Praise for Professional Excel Development

“Think you know Microsoft Excel? Think again. This book covers intermediate (class modules, dictator applications, etc.) to advanced topics like XLLs, C APIs and Web Services. It offers plenty of easy to understand code listings that show exactly what the authors are trying to convey without forcing the readers to follow step-by-step.”

Deepak Sharma, Sr. Systems Specialist, Tata Infotech Ltd.

“This book takes off where other Excel books stop. It covers Excel programming beyond VBA and looks at the professional issues—security, distribution, working with databases—using VB, VBA.NET and Windows API calls. The authors’ depth and practical experience shows in the details. They explain complex issues clearly, describe best practices and point out traps to avoid.”

Shauna Kelly, Microsoft Office MVP, www.ShaunaKelly.com

“The approach of following an application’s development is very effective in developing the concepts as the chapters unfold. The practical, working examples used are relevant to many professional programmers.”

Jan Karel Pieterse, JKP Application Development Services, www.jkp-ads.com

“This book stands out. While there are plenty of Excel books, I am not aware of any organized in this way. Information on .NET, and C, as well as other unique and useful chapters makes this a great offering.”

Ken Bluttman, Author of Developing Microsoft Office Solutions

“This book explains difficult concepts in detail. The authors provide more than one method for complex development topics, along with the advantages and disadvantages of using the various methods described. They have my applause for the incorporation of development best practices.”

Beth Melton, Microsoft Office MVP
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Professional Excel Development
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Contents

Acknowledgments .................................................. xv
About the Authors ............................................... xvii

Chapter 1: Introduction ........................................... 1

About This Book .................................................. 1
The Excel Developer ............................................... 2
Excel as an Application Development Platform .............. 3
Structure .............................................................. 7
Examples .............................................................. 8
Supported Versions ................................................. 9
Typefaces ............................................................ 9
On the CD ........................................................... 10
Help and Support ................................................... 11
Feedback ............................................................. 12

Chapter 2: Application Architectures ....................... 13

Concepts ............................................................. 13
Conclusion .......................................................... 25

Chapter 3: Excel and VBA Development Best Practices .... 29

Naming Conventions ............................................... 29
Best Practices for Application Structure and Organization ... 42
General Application Development Best Practices ............ 47
Conclusion .......................................................... 68

Chapter 4: Worksheet Design .................................. 69

Principles of Good Worksheet UI Design .................... 69
Program Rows and Columns: The Fundamental UI Design Technique ............................................. 70
Chapter 5: Function, General and Application-Specific Add-ins  109

The Four Stages of an Application ................................. 109
Function Library Add-ins ........................................... 112
General Add-ins ...................................................... 120
Application-Specific Add-Ins ....................................... 121
Practical Example ..................................................... 128
Conclusion ............................................................. 142

Chapter 6: Dictator Applications ................................. 143

Structure of a Dictator Application ............................. 143
Practical Example ..................................................... 159
Conclusion ............................................................. 166

Chapter 7: Using Class Modules to Create Objects ......... 167

Creating Objects ..................................................... 167
Creating a Collection ................................................ 172
Trapping Events ....................................................... 179
Raising Events ......................................................... 182
Practical Example ..................................................... 190
Conclusion ............................................................. 197

Chapter 8: Advanced Command Bar Handling ............. 199

Command Bar Design .................................................. 199
Table-Driven Command Bars ...................................... 201
Putting It All Together ............................................... 222
Loading Custom Icons from Files ............................... 232
### Chapter 9: Understanding and Using Windows API Calls

Overview .................................................. 255  
Working with the Screen ............................. 261  
Working with Windows ............................... 264  
Working with the Keyboard ......................... 274  
Working with the File System and Network ...... 279  
Practical Examples .................................... 294  
Conclusion ................................................. 297

### Chapter 10: Userform Design and Best Practices

Principles .................................................. 299  
Control Fundamentals ............................... 309  
Visual Effects ............................................. 316  
Userform Positioning and Sizing ................... 325  
Wizards .................................................... 332  
Dynamic Userforms .................................... 336  
Modeless Userforms .................................... 344  
Control Specifics ....................................... 350  
Practical Examples ..................................... 357  
Conclusion ............................................... 358

### Chapter 11: Interfaces

What Is an Interface? ................................. 359  
Code Reuse ............................................... 361  
Defining a Custom Interface ......................... 363  
Implementing a Custom Interface ................. 364  
Using a Custom Interface ............................ 366  
Polymorphic Classes ................................. 368  
Improving Robustness .................................. 373  
Simplifying Development ............................ 374  
A Plug-in Architecture ............................... 386  
Practical Example ..................................... 388  
Conclusion ............................................... 389
Chapter 12: VBA Error Handling  ............................................ 391

Error-Handling Concepts ................................................. 391
The Single Exit Point Principle ....................................... 401
Simple Error Handling ................................................... 402
Complex Project Error Handler Organization ................... 403
The Central Error Handler ............................................... 408
Error Handling in Classes and Userforms ......................... 415
Putting It All Together ................................................... 416
Practical Example .......................................................... 423
Conclusion ................................................................. 433

Chapter 13: Programming with Databases  ......................... 435

An Introduction to Databases ........................................... 435
Designing the Data Access Tier ....................................... 453
Data Access with SQL and ADO ....................................... 454
Further Reading ........................................................... 475
Practical Example .......................................................... 477
Conclusion ................................................................. 489

Chapter 14: Data Manipulation Techniques  ....................... 491

Excel’s Data Structures .................................................. 491
Data Processing Features ............................................... 497
Advanced Functions ...................................................... 509
Conclusion ................................................................. 517

Chapter 15: Advanced Charting Techniques  ...................... 519

Fundamental Techniques ................................................. 519
VBA Techniques .......................................................... 537
Conclusion ................................................................. 543

Chapter 16: VBA Debugging ............................................ 545

Basic VBA Debugging Techniques .................................... 545
The Immediate Window (Ctrl+G) ...................................... 556
The Call Stack (Ctrl+L) .................................................. 560
The Watch Window ....................................................... 561
### Chapter 17: Optimizing VBA Performance

- Measuring Performance ........................................ 587
- The PerfMon Utility ............................................. 588
- Creative Thinking ............................................... 592
- Macro-Optimization ............................................. 598
- Micro-Optimization ............................................. 609
- Conclusion ....................................................... 616

### Chapter 18: Controlling Other Office Applications

- Fundamentals .................................................... 619
- The Primary Office Application Object Models ............. 635
- Practical Example ................................................ 648
- Conclusion ....................................................... 649

### Chapter 19: XLLs and the C API

- Why Create an XLL-Based Worksheet Function ............. 651
- Creating an XLL Project in Visual Studio ..................... 652
- The Structure of an XLL ........................................ 657
- The XLOPER and OPER Data Types .......................... 667
- The Excel4 Function ............................................. 672
- Commonly Used C API Functions .............................. 674
- XLOPERs and Memory Management ........................... 675
- Registering and Unregistering Custom Worksheet Functions ... 676
- Sample Application Function .................................. 679
- Debugging the Worksheet Functions ........................... 682
- Miscellaneous Topics .......................................... 683
- Additional Resources .......................................... 684
- Conclusion ....................................................... 686
Chapter 24: Providing Help, Securing, Packaging and Distributing 863

Providing Help 863
Securing 872
Packaging 877
Distributing 883
Conclusion 884

Index 885
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Lastly, we want to thank you for buying this book. Please tell us what you think about it, either by e-mail or by writing a review at Amazon.com.

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He wrote his first programs in FORTRAN, took a part in the evolution of specialized planning languages on mainframes and, in the early 1980s, became interested in spreadsheet systems, including 1-2-3 and Excel.

John established his company, Execuplan Consulting, in 1980, developing computer-based planning applications and training users and developers.

John has had regular columns in a number of Australian magazines and has contributed chapters to a number of books, including Excel Expert Solutions and Using Visual Basic for Applications 5, published by Que. He is the principal author of Excel 2000 VBA Programmer’s Reference and its subsequent editions, published by Wrox Press.

Since 1995 he has been accorded the status of Most Valuable Professional by Microsoft for his contributions to the CompuServe Excel forum and MS Internet newsgroups.
In the *Programming with the Windows API* chapter of our *Excel 2002 VBA Programmers Reference*, we approached the subject of using Windows API calls by explaining how to locate the definitions for various functions on the MSDN Web site and translate those functions for use in VBA. The idea was to enable readers to browse through the API documentation and use anything of interest they found.

In reality, extremely few people use Windows API calls in that manner; indeed, trying to include previously unexplored API calls in our Excel applications is very likely to result in a maintenance problem, because it’s doubtful that another developer will understand what we were trying to do. Instead, most of us go to Google and search the Web or the newsgroups for the answer to a problem and find that the solution requires the use of API calls. (Searching Google for “Excel Windows API” results in more than 200,000 Web pages and 19,000 newsgroup posts.) We copy the solution into our application and hope it works, usually without really understanding what it does. This chapter shines a light on many of those solutions, explaining how they work, what they use the API calls for, and how they can be modified to better fit our applications. Along the way, we fill in some of the conceptual framework of common Windows API techniques and terminology.

By the end of the chapter, you will be comfortable about including API calls in your applications, understand how they work, accept their use in the example applications we develop in this book and be able to modify them to suit your needs.

**Overview**

When developing Excel-based applications, we can get most things done by using the Excel object model. Occasionally, though, we need some
information or feature that Excel doesn’t provide. In those cases, we can usually go directly to the files that comprise the Windows operating system to find what we’re looking for. The first step in doing that is to tell VBA the function exists, where to find it, what arguments it takes and what data type it returns. This is done using the Declare statement, such as that for GetSystemMetrics:

```
Declare Function GetSystemMetrics Lib "user32" _
   (ByVal nIndex As Long) As Long
```

This statement tells the VBA interpreter that there is a function called GetSystemMetrics located in the file user32.exe (or user32.dll, it’ll check both) that takes one argument of a Long value and returns a Long value. Once defined, we can call GetSystemMetrics in exactly the same way as if it is the VBA function:

```
Function GetSystemMetrics(ByVal nIndex As Long) As Long
End Function
```

The Declare statements can be used in any type of code module, can be Public or Private (just like standard procedures), but must always be placed in the Declarations section at the top of the module.

**Finding Documentation**

All of the functions in the Windows API are fully documented in the Windows Development/Platform SDK section of the MSDN library on the Microsoft Web site, at http://msdn.microsoft.com/library, although the terminology used and the code samples tend to be targeted at the C++ developer. A Google search will usually locate documentation more appropriate for the Visual Basic and VBA developer, but is unlikely to be as complete as MSDN. If you’re using API calls found on a Web site, the Web page will hopefully explain what they do, but it is a good idea to always check the official documentation for the functions to see whether any limitations or other remarks may affect your usage.

Unfortunately, the MSDN library’s search engine is significantly worse than using Google to search the MSDN site. We find that Google always gives us more relevant pages than MSDN’s search engine. To use Google to search MSDN, browse to http://www.google.com and click the Advanced Search link. Type in the search criteria and then in the Domain edit box type msdn.microsoft.com to restrict the search to MSDN.
Finding Declarations

It is not uncommon to encounter code snippets on the Internet that include incorrect declarations for API functions—such as declaring an argument’s data type as Integer or Boolean when it should be Long. Although using the declaration included in the snippet will probably work (hopefully the author tested it), it might not work for the full range of possible arguments that the function accepts and in rare cases may cause memory corruption and data loss. The official VBA-friendly declarations for many of the more commonly used API functions can be found in the win32api.txt file, which is included with a viewer in the Developer Editions of Office 97–2002, Visual Basic 6 and is available for download from http://support.microsoft.com/?kbid=178020. You’ll notice from the download page that the file hasn’t been updated for some time. It therefore doesn’t include the declarations and constants added in recent versions of Windows. If you’re using one of those newer declarations, you’ll have to trust the Web page author, examine a number of Web pages to check that they all use the same declaration or create your own VBA-friendly declaration by following the steps we described in the Excel 2002 VBA Programmers Reference.

