOLECtrlError**. This exception is reserved for ActiveX control wrapper errors, but it's currently not being used in VCL.
- **EOLEError**. This exception is raised when an OLE Automation error occurs.
 - **EOLESysError**. This exception is raised by the **OLECheck()** and **OLEError()** routines when an error occurs while calling an OLE API function.
 - **OLEException**. Raised when an error occurs inside of a **safecall** function or procedure.
- **EOutlineError**. This is a generic exception that's raised when an error occurs while working with a **TOutline** component.
- **EOutOfMemory**. This exception is raised when you call **New()**, **GetMem()**, or a class constructor and not enough memory is available on the heap for the allocation. This exception corresponds to runtime error 203.
 - **EOutOfResources**. This exception occurs when Windows cannot fill an allocation request for a Windows resource, such as a window handle. This exception often reflects bugs in your video driver, especially if you're running in a high-color (32KB or 64KB colors) mode. If this error goes away when you switch to using the standard Windows VGA driver or to a lesser mode of your normal video driver, it's very likely that you've found a bug in your video driver. Contact your video card manufacturer for a driver update.
- **EPackageError**. Raised when an error occurs loading, initializing, or finalizing a package.
- **EParserError**. Raised when Delphi is unable to parse your text form file back to the binary DFM format. Generally, this is the result of a syntax error while editing the form in the IDE.
- **EPrinter**. This is a generic exception that will be raised when an error occurs while you're trying to use the **TPrinter** object.
- **EPrivilege**. This exception indicates that an attempt was made to execute a privileged instruction.
- **EPropertyError**. This exception is raised when an error occurs inside of a component property editor.
- **ERegistryException**. The **TRegistry** and **TRegIniFile** objects raise this exception when an error occurs while reading from or writing to the system Registry.

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- **EStackOverflow**. This exception represents a serious operating system–level error in management of the stack. This error should be rare since an application’s stack is dynamically expanded as needed by the operating system, but can occur in low-memory conditions.
- **EReportError**. This is a generic exception for an error that occurs while working with a report component.
- **EResNotFound**. This exception is raised when there are problems loading a form from a DFM file. This exception usually indicates that you’ve edited the DFM file to make it invalid, the DFM or EXE file has become corrupted, or the DFM file was not linked into the EXE. Make sure you haven’t deleted or altered the `{$R *.DFM}` directive in your form unit.
- **EStreamError**. This exception is the base class of all stream exceptions. This exception usually indicates a problem loading a `TStrings` from a stream or setting the capacity of a memory stream. The following descendent exception classes signal other specific error conditions:
 - **EFCreateError**. Raised when an error occurs while creating a stream file. This exception often indicates that a file can’t be created because the filename is invalid or in use by another process.
 - **EFilerError**. This exception is raised when you attempt to register the same class twice using the `RegisterClasses()` procedure. This class also serves as the base for other filer-related exceptions:
 - **EClassNotFound**. This exception is raised when Delphi reads a component class name from a stream but cannot find a declaration for the component in its corresponding unit. Remember that code and declarations that are not used by a program will not be copied into the EXE file by Delphi’s smart linker.
 - **EInvalidImage**. This exception is raised when you attempt to read components from an invalid resource file.
 - **EMethodNotFound**. This exception is raised when a method specified in the DFM file or resource does not exist in the corresponding unit. This can happen if you’ve deleted code from the unit, recompiled the EXE, ignored the many warnings about the DFM file containing references to deleted code, and run the EXE anyway.
 - **EReadError**. This exception occurs when your application doesn’t read the number of bytes from a stream that it’s supposed to (for example, unexpected end of file) or when Delphi cannot read a property.

- `EFOPenError`. This exception is raised when the specified stream file cannot be opened; it usually occurs when the file does not exist.
- `EStringListError`. This is a generic exception that's raised when an error condition results while working with a `TStringList` object.
- `EThread`. This is a `TThread`-related exception. Currently, this exception is only raised when a user attempts to call `Synchronize()` on a waiting thread.
- `ETreeViewError`. This exception is raised when you pass an invalid item index to a `TTreeView` method or property.
- `EWin32Error`. This exception is raised when an error occurs calling a Win32 API function. The message associated with this exception has error code and error string information.

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AND EXCEPTIONS

Win32 System Errors

When you encounter an error in calling a Win32 API function or procedure, the error code is typically obtained by calling the `GetLastError()` function. Because the value returned from `GetLastError()` is a `DWORD` number, it's sometimes difficult to match that with an actual explanation of what might be the problem. To help you better decipher error codes, Table A.1 contains a list of the constant identifiers and values for the errors and a short description for each.

TABLE A.1 Win32 Error Codes

<i>Constant</i>	<i>Value</i>	<i>Description</i>
<code>ERROR_SUCCESS</code>	0	The operation completed successfully.
<code>ERROR_INVALID_FUNCTION</code>	1	The function is incorrect.
<code>ERROR_FILE_NOT_FOUND</code>	2	The system cannot find the file specified.
<code>ERROR_PATH_NOT_FOUND</code>	3	The system cannot find the path specified.
<code>ERROR_TOO_MANY_OPEN_FILES</code>	4	The system cannot open the file.
<code>ERROR_ACCESS_DENIED</code>	5	Access is denied.
<code>ERROR_INVALID_HANDLE</code>	6	The handle is invalid.
<code>ERROR_ARENA_TRASHED</code>	7	The storage control blocks were destroyed.
<code>ERROR_NOT_ENOUGH_MEMORY</code>	8	Not enough storage is available to process this command.
<code>ERROR_INVALID_BLOCK</code>	9	The storage control block address is invalid.
<code>ERROR_BAD_ENVIRONMENT</code>	10	The environment is incorrect.
<code>ERROR_BAD_FORMAT</code>	11	An attempt was made to load a program with an incorrect format.

continues

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_INVALID_ACCESS	12	The access code is invalid.
ERROR_INVALID_DATA	13	The data is invalid.
ERROR_OUTOFMEMORY	14	Not enough storage is available to complete this operation.
ERROR_INVALID_DRIVE	15	The system cannot find the drive specified.
ERROR_CURRENT_DIRECTORY	\$10	The directory cannot be removed.
ERROR_NOT_SAME_DEVICE	17	The system cannot move the file to a different disk drive.
ERROR_NO_MORE_FILES	18	There are no more files.
ERROR_WRITE_PROTECT	19	The media is write-protected.
ERROR_BAD_UNIT	20	The system cannot find the device specified.
ERROR_NOT_READY	21	The device is not ready.
ERROR_BAD_COMMAND	22	The device does not recognize the command.
ERROR_CRC	23	A data error (cyclic redundancy check) has occurred.
ERROR_BAD_LENGTH	24	The program issued a command, but the command length is incorrect.
ERROR_SEEK	25	The drive cannot locate a specific area or track on the disk.
ERROR_NOT_DOS_DISK	26	The specified disk or diskette cannot be accessed.
ERROR_SECTOR_NOT_FOUND	27	The drive cannot find the sector requested.
ERROR_OUT_OF_PAPER	28	The printer is out of paper.
ERROR_WRITE_FAULT	29	The system cannot write to the specified device.
ERROR_READ_FAULT	30	The system cannot read from the specified device.
ERROR_GEN_FAILURE	31	A device attached to the system is not functioning.
ERROR_SHARING_VIOLATION	\$20	The process cannot access the file because another process is using it.
ERROR_LOCK_VIOLATION	33	The process cannot access the file because another process has locked a portion of the file.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_WRONG_DISK	34	The wrong diskette is in the drive. Insert %2 (Volume Serial Number: %3) into drive %1.
ERROR_SHARING_BUFFER_EXCEEDED	36	Too many files have been opened for sharing.
ERROR_HANDLE_EOF	38	The end of the file has been reached.
ERROR_HANDLE_DISK_FULL	39	The disk is full.
ERROR_NOT_SUPPORTED	50	The network request is not supported.
ERROR_REM_NOT_LIST	51	The remote computer is not available.
ERROR_DUP_NAME	52	A duplicate name exists on the network.
ERROR_BAD_NETPATH	53	The network path was not found.
ERROR_NETWORK_BUSY	54	The network is busy.
ERROR_DEV_NOT_EXIST	55	The specified network resource or device is no longer available.
ERROR_TOO_MANY_CMDS	56	The network BIOS command limit has been reached.
ERROR_ADAP_HDW_ERR	57	A network adapter hardware error occurred.
ERROR_BAD_NET_RESP	58	The specified server cannot perform the requested operation.
ERROR_UNEXP_NET_ERR	59	An unexpected network error has occurred.
ERROR_BAD_REM_ADAP	60	The remote adapter is not compatible.
ERROR_PRINTQ_FULL	61	The printer queue is full.
ERROR_NO_SPOOL_SPACE	62	Space to store the file waiting to be printed is not available on the server.
ERROR_PRINT_CANCELLED	63	Your file waiting to be printed was deleted.
ERROR_NETNAME_DELETED	64	The specified network name is no longer available.
ERROR_NETWORK_ACCESS_DENIED	65	Network access is denied.
ERROR_BAD_DEV_TYPE	66	The network resource type is not correct.
ERROR_BAD_NET_NAME	67	The network name cannot be found.
ERROR_TOO_MANY_NAMES	68	The name limit for the local computer network adapter card was exceeded.
ERROR_TOO_MANY_SESS	69	The network BIOS session limit was exceeded.
ERROR_SHARING_PAUSED	70	The remote server has been paused or is in the process of being started.

A**ERROR MESSAGES
AND EXCEPTIONS***continues*

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_REQ_NOT_ACCEP	71	No more connections can be made to this remote computer at this time because there are already as many connections as the computer can accept.
ERROR_REDIR_PAUSED	72	The specified printer or disk device has been paused.
ERROR_FILE_EXISTS	80	The file exists.
ERROR_CANNOT_MAKE	82	The directory or file cannot be created.
ERROR_FAIL_I24	83	A failure has occurred on INT 24.
ERROR_OUT_OF_STRUCTURES	84	Storage to process this request is not available.
ERROR_OUT_OF_STRUCTURES	85	The local device name is already in use.
ERROR_INVALID_PASSWORD	86	The specified network password is not correct.
ERROR_INVALID_PARAMETER	87	The parameter is incorrect.
ERROR_NET_WRITE_FAULT	88	A write fault occurred on the network.
ERROR_NO_PROC_SLOTS	89	The system cannot start another process at this time.
ERROR_TOO_MANY_SEMAPHORES	100	Another system semaphore cannot be created.
ERROR_EXCL_SEM_ALREADY_OWNED	101	The exclusive semaphore is owned by another process.
ERROR_SEM_IS_SET	102	The semaphore is set and cannot be closed.
ERROR_TOO_MANY_SEM_REQUESTS	103	The semaphore cannot be set again.
ERROR_INVALID_AT_INTERRUPT_TIME	104	Exclusive semaphores cannot be requested at interrupt time.
ERROR_SEM_OWNER_DIED	105	The previous ownership of this semaphore has ended.
ERROR_SEM_USER_LIMIT	106	Insert the diskette for drive %1.
ERROR_DISK_CHANGE	107	The program has stopped because an alternate diskette was not inserted.
ERROR_DRIVE_LOCKED	108	The disk is in use or locked by another process.
ERROR_BROKEN_PIPE	109	The pipe has been ended.
ERROR_OPEN_FAILED	110	The system cannot open the device or file specified.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_BUFFER_OVERFLOW	111	The filename is too long.
ERROR_DISK_FULL	112	The disk does not contain enough space.
ERROR_NO_MORE_SEARCH_HANDLES	113	No more internal file identifiers are available.
ERROR_INVALID_TARGET_HANDLE	114	The target internal file identifier is incorrect.
ERROR_INVALID_CATEGORY	117	The IOCTL call made by the application program is not correct.
ERROR_INVALID_VERIFY_SWITCH	118	The verify-on-write switch parameter value is not correct.
ERROR_BAD_DRIVER_LEVEL	119	The system does not support the command requested.
ERROR_CALL_NOT_IMPLEMENTED	120	This function is only valid in Windows NT mode.
ERROR_SEM_TIMEOUT	121	The semaphore timeout period has expired.
ERROR_INSUFFICIENT_BUFFER	122	The data area passed to a system call is too small.
ERROR_INVALID_NAME	123	The filename, directory name, or volume label syntax is incorrect.
ERROR_INVALID_LEVEL	124	The system call level is not correct.
ERROR_NO_VOLUME_LABEL	125	The disk has no volume label.
ERROR_MOD_NOT_FOUND	126	The specified module could not be found.
ERROR_PROC_NOT_FOUND	127	The specified procedure could not be found.
ERROR_WAIT_NO_CHILDREN	\$80	There are no child processes to wait for.
ERROR_CHILD_NOT_COMPLETE	129	The %1 application cannot run in Windows NT mode.
ERROR_DIRECT_ACCESS_HANDLE	130	An attempt was made to use a file handle to an open disk partition for an operation other than raw disk I/O.
ERROR_NEGATIVE_SEEK	131	An attempt was made to move the file pointer before the beginning of the file.
ERROR_SEEK_ON_DEVICE	132	The file pointer cannot be set on the specified device or file.
ERROR_IS_JOIN_TARGET	133	A JOIN or SUBST command cannot be used for a drive that contains previously joined drives.

A

**ERROR MESSAGES
AND EXCEPTIONS**

continues

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_IS_JOINED	134	An attempt was made to use a JOIN or SUBST command on a drive that has already been joined.
ERROR_IS_SUBSTED	135	An attempt was made to use a JOIN or SUBST command on a drive that has already been substituted.
ERROR_NOT_JOINED	136	The system tried to delete the join of a drive that's not joined.
ERROR_NOT_SUBSTED	137	The system tried to delete the substitution of a drive that's not substituted.
ERROR_JOIN_TO_JOIN	138	The system tried to join a drive to a directory on a joined drive.
ERROR_SUBST_TO_SUBST	139	The system tried to substitute a drive to a directory on a substituted drive.
ERROR_JOIN_TO_SUBST	140	The system tried to join a drive to a directory on a substituted drive.
ERROR_SUBST_TO_JOIN	141	The system tried to perform a SUBST command on a drive to a directory on a joined drive.
ERROR_BUSY_DRIVE	142	The system cannot perform a JOIN or SUBST operation at this time.
ERROR_SAME_DRIVE	143	The system cannot join or substitute a drive to or for a directory on the same drive.
ERROR_DIR_NOT_ROOT	144	The directory is not a subdirectory of the root directory.
ERROR_DIR_NOT_EMPTY	145	The directory is not empty.
ERROR_IS_SUBST_PATH	146	The path specified is being used in a substitute.
ERROR_IS_JOIN_PATH	147	Not enough resources are available to process this command.
ERROR_PATH_BUSY	148	The path specified cannot be used at this time.
ERROR_IS_SUBST_TARGET	149	An attempt was made to join or substitute a drive for which a directory on the drive is the target of a previous substitute.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_SYSTEM_TRACE	150	System trace information was not specified in your CONFIG.SYS file or tracing is disallowed.
ERROR_INVALID_EVENT_COUNT	151	The number of specified semaphore events for DosMuxSemWait is not correct.
ERROR_TOO_MANY_MUXWAITERS	152	DosMuxSemWait did not execute; too many semaphores are already set.
ERROR_INVALID_LIST_FORMAT	153	The DosMuxSemWait list is not correct.
ERROR_LABEL_TOO_LONG	154	The volume label you entered exceeds the 11-character limit. The first 11 characters were written to disk. Any characters that exceeded the 11-character limit were automatically deleted.
ERROR_TOO_MANY_TCBS	155	Cannot create another thread.
ERROR_SIGNAL_REFUSED	156	The recipient process has refused the signal.
ERROR_DISCARDED	157	The segment is already discarded and cannot be locked.
ERROR_NOT_LOCKED	158	The segment is already unlocked.
ERROR_BAD_THREADID_ADDR	159	The address for the thread ID is not correct.
ERROR_BAD_ARGUMENTS	160	The argument string passed to DosExecPgm is not correct.
ERROR_BAD_PATHNAME	161	The specified path is invalid.
ERROR_SIGNAL_PENDING	162	A signal is already pending.
ERROR_MAX_THRDS_REACHED	164	No more threads can be created in the system.
ERROR_LOCK_FAILED	167	A region of a file cannot be locked.
ERROR_BUSY	170	The requested resource is in use.
ERROR_CANCEL_VIOLATION	173	A lock request was not outstanding for the supplied cancel region.
ERROR_ATOMIC_LOCKS_NOT_SUPPORTED	174	The file system does not support atomic changes to the lock type.
ERROR_INVALID_SEGMENT_NUMBER	180	The system detected a segment number that was not correct.
ERROR_INVALID_ORDINAL	182	The operating system cannot run %1.
ERROR_ALREADY_EXISTS	183	Cannot create a file when that file already exists.

A**ERROR MESSAGES
AND EXCEPTIONS***continues*

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_INVALID_FLAG_NUMBER	186	The flag passed is not correct.
ERROR_SEM_NOT_FOUND	187	The specified system semaphore name was not found.
ERROR_INVALID_STARTING_CODESEG	188	The operating system cannot run %1.
ERROR_INVALID_STACKSEG	189	The operating system cannot run %1.
ERROR_INVALID_MODULETYPE	190	The operating system cannot run %1.
ERROR_INVALID_EXE_SIGNATURE	191	Windows NT mode cannot run %1.
ERROR_EXE_MARKED_INVALID	192	The operating system cannot run %1.
ERROR_BAD_EXE_FORMAT	193	%1 is not a valid Windows NT application.
ERROR_ITERATED_DATA_EXCEEDS_64k	194	The operating system cannot run %1.
ERROR_INVALID_MINALLOCSIZE	195	The operating system cannot run %1.
ERROR_DYNLINK_FROM_INVALID_RING	196	The operating system cannot run this application program.
ERROR_IOPL_NOT_ENABLED	197	The operating system is not presently configured to run this application.
ERROR_INVALID_SEGDPL	198	The operating system cannot run %1.
ERROR_AUTODATASEG_EXCEEDS_64k	199	The operating system cannot run this application program.
ERROR_RING2SEG_MUST_BE_MOVABLE	200	The code segment cannot be greater than or equal to 64KB.
ERROR_RELOC_CHAIN_XCEEDS_SEGLIM	201	The operating system cannot run %1.
ERROR_INFLOOP_IN_RELOC_CHAIN	202	The operating system cannot run %1.
ERROR_ENVVAR_NOT_FOUND	203	The system could not find the environment option that was entered.
ERROR_NO_SIGNAL_SENT	205	No process in the command subtree has a signal handler.
ERROR_FILENAME_EXCED_RANGE	206	The filename or extension is too long.
ERROR_RING2_STACK_IN_USE	207	The ring 2 stack is in use.
ERROR_META_EXPANSION_TOO_LONG	208	The global filename characters (such as * and ?) are entered incorrectly or too many global filename characters are specified.
ERROR_INVALID_SIGNAL_NUMBER	209	The signal being posted is not correct.
ERROR_THREAD_1_INACTIVE	210	The signal handler cannot be set.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_LOCKED	212	The segment is locked and cannot be reallocated.
ERROR_TOO_MANY_MODULES	214	Too many dynamic link modules are attached to this program or dynamic link module.
ERROR_NESTING_NOT_ALLOWED	215	Calls can't be nested to LoadModule.
ERROR_BAD_PIPE	230	The pipe state is invalid.
ERROR_PIPE_BUSY	231	All pipe instances are busy.
ERROR_NO_DATA	232	The pipe is being closed.
ERROR_PIPE_NOT_CONNECTED	233	No process is on the other end of the pipe.
ERROR_MORE_DATA	234	More data is available.
ERROR_VC_DISCONNECTED	240	The session was cancelled.
ERROR_INVALID_EA_NAME	254	The specified extended attribute name was invalid.
ERROR_EA_LIST_INCONSISTENT	255	The extended attributes are inconsistent.
ERROR_NO_MORE_ITEMS	259	No more data is available.
ERROR_CANNOT_COPY	266	The Copy API cannot be used.
ERROR_DIRECTORY	267	The directory name is invalid.
ERROR_EAS_DIDNT_FIT	275	The extended attributes did not fit in the buffer.
ERROR_EA_FILE_CORRUPT	276	The extended attribute file on the mounted file system is corrupt.
ERROR_EA_TABLE_FULL	277	The extended attribute table file is full.
ERROR_INVALID_EA_HANDLE	278	The specified extended attribute handle is invalid.
ERROR_EAS_NOT_SUPPORTED	282	The mounted file system does not support extended attributes.
ERROR_NOT_OWNER	288	An attempt has been made to release a mutex not owned by the caller.
ERROR_TOO_MANY_POSTS	298	Too many posts were made to a semaphore.
ERROR_PARTIAL_COPY	299	Only part of a Read/Write ProcessMemory request was completed.
ERROR_MR_MID_NOT_FOUND	317	The system cannot find a message for message number %1 in message file for %2.
ERROR_INVALID_ADDRESS	487	Attempt to access invalid address.

A**ERROR MESSAGES
AND EXCEPTIONS***continues*

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_ARITHMETIC_OVERFLOW	534	The arithmetic result exceeded 32 bits.
ERROR_PIPE_CONNECTED	535	A process is on the other end of the pipe.
ERROR_PIPE_LISTENING	536	A pipe is waiting for a process to open the other end of the pipe.
ERROR_EA_ACCESS_DENIED	994	Access to the extended attribute was denied.
ERROR_OPERATION_ABORTED	995	The I/O operation has been aborted because of a thread exit or an application request.
ERROR_IO_INCOMPLETE	996	The overlapped I/O event is not in a signaled state.
ERROR_IO_PENDING	997	The overlapped I/O operation is in progress.
ERROR_NOACCESS	998	Access to the memory location is invalid.
ERROR_SWAPERROR	999	An error has occurred in performing in page operation.
ERROR_STACK_OVERFLOW	1001	Recursion is too deep and the stack overflowed.
ERROR_INVALID_MESSAGE	1002	The window cannot act on the sent message.
ERROR_CAN_NOT_COMPLETE	1003	This function cannot be completed.
ERROR_INVALID_FLAGS	1004	Flags are invalid.
ERROR_UNRECOGNIZED_VOLUME	1005	The volume does not contain a recognized file system. Make sure that all required file system drivers are loaded and that the volume is not corrupt.
ERROR_FILE_INVALID	1006	The volume for a file has been externally altered such that the opened file is no longer valid.
ERROR_FULLSCREEN_MODE	1007	The requested operation cannot be performed in full-screen mode.
ERROR_NO_TOKEN	1008	An attempt was made to reference a token that does not exist.
ERROR_BADDB	1009	The configuration Registry database is corrupt.
ERROR_BADKEY	1010	The configuration Registry key is invalid.
ERROR_CANTOPEN	1011	The configuration Registry key could not be opened.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_CANTREAD	1012	The configuration Registry key could not be read.
ERROR_CANTWRITE	1013	The configuration Registry key could not be written.
ERROR_REGISTRY_RECOVERED	1014	One of the files in the Registry database had to be recovered by use of a log or alternate copy. The recovery was successful.
ERROR_REGISTRY_CORRUPT	1015	The Registry is corrupt. The structure of one of the files that contains Registry data is corrupt, the system's image of the file in memory is corrupt, or the file could not be recovered because the alternate copy or log was absent or corrupt.
ERROR_REGISTRY_IO_FAILED	1016	An I/O operation initiated by the Registry failed and was unable to be recovered. The Registry could not read in, write out, or flush one of the files that contains the system's image of the Registry.
ERROR_NOT_REGISTRY_FILE	1017	The system has attempted to load or restore a file into the Registry, but the specified file is not in a Registry file format.
ERROR_KEY_DELETED	1018	An illegal operation was attempted on a Registry key that has been marked for deletion.
ERROR_NO_LOG_SPACE	1019	The system could not allocate the required space in a Registry log.
ERROR_KEY_HAS_CHILDREN	1020	A symbolic link could not be created in a Registry key that already has subkeys or values.
ERROR_CHILD_MUST_BE_VOLATILE	1021	A stable subkey under a volatile parent key could not be created.
ERROR_NOTIFY_ENUM_DIR	1022	A "notify change" request is being completed, and the information is not being returned in the caller's buffer. The caller now needs to enumerate the files to find the changes.
ERROR_DEPENDENT_SERVICES_RUNNING	1051	A stop control has been sent to a service upon which other running services depend.