Finding the Values of Constants

Most API functions are passed constants to modify their behavior or specify the type of value to return. For example, the GetSystemMetrics function shown previously accepts a parameter to specify which metric we want, such as SM_CXSCREEN to get the width of the screen in pixels or SM_CYSCREEN to get the height. All of the appropriate constants are shown on the MSDN page for that declaration. For example, the GetSystemMetrics function is documented at http://msdn.microsoft.com/library/en-us/sysinfo/base/getsystemmetrics.asp and shows more than 70 valid constants.

Although many of the constants are included in the win32api.txt file mentioned earlier, it does not include constants added for recent versions of Windows. The best way to find these values is by downloading and installing the core Platform SDK from http://www.microsoft.com/msdownload/platformsdk/sdkupdate/. This includes all the C++ header files that were used to build the DLLs, in a subdirectory called \include. The files in this directory can be searched using normal Windows file searching to find the file that
contains the constant we’re interested in. For example, searching for SM_CXSCREEN gives the file winuser.h. Opening that file and searching within it gives the following lines:

```
#define SM_CXSCREEN             0
#define SM_CYSCREEN             1
```

These constants can then be included in your VBA module by declaring them as Long variables with the values shown:

```
Const SM_CXSCREEN As Long = 0
Const SM_CYSCREEN As Long = 1
```

Sometimes, the values will be shown in hexadecimal form, such as 0x8000, which can be converted to VBA by replacing the 0x with &h and adding a further & on the end, such that

```
#define KF_UP               0x8000
```

becomes

```
Const KF_UP As Long = &h8000&
```

**Understanding Handles**

Within VBA, we’re used to setting a variable to reference an object using code like

```
Set wkbBackDrop = Workbooks("Backdrop.xls")
```

and releasing that reference by setting the variable to Nothing (or letting VBA do that for us when it goes out of scope at the end of the procedure). Under the covers, the thing that we see as the Backdrop.xls workbook is just an area of memory containing data structured in a specific way that only Excel understands. When we set the variable equal to that object, it is just given the memory location of that data structure. The Windows operating system works in a very similar way, but at a much more granular level; almost everything within Windows is maintained as a small data structure somewhere. If we want to work with the item that is represented by that structure (such as a window), we need to get a reference to it and pass that
reference to the appropriate API function. These references are known as *handles* and are just ID numbers that Windows uses to identify the data structure. Variables used to store handles are usually given the prefix `h` and are declared as `Long`.

When we ask for the handle to an item, some functions—such as `FindWindow`—give us the handle to a shared data structure; there is only one data structure for each window, so every call to `FindWindow` with the same parameters will return the same handle. In these cases, we can just discard the handle when we’re finished with it. In most situations, however, Windows allocates an area of memory, creates a new data structure for us to use and returns the handle to that structure. In these cases, we must tidy up after ourselves, by explicitly telling Windows that we’ve finished using the handle (and by implication, the memory used to store the data structure that the handle points to). If we fail to tidy up correctly, each call to our routine will use another bit of memory until Windows crashes—this is known as a *memory leak*. The most common cause of memory leaks is forgetting to include tidy-up code within a routine’s error handler. The MSDN documentation will tell you whether you need to release the handle and which function to call to do it.

**Encapsulating API Calls**

`GetSystemMetrics` is one of the few API calls that can easily be used in isolation—it has a meaningful name, takes a single parameter, returns a simple result and doesn’t require any preparation or cleanup. So long as you can remember what `SM_CXSCREEN` is asking for, it’s extremely easy to call this function; `GetSystemMetrics(SM_CXSCREEN)` gives us the width of the screen in pixels.

In general practice, however, it is a very good idea to wrap your API calls inside their own VBA functions and to place those functions in modules dedicated to specific areas of the Windows API, for the following reasons:

- The VBA routine can include some validity checks before trying to call the API function. Passing invalid data to API functions will often result in a crash.
- Most of the textual API functions require string variables to be defined and passed in, which are then populated by the API function. Using a VBA routine hides that complexity.
Many API functions accept parameters that we don’t need to use. A VBA routine can expose only the parameters that are applicable to our application.

Few API functions can be used in isolation; most require extra preparatory and clean up calls. Using a VBA routine hides that complexity.

The API declarations themselves can be declared Private to the module in which they’re contained, so they can be hidden from use by other developers who may not understand how to use them; their functionality can then be exposed through more friendly VBA routines.

Some API functions, such as the encryption or Internet functions, require an initial set of preparatory calls to open resources, a number of routines that use those resources and a final set of routines to close the resources and tidy up. Such routines are ideally encapsulated in a class module, with the Class_Initialize and Class_Terminate procedures used to ensure the resources are opened and closed correctly.

By using dedicated modules for specific areas of the Windows API, we can easily copy the routines between applications, in the knowledge that they are self-contained.

When you start to include lots of API calls in your application, it quickly becomes difficult to keep track of which constants belong to which functions. We can make the constants much easier to manage if we encapsulate them in an enumeration and use that enumeration for our VBA function’s parameter, as shown in Listing 9-1. By doing this, the applicable constants are shown in the Intellisense list when the VBA function is used, as shown in Figure 9-1. The ability to define enumerations was added in Excel 2000.

### Listing 9-1  Encapsulating the GetSystemMetrics API Function and Related Constants

```vba
' Declare all the API-specific items Private to the module
Private Declare Function GetSystemMetrics Lib "user32" _
    (ByVal nIndex As Long) As Long
Private Const SM_CXSCREEN As Long = 0
Private Const SM_CYSCREEN As Long = 1

' Wrap the API constants in a public enumeration,
```
'so they appear in the Intellisense drop-down
Public Enum SystemMetricsConstants
    smScreenWidth = SM_CXSCREEN
    smScreenHeight = SM_CYSCREEN
End Enum

'Wrapper for the GetSystemMetrics API function, 'using the SystemMetricsConstants enumeration
Public Function SystemMetrics(ByVal uIndex As SystemMetricsConstants) As Long
    SystemMetrics = GetSystemMetrics(uIndex)
End Function

Figure 9-1 By Using the Enumeration, the Relevant Constants Appear in the Intellisense Drop-Down

Working with the Screen

The procedures included in this section all relate to the Windows screen and can be found in the MScreen module of the API Examples.xls workbook.

Reading the Screen Resolution

The GetSystemMetrics API function has been used to illustrate the general concepts above. It can be used to discover many of the simpler aspects of the operating system, from whether a mouse or network is present to the height of the standard window title bar. By far its most common use in Excel is to find the screen resolution, to check that it is at least a minimum size (for example, 800×600) or to work out which userform to display if you have different layouts optimized for different resolutions. The code in Listing 9-2 wraps the GetSystemMetrics API function, exposing it as separate ScreenWidth and ScreenHeight functions.
Listing 9-2 Reading the Screen Resolution

' Declare all the API-specific items Private to the module
Private Declare Function GetSystemMetrics Lib "user32" _
(ByVal nIndex As Long) As Long
Private Const SM_CXSCREEN = 0     'Screen width
Private Const SM_CYSCREEN = 1     'Screen height

' The width of the screen, in pixels
Public Function ScreenWidth() As Long
    ScreenWidth = GetSystemMetrics(SM_CXSCREEN)
End Function

' The height of the screen, in pixels
Public Function ScreenHeight() As Long
    ScreenHeight = GetSystemMetrics(SM_CYSCREEN)
End Function

Finding the Size of a Pixel

In general, Excel measures distances in points, whereas most API functions use pixels and many ActiveX controls (such as the Microsoft Flexgrid) use twips. A point is defined as being 1/72 (logical) inches, and a twip is defined as 1/20th of a point. To convert between pixels and points, we need to know how many pixels Windows is displaying for each logical inch. This is the DPI (dots per inch) set by the user in Control Panel > Display > Settings > Advanced > General > Display, which is usually set at either Normal size (96 DPI) or Large size (120 DPI). In versions of Windows prior to XP, this was known as Small Fonts and Large Fonts. The value of this setting can be found using the GetDeviceCaps API function, which is used to examine the detailed capabilities of a specific graphical device, such as a screen or printer.

Device Contexts

One of the fundamental features of Windows is that applications can interact with all graphical devices (screens, printers, or even individual picture files) in a standard way. This is achieved by operating through a layer of indirection called a device context, which represents a drawing layer. An application obtains a reference (handle) to the drawing layer for a specific device (for example, the screen), examines its capabilities (such as the size
of a dot, whether it can draw curves and how many colors it supports),
draws onto the drawing layer and then releases the reference. Windows
takes care of exactly how the drawing layer is represented on the graphical
device. In this example, we’re only examining the screen’s capabilities.

The code to retrieve the size of a pixel is shown in Listing 9-3.
Remember that when adding this code to an existing module, the declara-
tions must always be placed at the top of the module.

Listing 9-3 Finding the Size of a Pixel

```vbnet
Private Declare Function GetDC Lib "user32" _
(ByVal hwnd As Long) As Long

Private Declare Function GetDeviceCaps Lib "gdi32" _
(ByVal hDC As Long, ByVal nIndex As Long) As Long

Private Declare Function ReleaseDC Lib "user32" _
(ByVal hwnd As Long, ByVal hDC As Long) As Long

Private Const LOGPIXELSX = 88    'Pixels/inch in X
' A point is defined as 1/72 inches
Private Const POINTS_PER_INCH As Long = 72

' The size of a pixel, in points
Public Function PointsPerPixel() As Double

    Dim hDC As Long
    Dim lDotsPerInch As Long

    hDC = GetDC(0)
    lDotsPerInch = GetDeviceCaps(hDC, LOGPIXELSX)
    PointsPerPixel = POINTS_PER_INCH / lDotsPerInch
    ReleaseDC 0, hDC

End Function
```

The first thing to notice about this routine is that we cannot just call
GetDeviceCaps directly; we need to give it a handle to the screen’s device
context. This handle is obtained by calling the GetDC function, where the
zero parameter conveniently gives us the device context for the screen. We
then call GetDeviceCaps, passing the constant LOGPIXELSX, which asks
for the number of pixels per logical inch horizontally. (For screens, the horizontal and vertical DPI is the same, but it might not be for printers, which is why circles on screen often print out as ovals.) With Normal size chosen, we get 96 dots per inch. We divide the 72 points per inch by the 96 DPI, telling us that a dot (that is, pixel) is 0.75 points; so if we want to move something in Excel by one pixel, we need to change its Top or Left by 0.75. With Large Size selected, a pixel is 0.6 points.

Every time we use GetDC to obtain a handle to a device context, we use up a small amount of Window's graphical resources. If we didn't release the handle after using it, we would eventually use up all of Window's graphical resources and crash. To avoid that, we have to be sure to release any resources we obtain, in this case by calling ReleaseDC.

**Working with Windows**

Everything that we see on the screen is either a window or is contained within a window, from the Windows desktop to the smallest popup tooltip. Consequently, if we want to modify something on the screen, we always start by locating its window. The windows are organized into a hierarchy, with the desktop at the root. The next level down includes the main windows for all open applications and numerous system-related windows. Each application then owns and maintains its own hierarchy of windows. Every window is identified by its window handle, commonly referred to as hWnd. By far the best tool for locating and examining windows is the Spy++ utility that is included with Visual Studio. Figure 9-2 shows the Spy++ display for the window hierarchy of a typical Excel session.