A**ERROR MESSAGES
AND EXCEPTIONS***continues*

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_INVALID_SERVICE_CONTROL	1052	The requested control is not valid for this service.
ERROR_SERVICE_REQUEST_TIMEOUT	1053	The service did not respond to the start or control request in a timely fashion.
ERROR_SERVICE_NO_THREAD	1054	A thread could not be created for the service.
ERROR_SERVICE_DATABASE_LOCKED	1055	The service database is locked.
ERROR_SERVICE_ALREADY_RUNNING	1056	An instance of the service is already running.
ERROR_INVALID_SERVICE_ACCOUNT	1057	The account name is invalid or does not exist.
ERROR_SERVICE_DISABLED	1058	The specified service is disabled and cannot be started.
ERROR_CIRCULAR_DEPENDENCY	1059	A circular service dependency was specified.
ERROR_SERVICE_DOES_NOT_EXIST	1060	The specified service does not exist as an installed service.
ERROR_SERVICE_CANNOT_ACCEPT_CTRL	1061	The service cannot accept control messages at this time.
ERROR_SERVICE_NOT_ACTIVE	1062	The service has not been started.
ERROR_FAILED_SERVICE_CONTROLLER	1063	The service process could not connect to the service controller.
ERROR_EXCEPTION_IN_SERVICE	1064	An exception occurred in the service when handling the control request.
ERROR_DATABASE_DOES_NOT_EXIST	1065	The database specified does not exist.
ERROR_SERVICE_SPECIFIC_ERROR	1066	The service has returned a service-specific error code.
ERROR_PROCESS_ABORTED	1067	The process terminated unexpectedly.
ERROR_SERVICE_DEPENDENCY_FAIL	1068	The dependency service or group failed to start.
ERROR_SERVICE_LOGON_FAILED	1069	The service did not start due to a logon failure.
ERROR_SERVICE_START_HANG	1070	After starting, the service hung up in a start-pending state.
ERROR_INVALID_SERVICE_LOCK	1071	The specified service database lock is invalid.
ERROR_SERVICE_MARKED_FOR_DELETE	1072	The specified service has been marked for deletion.
ERROR_SERVICE_EXISTS	1073	The specified service already exists.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_ALREADY_RUNNING_LKG	1074	The system is currently running with the last-known-good configuration.
ERROR_SERVICE_DEPENDENCY_DELETED	1075	The dependency service does not exist or has been marked for deletion.
ERROR_BOOT_ALREADY_ACCEPTED	1076	The current boot has already been accepted for use as the last-known-good control set.
ERROR_SERVICE_NEVER_STARTED	1077	No attempts to start the service have been made since the last boot.
ERROR_DUPLICATE_SERVICE_NAME	1078	The name is already in use as either a service name or a service display name.
ERROR_END_OF_MEDIA	1100	The physical end of the tape has been reached.
ERROR_FILEMARK_DETECTED	1101	A tape access reached a filemark.
ERROR_BEGINNING_OF_MEDIA	1102	The beginning of the tape or partition was encountered.
ERROR_SETMARK_DETECTED	1103	A tape access reached the end of a set of files.
ERROR_NO_DATA_DETECTED	1104	No more data is on the tape.
ERROR_PARTITION_FAILURE	1105	The tape could not be partitioned.
ERROR_INVALID_BLOCK_LENGTH	1106	During the access of a new tape of a multivolume partition, the current block size is incorrect.
ERROR_DEVICE_NOT_PARTITIONED	1107	The tape partition information could not be found when a tape was loaded.
ERROR_UNABLE_TO_LOCK_MEDIA	1108	The media-eject mechanism could not be locked.
ERROR_UNABLE_TO_UNLOAD_MEDIA	1109	The media could not be loaded.
ERROR_MEDIA_CHANGED	1110	The media in the drive may have changed.
ERROR_BUS_RESET	1111	The I/O bus was reset.
ERROR_NO_MEDIA_IN_DRIVE	1112	No media was in the drive.
ERROR_NO_UNICODE_TRANSLATION	1113	No mapping for the Unicode character exists in the target multibyte code page.
ERROR_DLL_INIT_FAILED	1114	A dynamic link library (DLL) initialization routine failed.
ERROR_SHUTDOWN_IN_PROGRESS	1115	A system shutdown is in progress.

A**ERROR MESSAGES
AND EXCEPTIONS***continues*

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_NO_SHUTDOWN_IN_PROGRESS	1116	The system shutdown could not be aborted because no shutdown was in progress.
ERROR_IO_DEVICE	1117	The request could not be performed because of an I/O device error.
ERROR_SERIAL_NO_DEVICE	1118	No serial device was successfully initialized. The serial driver will unload.
ERROR_IRQ_BUSY	1119	A device could not be opened that was sharing an interrupt request (IRQ) with other devices. At least one other device that uses that IRQ was already opened.
ERROR_MORE_WRITES	1120	A serial I/O operation was completed by another write to the serial port. (IOCTL_SERIAL_XOFF_COUNTER reached zero.)
ERROR_COUNTER_TIMEOUT	1121	A serial I/O operation completed because the timeout period expired. (IOCTL_SERIAL_XOFF_COUNTER did not reach zero.)
ERROR_FLOPPY_ID_MARK_NOT_FOUND	1122	No ID address mark was found on the floppy disk.
ERROR_FLOPPY_WRONG_CYLINDER	1123	A mismatch occurred between the floppy disk sector ID field and the floppy disk controller track address.
ERROR_FLOPPY_UNKNOWN_ERROR	1124	The floppy disk controller reported an error that the floppy disk driver does not recognize.
ERROR_FLOPPY_BAD_REGISTERS	1125	The floppy disk controller returned inconsistent results in its registers.
ERROR_DISK_RECALIBRATE_FAILED	1126	During a hard disk access, a recalibrate operation failed, even after retries.
ERROR_DISK_OPERATION_FAILED	1127	During a hard disk access, a disk operation failed, even after retries.
ERROR_DISK_RESET_FAILED	1128	During a hard disk access, a disk controller reset was needed, but even that failed.
ERROR_EOM_OVERFLOW	1129	The physical end of the tape was encountered.
ERROR_NOT_ENOUGH_SERVER_MEMORY	1130	Not enough server storage is available to process this command.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_POSSIBLE_DEADLOCK	1131	A potential deadlock condition has been detected.
ERROR_MAPPED_ALIGNMENT	1132	The base address or the file offset specified does not have the proper alignment.
ERROR_SET_POWER_STATE_VETOED	1140	An attempt to change the system power state was vetoed by another application or driver.
ERROR_SET_POWER_STATE_FAILED	1141	The system BIOS failed an attempt to change the system power state.
ERROR_OLD_WIN_VERSION	1150	The specified program requires a newer version of Windows.
ERROR_APP_WRONG_OS	1151	The specified program is not a Windows or MS-DOS program.
ERROR_SINGLE_INSTANCE_APP	1152	You cannot start more than one instance of the specified program.
ERROR_RMODE_APP	1153	You cannot start more than one instance of the specified program.
ERROR_INVALID_DLL	1154	One of the library files needed to run this application is damaged.
ERROR_NO_ASSOCIATION	1155	No application is associated with the specified file for this operation.
ERROR_DDE_FAIL	1156	An error occurred in sending the command to the application.
ERROR_DLL_NOT_FOUND	1157	One of the library files needed to run this application cannot be found.
ERROR_BAD_USERNAME	2202	The specified username is invalid.
ERROR_NOT_CONNECTED	2250	This network connection does not exist.
ERROR_OPEN_FILES	2401	This network connection has files open or requests pending.
ERROR_ACTIVE_CONNECTIONS	2402	Active connections still exist.
ERROR_DEVICE_IN_USE	2404	The device is in use by an active process and cannot be disconnected.
ERROR_BAD_DEVICE	1200	The specified device name is invalid.
ERROR_CONNECTION_UNAVAIL	1201	The device is not currently connected, but it is a remembered connection.
ERROR_DEVICE_ALREADY_REMEMBERED	1202	An attempt was made to remember a device that had previously been remembered.

A**ERROR MESSAGES
AND EXCEPTIONS***continues*

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_NO_NET_OR_BAD_PATH	1203	No network provider accepted the given network path.
ERROR_BAD_PROVIDER	1204	The specified network provider name is invalid.
ERROR_CANNOT_OPEN_PROFILE	1205	The network connection profile could not be opened.
ERROR_BAD_PROFILE	1206	The network connection profile is corrupt.
ERROR_NOT_CONTAINER	1207	A noncontainer cannot be enumerated.
ERROR_EXTENDED_ERROR	1208	An extended error has occurred.
ERROR_INVALID_GROUPNAME	1209	The format of the specified group name is invalid.
ERROR_INVALID_COMPUTERNAME	1210	The format of the specified computer name is invalid.
ERROR_INVALID_EVENTNAME	1211	The format of the specified event name is invalid.
ERROR_INVALID_DOMAINNAME	1212	The format of the specified domain name is invalid.
ERROR_INVALID_SERVICENAME	1213	The format of the specified service name is invalid.
ERROR_INVALID_NETNAME	1214	The format of the specified network name is invalid.
ERROR_INVALID_SHARENAME	1215	The format of the specified share name is invalid.
ERROR_INVALID_PASSWORDNAME	1216	The format of the specified password is invalid.
ERROR_INVALID_MESSAGE_NAME	1217	The format of the specified message name is invalid.
ERROR_INVALID_MESSAGEDEST	1218	The format of the specified message destination is invalid.
ERROR_SESSION_CREDENTIAL_CONFLICT	1219	The credentials supplied conflict with an existing set of credentials.
ERROR_REMOTE_SESSION_LIMIT_EXCEEDED	1220	An attempt was made to establish a session to a network server, but too many sessions are already established to that server.
ERROR_DUP_DOMAINNAME	1221	Another computer on the network is already using the workgroup or domain name.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_NO_NETWORK	1222	The network is not present or not started.
ERROR_CANCELLED	1223	The user cancelled the operation.
ERROR_USER_MAPPED_FILE	1224	The requested operation cannot be performed on a file with a user-mapped section open.
ERROR_CONNECTION_REFUSED	1225	The remote system refused the network connection.
ERROR_GRACEFUL_DISCONNECT	1226	The network connection was gracefully closed.
ERROR_ADDRESS_ALREADY_ASSOCIATED	1227	The network transport endpoint already has an address associated with it.
ERROR_ADDRESS_NOT_ASSOCIATED	1228	An address has not yet been associated with the network endpoint.
ERROR_CONNECTION_INVALID	1229	An operation was attempted on a nonexistent network connection.
ERROR_CONNECTION_ACTIVE	1230	An invalid operation was attempted on an active network connection.
ERROR_NETWORK_UNREACHABLE	1231	The transport cannot reach the remote network.
ERROR_HOST_UNREACHABLE	1232	The transport cannot reach the remote system.
ERROR_PROTOCOL_UNREACHABLE	1233	The transport protocol cannot reach the remote system.
ERROR_PORT_UNREACHABLE	1234	No service is operating at the destination network endpoint on the remote system.
ERROR_REQUEST_ABORTED	1235	The request was aborted.
ERROR_CONNECTION_ABORTED	1236	The local system aborted the network connection.
ERROR_RETRY	1237	The operation could not be completed. A retry should be performed.
ERROR_CONNECTION_COUNT_LIMIT	1238	A connection to the server could not be made because the limit on the number of concurrent connections for this account has been reached.
ERROR_LOGIN_TIME_RESTRICTION	1239	An attempt was made to log in during an unauthorized time of day for this account.
ERROR_LOGIN_WKSTA_RESTRICTION	1240	The account is not authorized to log in from this station.

A**ERROR MESSAGES
AND EXCEPTIONS***continues*

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_INCORRECT_ADDRESS	1241	The network address could not be used for the operation requested.
ERROR_ALREADY_REGISTERED	1242	The service is already registered.
ERROR_SERVICE_NOT_FOUND	1243	The specified service does not exist.
ERROR_NOT_AUTHENTICATED	1244	The operation being requested was not performed because the user has not been authenticated.
ERROR_NOT_LOGGED_ON	1245	The operation being requested was not performed because the user has not logged onto the network. The specified service does not exist.
ERROR_CONTINUE	1246	This is a return that wants the caller to continue with work in progress.
ERROR_ALREADY_INITIALIZED	1247	An attempt was made to perform an initialization operation when initialization has already been completed.
ERROR_NO_MORE_DEVICES	1248	No more local devices exist.
ERROR_NOT_ALL_ASSIGNED	1300	Not all privileges referenced are assigned to the caller.
ERROR_SOME_NOT_MAPPED	1301	Some mapping between account names and security IDs was not done.
ERROR_NO_QUOTAS_FOR_ACCOUNT	1302	No system quota limits are specifically set for this account.
ERROR_LOCAL_USER_SESSION_KEY	1303	No encryption key is available. A well-known encryption key was returned.
ERROR_NULL_LM_PASSWORD	1304	The NT password is too complex to be converted to a LAN Manager password. The LAN Manager password returned is a null string.
ERROR_UNKNOWN_REVISION	1305	The revision level is unknown.
ERROR_REVISION_MISMATCH	1306	The two revision levels are incompatible.
ERROR_INVALID_OWNER	1307	This security ID may not be assigned as the owner of this object.
ERROR_INVALID_PRIMARY_GROUP	1308	This security ID may not be assigned as the primary group of an object.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_NO_IMPERSONATION_TOKEN	1309	A thread that's not currently impersonating a client has made an attempt to operate on an impersonation token.
ERROR_CANT_DISABLE_MANDATORY	1310	The group may not be disabled.
ERROR_NO_LOGON_SERVERS	1311	No logon servers are currently available to service the logon request.
ERROR_NO_SUCH_LOGON_SESSION	1312	A specified logon session does not exist. It may already have been terminated.
ERROR_NO_SUCH_PRIVILEGE	1313	A specified privilege does not exist.
ERROR_PRIVILEGE_NOT_HELD	1314	A required privilege is not held by the client.
ERROR_INVALID_ACCOUNT_NAME	1315	The name provided is not a properly formed account name.
ERROR_USER_EXISTS	1316	The specified user already exists.
ERROR_NO_SUCH_USER	1317	The specified user does not exist.
ERROR_GROUP_EXISTS	1318	The specified group already exists.
ERROR_NO_SUCH_GROUP	1319	The specified group does not exist.
ERROR_MEMBER_IN_GROUP	1320	Either the specified user account is already a member of the specified group or the specified group cannot be deleted because it contains a member.
ERROR_MEMBER_NOT_IN_GROUP	1321	The specified user account is not a member of the specified group account.
ERROR_LAST_ADMIN	1322	The last remaining administration account cannot be disabled or deleted.
ERROR_WRONG_PASSWORD	1323	The password cannot be updated. The value provided as the current password is incorrect.
ERROR_ILL_FORMED_PASSWORD	1324	The password cannot be updated. The value provided for the new password contains values that are not allowed in passwords.
ERROR_PASSWORD_RESTRICTION	1325	The password cannot be updated because a password update rule has been violated.
ERROR_LOGON_FAILURE	1326	A logon failure has occurred: unknown user name or bad password.
ERROR_ACCOUNT_RESTRICTION	1327	A logon failure has occurred: user account restriction.

A**ERROR MESSAGES
AND EXCEPTIONS***continues*

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_INVALID_LOGON_HOURS	1328	A logon failure has occurred: Account logon time restriction violation.
ERROR_INVALID_WORKSTATION	1329	A logon failure has occurred: The user is not allowed to logon to this computer.
ERROR_PASSWORD_EXPIRED	1330	A logon failure has occurred: The specified account password has expired.
ERROR_ACCOUNT_DISABLED	1331	A logon failure has occurred: The account has been currently disabled.
ERROR_NONE_MAPPED	1332	No mapping between account names and security IDs was done.
ERROR_TOO_MANY_LUIDS_REQUESTED	1333	Too many local user identifiers (LUIDs) were requested at one time.
ERROR_LUIDS_EXHAUSTED	1334	No more local user identifiers (LUIDs) are available.
ERROR_INVALID_SUB_AUTHORITY	1335	The subauthority part of a security ID is invalid for this particular use.
ERROR_INVALID_ACL	1336	The Access Control List (ACL) structure is invalid.
ERROR_INVALID_SID	1337	The security ID structure is invalid.
ERROR_INVALID_SECURITY_DESCR	1338	The security descriptor structure is invalid.
ERROR_BAD_INHERITANCE_ACL	1340	The inherited Access Control List (ACL) or Access Control Entry (ACE) could not be built.
ERROR_SERVER_DISABLED	1341	The server is currently disabled.
ERROR_SERVER_NOT_DISABLED	1342	The server is currently enabled.
ERROR_INVALID_ID_AUTHORITY	1343	The value provided was an invalid value for an identifier authority.
ERROR_ALLOTTED_SPACE_EXCEEDED	1344	No more memory is available for security information updates.
ERROR_INVALID_GROUP_ATTRIBUTES	1345	The specified attributes are invalid or incompatible with the attributes for the group as a whole.
ERROR_BAD_IMPERSONATION_LEVEL	1346	Either a required impersonation level was not provided or the provided impersonation level is invalid.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_CANT_OPEN_ANONYMOUS	1347	An anonymous-level security token cannot be opened.
ERROR_BAD_VALIDATION_CLASS	1348	The validation information class requested was invalid.
ERROR_BAD_TOKEN_TYPE	1349	The type of the token is inappropriate for its attempted use.
ERROR_NO_SECURITY_ON_OBJECT	1350	A security operation could not be performed on an object that has no associated security.
ERROR_CANT_ACCESS_DOMAIN_INFO	1351	A Windows NT server could not be contacted or objects within the domain are protected such that necessary information could not be retrieved.
ERROR_INVALID_SERVER_STATE	1352	The Security Account Manager (SAM) or Local Security Authority (LSA) server was in the wrong state to perform the security operation.
ERROR_INVALID_DOMAIN_STATE	1353	The domain was in the wrong state to perform the security operation.
ERROR_INVALID_DOMAIN_ROLE	1354	This operation is only allowed for the Primary Domain Controller of the domain.
ERROR_NO_SUCH_DOMAIN	1355	The specified domain did not exist.
ERROR_DOMAIN_EXISTS	1356	The specified domain already exists.
ERROR_DOMAIN_LIMIT_EXCEEDED	1357	An attempt was made to exceed the limit on the number of domains per server.
ERROR_INTERNAL_DB_CORRUPTION	1358	The requested operation could not be completed because of a catastrophic media failure or a data structure corruption on the disk.
ERROR_INTERNAL_ERROR	1359	The security account database contains an internal inconsistency.
ERROR_GENERIC_NOT_MAPPED	1360	Generic access types were contained in an access mask that should already be mapped to nongeneric types.
ERROR_BAD_DESCRIPTOR_FORMAT	1361	A security descriptor is not in the correct format (absolute or self-relative).
ERROR_NOT_LOGON_PROCESS	1362	The requested action is restricted for use by logon processes only. The calling process has not been registered as a logon process.

A

**ERROR MESSAGES
AND EXCEPTIONS**
continues

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_LOGON_SESSION_EXISTS	1363	You cannot start a new logon session with an ID that's already in use.
ERROR_NO_SUCH_PACKAGE	1364	A specified authentication package is unknown.
ERROR_BAD_LOGON_SESSION_STATE	1365	The logon session is not in a state that's consistent with the requested operation.
ERROR_LOGON_SESSION_COLLISION	1366	The logon session ID is already in use.
ERROR_INVALID_LOGON_TYPE	1367	A logon request contained an invalid logon type value.
ERROR_CANNOT_IMPERSONATE	1368	You cannot impersonate via a named pipe until data has been read from that pipe.
ERROR_RXACT_INVALID_STATE	1369	The transaction state of a Registry subtree is incompatible with the requested operation.
ERROR_RXACT_COMMIT_FAILURE	1370	An internal security database corruption has been encountered.
ERROR_SPECIAL_ACCOUNT	1371	You cannot perform this operation on built-in accounts.
ERROR_SPECIAL_GROUP	1372	You cannot perform this operation on this built-in special group.
ERROR_SPECIAL_USER	1373	You cannot perform this operation on this built-in special user.
ERROR_MEMBERS_PRIMARY_GROUP	1374	The user cannot be removed from a group because the group is currently the user's primary group.
ERROR_TOKEN_ALREADY_IN_USE	1375	The token is already in use as a primary token.
ERROR_NO_SUCH_ALIAS	1376	The specified local group does not exist.
ERROR_MEMBER_NOT_IN_ALIAS	1377	The specified account name is not a member of the local group.
ERROR_MEMBER_IN_ALIAS	1378	The specified account name is already a member of the local group.
ERROR_ALIAS_EXISTS	1379	The specified local group already exists.
ERROR_LOGON_NOT_GRANTED	1380	A logon failure has occurred: The user has not been granted the requested logon type at this computer.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_TOO_MANY_SECRETS	1381	The maximum number of secrets that may be stored in a single system has been exceeded.
ERROR_SECRET_TOO_LONG	1382	The length of a secret exceeds the maximum length allowed.
ERROR_INTERNAL_DB_ERROR	1383	The Local Security Authority database contains an internal inconsistency.
ERROR_TOO_MANY_CONTEXT_IDS	1384	During a logon attempt, the user's security context accumulated too many security IDs.
ERROR_LOGON_TYPE_NOT_GRANTED	1385	A logon failure has occurred: The user has not been granted the requested logon type at this computer.
ERROR_NT_CROSS_ENCRYPTION_REQUIRE	1386	A cross-encrypted password is necessary to change a user password.
ERROR_NO_SUCH_MEMBER	1387	A new member could not be added to a local group because the member does not exist.
ERROR_INVALID_MEMBER	1388	A new member could not be added to a local group because the member has the wrong account type.
ERROR_TOO_MANY_SIDS	1389	Too many security IDs have been specified.
ERROR_LM_CROSS_ENCRYPTION_REQUIRE	1390	A cross-encrypted password is necessary to change this user password.
ERROR_NO_INHERITANCE	1391	Indicates a ACL contains no inheritable components.
ERROR_FILE_CORRUPT	1392	The file or directory is corrupt and unable to be read.
ERROR_DISK_CORRUPT	1393	The disk structure is corrupt and unable to be read.
ERROR_NO_USER_SESSION_KEY	1394	No user session key exists for the specified logon session.
ERROR_LICENSE_QUOTA_EXCEEDED	1395	The service being accessed is licensed for a particular number of connections. No more connections can be made to the service at this time because as many connections as the service can accept already exist.
ERROR_INVALID_WINDOW_HANDLE	1400	The window handle is invalid.
ERROR_INVALID_MENU_HANDLE	1401	The menu handle is invalid.