**Window Classes**

As well as showing the hierarchy, the Spy++ display shows three key attributes for each window: the handle (in hexadecimal), the caption and the class. Just like class modules, a window class defines a type of window. Some classes, such as the ComboBox class, are provided by the Windows operating system, but most are defined as part of an application. Each window class is usually associated with a specific part of an application, such as XLMAIN being Excel's main application window. Table 9-1 lists the window classes shown in the Spy++ hierarchy and their uses, plus some other window classes commonly encountered during Excel application development.
Figure 9-2 The Spy++ Display of the Excel Window Hierarchy

Table 9-1 Excel Window Classes and Their Uses

<table>
<thead>
<tr>
<th>Window Class</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>XLMAIN</td>
<td>The main Excel application window.</td>
</tr>
<tr>
<td>EXCEL1</td>
<td>The left half of the formula bar, including the Name drop-down.</td>
</tr>
<tr>
<td>ComboBox</td>
<td>A standard Windows combo box (in this case, it's the Name drop-down).</td>
</tr>
<tr>
<td>EXCEL2</td>
<td>The edit box section of the formula bar.</td>
</tr>
<tr>
<td>EXCELE</td>
<td>The four command bar docking areas (top, left, right and bottom).</td>
</tr>
<tr>
<td>MsoCommandBar</td>
<td>A command bar.</td>
</tr>
<tr>
<td>XLDESK</td>
<td>The Excel desktop.</td>
</tr>
<tr>
<td>EXCEL7</td>
<td>A workbook window. In this example, Book1 has two windows open.</td>
</tr>
<tr>
<td>EXCELE</td>
<td>A window used to provide in-sheet editing of embedded charts.</td>
</tr>
<tr>
<td>EXCEL4</td>
<td>The status bar.</td>
</tr>
</tbody>
</table>
Finding Windows

The procedures shown in the sections that follow can be found in the MWindows module of the API Examples.xls workbook.

To work with a window, we first need to find its handle. In Excel 2002, the hWnd property was added to the Application object, giving us the handle of the main Excel application window. In previous versions and for all other top-level windows (that is, windows that are direct children of the desktop), we can use the FindWindow API call, which is defined as follows:

```
Declare Function FindWindow Lib "user32" Alias "FindWindowA" _
    (ByVal lpClassName As String, _
    ByVal lpWindowName As String) As Long
```

To use the FindWindow function, we need to supply a class name and/or a window caption. We can use the special constant vbNullString for either, which tells the function to match on any class or caption. The function searches through all the immediate children of the desktop window (known as top-level windows), looking for any that have the given class and/or caption that we specified. To find the main Excel window in versions prior to Excel 2002, we might use the following:

```
hWndExcel = FindWindow("XLMAIN", Application.Caption)
```

ANSI vs. Unicode and the Alias Clause

You might have noticed that the declaration for FindWindow contains an extra clause that we haven’t used before—the **Alias** clause. All Windows API functions that have textual parameters come in two flavors: Those that operate on ANSI strings have an A suffix, whereas those that operate on Unicode strings have a W suffix. So while all the documentation and searches on MSDN talk about FindWindow, the Windows DLLs do not actually contain a function of that name—they contain two functions called FindWindowA and FindWindowW. We use the Alias statement to provide the actual name (case sensitive) for the function contained in the DLL. In fact, as long as we provide the correct name in the Alias clause, we can give it any name we like:

```
Declare Function Foo Lib "user32" Alias "FindWindowA" _
    (ByVal lpClassName As String, _
```
Although VBA stores strings internally as Unicode, it always converts them to ANSI when passing them to API functions. This is usually sufficient, and it is quite rare to find examples of VB or VBA calling the Unicode versions. In some cases, however, we need to support the full Unicode character set and can work around VBA's conversion behavior by calling the W version of the API function and using StrConv to do an extra ANSI-to-Unicode conversion within our API function calls:

```vbnet
Declare Function FindWindow Lib "user32" Alias "FindWindowW" (ByVal lpClassName As String, ByVal lpWindowName As String) As Long
ApphWnd = FindWindow(StrConv("XLMAIN", vbUnicode), StrConv(Application.Caption, vbUnicode))
```

**Finding Related Windows**

The problem with the (very common) usage of FindWindow to get the main Excel window handle is that if we have multiple instances of Excel open that have the same caption, there is no easy way to tell which one we get, so we might end up modifying the wrong instance! It is a common problem if the user typically doesn’t have his workbook windows maximized, because all instances of Excel will then have the same caption of “Microsoft Excel.”

A more robust and foolproof method is to use the FindWindowEx function to scan through all children of the desktop window, stopping when we find one that belongs to the same process as our current instance of Excel. FindWindowEx works in exactly the same way as FindWindow, but we provide the parent window handle and the handle of a child window to start searching after (or zero to start with the first). Listing 9-4 shows a specific ApphWnd function, which calls a generic FindOurWindow function, which uses the following API functions:

- GetCurrentProcessID to retrieve the ID of the instance of Excel running the code
GetDesktopWindow to get the handle of the desktop window, that we pass to FindWindowEx to look through its children (because all application windows are children of the desktop)

- FindWindowEx to find the next window that matches the given class and caption
- GetWindowThreadProcessID to retrieve the ID of the instance of Excel that owns the window that FindWindowEx found

**Listing 9-4 Foolproof Way to Find the Excel Main Window Handle**

```vba
'Get the handle of the desktop window
Declare Function GetDesktopWindow Lib "user32" () As Long

'Find a child window with a given class name and caption
Declare Function FindWindowEx Lib "user32" _
    Alias "FindWindowExA" _
    (ByVal hWnd1 As Long, ByVal hWnd2 As Long, _
    ByVal lpsz1 As String, ByVal lpsz2 As String) _
    As Long

'Get the process ID of this instance of Excel
Declare Function GetProcessId Lib "kernel32" () As Long

'Get the ID of the process that a window belongs to
Declare Function GetWindowThreadProcessId Lib "user32" _
    (ByVal hWnd As Long, ByRef lpdwProcessId As Long) _
    As Long

'Foolproof way to find the main Excel window handle
Function ApphWnd() As Long
    'Excel 2002 and above have a property for the hWnd
    If Val(Application.Version) >= 10 Then
        ApphWnd = Application.hWnd
    Else
        ApphWnd = FindOurWindow("XLMAIN", Application.Caption)
    End If

End Function
```
'Finds a top-level window of the given class and caption
'that belongs to this instance of Excel, by matching the
'process IDs
Function FindOurWindow( _
    Optional sClass As String = vbNullString, _
    Optional sCaption As String = vbNullString)
    
    Dim hWndDesktop As Long
    Dim hWnd As Long
    Dim hProcThis As Long
    Dim hProcWindow As Long

    'Get the ID of this instance of Excel, to match to
    hProcThis = GetCurrentProcessId

    'All top-level windows are children of the desktop,
    'so get that handle first
    hWndDesktop = GetDesktopWindow

    Do
        'Find the next child window of the desktop that
        'matches the given window class and/or caption.
        'The first time in, hWnd will be zero, so we'll get
        'the first matching window. Each call will pass the
        'handle of the window we found the last time,
        'thereby getting the next one (if any)
        hWnd = FindWindowEx(hWndDesktop, hWnd, sClass, _
            sCaption)

        'Get the ID of the process that owns the window
        GetWindowThreadProcessId hWnd, hProcWindow

        'Loop until the window's process matches this process,
        'or we didn't find a window
        Loop Until hProcWindow = hProcThis Or hWnd = 0

    'Return the handle we found
    FindOurWindow = hWnd

End Function

The FindOurWindow function can also be used to safely find any of
the top-level windows that Excel creates, such as userforms.
After we've found Excel’s main window handle, we can use the FindWindowEx function to navigate through Excel’s window hierarchy. Listing 9-5 shows a function to return the handle of a given Excel workbook’s window. To get the window handle, we start at Excel’s main window, find the desktop (class XLDESK) and then find the window (class EXCEL7) with the appropriate caption.

Listing 9-5 Function to Find a Workbook’s Window Handle

```vba
Private Declare Function FindWindowEx Lib "user32" _
    Alias "FindWindowExA" _
    (ByVal hWnd1 As Long, ByVal hWnd2 As Long, _
    ByVal lpsz1 As String, ByVal lpsz2 As String) _
    As Long

'Function to find the handle of a given workbook window
Function WorkbookWindow(hWnd As Window) As Long
    Dim hWndExcel As Long
    Dim hWndDesk As Long

    'Get the main Excel window
    hWndExcel = App.hWnd

    'Find the desktop
    hWndDesk = FindWindowEx(hWndExcel, 0, _
        "XLDESK", vbNullString)

    'Find the workbook window
    WorkbookWindow hWnd = FindWindowEx(hWndDesk, 0, _
        "EXCEL7", hWnd.Caption)

End Function
```

Windows Messages

At the lowest level, windows communicate with each other and with the operating system by sending simple messages. Every window has a main message-handling procedure (commonly called its wndproc) to which messages are sent. Every message consists of four elements: the handle of
the window to which the message is being sent, a message ID and two numbers that provide extra information about the message (if required). Within each wndproc, there is a huge case statement that works out what to do for each message ID. For example, the system will send the WM_PAINT message to a window when it requires the window to redraw its contents.

It will probably come as no surprise that we can also send messages directly to individual windows, using the SendMessage function. The easiest way to find which messages can be sent to which window class is to search the MSDN library using a known constant and then look in the See Also list for a link to a list of related messages. Look down the list for a message that looks interesting, then go to its details page to see the parameters it requires. For example, if we look again at Figure 9-1, we can see that the EXCEL; window contains a combo box. This combo box is actually the Name drop-down to the left of the formula bar. Searching the MSDN library (using Google) with the search term “combo box messages” gives us a number of relevant hits. One of them takes us to msdn.microsoft.com/library/en-us/shellcc/platform/commctls/comboboxes/comboboxes.asp. Looking down the list of messages we find the CB_SETDROPPEDWIDTH message that we can use to change the width of the drop-down portion of the Name box. In Listing 9-6, we use the SendMessage function to make the Name drop-down 200 pixels wide, enabling us to see the full text of lengthy defined names.

**Listing 9-6 Changing the Width of the Name Drop-Down List**

```vba
Private Declare Function FindWindowEx Lib "user32" _
    Alias "FindWindowExA" _
    (ByVal hWnd1 As Long, ByVal hWnd2 As Long, _
    ByVal lpsz1 As String, ByVal lpsz2 As String) _
    As Long

Private Declare Function SendMessage Lib "user32" _
    Alias "SendMessageA" _
    (ByVal hwnd As Long, ByVal wMsg As Long, _
    ByVal wParam As Long, ByVal lParam As Long) _
    As Long

'Not included in win32api.txt, but found in winuser.h
```
Private Const CB_SETDROPPEDWIDTH As Long = &H160&

' Make the Name dropdown list 200 pixels wide
Sub SetNameDropdownWidth()

    Dim hWndExcel As Long
    Dim hWndFormulaBar As Long
    Dim hWndNameCombo As Long

    ' Get the main Excel window
    hWndExcel = ApphWnd

    ' Get the handle for the formula bar window
    hWndFormulaBar = FindWindowEx(hWndExcel, 0, _
        "EXCEL;", vbNullString)

    ' Get the handle for the Name combobox
    hWndNameCombo = FindWindowEx(hWndFormulaBar, 0, _
        "combobox", vbNullString)

    ' Set the dropdown list to be 200 pixels wide
    SendMessage hWndNameCombo, CB_SETDROPPEDWIDTH, 200, 0

End Sub

---

**Changing the Window Icon**

When creating a dictator application, the intent is usually to make it look as though it is a normal Windows application and not necessarily running within Excel. Two of the giveaways are the application and worksheet icons. These can be changed to our own icons using API functions. We first use the ExtractIcon function to get a handle to an icon from a file, then send that icon handle to the window in a WM_SETICON message, as shown in Listing 9-7. The SetIcon routine is given a window handle and the path to an icon file, so it can be used to set either the application’s icon or a workbook window’s icon. For best use, the icon file should contain both 32×32 and 16×16 pixel versions of the icon image. Note that when setting the workbook window’s icon, Excel doesn’t refresh the image to the left of the menu bar until a window is maximized or minimized/restored, so you may need to toggle the WindowState to force the update.
Listing 9-7 Setting a Window’s Icon