A**ERROR MESSAGES
AND EXCEPTIONS***continues*

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_INVALID_CURSOR_HANDLE	1402	The cursor handle is invalid.
ERROR_INVALID_ACCEL_HANDLE	1403	The accelerator table handle is invalid.
ERROR_INVALID_HOOK_HANDLE	1404	The hook handle is invalid.
ERROR_INVALID_DWP_HANDLE	1405	The handle to a multiple-window position structure is invalid.
ERROR_TLW_WITH_WSCHILD	1406	A top-level child window cannot be created.
ERROR_CANNOT_FIND_WND_CLASS	1407	A window class cannot be found.
ERROR_WINDOW_OF_OTHER_THREAD	1408	The window is invalid; it belongs to the other thread.
ERROR_HOTKEY_ALREADY_REGISTERED	1409	The hotkey is already registered.
ERROR_CLASS_ALREADY_EXISTS	1410	The class already exists.
ERROR_CLASS_DOES_NOT_EXIST	1411	The class does not exist.
ERROR_CLASS_HAS_WINDOWS	1412	The class still has open windows.
ERROR_INVALID_INDEX	1413	The index is invalid.
ERROR_INVALID_ICON_HANDLE	1414	The icon handle is invalid.
ERROR_PRIVATE_DIALOG_INDEX	1415	You're using private dialog window words.
ERROR_LISTBOX_ID_NOT_FOUND	1416	The list box identifier was not found.
ERROR_NO_WILDCARD_CHARACTERS	1417	No wildcards were found.
ERROR_CLIPBOARD_NOT_OPEN	1418	The thread does not have a Clipboard open.
ERROR_HOTKEY_NOT_REGISTERED	1419	The hotkey is not registered.
ERROR_WINDOW_NOT_DIALOG	1420	The window is not a valid dialog window.
ERROR_CONTROL_ID_NOT_FOUND	1421	The control ID was not found.
ERROR_INVALID_COMBOBOX_MESSAGE	1422	The message for a combo box was invalid because it does not have an edit control.
ERROR_WINDOW_NOT_COMBOBOX	1423	The window is not a combo box.
ERROR_INVALID_EDIT_HEIGHT	1424	The height must be less than 256 pixels.
ERROR_DC_NOT_FOUND	1425	The device context (DC) handle is invalid.
ERROR_INVALID_HOOK_FILTER	1426	The hook procedure type is invalid.
ERROR_INVALID_FILTER_PROC	1427	The hook procedure is invalid.
ERROR_HOOK_NEEDS_HMOD	1428	You cannot set a nonlocal hook without a module handle.
ERROR_GLOBAL_ONLY_HOOK	1429	This hook procedure can only be set globally.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_JOURNAL_HOOK_SET	1430	The journal hook procedure is already installed.
ERROR_HOOK_NOT_INSTALLED	1431	The hook procedure is not installed.
ERROR_INVALID_LB_MESSAGE	1432	The message for a single-selection list box is invalid.
ERROR_SETCOUNT_ON_BAD_LB	1433	LB_SETCOUNT was sent to a nonlazy list box.
ERROR_LB_WITHOUT_TABSTOPS	1434	This list box does not support tab stops.
ERROR_DESTROY_OBJECT_OF_OTHER_TH	1435	You cannot destroy an object created by another thread.
ERROR_CHILD_WINDOW_MENU	1436	Child windows cannot have menus.
ERROR_NO_SYSTEM_MENU	1437	The window does not have a system menu.
ERROR_INVALID_MSGBOX_STYLE	1438	The message box style is invalid.
ERROR_INVALID_SPI_VALUE	1439	The systemwide (SPI_*) parameter is invalid.
ERROR_SCREEN_ALREADY_LOCKED	1440	The screen is already locked.
ERROR_HWNDS_HAVE_DIFF_PARENT	1441	All handles to windows in a multiple-window position structure must have the same parent.
ERROR_NOT_CHILD_WINDOW	1442	The window is not a child window.
ERROR_INVALID_GW_COMMAND	1443	The GW_* command is invalid.
ERROR_INVALID_THREAD_ID	1444	The thread identifier is invalid.
ERROR_NON_MDICHILD_WINDOW	1445	A message cannot be processed from a window that's not a multiple-document interface (MDI) window.
ERROR_POPUP_ALREADY_ACTIVE	1446	The pop-up menu is already active.
ERROR_NO_SCROLLBARS	1447	The window does not have scrollbars.
ERROR_INVALID_SCROLLBAR_RANGE	1448	The scrollbar range cannot be greater than \$7FFF.
ERROR_INVALID_SHOWWIN_COMMAND	1449	You cannot show or remove the window in the way specified.
ERROR_EVENTLOG_FILE_CORRUPT	1500	The event log file is corrupt.
ERROR_EVENTLOG_CANT_START	1501	No event log file could be opened, so the event-logging service did not start.
ERROR_LOG_FILE_FULL	1502	The event log file is full.
ERROR_EVENTLOG_FILE_CHANGED	1503	The event log file has changed between reads.

A

**ERROR MESSAGES
AND EXCEPTIONS**
continues

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_INVALID_USER_BUFFER	1784	The supplied user buffer is not valid for the requested operation.
ERROR_UNRECOGNIZED_MEDIA	1785	The disk media is not recognized. It might not be formatted.
ERROR_NO_TRUST_LSA_SECRET	1786	The workstation does not have a trust secret.
ERROR_NO_TRUST_SAM_ACCOUNT	1787	The SAM database on the Windows NT server does not have a computer account for this workstation trust relationship.
ERROR_TRUSTED_DOMAIN_FAILURE	1788	The trust relationship between the primary domain and the trusted domain failed.
ERROR_TRUSTED_RELATIONSHIP_FAILU	1789	The trust relationship between this workstation and the primary domain failed.
ERROR_TRUST_FAILURE	1790	The network logon failed.
ERROR_NETLOGON_NOT_STARTED	1792	A remote procedure call is already in progress for this thread. An attempt was made to log on, but the network logon service was not started.
ERROR_ACCOUNT_EXPIRED	1793	The user's account has expired.
ERROR_REDIRECTOR_HAS_OPEN_HANDLE	1794	The redirector is in use and cannot be unloaded.
ERROR_PRINTER_DRIVER_ALREADY_INS	1795	The specified printer driver is already installed.
ERROR_UNKNOWN_PORT	1796	The specified port is unknown.
ERROR_UNKNOWN_PRINTER_DRIVER	1797	The printer driver is unknown.
ERROR_UNKNOWN_PRINTPROCESSOR	1798	The print processor is unknown.
ERROR_INVALID_SEPARATOR_FILE	1799	The specified separator file is invalid.
ERROR_INVALID_PRIORITY	1800	The specified priority is invalid.
ERROR_INVALID_PRINTER_NAME	1801	The printer name is invalid.
ERROR_PRINTER_ALREADY_EXISTS	1802	The printer already exists.
ERROR_INVALID_PRINTER_COMMAND	1803	The printer command is invalid.
ERROR_INVALID_DATATYPE	1804	The specified data type is invalid.
ERROR_INVALID_ENVIRONMENT	1805	The environment specified is invalid.
ERROR_NOLOGON_INTERDOMAIN_TRUST	1807	No more bindings exist. The account used is an interdomain trust account. Use your global user account or local user account to access this server.

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_NOLOGON_WORKSTATION_TRUST	1808	The account used is a computer account. Use your global user account or local user account to access this server.
ERROR_NOLOGON_SERVER_TRUST_ACCOU	1809	The account used is an server trust account. Use your global user account or local user account to access this server.
ERROR_DOMAIN_TRUST_INCONSISTENT	1810	The name or security ID (SID) of the domain specified is inconsistent with the trust information for that domain.
ERROR_SERVER_HAS_OPEN_HANDLES	1811	The server is in use and cannot be unloaded.
ERROR_RESOURCE_DATA_NOT_FOUND	1812	The specified image file did not contain a resource section.
ERROR_RESOURCE_TYPE_NOT_FOUND	1813	The specified resource type cannot be found in the image file.
ERROR_RESOURCE_NAME_NOT_FOUND	1814	The specified resource name cannot be found in the image file.
ERROR_RESOURCE_LANG_NOT_FOUND	1815	The specified resource language ID cannot be found in the image file.
ERROR_NOT_ENOUGH_QUOTA	1816	Not enough quota is available to process this command.
ERROR_INVALID_TIME	1901	The specified time is invalid.
ERROR_INVALID_FORM_NAME	1902	The specified form name is invalid.
ERROR_INVALID_FORM_SIZE	1903	The specified form size is invalid.
ERROR_ALREADY_WAITING	1904	The specified printer handle is already being waited on.
ERROR_PRINTER_DELETED	1905	The specified printer has been deleted.
ERROR_INVALID_PRINTER_STATE	1906	The state of the printer is invalid.
ERROR_PASSWORD_MUST_CHANGE	1907	The user must change his or her password before logging on for the first time.
ERROR_DOMAIN_CONTROLLER_NOT_FOUN	1908	The domain controller for this domain could not be found.
ERROR_ACCOUNT_LOCKED_OUT	1909	The referenced account is currently locked out and may not be logged on to.
ERROR_NO_BROWSER_SERVERS_FOUND	6118	The list of servers for this workgroup is not currently available.
ERROR_INVALID_PIXEL_FORMAT	2000	The pixel format is invalid.

A**ERROR MESSAGES
AND EXCEPTIONS***continues*

TABLE A.1 Continued

<i>Constant</i>	<i>Value</i>	<i>Description</i>
ERROR_BAD_DRIVER	2001	The specified driver is invalid.
ERROR_INVALID_WINDOW_STYLE	2002	The window style or class attribute is invalid for this operation.
ERROR_METAFILE_NOT_SUPPORTED	2003	The requested metafile operation is not supported.
ERROR_TRANSFORM_NOT_SUPPORTED	2004	The requested transformation operation is not supported.
ERROR_CLIPPING_NOT_SUPPORTED	2005	The requested clipping operation is not supported.
ERROR_UNKNOWN_PRINT_MONITOR	3000	The specified print monitor is unknown.
ERROR_PRINTER_DRIVER_IN_USE	3001	The specified printer driver is currently in use.
ERROR_SPOOL_FILE_NOT_FOUND	3002	The spool file was not found.
ERROR_SPL_NO_STARTDOC	3003	A StartDocPrinter call was not issued.
ERROR_SPL_NO_ADDJOB	3004	An AddJob call was not issued.
ERROR_PRINT_PROCESSOR_ALREADY_IN	3005	The specified print processor has already been installed.
ERROR_PRINT_MONITOR_ALREADY_INST	3006	The specified print monitor has already been installed.
ERROR_WINS_INTERNAL	4000	WINS encountered an error while processing the command.
ERROR_CAN_NOT_DEL_LOCAL_WINS	4001	The local WINS cannot be deleted.
ERROR_STATIC_INIT	4002	The importation from the file failed.
ERROR_INC_BACKUP	4003	The backup failed. Was a full backup done before?
ERROR_FULL_BACKUP	4004	The backup failed. Check the directory to which you are backing up the database.
ERROR_REC_NON_EXISTENT	4005	The name does not exist in the WINS database.
ERROR_RPL_NOT_ALLOWED	4006	Replication with an unconfigured partner is not allowed.

BDE Error Codes

APPENDIX

B

When working with the Borland Database Engine, occasionally you'll receive an error dialog box indicating that some error has occurred in the engine. Most commonly, this happens when customers or clients install your software on their machines and they have some configuration problems with their machines that you're trying to track down for them. Typically, the aforementioned error dialog box provides you with a hexadecimal error code as the description of the error. The question is how to turn that number into a meaningful error message. In order to help you with this task, we've provided the following table. Table B.1 lists all the possible BDE error codes as well as the BDE error strings associated with these error codes.

TABLE B.1 BDE Error Codes

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
0	0000	Successful completion.
33	0021	System error.
34	0022	Object of interest not found.
35	0023	Physical data corruption.
36	0024	I/O-related error.
37	0025	Resource or limit error.
38	0026	Data integrity violation.
39	0027	Invalid request.
40	0028	Lock violation.
41	0029	Access/security violation.
42	002A	Invalid context.
43	002B	OS error.
44	002C	Network error.
45	002D	Optional parameter.
46	002E	Query processor.
47	002F	Version mismatch.
48	0030	Capability not supported.
49	0031	System configuration error.
50	0032	Warning.
51	0033	Miscellaneous.
52	0034	Compatibility error.
62	003E	Driver-specific error.
63	003F	Internal symbol.
256	0100	KEYVIOL.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
257	0101	PROBLEMS.
258	0102	CHANGED.
512	0200	Production index file missing, corrupt, or cannot interpret index key.
513	0201	Open read-only.
514	0202	Open the table in read-only mode.
515	0203	Open and detach.
516	0204	Open the table and detach the production index file.
517	0205	Fail open.
518	0206	Do not open the table.
519	0207	Convert non-dBASE index.
520	0208	Convert production index to dBASE format.
521	0209	BLOB file not found.
522	020A	Open without BLOB file.
523	020B	Open the table without the BLOB file.
524	020C	Empty all BLOB fields.
525	020D	Reinitialize BLOB file and lose all BLOBs.
526	020E	Fail open.
527	020F	Do not open the table.
528	0210	Import non-dBASE BLOB file.
529	0211	Import BLOB file to dBASE format.
530	0212	Open as non-dBASE table.
531	0213	Open table and BLOB file in its native format.
532	0214	Production index language driver mismatch.
533	0215	Production index damaged.
534	0216	Rebuild production index.
535	0217	Rebuild all the production indexes.
1024	0400	Lookup table not found or corrupt.
1025	0401	BLOB file not found or corrupt.
1026	0402	Open read-only.
1027	0403	Open the table in read-only mode.
1028	0404	Fail open.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
1029	0405	Do not open the table.
1030	0406	Remove lookup.
1031	0407	Remove link to lookup table.
1280	0500	Dictionary object exists.
1281	0501	Skip this object.
1282	0502	Skip importing this object and its associated relationships.
1283	0503	Use existing object.
1284	0504	Use existing dictionary object for relationships.
1285	0505	Abort.
1286	0506	Abort the operation.
1287	0507	Dictionary object import failed.
4608	1200	SQL Unknown.
4609	1201	SQL Prepare.
4610	1202	SQL Execute.
4611	1203	SQL Error.
4612	1204	SQL STMT.
4613	1205	SQL Connect.
4614	1206	SQL Transact.
4615	1207	SQL BLOB I/O.
4616	1208	SQL Misc.
4617	1209	SQL Vendor.
4618	120A	ORACLE - or1on.
4619	120B	ORACLE - o1on.
4620	120C	ORACLE - o1ogof.
4621	120D	ORACLE - ocon.
4622	120E	ORACLE - ocof.
4623	120F	ORACLE - oopen.
4624	1210	ORACLE - osql3.
4625	1211	ORACLE - odsc.
4626	1212	ORACLE - odefin.
4627	1213	ORACLE - obndrv.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
4628	1214	ORACLE - obndrvn.
4629	1215	ORACLE - oexec.
4630	1216	ORACLE - ofetch.
4631	1217	ORACLE - ofen.
4632	1218	ORACLE - ocan.
4633	1219	ORACLE - oclose.
4634	121A	ORACLE - oerhms.
4635	121B	ORACLE - oparse.
4636	121C	ORACLE - oflmg.
4637	121D	ORACLE - odessp.
4638	121E	ORACLE - odescr.
4639	121F	ORACLE - oexn.
4648	1228	INTRBASE - isc_attach_database.
4649	1229	INTRBASE - isc_blob_default_desc.
4650	122A	INTRBASE - isc_blob_gen_bpb.
4651	122B	INTRBASE - isc_blob_info.
4652	122C	INTRBASE - isc_blob_lookup_desc.
4653	122D	INTRBASE - isc_close_blob.
4654	122E	INTRBASE - isc_commit_retaining.
4655	122F	INTRBASE - isc_commit_transaction.
4656	1230	INTRBASE - isc_create_blob.
4657	1231	INTRBASE - isc_create_blob2.
4658	1232	INTRBASE - isc_decode_date.
4659	1233	INTRBASE - isc_detach_database.
4660	1234	INTRBASE - isc_dsql_allocate_statement.
4661	1235	INTRBASE - isc_dsql_execute.
4662	1236	INTRBASE - isc_dsql_execute2.
4663	1237	INTRBASE - isc_dsql_fetch.
4664	1238	INTRBASE - isc_dsql_free_statement.
4665	1239	INTRBASE - isc_dsql_prepare.
4666	123A	INTRBASE - isc_dsql_set_cursor_name.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
4667	123B	INTRBASE - isc_dsqli_sql_info.
4668	123C	INTRBASE - isc_encode_date.
4669	123D	INTRBASE - isc_get_segment.
4670	123E	INTRBASE - isc_interprete.
4671	123F	INTRBASE - isc_open_blob.
4672	1240	INTRBASE - isc_open_blob2.
4673	1241	INTRBASE - isc_put_segment.
4674	1242	INTRBASE - isc_rollback_transaction.
4675	1243	INTRBASE - isc_sqlcode.
4676	1244	INTRBASE - isc_start_transaction.
4677	1245	INTRBASE - isc_vax_integer.
4688	1250	MSSQL - dbbind.
4689	1251	MSSQL - dbcmd.
4690	1252	MSSQL - dbcancel.
4691	1253	MSSQL - dbclose.
4692	1254	MSSQL - dbcollen.
4693	1255	MSSQL - dbcolname.
4694	1256	MSSQL - dbcoltype.
4695	1257	MSSQL - dbconvert.
4696	1258	MSSQL - dbdataready.
4697	1259	MSSQL - dbdatlen.
4698	125A	MSSQL - dberrhandle.
4699	125B	MSSQL - dbfreebuf.
4700	125C	MSSQL - dbfreelogin.
4701	125D	MSSQL - dbhasretstat.
4702	125E	MSSQL - dbinit.
4703	125F	MSSQL - dblogin.
4704	1260	MSSQL - dbmoretext.
4705	1261	MSSQL - dbmsghandle.
4706	1262	MSSQL - dbnextrow.
4707	1263	MSSQL - dbnumcols.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
4708	1264	MSSQL - dbnumrets.
4709	1265	MSSQL - dbopen.
4710	1266	MSSQL - dbresults.
4711	1267	MSSQL - dbretdata.
4712	1268	MSSQL - dbretlen.
4713	1269	MSSQL - dbretstatus.
4714	126A	MSSQL - dbrpcinit.
4715	126B	MSSQL - dbrpcparam.
4716	126C	MSSQL - dbrpcsend.
4717	126D	MSSQL - dbsetlogintime.
4718	126E	MSSQL - dbsetmaxprocs.
4719	126F	MSSQL - dbsetopt.
4720	1270	MSSQL - dbsettime.
4721	1271	MSSQL - dbsqlexec.
4722	1272	MSSQL - dbsqllok.
4723	1273	MSSQL - dbsqlsend.
4724	1274	MSSQL - dbtxptr.
4725	1275	MSSQL - dbtxtimestamp.
4726	1276	MSSQL - dbtxtsnewval.
4727	1277	MSSQL - dbuse.
4728	1278	MSSQL - dbwinexit.
4729	1279	MSSQL - dbwritetext.
4738	1282	ODBC - SQLAllocConnect.
4739	1283	ODBC - SQLAllocEnv.
4740	1284	ODBC - SQLAllocStmt.
4741	1285	ODBC - SQLBindCol.
4742	1286	ODBC - SQLBindParameter.
4743	1287	ODBC - SQLCancel.
4744	1288	ODBC - SQLColumns.
4745	1289	ODBC - SQLConnect.
4746	128A	ODBC - SQLDataSources.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
4747	128B	ODBC - SQLDescribeCol.
4748	128C	ODBC - SQLDisconnect.
4750	128E	ODBC - SQLError.
4751	128F	ODBC - SQLExecDirect.
4752	1290	ODBC - SQLExtendedFetch.
4753	1291	ODBC - SQLFetch.
4754	1292	ODBC - SQLFreeConnect.
4755	1293	ODBC - SQLFreeEnv.
4756	1294	ODBC - SQLFreeStmt.
4757	1295	ODBC - SQLGetConnectOption.
4758	1296	ODBC - SQLGetCursorName.
4760	1298	ODBC - SQLGetFunctions.
4761	1299	ODBC - SQLGetInfo.
4762	129A	ODBC - SQLGetTypeInfo.
4763	129B	ODBC - SQLNumResultCols.
4764	129C	ODBC - SQLProcedures.
4765	129D	ODBC - SQLProcedureColumns.
4766	129E	ODBC - SQLRowCount.
4767	129F	ODBC - SQLSetConnectOption.
4768	12A0	ODBC - SQLSetCursorName.
4769	12A1	ODBC - SQLSetParam.
4770	12A2	ODBC - SQLSetStmtOption.
4771	12A3	ODBC - SQLStatistics.
4772	12A4	ODBC - SQLTables.
4773	12A5	ODBC - SQLTransact.
4788	12B4	SYBASE - dbbind.
4789	12B5	SYBASE - dbcmd.
4790	12B6	SYBASE - dbcancel.
4791	12B7	SYBASE - dbclose.
4792	12B8	SYBASE - dbcollen.
4793	12B9	SYBASE - dbcolname.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
4794	12BA	SYBASE - dbcoltype.
4795	12BB	SYBASE - dbconvert.
4796	12BC	SYBASE - dbpoll.
4797	12BD	SYBASE - dbdatlen.
4798	12BE	SYBASE - dberrhandle.
4799	12BF	SYBASE - dbfreebuf.
4800	12C0	SYBASE - dbloginfree.
4801	12C1	SYBASE - dbhasretstat.
4802	12C2	SYBASE - dbinit.
4803	12C3	SYBASE - dblogin.
4804	12C4	SYBASE - dbmoretext.
4805	12C5	SYBASE - dbmsghandle.
4806	12C6	SYBASE - dbnextrow.
4807	12C7	SYBASE - dbnumcols.
4808	12C8	SYBASE - dbnumrets.
4809	12C9	SYBASE - dbopen.
4810	12CA	SYBASE - dbresults.
4811	12CB	SYBASE - dbretdata.
4812	12CC	SYBASE - dbretlen.
4813	12CD	SYBASE - dbretstatus.
4814	12CE	SYBASE - dbrpcinit.
4815	12CF	SYBASE - dbrpcparam.
4816	12D0	SYBASE - dbrpcsend.
4817	12D1	SYBASE - dbsetlogintime.
4818	12D2	SYBASE - dbsetmaxprocs.
4819	12D3	SYBASE - dbsetopt.
4820	12D4	SYBASE - dbsettime.
4821	12D5	SYBASE - dbsqlexec.
4822	12D6	SYBASE - dbsqllok.
4823	12D7	SYBASE - dbsqlsend.
4824	12D8	SYBASE - dbtxptr.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
4825	12D9	SYBASE - dbtxtimestamp.
4826	12DA	SYBASE - dbtxtsnewval.
4827	12DB	SYBASE - dbuse.
4828	12DC	SYBASE - dbwinexit.
4829	12DD	SYBASE - dbwritetext.
4830	12DE	SYBASE - dbcount.
4831	12DF	SYBASE - dbdead.
4942	134E	Unmapped SQL error code.
8449	2101	Cannot open a system file.
8450	2102	I/O error on a system file.
8451	2103	Data structure corruption.
8452	2104	Cannot find engine configuration file.
8453	2105	Cannot write to engine configuration file.
8454	2106	Cannot initialize with different configuration file.
8455	2107	System has been illegally reentered.
8456	2108	Cannot locate IDAPI32.DLL.
8457	2109	Cannot load IDAPI32.DLL.
8458	210A	Cannot load an IDAPI service library.
8459	210B	Cannot create or open temporary file.
8705	2201	At beginning of table.
8706	2202	At end of table.
8707	2203	Record moved because key value changed.
8708	2204	Record/key deleted.
8709	2205	No current record.
8710	2206	Could not find record.
8711	2207	End of BLOB.
8712	2208	Could not find object.
8713	2209	Could not find family member.
8714	220A	BLOB file is missing.
8715	220B	Could not find language driver.
8961	2301	Corrupt table/index header.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
8962	2302	Corrupt file - other than header.
8963	2303	Corrupt memo/BLOB file.
8965	2305	Corrupt index.
8966	2306	Corrupt lock file.
8967	2307	Corrupt family file.
8968	2308	Corrupt or missing VAL file.
8969	2309	Foreign index file format.
9217	2401	Read failure.
9218	2402	Write failure.
9219	2403	Cannot access directory.
9220	2404	File Delete operation failed.
9221	2405	Cannot access file.
9222	2406	Access to table disabled because of previous error.
9473	2501	Insufficient memory for this operation.
9474	2502	Not enough file handles.
9475	2503	Insufficient disk space.
9476	2504	Temporary table resource limit.
9477	2505	Record size is too big for table.
9478	2506	Too many open cursors.
9479	2507	Table is full.
9480	2508	Too many sessions from this workstation.
9481	2509	Serial number limit (Paradox).
9482	250A	Some internal limit (see context).
9483	250B	Too many open tables.
9484	250C	Too many cursors per table.
9485	250D	Too many record locks on table.
9486	250E	Too many clients.
9487	250F	Too many indexes on table.
9488	2510	Too many sessions.
9489	2511	Too many open databases.
9490	2512	Too many passwords.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
9491	2513	Too many active drivers.
9492	2514	Too many fields in Table Create.
9493	2515	Too many table locks.
9494	2516	Too many open BLOBs.
9495	2517	Lock file has grown too large.
9496	2518	Too many open queries.
9498	251A	Too many BLOBs.
9499	251B	Filename is too long for a Paradox version 5.0 table.
9500	251C	Row fetch limit exceeded.
9501	251D	Long name not allowed for this table level.
9729	2601	Key violation.
9730	2602	Minimum validity check failed.
9731	2603	Maximum validity check failed.
9732	2604	Field value required.
9733	2605	Master record missing.
9734	2606	Master has detail records. Cannot delete or modify.
9735	2607	Master table level is incorrect.
9736	2608	Field value out of lookup table range.
9737	2609	Lookup Table Open operation failed.
9738	260A	Detail Table Open operation failed.
9739	260B	Master Table Open operation failed.
9740	260C	Field is blank.
9741	260D	Link to master table already defined.
9742	260E	Master table is open.
9743	260F	Detail tables exist.
9744	2610	Master has detail records. Cannot empty it.
9745	2611	Self-referencing referential integrity must be entered one at a time with no other changes to the table.
9746	2612	Detail table is open.
9747	2613	Cannot make this master a detail of another table if its details are not empty.
9748	2614	Referential integrity fields must be indexed.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
9749	2615	A table linked by referential integrity requires password to open.
9750	2616	Field(s) linked to more than one master.
9985	2701	Number is out of range.
9986	2702	Invalid parameter.
9987	2703	Invalid filename.
9988	2704	File does not exist.
9989	2705	Invalid option.
9990	2706	Invalid handle to the function.
9991	2707	Unknown table type.
9992	2708	Cannot open file.
9993	2709	Cannot redefine primary key.
9994	270A	Cannot change this RINTDesc.
9995	270B	Foreign and primary key do not match.
9996	270C	Invalid modify request.
9997	270D	Index does not exist.
9998	270E	Invalid offset into the BLOB.
9999	270F	Invalid descriptor number.
10000	2710	Invalid field type.
10001	2711	Invalid field descriptor.
10002	2712	Invalid field transformation.
10003	2713	Invalid record structure.
10004	2714	Invalid descriptor.
10005	2715	Invalid array of index descriptors.
10006	2716	Invalid array of validity check descriptors.
10007	2717	Invalid array of referential integrity descriptors.
10008	2718	Invalid ordering of tables during restructure.
10009	2719	Name not unique in this context.
10010	271A	Index name required.
10011	271B	Invalid session handle.
10012	271C	Invalid restructure operation.
10013	271D	Driver not known to system.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
10014	271E	Unknown database.
10015	271F	Invalid password given.
10016	2720	No callback function.
10017	2721	Invalid callback buffer length.
10018	2722	Invalid directory.
10019	2723	Translate Error. Value out of bounds.
10020	2724	Cannot set cursor of one table to another.
10021	2725	Bookmarks do not match table.
10022	2726	Invalid index/tag name.
10023	2727	Invalid index descriptor.
10024	2728	Table does not exist.
10025	2729	Table has too many users.
10026	272A	Cannot evaluate key or key does not pass filter condition.
10027	272B	Index already exists.
10028	272C	Index is open.
10029	272D	Invalid BLOB length.
10030	272E	Invalid BLOB handle in record buffer.
10031	272F	Table is open.
10032	2730	Need to do (hard) restructure.
10033	2731	Invalid mode.
10034	2732	Cannot close index.
10035	2733	Index is being used to order table.
10036	2734	Unknown username or password.
10037	2735	Multilevel cascade is not supported.
10038	2736	Invalid field name.
10039	2737	Invalid table name.
10040	2738	Invalid linked cursor expression.
10041	2739	Name is reserved.
10042	273A	Invalid file extension.
10043	273B	Invalid language driver.
10044	273C	Alias is not currently opened.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
10045	273D	Incompatible record structures.
10046	273E	Name is reserved by DOS.
10047	273F	Destination must be indexed.
10048	2740	Invalid index type.
10049	2741	Language drivers of table and index do not match.
10050	2742	Filter handle is invalid.
10051	2743	Invalid filter.
10052	2744	Invalid Table Create request.
10053	2745	Invalid Table Delete request.
10054	2746	Invalid Index Create request.
10055	2747	Invalid Index Delete request.
10056	2748	Invalid table specified.
10058	274A	Invalid time.
10059	274B	Invalid date.
10060	274C	Invalid date/time.
10061	274D	Tables in different directories.
10062	274E	Mismatch in the number of arguments.
10063	274F	Function not found in service library.
10064	2750	Must use <code>baseorder</code> for this operation.
10065	2751	Invalid procedure name.
10066	2752	The field map is invalid.
10241	2801	Record locked by another user.
10242	2802	Unlock failed.
10243	2803	Table is busy.
10244	2804	Directory is busy.
10245	2805	File is locked.
10246	2806	Directory is locked.
10247	2807	Record already locked by this session.
10248	2808	Object not locked.
10249	2809	Lock timeout.
10250	280A	Key group is locked.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
10251	280B	Table lock was lost.
10252	280C	Exclusive access was lost.
10253	280D	Table cannot be opened for exclusive use.
10254	280E	Conflicting record lock in this session.
10255	280F	A deadlock was detected.
10256	2810	A user transaction is already in progress.
10257	2811	No user transaction is currently in progress.
10258	2812	Record lock failed.
10259	2813	Couldn't perform the edit because another user changed the record.
10260	2814	Couldn't perform the edit because another user deleted or moved the record.
10497	2901	Insufficient field rights for operation.
10498	2902	Insufficient table rights for operation. Password required.
10499	2903	Insufficient family rights for operation.
10500	2904	This directory is read-only.
10501	2905	Database is read-only.
10502	2906	Trying to modify read-only field.
10503	2907	Encrypted dBASE tables not supported.
10504	2908	Insufficient SQL rights for operation.
10753	2A01	Field is not a BLOB.
10754	2A02	BLOB already opened.
10755	2A03	BLOB not opened.
10756	2A04	Operation not applicable.
10757	2A05	Table is not indexed.
10758	2A06	Engine not initialized.
10759	2A07	Attempt to reinitialize engine.
10760	2A08	Attempt to mix objects from different sessions.
10761	2A09	Paradox driver not active.
10762	2A0A	Driver not loaded.
10763	2A0B	Table is read only.
10764	2A0C	No associated index.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
10765	2A0D	Table(s) open. Cannot perform this operation.
10766	2A0E	Table does not support this operation.
10767	2A0F	Index is read only.
10768	2A10	Table does not support this operation because it is not uniquely indexed.
10769	2A11	Operation must be performed on the current session.
10770	2A12	Invalid use of keyword.
10771	2A13	Connection is in use by another statement.
10772	2A14	Passthrough SQL connection must be shared.
11009	2B01	Invalid function number.
11010	2B02	File or directory does not exist.
11011	2B03	Path not found.
11012	2B04	Too many open files. You may need to increase MAXFILEHANDLE limit in IDAPI configuration.
11013	2B05	Permission denied.
11014	2B06	Bad file number.
11015	2B07	Memory blocks destroyed.
11016	2B08	Not enough memory.
11017	2B09	Invalid memory block address.
11018	2B0A	Invalid environment.
11019	2B0B	Invalid format.
11020	2B0C	Invalid access code.
11021	2B0D	Invalid data.
11023	2B0F	Device does not exist.
11024	2B10	Attempt to remove current directory.
11025	2B11	Not same device.
11026	2B12	No more files.
11027	2B13	Invalid argument.
11028	2B14	Argument list is too long.
11029	2B15	Execution format error.
11030	2B16	Cross-device link.
11041	2B21	Math argument.