Private Declare Function ExtractIcon Lib "shell32.dll" _
    Alias "ExtractIconA" _
    (ByVal hInst As Long, _
    ByVal lpszExeFileName As String, _
    ByVal nIconIndex As Long) As Long

Private Declare Function SendMessage Lib "user32" _
    Alias "SendMessageA" _
    (ByVal hwnd As Long, ByVal wMsg As Long, _
    ByVal wParam As Long, ByVal lParam As Long) _
    As Long

Private Const WM_SETICON As Long = &H80

' Set a window’s icon
Sub SetIcon(ByVal hWnd As Long, ByVal sIcon As String)
    Dim hIcon As Long

    ' Get the icon handle
    hIcon = ExtractIcon(0, sIcon, 0)

    ' Set the big (32x32) and small (16x16) icons
    SendMessage hWnd, WM_SETICON, 1, hIcon
    SendMessage hWnd, WM_SETICON, 0, hIcon

End Sub

Changing Windows Styles

If you look at all the windows on your screen, you might notice that they all look a little different. Some have a title bar, some have minimize and maximize buttons, some have an [x] to close them, some have a 3D look, some are resizable, some are a fixed size and so on. All of these things are individual attributes of the window and are stored as part of the window’s data structure. They’re all on/off flags stored as bits in two Long numbers. We can use the GetWindowLong function to retrieve a window’s style settings, switch individual bits on or off and write them back using SetWindowLong. Modifying windows styles in this way is most often done for userforms and is covered in Chapter 10 — Userform Design and Best Practices.
Working with the Keyboard

The behavior of many of Excel's toolbar buttons and some of the dialog buttons changes if the Shift key is held down when the button is clicked. For example, the Increase decimal toolbar button normally increases the number of decimal places shown in a cell, but decreases the number of decimal places if it is clicked with the Shift key held down. Similarly, when closing Excel, if you hold down the Shift key when clicking the No button on the Save Changes? dialog, it acts like a “No to All” button. We can do exactly the same in our applications by using API functions to examine the state of the keyboard. The procedures included in this section can be found in the MKeyboard module of the API Examples.xls workbook.

Checking for Shift, Ctrl, Alt, Caps Lock, Num Lock and Scroll Lock

The GetKeyState API function tells us whether a given key on the keyboard is currently held down or “on” (in the case of Caps Lock, Num Lock and Scroll Lock). The function is used by passing a code representing the key we’re interested in and returns whether the key is being held down or is “on.” Listing 9-8 shows a function to determine whether one of the six “special” keys is currently pressed. Note that we have again encapsulated the key code constants inside a more meaningful enumeration.

Listing 9-8 Checking Whether a Key Is Held Down

Private Declare Function GetKeyState Lib "user32" _
(ByVal vKey As Long) As Integer

Private Const VK_SHIFT As Long = &H10
Private Const VK_CONTROL As Long = &H11
Private Const VK_MENU As Long = &H12
Private Const VK_CAPITAL = &H14
Private Const VK_NUMLOCK = &H90
Private Const VK_SCROLL = &H91

Public Enum GetKeyStateKeyboardCodes
    gksKeyboardShift = VK_SHIFT
    gksKeyboardCtrl = VK_CONTROL
    gksKeyboardAlt = VK_MENU
gksKeyboardCapsLock = VK_CAPITAL
gksKeyboardNumLock = VK_NUMLOCK
gksKeyboardScrollLock = VK_SCROLL
End Enum

Public Function IsKeyPressed ByVal lKey As GetKeyStateKeyboardCodes As Boolean

Dim iResult As Integer
iResult = GetKeyState(lKey)

Select Case lKey
Case gksKeyboardCapsLock, gksKeyboardNumLock, gksKeyboardScrollLock
    'For the three 'toggle' keys, the 1st bit says if it's 'on or off, so clear any other bits that might be set, 'using a binary AND
    iResult = iResult And 1
Case Else
    'For the other keys, the 16th bit says if it's down or 'up, so clear any other bits that might be set, using a 'binary AND
    iResult = iResult And &H8000
End Select

IsKeyPressed = (iResult <> 0)
End Function

**Bit Masks**

The value obtained from the call to GetKeyState should not be interpreted as a simple number, but as its binary representation where each individual bit represents whether a particular attribute is on or off. This is one of the few functions that return a 16-bit Integer value, rather than the more common 32-bit Long. The MSDN documentation for GetKeyState says that “If the high-order bit is 1, the key is down, otherwise the key is up. If the low-order bit is 1, the key is on, otherwise the key is off.” The
first sentence is applicable for all keys (down/up), whereas the second is only applicable to the Caps Lock, Num Lock and Scroll Lock keys. It is possible for both bits to be set, if the Caps Lock key is held down and “on.” The low-order bit is the rightmost bit, and the high-order bit is the leftmost (16th) bit. To examine whether a specific bit has been set, we have to apply a bit mask, to zero-out the bits we’re not interested in, by performing a binary AND between the return value and a binary value that has a single 1 in the position we’re interested in. In the first case, we’re checking for a 1 in the first bit, which is the number 1. In the second case, we’re checking for a 1 in the 16th bit, i.e. the binary number 1000 0000 0000 0000, which is easiest to represent in code as the hexadecimal number &h8000. After we’ve isolated that bit, a zero value means off/up and a nonzero value means on/down.

**Testing for a Key Press**

As mentioned previously, at the lowest level, windows communicate through messages sent to their wndproc procedure. When an application is busy (such as Excel running some code), the wndproc only processes critical messages (such as the system shutting down). All other messages get placed in a queue and are processed when the application next has some spare time. This is why using SendKeys is so unreliable; it’s not until the code stops running (or issues a DoEvents statement) that Excel checks its message queue to see whether there are any key presses to process.

We can use Excel’s message queuing to allow the user to interrupt our code by pressing a key. Normally, if we want to allow the user to stop a lengthy looping process, we can either show a modeless dialog with a Cancel button (as explained in Chapter 10 — Userform Design and Best Practices), or allow the user to press the Cancel key to jump into the routine’s error handler (as explained in Chapter 12 — VBA Error Handling). An easier way is to check Excel’s message queue during each iteration of the loop to see whether the user has pressed a key. This is achieved using the PeekMessage API function:

```vba
Declare Function PeekMessage Lib "user32" _
    Alias "PeekMessageA" _
    (ByRef lpMsg As MSG, _
    ByVal hWnd As Long, _
    ByVal wMsgFilterMin As Long, _
    ByVal wMsgFilterMax As Long, _
    ByVal wRemoveMsg As Long) As Long
```

276 Chapter 9 Understanding and Using Windows API Calls
Structures

If you look at the first parameter of the PeekMessage function, you’ll see it is declared As MSG and is passed ByRef. MSG is a windows structure and is implemented in VBA as a user-defined type. To use it in this case, we declare a variable of that type and pass it in to the function. The function sets the value of each element of the UDT, which we then read. Many API functions use structures as a convenient way of passing large amounts of information into the function, instead of having a long list of parameters. Many messages that we send using the SendMessage function require a structure to be passed as the final parameter (as opposed to a single Long value). In those cases, we use a different form of the SendMessage declaration, where the final parameter is declared As Any and is passed ByRef:

```vba
Declare Function SendMessageAny Lib "user32" _
    Alias "SendMessageA" _
    (ByVal hwnd As Long, ByVal wMsg As Long, _
     ByVal wParam As Long, _
     ByRef lParam As Any) As Long
```

When we use this declaration, we’re actually sending a pointer to the memory where our UDT is stored. If we have an error in the definition of our UDT, or if we use this version of the declaration to send a message that is not expecting a memory pointer, the call will at best fail and possibly crash Excel.

Listing 9-9 shows the full code to check for a key press.

Listing 9-9  Testing for a Key Press

```vba
'Type to hold the coordinates of the mouse pointer
Private Type POINTAPI
    x As Long
    y As Long
End Type

'Type to hold the Windows message information
Private Type MSG
    hWnd As Long   'the window handle of the app
    message As Long 'the type of message (e.g. keydown)
    wParam As Long  'the key code
    lParam As Long  'not used
    time As Long    'time when message posted
```
pt As POINTAPI  'coordinate of mouse pointer
End Type

'Look in the message buffer for a message
Private Declare Function PeekMessage Lib "user32" _
    Alias "PeekMessageA" _
    (ByRef lpMsg As MSG, ByVal hWnd As Long, _
    ByVal wMsgFilterMin As Long, _
    ByVal wMsgFilterMax As Long, _
    ByVal wRemoveMsg As Long) As Long

'Translate the message from a key code to a ASCII code
Private Declare Function TranslateMessage Lib "user32" _
    (ByRef lpMsg As MSG) As Long

'Windows API constants
Private Const WM_CHAR As Long = &H102
Private Const WM_KEYDOWN As Long = &H100
Private Const PM_REMOVE As Long = &H1
Private Const PM_NOYIELD As Long = &H2

'Check for a key press
Public Function CheckKeyboardBuffer() As String

    'Dimension variables
    Dim msgMessage As MSG
    Dim hWnd As Long
    Dim lResult As Long

    'Get the window handle of this application
    hWnd = ApphWnd

    'See if there are any "Key down" messages
    lResult = PeekMessage(msgMessage, hWnd, WM_KEYDOWN, _
    WM_KEYDOWN, PM_REMOVE + PM_NOYIELD)

    'If so ...
    If lResult <> 0 Then

        '... translate the key-down code to a character code,
        'which gets put back in the message queue as a WM_CHAR
        'message ...
        lResult = TranslateMessage(msgMessage)
When we press a key on the keyboard, the active window is sent a WM_KEYDOWN message, with a low-level code to identify the physical key pressed. The first thing we need to do, then, is to use PeekMessage to look in the message queue to see whether there are any pending WM_KEYDOWN messages, removing it from the queue if we find one. If we found one, we have to translate it into a character code using TranslateMessage, which sends the translated message back to Excel's message queue as a WM_CHAR message. We then look in the message queue for this WM_CHAR message and return the character pressed.

Working with the File System and Network

The procedures included in this section can be found in the MFileSys module of the API Examples.xls workbook.

Finding the User ID

Excel has its own user name property, but does not tell us the user's network logon ID. This ID is often required in Excel applications for security validation, auditing, logging change history and so on. It can be retrieved using the API call shown in Listing 9-10.

Listing 9-10 Reading the User’s Login ID

```vba
Private Declare Function GetUserName Lib "advapi32.dll" _
    Alias "GetUserNameA" _
    (ByVal lpBuffer As String, _
     ByVal nSize As Long) As Long
```
Get the user's login ID
Function UserName() As String

' A buffer that the API function fills with the login name
Dim sBuffer As String * 255

' Variable to hold the length of the buffer
Dim lStringLength As Long

' Initialize to the length of the string buffer
lStringLength = Len(sBuffer)

' Call the API function, which fills the buffer
' and updates lStringLength with the length of the login ID,
' including a terminating null - vbNullChar - character
GetUserName sBuffer, lStringLength

If lStringLength > 0 Then
  ' Return the login id, stripping off the final vbNullChar
  UserName = Left$(sBuffer, lStringLength - 1)
End If

End Function

Buffers

Every API function that returns textual information, such as the user name, does so by using a buffer that we provide. A buffer comprises a String variable initialized to a fixed size and a Long variable to tell the function how big the buffer is. When the function is called, it writes the text to the buffer (including a final Null character) and (usually) updates the length variable with the number of characters written. (Some functions return the text length as the function’s result instead of updating the variable.) We can then look in the buffer for the required text. Note that VBA stores strings in a very different way than the API functions expect, so whenever we pass strings to API functions, VBA does some conversion for us behind the scenes. For this to work properly, we always pass strings by value (ByVal) to API functions, even when the function updates the string. Some people prefer to ignore the buffer length information, looking instead for the first vbNullChar character in the buffer and assuming that’s the end of the retrieved string, so you may encounter usage like that shown in Listing 9-11.
Listing 9-11  Using a Buffer, Ignoring the Buffer Length Variable

'Get the user's login ID, without using the buffer length
Function UserName2() As String
    Dim sBuffer As String * 255
    GetUserName sBuffer, 255
    UserName2 = Left$(sBuffer, InStr(sBuffer, vbNullChar) - 1)
End Function

Changing to a UNC Path

VBA's intrinsic ChDrive and ChDir statements can be used to change the active path prior to using Application.GetOpenFilename, such that the dialog opens with the correct path preselected. Unfortunately, that can only be used to change the active path to local folders or network folders that have been mapped to a drive letter. Note that once set, the VBA CurDir function will return a UNC path. We need to use API functions to change the folder to a network path of the form \server\share\path, as shown in Listing 9-12. In practice, the SetCurDir API function is one of the few that can be called directly from your code.

Listing 9-12  Changing to a UNC Path

Private Declare Function SetCurDir Lib "kernel32" _
    Alias "SetCurrentDirectoryA" _
    (ByVal lpPathName As String) As Long

'Change to a UNC Directory
Sub ChDirUNC(ByVal sPath As String)
    Dim lReturn As Long

    'Call the API function to set the current directory
    lReturn = SetCurDir(sPath)

    'A zero return value means an error
    If lReturn = 0 Then
        Err.Raise vbObjectError + 1, "Error setting path."
    End If
End Sub
**Locating Special Folders**

Windows maintains a large number of special folders that relate to either the current user or the system configuration. When a user is logged in to Windows with relatively low privileges, such as the basic User account, it is highly likely that the user will only have full access to his personal folders, such as his *My Documents* folder. These folders can usually be found under `C:\Documents and Settings\UserName`, but could be located anywhere. We can use an API function to give us the correct paths to these special folders, using the code shown in Listing 9-13. Note that this listing contains a subset of all the possible folder constants. The full list can be found by searching MSDN for “CSIDL Values.” The notable exception from this list is the user’s Temp folder, which can be found by using the GetTempPath function. Listing 9-13 includes a special case for this folder, so that it can be obtained through the same function.

**Listing 9-13 Locating a Windows Special Folder**

```vbnet
Private Declare Function SHGetFolderPath Lib "shell32" Alias "SHGetFolderPathA" (ByVal hwndOwner As Long, ByVal nFolder As Long, ByVal hToken As Long, ByVal dwFlags As Long, ByVal pszPath As String) As Long

Private Declare Function GetTempPath Lib "kernel32" Alias "GetTempPathA" (ByVal nBufferLength As Long, ByVal lpBuffer As String) As Long

' More Commonly used CSIDL values.
' For the full list, search MSDN for "CSIDL Values"
Private Const CSIDL_PROGRAMS As Long = &H2
Private Const CSIDL_PERSONAL As Long = &H5
Private Const CSIDL_FAVORITES As Long = &H6
Private Const CSIDL_STARTMENU As Long = &HB
Private Const CSIDL_MYDOCUMENTS As Long = &HC
Private Const CSIDL_APPDATA As Long = &H1A
Private Const CSIDL_LOCAL_APPDATA As Long = &H1C
Private Const CSIDL_INTERNET_CACHE As Long = &H20
```
Private Const CSIDL_WINDOWS As Long = &H24
Private Const CSIDL_SYSTEM As Long = &H25
Private Const CSIDL_PROGRAM_FILES As Long = &H26
Private Const CSIDL_MYPICTURES As Long = &H27

'Constants used in the SHGetFolderPath call
Private Const CSIDL_FLAG_CREATE As Long = &H8000&
Private Const SHGFP_TYPE_CURRENT = 0
Private Const SHGFP_TYPE_DEFAULT = 1
Private Const MAX_PATH = 260

'Public enumeration to give friendly names for the CSIDL values
Public Enum SpecialFolderIDs
    sfAppDataRoaming = CSIDL_APPDATA
    sfAppDataNonRoaming = CSIDL_LOCAL_APPDATA
    sfStartMenu = CSIDL_STARTMENU
    sfStartMenuPrograms = CSIDL_PROGRAMS
    sfMyDocuments = CSIDL_PERSONAL
    sfMyMusic = CSIDL_MYMUSIC
    sfMyPictures = CSIDL_MYPICTURES
    sfMyVideo = CSIDL_MYVIDEO
    sfFavorites = CSIDL_FAVORITES
    sfDesktopDir = CSIDL_DESKTOPDIRECTORY
    sfInternetCache = CSIDL_INTERNET_CACHE
    sfWindows = CSIDL_WINDOWS
    sfWindowsSystem = CSIDL_SYSTEM
    sfProgramFiles = CSIDL_PROGRAM_FILES
End Enum

'There is no CSIDL for the temp path,
'so we need to give it a dummy value
'and treat it differently in the function
sfTemporary = &HFF
End Enum

'Get the path for a Windows special folder
Public Function SpecialFolderPath( _
    ByVal uFolderID As SpecialFolderIDs) As String

    'Create a buffer of the correct size
    Dim sBuffer As String * MAX_PATH
    Dim lResult As Long

    If uFolderID = sfTemporary Then
'Use GetTempPath for the temporary path
lResult = GetTempPath(MAX_PATH, sBuffer)

'The GetTempPath call returns the length and a
'trailing \ which we remove for consistency
SpecialFolderPath = Left$(sBuffer, lResult - 1)
Else
'Call the function, passing the buffer
lResult = SHGetFolderPath(0, _
    uFolderID + CSIDL_FLAG_CREATE, 0, _
    SHGFP_TYPE_CURRENT, sBuffer)

'The SHGetFolderPath function doesn't give us a
'length, so look for the first vbNullChar
SpecialFolderPath = Left$(sBuffer, _
    InStr(sBuffer, vbNullChar) - 1)
End If

End Function

The observant among you might have noticed that we've now come
across all three ways in which buffers are filled by API functions:

- GetUserName returns the length of the text by modifying the input
  parameter.
- GetTempPath returns the length of the text as the function's return
  value.
- SHGetFolderPath doesn't return the length at all, so we search for
  the first vbNullChar.

**Deleting a File to the Recycle Bin**

The VBA Kill statement is used to delete a file, but does not send it to
the recycle bin for potential recovery by the user. To send a file to the recycle
bin, we need to use the SHFileOperation function, as shown in Listing 9-14:

**Listing 9-14 Deleting a File to the Recycle Bin**

'Structure to tell the SHFileOperation function what to do
Private Type SHFILEOPTSTRUCT
    hwnd As Long
wFunc As Long
pFrom As String
pTo As String
fFlags As Integer
fAnyOperationsAborted As Boolean
hNameMappings As Long
lpszProgressTitle As String
End Type

Private Declare Function SHFileOperation Lib "shell32.dll" _
    Alias "SHFileOperationA" _
    (ByRef lpFileOp As SHFILEOPSTRUCT) As Long

Private Const FO_DELETE = &H3
Private Const FOF_SILENT = &H4
Private Const FOF_NOCONFIRMATION = &H10
Private Const FOF_ALLOWUNDO = &H40

'Delete a file, sending it to the recycle bin
Sub DeleteToRecycleBin(ByVal sFile As String)
    Dim uFileOperation As SHFILEOPSTRUCT
    Dim lReturn As Long

    'Fill the UDT with information about what to do
    With FileOperation
        .wFunc = FO_DELETE
        .pFrom = sFile
        .pTo = vbNullChar
        .fFlags = FOF_SILENT + FOF_NOCONFIRMATION + _
            FOF_ALLOWUNDO
    End With

    'Pass the UDT to the function
    lReturn = SHFileOperation(FileOperation)

    If lReturn <> 0 Then
        Err.Raise vbObjectError + 1, "Error deleting file."
    End If

End Sub
There are two things to note about this function. First, the function uses a user-defined type to tell it what to do, instead of the more common method of having multiple input parameters. Second, the function returns a value of zero to indicate success. If you recall the SetCurDir function in Listing 9-12, it returns a value of zero to indicate failure! The only way to know which to expect is to check the Return Values section of the function’s information page on MSDN.

**Browsing for a Folder**

All versions of Excel have included the GetOpenFilename and GetSaveAsFilename functions to allow the user to select a filename to open or save. Excel 2002 introduced the common Office FileDialog object, which can be used to browse for a folder, using the code shown in Listing 9-15, which results in the dialog shown in Figure 9-3.

**Listing 9-15 Using Excel 2002’s FileDialog to Browse for a Folder**

```vba
'Browse for a folder, using the Excel 2002 FileDialog
Sub BrowseForFolder()

    Dim fdBrowser As FileDialog

    'Get the File Dialog object
    Set fdBrowser = Application.FileDialog(msoFileDialogFolderPicker)

    With fdBrowser

        'Initialize it
        .Title = "Select Folder"
        .InitialFileName = "c:\"

        'Display the dialog
        If .Show Then
            MsgBox "You selected " & .SelectedItems(1)
        End If
    End With

End Sub
```
We consider this layout far too complicated, when all we need is a simple tree view of the folders on the computer. We can use API functions to show the standard Windows Browse for folder dialog shown in Figure 9-4, which our users tend to find much easier to use. The Windows dialog also gives us the option to display some descriptive text to tell our users what they should be selecting.

Callbacks

So far, every function we’ve encountered just does its thing and returns its result. However, a range of API functions (including the SHBrowseForFolder function that we’re about to use) interact with the calling program while they’re working. This mechanism is known as a callback. Excel 2000 added a VBA function called AddressOf, which provides the address in memory where a given procedure can be found. This address is passed to the API function, which calls back to the procedure found at that address as required. For example, the EnumWindows function iterates through all the top-level windows, calling back to the procedure with the details of each window it finds. Obviously, the procedure being called must be defined exactly as Windows expects it to be so the API function can pass it the correct number and type of parameters.
The `SHBrowseForFolder` function uses a callback to tell us when the dialog is initially shown, enabling us to set its caption and initial selection, and each time the user selects a folder, enabling us to check the selection and enable/disable the OK button. The full text for the function is contained in the `MBrowseForFolder` module of the `API Examples.xls` workbook and a slightly simplified version is shown in Listing 9-16.