B**BDE ERROR
CODES**

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
11042	2B22	Result is too large.
11043	2B23	File already exists.
11047	2B27	Unknown internal operating system error.
11058	2B32	Share violation.
11059	2B33	Lock violation.
11060	2B34	Critical DOS error.
11061	2B35	Drive not ready.
11108	2B64	Not exact read/write.
11109	2B65	Operating system network error.
11110	2B66	Error from Novell file server.
11111	2B67	Novell server out of memory.
11112	2B68	Record already locked by this workstation.
11113	2B69	Record not locked.
11265	2C01	Network initialization failed.
11266	2C02	Network user limit exceeded.
11267	2C03	Wrong NET file version.
11268	2C04	Cannot lock network file.
11269	2C05	Directory is not private.
11270	2C06	Directory is controlled by other NET file.
11271	2C07	Unknown network error.
11272	2C08	Not initialized for accessing network files.
11273	2C09	Share not loaded. It is required to share local files.
11274	2C0A	Not on a network. Not logged in or wrong network driver.
11275	2C0B	Lost communication with SQL server.
11277	2C0D	Cannot locate or connect to SQL server.
11278	2C0E	Cannot locate or connect to network server.
11521	2D01	Optional parameter is required.
11522	2D02	Invalid optional parameter.
11777	2E01	Obsolete.
11778	2E02	Obsolete.
11779	2E03	Ambiguous use of ! (inclusion operator).