**Listing 9-16** Using Callbacks to Interact with the Windows File Picker Dialog

```vba
'UDT to pass information to the SHBrowseForFolder function
Private Type BROWSEINFO
    hOwner As Long
    pidlRoot As Long
    pszDisplayName As String
    lpszTitle As String
    ulFlags As Long
    lpfn As Long
    lParam As Long
    iImage As Long
End Type
```
'Commonly used ulFlags constants

'Only return file system directories.
'If the user selects folders that are not
'part of the file system (such as 'My Computer'),
'the OK button is grayed.
Private Const BIF_RETURNONLYFSDIRS As Long = &H1

'Use a newer dialog style, which gives a richer experience
Private Const BIF_NEWDIALOGSTYLE As Long = &H40

'Hide the default 'Make New Folder' button
Private Const BIF_NONEWFOLDERBUTTON As Long = &H200

'Messages sent from dialog to callback function
Private Const BFFM_INITIALIZED = 1
Private Const BFFM_SELCHANGED = 2

'Messages sent to browser from callback function
Private Const WM_USER = &H400

'Set the selected path
Private Const BFFM_SETSELECTIONA = WM_USER + 102

'Enable/disable the OK button
Private Const BFFM_ENABLEOK = WM_USER + 101

'The maximum allowed path
Private Const MAX_PATH = 260

'Main Browse for directory function
Declare Function SHBrowseForFolder Lib "shell32.dll" _
         Alias "SHBrowseForFolderA" _
         (ByRef lpBrowseInfo As BROWSEINFO) As Long

'Gets a path from a pidl
Declare Function SHGetPathFromIDList Lib "shell32.dll" _
         Alias "SHGetPathFromIDListA" _
         (ByVal pidl As Long, _
           ByVal pszPath As String) As Long
'Used to set the browser dialog’s title
Declare Function SetWindowText Lib "user32" _
    Alias "SetWindowTextA" _
    (ByVal hwnd As Long, _
     ByVal lpString As String) As Long

'A versions of SendMessage, to send strings to the browser
Private Declare Function SendMessageString Lib "user32" _
    Alias "SendMessageA" (ByVal hwnd As Long, _
     ByVal wMsg As Long, ByVal wParam As Long, _
     ByVal lParam As String) As Long

'Variables to hold the initial options,
'set in the callback function
Dim msInitialPath As String
Dim msTitleBarText As String

'The main function to initialize and show the dialog
Function GetDirectory(Optional ByVal sInitDir As String, _
    Optional ByVal sTitle As String, _
    Optional ByVal sMessage As String, _
    Optional ByVal hwndOwner As Long, _
    Optional ByVal bAllowCreateFolder As Boolean) _
    As String

    'A variable to hold the UDT
    Dim uInfo As BROWSEINFO

    Dim sPath As String
    Dim lResult As Long

    'Check that the initial directory exists
    On Error Resume Next
    sPath = Dir(sInitDir & "\*.", vbNormal + vbDirectory)
    If Len(sPath) = 0 Or Err.Number <> 0 Then sInitDir = ""
    On Error GoTo 0

    'Store the initials setting in module-level variables,
    'for use in the callback function
    msInitialPath = sInitDir
    msTitleBarText = sTitle

    'If no owner window given, use the Excel window
'N.B. Uses the ApphWnd function in MWindows
If hwndOwner = 0 Then hwndOwner = ApphWnd

'Initialise the structure to pass to the API function
With uInfo
    .hOwner = hwndOwner
    .pszDisplayName = String$(MAX_PATH, vbNullChar)
    .lpszTitle = sMessage
    .ulFlags = BIF_RETURNONLYFSDIRS + BIF_NEWDIALOGSTYLE +
               IIf(bAllowCreateFolder, 0, BIF_NONEW FOLDERBUTTON)
End With

'Pass the address of the callback function in the UDT
.lpfn = LongToLong(AddressOf BrowseCallBack)

End Function

'Windows calls this function when the dialog events occur
Private Function BrowseCallBack (ByVal hwnd As Long, ByVal Msg As Long, ByVal lParam As Long, ByVal pData As Long) As Long

Dim sPath As String

'This is called by Windows, so don't allow any errors!
On Error Resume Next

Select Case Msg
Case BFFM_INITIALIZED
    'Dialog is being initialized,
    'so set the initial parameters

    'The dialog caption
    If msTitleBarText <> "" Then
        SetWindowText hwnd, msTitleBarText
    End If

End Function
'The initial path to display
If msInitialPath <> "" Then
    SendMessage hwnd, BFFM_SETSELECTIONA, 1, _
        msInitialPath
End If

Case BFFM_SELCHANGED
    'User selected a folder
    'lParam contains the pidl of the folder, which can be
    'converted to the path using GetPathFromID
    'sPath = GetPathFromID(lParam)

    'We could put extra checks in here,
    'e.g. to check if the folder contains any workbooks,
    'and send the BFFM_ENABLEOK message to enable/disable
    'the OK button:
    'SendMessage hwnd, BFFM_ENABLEOK, 0, True/False
End Select

End Function

'Converts a PIDL to a path string
Private Function GetPathFromID(ByVal lID As Long) As String

    Dim lResult As Long
    Dim sPath As String * MAX_PATH

    lResult = SHGetPathFromIDList(lID, sPath)

    If lResult <> 0 Then
        GetPathFromID = Left$(sPath, InStr(sPath, Chr$(0)) - 1)
    End If

End Function

'VBA doesn't let us assign the result of AddressOf
'to a variable, but does allow us to pass it to a function.
'This 'do nothing' function works around that problem
Private Function LongToLong(ByVal lAddr As Long) As Long
    LongToLong = lAddr
End Function
Let’s take a closer look at how this all works. First, most of the shell functions use things called PIDLs to uniquely identify folders and files. For simplicity’s sake, you can think of a PIDL as a handle to a file or folder, and there are API functions to convert between the PIDL and the normal file or folder name.

The GetDirectory function is the main function in the module and is the function that should be called to display the dialog. It starts by validating the (optional) input parameters, then populates the BROWSEINFO user-defined type that is used to pass all the required information to the SHBrowseForFolder function. The hOwner element of the UDT is used to provide the parent window for the dialog, which should be the handle of the main Excel window, or the handle of the userform window if showing this dialog from a userform. The ulFlags element is used to specify detailed behavior for the dialog, such as whether to show a Make Folder button. The full list of possible flags and their purpose can be found on MSDN by searching for the SHBrowseForFolder function. The lpfn element is where we pass the address of the callback function, BrowseCallBack. We have to wrap the AddressOf value in a simple LongToLong function, because VB doesn’t let us assign the value directly to an element of a UDT.

After the UDT has been initialized, we pass it to the SHBrowseForFolder API function. That function displays the dialog and Windows calls back to our BrowseCallBack function, passing the BFFM_INITIALIZED message. We respond to that message by setting the dialog’s caption (using the SetWindowText API function) and the initial folder selection (by sending the BFFM_SETSELECTIONA message back to the dialog with the path string).

Every time the user clicks a folder, it triggers a Windows callback to our BrowseCallBack function, passing the BFFM_SELCHANGED message and the ID of the selected folder. All the code to respond to that message is commented out in this example, but we could add code to check whether the folder is a valid selection for our application (such as whether it contains any workbooks) and enable/disable the OK button appropriately (by sending the BFFM_ENABLEOK message back to the dialog).

When the user clicks the OK or Cancel button, the function returns the ID of the selected folder and execution continues back in the GetDirectory function. We get the textual path from the returned ID and return it to the calling code.
Practical Examples

All the routines included in this chapter have been taken out of actual Excel applications, so are themselves practical examples of API calls.

The PETRAS application files for this chapter can be found on the CD in the folder \Application\Ch09—Understanding and Using Windows API Calls and now includes the following files:

- **PetrasTemplate.xlt**—The timesheet template
- **PetrasAddin.xla**—The timesheet data-entry support add-in
- **PetrasReporting.xla**—The main reporting application
- **PetrasConsolidation.xlt**—A template to use for new results workbooks
- **Debug.ini**—A dummy file that tells the application to run in debug mode
- **PetrasIcon.ico**—A new icon file, to use for Excel’s main window

**PETRAS Timesheet**

Until this chapter, the location used by the Post to Network routine has used Application.GetOpenFilename to allow the user to select the directory to save the timesheet workbook to. The problem with that call is that the directory must already contain at least one file. In this chapter, we add the BrowseForFolder dialog and use that instead of GetOpenFilename, which allows empty folders to be selected.

We’ve also added a new feature to the timesheet add-in. In previous versions you were prompted to specify the consolidation location the first time you posted a timesheet workbook to the network. When you selected a location, that location was stored in the registry and from there on out the application simply read the location from the registry whenever you posted a new timesheet.

What this didn’t take into account is the possibility that the consolidation location might change. If it did, you would have no way, short of editing the application’s registry entries directly, of switching to the new location. Our new Specify Consolidation Folder feature enables you to click a button on the toolbar and use the Windows browse for folders...
dialog to modify the consolidation folder. The SpecifyConsolidationFolder procedure is shown in Listing 9-17 and the updated toolbar is shown in Figure 9-5.

**Listing 9-17 The New SpecifyConsolidationFolder Procedure**

```vba
Public Sub SpecifyConsolidationFolder()

    Dim sSavePath As String
    InitGlobals

    ' Get the current consolidation path.
    sSavePath = GetSetting(gsREG_APP, gsREG_SECTION, _
    gsREG_KEY, "")

    ' Display the browse for folders dialog with the initial
    ' path display set to the current consolidation folder.
    sSavePath = GetDirectory(sSavePath, _
    gsCAPTION_SELECT_FOLDER, gsMSG_SELECT_FOLDER)

    If Len(sSavePath) > 0 Then
        ' Save the selected path to the registry.
        If Right$(sSavePath, 1) <> "\" Then _
            sSavePath = sSavePath & "\"
        ;SaveSetting gsREG_APP, gsREG_SECTION, _
        gsREG_KEY, sSavePath
    End If

End Sub
```

Table 9-2 summarizes the changes that have been made to the timesheet add-in for this chapter.

**Figure 9-5 The Updated PETRAS Timesheet Toolbar**
The changes made to the central reporting application for this chapter are to display a custom icon for the application and to enable the user to close all the results workbooks simultaneously, by holding down the Shift key while clicking the *File > Close* menu. The detailed changes are shown in Table 9-3, and Listing 9-18 shows the new *MenuFileClose* routine that includes the check for the Shift key.

### Table 9-2: Changes to the PETRAS Timesheet Add-in to Use the *BrowseForFolder* Routine

<table>
<thead>
<tr>
<th>Module</th>
<th>Procedure</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBrowseForFolder</td>
<td></td>
<td>Included the entire MBrowseForFolder module shown in Listing 9-16</td>
</tr>
<tr>
<td>(new module)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEntryPoints</td>
<td>PostTimeEntriesToNetwork</td>
<td>Added call to the GetDirectory function in MBrowseForFolder</td>
</tr>
<tr>
<td></td>
<td>SpecifyConsolidationFolder</td>
<td>New feature to update the consolidation folder location</td>
</tr>
</tbody>
</table>

### Table 9-3: Changes to the PETRAS Reporting Application for Chapter 9

<table>
<thead>
<tr>
<th>Module</th>
<th>Procedure</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAPIWrappers</td>
<td>ApphWnd</td>
<td>Included Listing 9-4 to obtain the handle of Excel's main window</td>
</tr>
<tr>
<td>(new module)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAPIWrappers</td>
<td>SetIcon</td>
<td>Included Listing 9-7 to display a custom icon, read from the new PetrasIcon.ico file.</td>
</tr>
<tr>
<td>(new module)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAPIWrappers</td>
<td>IsKeyPressed</td>
<td>Included Listing 9-8 to check for the Shift key held down when clicking <em>File &gt; Close</em></td>
</tr>
<tr>
<td>MGlobals</td>
<td></td>
<td>Added a constant for the icon filename</td>
</tr>
<tr>
<td>MWorkspace</td>
<td>ConfigureExcelEnvironment</td>
<td>Added a call to SetIcon</td>
</tr>
<tr>
<td>MEntryPoint</td>
<td>MenuFileClose</td>
<td>Added check for Shift key being held down, shown in Listing 9-17, doing a Close All if so</td>
</tr>
</tbody>
</table>
Listing 9-18 The New MenuFileClose Routine, Checking for a Shift+Close

'Handle the File > Close menu
Sub MenuFileClose()

    Dim wkbWorkbook As Workbook

    'Ch09+
    'Check for a Shift+Close
    If IsKeyPressed(gksKeyboardShift) Then

        'Close all results workbooks
        For Each wkbWorkbook In Workbooks
            If IsResultsWorkbook(wkbWorkbook) Then
                CloseWorkbook wkbWorkbook
            End If
        Next
    Else

        'Ch09-

        'Close only the active workbook
        If IsResultsWorkbook(ActiveWorkbook) Then
            CloseWorkbook ActiveWorkbook
        End If
    End If

End Sub

Later chapters, particularly Chapter 10 — Userform Design and Best Practices, use more of the routines and concepts introduced in this chapter.

Conclusion

The Excel object model provides an extremely rich set of tools for us to use when creating our applications. By including calls to Windows API functions, we can enhance our applications to give them a truly professional look and feel.
This chapter has explained most of the uses of API functions that are commonly encountered in Excel application development. All the fundamental concepts have been explained and you should now be able to interpret and understand new uses of API functions as you encounter them.

All of the example routines included in this chapter have been taken from actual Excel applications and are ready for you to use in your own workbooks.
Advanced Charting Techniques

Only a few minutes are required to learn the basics of Excel’s charting module, but many frustrating hours are required to get a chart looking “just right.” Most people create charts using one of the built-in chart types, but are unable to modify them to meet their exact requirements. This chapter introduces and explains the fundamental techniques we can use to impose our will on Excel’s charting engine to produce charts that look exactly how we want them to.

The chapter focuses solely on the technical aspects of working with the chart engine. We do not investigate which chart type should be used in any given situation, nor the pros and cons of whether 3D charts can be used to present data accurately, nor whether you should use as few or as many of the colorful formatting options that Excel supports.

Fundamental Techniques

Combining Chart Types

When most people create charts, they start the Chart Wizard and browse through all the standard and custom chart types shown in Step 1, trying to find one that most closely resembles the look they’re trying to achieve. More often than not, there isn’t a close enough match and they end up thinking that Excel doesn’t support the chart they’re trying to create. In fact, we can include any number of column, bar, line, XY and/or area series within the same chart. All of the choices on the Custom Types tab of Step 1 of the Chart Wizard are no more than preformatted combinations of these basic styles, with a bit of formatting thrown in. Instead of relying on these custom types, we can usually get better results (and a greater understanding of the chart engine) by creating these combination charts ourselves. Unfortunately, we can’t combine the different 3D styles, pie charts or bubble charts with other types.
Let's start by creating a simple column/line combination chart for the data shown in Figure 15-1, where we want the 2004 sales to be shown as columns, with the forecast shown as lines.

The easiest way to start is by selecting the data region, A3:C8 and create a simple column chart from it, as shown in Figure 15-2. We usually find it easiest to start with a column chart, but perhaps that’s because it’s the default selection in the Chart Wizard, so we can create the chart by selecting the source data, clicking the Chart Wizard toolbar button and then the Finish button on the Chart Wizard.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2004 Fruit Sales</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Sales</td>
<td>Forecast</td>
</tr>
<tr>
<td>4</td>
<td>Apples</td>
<td>1000</td>
</tr>
<tr>
<td>5</td>
<td>Oranges</td>
<td>1200</td>
</tr>
<tr>
<td>6</td>
<td>Peaches</td>
<td>600</td>
</tr>
<tr>
<td>7</td>
<td>Pears</td>
<td>700</td>
</tr>
<tr>
<td>8</td>
<td>Bananas</td>
<td>1100</td>
</tr>
</tbody>
</table>

**Figure 15-1** The Sample Data to Plot as a Combination Column/Line Chart

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2004 Fruit Sales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Sales</td>
<td>Forecast</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Apples</td>
<td>1000</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Oranges</td>
<td>1200</td>
<td>1400</td>
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<td></td>
</tr>
<tr>
<td>6</td>
<td>Peaches</td>
<td>600</td>
<td>800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Pears</td>
<td>700</td>
<td>1100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Bananas</td>
<td>1100</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 15-2** The Chart Wizard Created a Standard Column Chart
To change the Forecast values from a column to a line, select the series, click the \textit{Chart > Chart Type} menu item and select one of the 2D Line chart types, choosing to apply the chart type to the selected series, as shown in Figure 15-3.

![Chart Type](image)

\textbf{Figure 15-3} Selecting the New Type for the Selected Series

When you click OK, the Forecast series will display as a line, while the Sales series remains as the original column, as shown in Figure 15-4. (We’ve also modified the format of the Forecast line to make it stand out in the book.)

That’s just about all there is to it. Start with a simple column chart with multiple series, select each series in turn, use the \textit{Chart > Chart Type} menu to change its type and then apply the required formatting. The possible combinations are limited only by our imagination and the legibility of the final chart!
Using Multiple Axes

When we create one of the standard 2D charts, the plot area can have two sets of axes. The primary axes are usually displayed on the bottom and left, whereas the secondary axes are usually displayed on the top and right. If we have more than one series on the chart, we can choose which set of axes to use for each series by double-clicking the series and making our choice on the Axis tab of the Format Data Series dialog. When instructed to place a series on the secondary axis, Excel usually only displays a secondary Y axis on the chart. This can be changed using the Chart > Chart Options menu command, clicking the Axes tab and choosing whatever combination of primary and secondary axes are desired. When two series are plotted on different axes, the axes are scaled independently. Care must be taken to ensure that it is obvious to the viewer which series is plotted on which axis, by adding relevant axis labels and matching them to the series labels, as shown in Figure 15-5.

Figure 15-4 The Resulting Combination Column/Line Chart
Using Defined Names to Link Charts to Data

A key point to understand is that our charts do not have to refer directly to the cells containing their data. The source data for a chart series is provided by the =SERIES() function, which can be seen in the formula bar when a series is selected. The SERIES() function has the following format:

=SERIES(Name, XValues, YValues, PlotOrder)

Each of the four parameters can be a constant or array of constants, a direct range reference or a reference to a defined name. All the lines in Listing 15-1 are examples of valid functions.

Listing 15-1 Examples of Valid SERIES() Functions

=SERIES(Sheet1!$B$1,Sheet1$A$2:$A$20,Sheet1!$B2:$B20,1)
=SERIES("Sales",Sheet1$A$2:$A$20,Sheet1!$B2:$B20,1)
=SERIES("Horizontal Line",0,1,{123,123},1)
=SERIES("Book Names",Book1.xls!chtXName,Book1.xls!chtYName,1)
=SERIES("Sheet Names",Sheet1!chtXName,Sheet1!chtYName,1)
The last two versions of the \texttt{SERIES()} formula use workbook-level and sheet-level defined names respectively instead of direct cell references. This indirection enables us to use the defined names' definitions to modify the ranges or arrays passed to the chart, as shown in the following examples.

\textit{Setting Up the Defined Name Links}

When you use a defined name in a \texttt{SERIES} formula, for best results you should begin with a name that references a worksheet range directly. After you have this working correctly, you can modify the name to perform more complex operations. Sometimes, if the formula for the defined name is particularly complex, or if we make an error in its definition, the charting module will refuse to accept the name in the \texttt{SERIES()} function. By starting with a very simple definition for the names, we are able to add them to the \texttt{SERIES()} function without problem.

Figure 15-6 shows a simple line chart, with the series selected and the \texttt{SERIES()} function displayed in the formula bar.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{chart.png}
\caption{A Simple Line Chart}
\end{figure}

To change the chart to use defined names, we first create two defined names, for the Date and Value ranges. Select \textit{Insert} > \textit{Name} > \textit{Define} from the menu and create the following two names:

\begin{verbatim}
Name:   Sheet1!chtDates
Refers to:  =Sheet1!$A$2:$A$9
\end{verbatim}
Now select the chart series and edit the SERIES() formula to read as follows:

=SERIES("Value",Sheet1!chtDates,Sheet1!chtValues,1)

That’s it! The chart series is now linked to the defined names and the defined names refer to the source data ranges. Obviously, if we had more series in our chart, we would have to create extra names for the values for each additional series. Now that we’ve set up the linkage, we can modify the Refers To: formulas for the names (their definitions) to create some interesting and time-saving effects.

**Auto-Expanding Charts**

One of the most frequently asked questions in the microsoft.public.excel.charting newsgroup is how to get a chart to automatically include new data as it’s typed in. In Excel 2003, if we create a List from the data range and set either the chart or the defined names to refer to an entire column of the List, the reference will automatically be adjusted to include any new data. In previous versions, or if we prefer not to convert the range to a List in Excel 2003, we can use defined names to do the automatic updating.

The trick is to use a combination of the OFFSET() and COUNTA() functions in the definition of the name used for the X values, then define the name used for the Y values as an offset from the X values range. Select a cell in the worksheet, then choose Insert > Name > Define. Change the definition of the chtDates range to be the following by selecting the existing chtDates entry, typing the new definition and clicking the Add button:

Name: Sheet1!chtDates
Refers to: =OFFSET(Sheet1!$A$2,0,0,COUNTA(Sheet1!$A:$A)-1,1)

The OFFSET() function has the following parameters:

=OFFSET(SourceRange, RowsToMoveDown, ColumnsToMoveAcross, NumberOfRowsToInclude, NumberOfColumnsToInclude)
The COUNTA() function returns the number of non-blank cells in the
range, which in our case includes the header row. We therefore subtract
one to get the number of data items. Putting the two together gives us a
reference that starts in A2, moves down zero rows and across zero columns
(so remains in A2), has a number of rows equal to the count of our data
items and is one column wide. While in the Define Name dialog with the
chtDates name selected, if we tab into the Refers to: box, Excel will high-
light the resulting range with its “dancing ants,” as shown in Figure 15-7.

![Figure 15-7 Excel’s Dancing Ants Showing the Range Referred to by the Defined Name](image)

While we’re in the Define Name dialog, we need to modify the defini-
tion of the chtValues name. The easiest way to do that is to again use the
OFFSET() function, but this time to start at the range referred to by the
chtDates name and move one column across, keeping the same height and
width:

Name: Sheet1!chtValues
Refers to: =OFFSET(Sheet1!chtDates,0,1)

After clicking OK to apply those changes and return to the worksheet,
the chart should be showing exactly the same as before—the new defini-
tions resolve to the same ranges we started off with. The difference now is
that if we type a new data point in row 10, it will automatically appear on
the chart (assuming calculation is set to Automatic)!

To recap, it works because the COUNTA() function contained within
the definition of the chtDates range returns the number of items in col-
mum A, which now includes the new entry. That feeds into the OFFSET()
function, making it include the new entry in its resulting reference (now
A2:A10). The chtValues range is updated to refer to one column across
from the expanded chtDates range, so becomes B2:B10 and both those
names feed into the chart series =SERIES() function, making the chart
redraw to include the new data. The functions used in the defined name
assume that the source data is contiguous, starting in cell A2. Blank cells
will result in an incorrectly calculated range. More precise formulas are
outside the scope of this book, but can easily be found by searching the
Google newsgroup archives.

It is fundamental to the rest of this section that you fully understand
the mechanism we’re using. If anything is unclear, take some time to go
through the example, perhaps trying to create an auto-expanding chart
with two or three data series.

**Scrolling and Zooming a Time Series**

In the auto-expanding chart, we were only updating one of the OFFSET()
function’s parameters. If we modify both the row offset and number of
rows, we can provide a simple, codeless mechanism for our users to scroll
and zoom through a time series. In the worksheet shown in Figure 15-8,
we’ve added two scrollbars from the Forms toolbar below the chart, set
their Min and Max values to correspond to the number of data points and
linked their values to the cells in column D, using two defined names
ZoomVal and ScrollVal to refer to cells D24 and D25 respectively.

In the definition for the chtDates name for this example, the ScrollVal
figure is used for the row offset and the ZoomVal figure provides the num-
ber of data points to include in the range:

```excel
Name: Sheet1!chtDates
Refers to: =OFFSET(Sheet1!$A$1,Sheet1!ScrollVal,0,
Sheet1!ZoomVal,1)
```

The chtValues definition is the same as before, =OFFSET(chtDates,
0,1).
In the previous two examples, we’ve used the OFFSET() function in the defined name to change the range of values drawn on the chart, but keeping the actual data intact. We can also use defined names to modify the data itself prior to plotting it, such as transforming between polar and x, y coordinate systems. In polar coordinates, a point’s location is defined by its angle and distance from the origin, rather than the distance-along and distance-up of the standard XY chart. Excel does not have a built-in chart type that will plot data in polar coordinates, but we can use defined names to convert the (angle, length) polar coordinate to (x, y), which can then be drawn on a standard XY chart. We’re going to show you how to create the chart shown in Figure 15-9 from the data shown beside it by using defined names. In this example, the length figures are calculated from the angle using the formula \( a \sin(a) \).
To demonstrate how the various uses of defined names can be combined, we’ll implement two levels of indirection. The first level will use the technique from the *Auto-Expanding Charts* section above to automatically handle changing data sets, while a second level will perform the coordinate transformation.