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
11780	2E04	Obsolete.
11781	2E05	Obsolete.
11782	2E06	A SET operation cannot be included in its own grouping.
11783	2E07	Only numeric and date/time fields can be averaged.
11784	2E08	Invalid expression.
11785	2E09	Invalid OR expression.
11786	2E0A	Obsolete.
11787	2E0B	Bitmap.
11788	2E0C	CALC expression cannot be used in INSERT, DELETE, CHANGETO, and SET rows.
11789	2E0D	Type error in CALC expression.
11790	2E0E	CHANGETO can be used in only one query form at a time.
11791	2E0F	Cannot modify CHANGED table.
11792	2E10	A field can contain only one CHANGETO expression.
11793	2E11	A field cannot contain more than one expression to be inserted.
11794	2E12	Obsolete.
11795	2E13	CHANGETO must be followed by the new value for the field.
11796	2E14	Checkmark or CALC expressions cannot be used in FIND queries.
11797	2E15	Cannot perform operation on CHANGED table together with a CHANGETO query.
11798	2E16	Chunk.
11799	2E17	More than 255 fields in ANSWER table.
11800	2E18	AS must be followed by the name for the field in the ANSWER table.
11801	2E19	DELETE can be used in only one query form at a time.
11802	2E1A	Cannot perform operation on DELETED table together with a DELETE query.
11803	2E1B	Cannot delete from the DELETED table.
11804	2E1C	Example element is used in two fields with incompatible types or with a BLOB.
11805	2E1D	Cannot use example elements in an OR expression.
11806	2E1E	Expression in this field has the wrong type.
11807	2E1F	Extra comma found.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
11808	2E20	Extra OR found.
11809	2E21	One or more query rows do not contribute to the ANSWER.
11810	2E22	FIND can be used in only one query form at a time.
11811	2E23	FIND cannot be used with the ANSWER table.
11812	2E24	A row with GROUPBY must contain SET operations.
11813	2E25	GROUPBY can be used only in SET rows.
11814	2E26	Use only INSERT, DELETE, SET, or FIND in leftmost column.
11815	2E27	Use only one INSERT, DELETE, SET, or FIND per line.
11816	2E28	Syntax error in expression.
11817	2E29	INSERT can be used in only one query form at a time.
11818	2E2A	Cannot perform operation on INSERTED table together with an INSERT query.
11819	2E2B	INSERT, DELETE, CHANGETO, and SET rows may not be checked.
11820	2E2C	Field must contain an expression to insert (or be blank).
11821	2E2D	Cannot insert into the INSERTED table.
11822	2E2E	Variable is an array and cannot be accessed.
11823	2E2F	Label.
11824	2E30	Rows of example elements in CALC expression must be linked.
11825	2E31	Variable name is too long.
11826	2E32	Query may take a long time to process.
11827	2E33	Reserved word or one that can't be used as a variable name.
11828	2E34	Missing comma.
11829	2E35	Missing right parenthesis.
11830	2E36	Missing right quote.
11831	2E37	Cannot specify duplicate column names.
11832	2E38	Query has no checked fields.
11833	2E39	Example element has no defining occurrence.
11834	2E3A	No grouping is defined for SET operation.
11835	2E3B	Query makes no sense.
11836	2E3C	Cannot use patterns in this context.
11837	2E3D	Date does not exist.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
11838	2E3E	Variable has not been assigned a value.
11839	2E3F	Invalid use of example element in summary expression.
11840	2E40	Incomplete query statement. Query only contains a SET definition.
11841	2E41	Example element with ! makes no sense in expression.
11842	2E42	Example element cannot be used more than twice with a ! query.
11843	2E43	Row cannot contain expression.
11844	2E44	Obsolete.
11845	2E45	Obsolete.
11846	2E46	No permission to insert or delete records.
11847	2E47	No permission to modify field.
11848	2E48	Field not found in table.
11849	2E49	Expecting a column separator in table header.
11850	2E4A	Expecting a column separator in table.
11851	2E4B	Expecting a column name in table.
11852	2E4C	Expecting table name.
11853	2E4D	Expecting consistent number of columns in all rows of table.
11854	2E4E	Cannot open table.
11855	2E4F	Field appears more than once in table.
11856	2E50	This DELETE, CHANGE, or INSERT query has no ANSWER.
11857	2E51	Query is not prepared. Properties unknown.
11858	2E52	DELETE rows cannot contain quantifier expression.
11859	2E53	Invalid expression in INSERT row.
11860	2E54	Invalid expression in INSERT row.
11861	2E55	Invalid expression in SET definition.
11862	2E56	Row use.
11863	2E57	SET keyword expected.
11864	2E58	Ambiguous use of example element.
11865	2E59	Obsolete.
11866	2E5A	Obsolete.
11867	2E5B	Only numeric fields can be summed.
11868	2E5C	Table is write protected.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
11869	2E5D	Token not found.
11870	2E5E	Cannot use example element with ! more than once in a single row.
11871	2E5F	Type mismatch in expression.
11872	2E60	Query appears to ask two unrelated questions.
11873	2E61	Unused SET row.
11874	2E62	INSERT, DELETE, FIND, and SET can be used only in the leftmost column.
11875	2E63	CHANGETO cannot be used with INSERT, DELETE, SET, or FIND.
11876	2E64	Expression must be followed by an example element defined in a SET.
11877	2E65	Lock failure.
11878	2E66	Expression is too long.
11879	2E67	Refresh exception during query.
11880	2E68	Query canceled.
11881	2E69	Unexpected database engine error.
11882	2E6A	Not enough memory to finish operation.
11883	2E6B	Unexpected exception.
11884	2E6C	Feature not implemented yet in query.
11885	2E6D	Query format is not supported.
11886	2E6E	Query string is empty.
11887	2E6F	Attempted to prepare an empty query.
11888	2E70	Buffer too small to contain query string.
11889	2E71	Query was not previously parsed or prepared.
11890	2E72	Function called with bad query handle.
11891	2E73	QBE syntax error.
11892	2E74	Query extended syntax field count error.
11893	2E75	Field name in sort or field clause not found.
11894	2E76	Table name in sort or field clause not found.
11895	2E77	Operation is not supported on BLOB fields.
11896	2E78	General BLOB error.
11897	2E79	Query must be restarted.
11898	2E7A	Unknown answer table type.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
11926	2E96	Blob cannot be used as grouping field.
11927	2E97	Query properties have not been fetched.
11928	2E98	Answer table is of unsuitable type.
11929	2E99	Answer table is not yet supported under server alias.
11930	2E9A	Non-null BLOB field required. Can't insert records.
11931	2E9B	Unique index required to perform CHANGETO.
11932	2E9C	Unique index required to delete records.
11933	2E9D	Update of table on the server failed.
11934	2E9E	Can't process this query remotely.
11935	2E9F	Unexpected end of command.
11936	2EA0	Parameter not set in query string.
11937	2EA1	Query string is too long.
11946	2EAA	No such table or correlation name.
11947	2EAB	Expression has ambiguous data type.
11948	2EAC	Field in ORDER BY must be in resultset.
11949	2EAD	General parsing error.
11950	2EAE	Record or field constraint failed.
11951	2EAF	Field in group by must be in resultset.
11952	2EB0	User-defined function is not defined.
11953	2EB1	Unknown error from user-defined function.
11954	2EB2	Single-row subquery produced more than one row.
11955	2EB3	Expressions in GROUP BY are not supported.
11956	2EB4	Queries on text or ASCII tables is not supported.
11957	2EB5	ANSI join keywords USING and NATURAL are not supported in this release.
11958	2EB6	SELECT DISTINCT may not be used with UNION unless UNION ALL is used.
11959	2EB7	GROUP BY is required when both aggregate and nonaggregate fields are used in resultset.
11960	2EB8	INSERT and UPDATE operations are not supported on autoincrement field type.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
11961	2EB9	UPDATE on primary key of a master table may modify more than one record.
12033	2F01	Interface mismatch. Engine version different.
12034	2F02	Index is out of date.
12035	2F03	Older version (see context).
12036	2F04	VAL file is out of date.
12037	2F05	BLOB file version is too old.
12038	2F06	Query and engine DLLs are mismatched.
12039	2F07	Server is incompatible version.
12040	2F08	Higher table level required.
12289	3001	Capability not supported.
12290	3002	Not implemented yet.
12291	3003	SQL replicas not supported.
12292	3004	Non-BLOB column in table required to perform operation.
12293	3005	Multiple connections not supported.
12294	3006	Full dBASE expressions not supported.
12545	3101	Invalid database alias specification.
12546	3102	Unknown database type.
12547	3103	Corrupt system configuration file.
12548	3104	Network type unknown.
12549	3105	Not on the network.
12550	3106	Invalid configuration parameter.
12801	3201	Object implicitly dropped.
12802	3202	Object may be truncated.
12803	3203	Object implicitly modified.
12804	3204	Should field constraints be checked?
12805	3205	Validity check field modified.
12806	3206	Table level changed.
12807	3207	Copy linked tables?
12809	3209	Object implicitly truncated.
12810	320A	Validity check will not be enforced.
12811	320B	Multiple records found, but only one was expected.

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
12812	320C	Field will be trimmed. Cannot put master records into problem table.
13057	3301	File already exists.
13058	3302	BLOB has been modified.
13059	3303	General SQL error.
13060	3304	Table already exists.
13061	3305	Paradox 1.0 tables are not supported.
13062	3306	Update aborted.
13313	3401	Different sort order.
13314	3402	Directory in use by earlier version of Paradox.
13315	3403	Needs Paradox 3.5-compatible language driver.
13569	3501	Data dictionary is corrupt.
13570	3502	Data dictionary info BLOB corrupted.
13571	3503	Data dictionary schema is corrupt.
13572	3504	Attribute type exists.
13573	3505	Invalid object type.
13574	3506	Invalid relation type.
13575	3507	View already exists.
13576	3508	No such view exists.
13577	3509	Invalid record constraint.
13578	350A	Object is in a logical DB.
13579	350B	Dictionary already exists.
13580	350C	Dictionary does not exist.
13581	350D	Dictionary database does not exist.
13582	350E	Dictionary info is out of date. Needs refreshed.
13584	3510	Invalid dictionary name.
13585	3511	Dependent objects exist.
13586	3512	Too many relationships for this object type.
13587	3513	Relationships to the object exist.
13588	3514	Dictionary exchange file is corrupt.
13589	3515	Dictionary exchange file version mismatch.
13590	3516	Dictionary object type mismatch.

B**BDE ERROR
CODES***continues*

TABLE B.1 Continued

<i>Error Code</i>		
<i>Decimal</i>	<i>Hex</i>	<i>Error String</i>
13591	3517	Object exists in target dictionary.
13592	3518	Cannot access data dictionary.
13593	3519	Cannot create data dictionary.
13594	351A	Cannot open database.
15873	3E01	Wrong driver name.
15874	3E02	Wrong system version.
15875	3E03	Wrong driver version.
15876	3E04	Wrong driver type.
15877	3E05	Cannot load driver.
15878	3E06	Cannot load language driver.
15879	3E07	Vendor initialization failed.
15880	3E08	Your application is not enabled for use with this driver.

Suggested Reading

APPENDIX

C

IN THIS APPENDIX

- **Delphi Programming 1928**
- **Component Design 1928**
- **Windows Programming 1928**
- **Object-Oriented Programming 1928**
- **Software Project Management and User Interface Design 1928**
- **COM/ActiveX/OLE 1929**

Delphi Programming

- *The Tomes of Delphi 3: Win32 Graphical API*, by John Ayres, David Bowden, Larry Diehl, Phil Dorcas, Kenneth Harrison, Rod Mathes, Ovias Reza, and Mike Tobin (Wordware Publishing, Inc., 1998).
- *The Tomes of Delphi 3: Win32 Core API*, by John Ayres, David Bowden, Larry Diehl, Phil Dorcas, Kenneth Harrison, Rod Mathes, Ovias Reza, and Mike Tobin (Wordware Publishing, Inc., 1997).
- *Charlie Calvert's Delphi 4 Unleashed*, by Charlie Calvert (Sams Publishing, 1998).
- *Mastering Delphi 5*, by Marco Cantu (Sybex, 1999).
- *Delphi Developer's Handbook*, by Marco Cantu, Tim Gooch, and John F. Lam (Sybex, 1997).
- *Hidden Paths of Delphi 3*, by Ray Lischner (Informant Communications Group, 1997).
- *Secrets of Delphi 2*, by Ray Lischner (Waite Group Press, 1996).

Component Design

The following two books are listed as out of print. However, it may still be possible to get them through Amazon.com or another retailer.

- *Developing Custom Delphi 3 Components*, by Ray Konopka (Coriolis Group Books, 1997).
- *Delphi Component Design*, by Danny Thorpe (Addison-Wesley, 1997).

Windows Programming

- *Advanced Windows, 3rd Ed.*, by Jeffrey Richter (Microsoft Press, 1997).

Object-Oriented Programming

- *Object-Oriented Analysis and Design with Applications, 2nd Ed.*, by Grady Booch (Addison-Wesley, 1994).
- *Design Patterns: Elements of Reusable Object-Oriented Software*, by Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides (Addison-Wesley, 1995).

Software Project Management and User Interface Design

- *About Face: The Essentials of User Interface Design*, by Alan Cooper (IDG Books, 1995).

- *Rapid Development*, by Steve McConnell (Microsoft Press, 1996).
- *Software Project Survival Guide*, by Steve McConnell (Microsoft Press, 1998).
- *Code Complete*, by Steve McConnell (Microsoft Press, 1993).

COM/ActiveX/OLE

- *Essential COM*, by Don Box (Addison-Wesley, 1998).
- *Inside OLE, 2nd Ed.*, by Kraig Brockschmidt (Microsoft Press, 1995).

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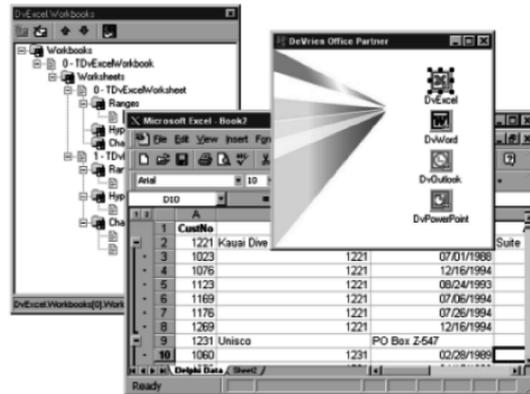
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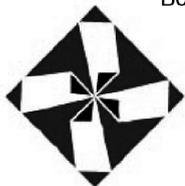


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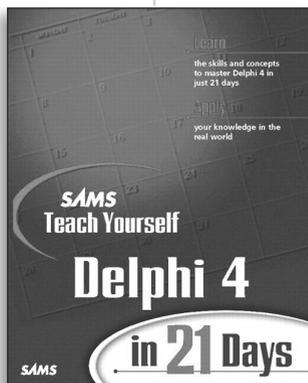


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