The names to handle the automatic updates are defined as follows:

Name: Sheet1!datAngle  
**Refers to:** =OFFSET(Sheet1!$A$3,1,0,  
COUNTA(Sheet1!$A$3:$A$5000)-1,1)

Name: Sheet1!datLength  
**Refers to:** =OFFSET(Sheet1!datAngle,0,1)

The observant reader might have noticed that we’re using a slight different version of the OFFSET() function in the definition for the datAngle name. The version shown here is slightly more robust, as it counts within
a specific range of 5,000 cells, starting with the data header cell. You may have seen a variation on this technique in which the entire column address was used in the COUNTA function. By limiting the range in the way we do here, it doesn’t matter whether the user changes the contents of the cells above the data range, such as adding extra titles to the sheet.

With the datAngle and datLength names referring to our source data, we can define two more names to convert from the polar to x, y coordinates:

Name: Sheet1!chtX
Refers to: =Sheet1!datLength* COS(Sheet1!datAngle*PI()/180)

Name: Sheet1!chtY
Refers to: =Sheet1!datLength* SIN(Sheet1!datAngle*PI()/180)

The chart series can then use the chtX and chtY names for the X and Y data:

=SERIES("Polar Plot",Sheet1!chtX,Sheet1!chtY,1)

**Charting a Function**

So we’ve used defined names to change the range of cells to plot and to manipulate the data in that range before we plot it. In *Chapter 14 — Data Manipulation Techniques*, we introduced array formulas and explained how they can be used to perform calculations on arrays of data. We also showed a specific array formula that is often used to generate a number sequence for use in other array formulas. What we didn’t mention was that we can also use array formulas in our defined names and refer to them from charts! Figure 15-10 shows a worksheet that uses array formulas in defined names to plot a mathematical function over a range of x values, without needing to read any data from the worksheet.

This worksheet combines a number of Excel tricks to generate the x axis values and use them to calculate the y axis results. We create a defined named to generate the values for the x axis and give it the name x, for reasons explained below:

Name: Sheet1!x
Refers to: =$C$6+(ROW(OFFSET($A$1,0,0,$C$8,1))-
1)*($C$7-$C$6)/($C$8-1)
Working through the parts of this array formula:

- OFFSET($A$1,0,0, $C$8,1) gives the range A1:A51.
- ROW(OFFSET($A$1,0,0, $C$8,1)) converts the range to the array \{1, 2, 3, \ldots, 50, 51\}.
- (ROW(OFFSET($A$1,0,0, $C$8,1))-1) subtracts 1 from each item in the array, giving \{0, 1, 2, \ldots, 49, 50\}.
- (\$C$7-\$C$6)/(\$C$8-1) calculates the x axis increment for each point, giving 0.1 in our example.
- (ROW(OFFSET($A$1,0,0,\$C$8,1))-1)*(\$C$7-\$C$6)/(\$C$8-1) multiplies each item in the array by the x axis increment, giving the array \{0, 0.1, 0.2, \ldots, 4.9, 5.0\}.
- \$C$6+(ROW(OFFSET($A$1,0,0,\$C$8,1))-1)*(\$C$7-\$C$6)/(\$C$8-1) adds the array to the required x value start point, resulting in the range of x values to use in the chart \{-4.5, -4.4, -4.3, \ldots, 0.49, 0.50\}.

Unfortunately, if we try to include Sheet1!x in the chart SERIES() function, we get an error about an incorrect range reference. To create the chart, we use the workaround described at the start of this section, by
creating two names chtX and chtY that point to worksheet cells, use them
to create the chart and then change them to their real definitions:

Name:        Sheet1!chtX
Refers to:   =Sheet1!x

Name:        Sheet1!chtY
Refers to:   =EVALUATE(Sheet1!$B$3&"+x*0")

The definition for chtX is just a workaround for Excel not allowing us
to use the x name in the chart itself. The definition for chtY needs
some explaining! Cell B3 contains the equation to be plotted,
\( \exp(x) \sin(x^2) \), as text. The EVALUATE function is an XLM macro
function, equivalent to the VBA Application.Evaluate method, but which
can be called from within a defined name. XLM functions were the pro-
gramming language for Excel 4, replaced by VBA in Excel 5, but still sup-
ported in Excel 2003. The documentation for the XLM functions can be
downloaded from the Microsoft Web site, by searching for “macrofun.exe”
or “xlmacro.exe.” At the time of writing, one version of the file is available

EVALUATE() evaluates the expression it's given, returning a numeric
result. In our case, when the expression is evaluated, Excel replaces the x's
in the formula with the array of values produced by our Sheet1!x defined
name (which is exactly why we called it x) and returns an array containing
the result of the function for each of our x axis values. These arrays are
plotted on the chart, to give the line for the equation. The \&"+x*0" part
of the chtY definition works around an error in Excel that sometimes
causes trig functions to not evaluate as array formulas, by forcing the entire
formula to be evaluated as an array.

**Faking It**

A chart is a visual artifact, designed to impart information to the viewer in
a graphical manner. As such, we should mainly be interested in whether
the final chart looks correct and performs its purpose of providing clear
information. We should not be too bothered about whether the chart has
been constructed according to a notional set of generally approved guide-
lines. In other words, we often need to cheat by using some of the chart
engine’s features in “creative and imaginative” ways. This section explains
a few ways in which we can get creative with Excel’s chart engine, by using
some of its features in ways they were probably not designed to be used.
Error Bars

When is a line not a line? When it's an error bar! From a purely visual perspective, an error bar is a horizontal or vertical line emanating from a data point, so if we ever have the need to draw horizontal or vertical lines around our data points, we might consider using error bars for those lines. A great example is the step chart shown in Figure 15-11, where the vertical lines show the change in an item’s price during a day and the horizontal lines connect the end price from one day to the start price for the next day.

![Figure 15-11 A Step Chart](image)

Because Excel doesn’t include a built-in Step Chart type, many people believe that Excel can’t create them. There are quite a few ways in which it can be done, but the easiest is probably to use an XY chart with both vertical and horizontal error bars. The basic data for the chart consists of a list of dates and end-of-day prices, with a calculated field for the change in price from the end of the previous day. From this basic data, we start with a normal XY chart to plot the price against the date, as shown in Figure 15-12.

Below each data point, we want to display a vertical line equal to the change in price for that day, which we do by specifying a custom minus error value in the Y Error Bars tab of the Format Data Series Dialog, as shown in Figure 15-13.
Figure 15-12  Start with a Normal XY (Scatter) Chart of Price vs. Date

![Formal Data Series dialog box]

Figure 15-13  Add a Custom Minus Y Error Bar for the Day's Change in Price
The horizontal lines need to join each data point to the bottom of the subsequent point's error bar. That sounds difficult, but because these are daily prices all you need to do is add Plus markers to the X error bars with a fixed value setting of 1. With the error bars configured, you should be seeing a chart something like that shown in Figure 15-14.

![The Chart with the Additional Error Bars](image)

**Figure 15-14** The Chart with the Additional Error Bars

All that remains is to double-click the error bar lines and use the Patterns tab to change their color, thickness and marker style, and then double-click the original XY line and format that to have no line and no marker. The result appears to be the step chart from Figure 15-11, even though it’s actually only error bars being drawn.

**Dummy XY Series**

When is an axis not an axis? When it’s an XY series with data labels! Excel’s value axes are either boringly linear or logarithmic. They do not support breaks in the axis, nor scales that vary along the axis nor many other complex-axis effects. Figure 15-15 shows a chart with a variable Y axis, where the bottom half of the chart plots values from 0 to 100 in steps of 20, but the top half plots 100 to 1,000 in steps of 200:
In this chart, the real Y axis goes from zero to 200, but we’ve added a dummy XY series using the data from B10:C20, added data labels to the XY series, set them to display to the left of the point and customized their text to that shown in the figure. The result appears to be a complex axis scale that varies up the chart. The final step is to transform the real sales data in B3:B7 into the correct values for Excel to plot on its linear 0 to 200 scale, which is done using a simple mapping formula in C3:C7 of

\[=IF(B3<=100,B3,100+B3/10)\]

which is the data that Excel plots.

We can use this technique to implement any axis scale of our choosing, such as including breaks in our axes, plotting using logarithmic, hyperbolic or probability scales or even including multiple dummy XY series to make the chart appear to have many axes (as long as the user can determine which series is plotted against which axis). This effect can be misleading, if it is not clearly shown that a break in the axis scale exists. The chart in Figure 15-15 looks linear along its entire range, but if plotted on a true linear scale, it would resemble a boomerang with a large angle in the middle. An easy way to indicate a break in the axis is to set an individual point's data marker using a custom image, as we have done. Draw the image using Paint or other graphics program, copy it to the clipboard, select the data point and paste the image.
VBA Techniques

So far, we've concentrated on the techniques we can use to get the most out of Excel's charting engine through the user interface. In this section, we examine how we can use VBA to manipulate charts.

Converting Between Chart Coordinate Systems

When using VBA to work with charts, there are (at least) four different coordinate systems that we often need to convert between:

- The chart series data displayed inside the plot area is in the axis coordinates if it's an XY Scatter chart.
- The mouse pointer coordinates given in the MouseMove etc. events are measured in pixels, with the origin in the top-left corner of the ChartObject window.
- The coordinates of any drawing objects added to the chart are in points, with the origin being the top left of the chart area, slightly inside the ChartObject window.
- The coordinates used by the GET.CHART.ITEM XLM function to locate the vertices of chart objects are in points, but with the origin in the bottom-left corner of the chart area. See the Locating Chart Items section later for an example of its use.

Furthermore, if the chart is embedded on a worksheet, the worksheet zoom factor affects the mouse pointer coordinates, but not the data nor location of any drawing objects on the chart.

Listing 15-2 shows a MouseMove event for a chart, within which we convert the X, Y mouse coordinates given to the event into both data coordinates (displayed in the status bar) and drawing object coordinates (which we use to move an oval to follow the mouse pointer). Note that this code uses the PointsPerPixel function defined in Chapter 9 — Understanding and Using Windows API Calls:

Listing 15-2 Converting from Mouse Coordinates to Data and Drawing Object Coordinates

```vba
Private Sub mchtChart_MouseMove(ByVal Button As Long, ByVal Shift As Long, ByVal X As Long, ByVal Y As Long)
```
Dim dZoom As Double
Dim dXVal As Double
Dim dYVal As Double
Dim dPixelSize As Double

On Error Resume Next

' The active window zoom factor
dZoom = ActiveWindow.Zoom / 100

' The pixel size, in points
dPixelSize = PointsPerPixel

'Mouse coordinates to (XY) Data coordinates
With mchtChart
    dXVal = .Axes(xlCategory).MinimumScale + |
        (.Axes(xlCategory).MaximumScale - |
        .Axes(xlCategory).MinimumScale) * |
        (X * dPixelSize / dZoom - |
        (.PlotArea.InsideLeft + .ChartArea.Left)) / |
        .PlotArea.InsideWidth

    dYVal = .Axes(xlValue).MinimumScale + |
        (.Axes(xlValue).MaximumScale - |
        .Axes(xlValue).MinimumScale) * |
        (1 - (Y * dPixelSize / dZoom - |
        (.PlotArea.InsideTop + .ChartArea.Top)) / |
        .PlotArea.InsideHeight)
End With

Application.StatusBar = "(" & Application.Round(dXVal, 2) |
    & ", " & Application.Round(dYVal, 2) & ")"

'Mouse coordinates to Drawing Object Points

'We'll only move the oval if the Shift key is pressed
If Shift = 1 Then
    With mchtChart
        dXVal = (X * dPixelSize / dZoom - .ChartArea.Left)
        dYVal = (Y * dPixelSize / dZoom - .ChartArea.Top)

        With .Shapes("ovlPointer")
            .Left = dXVal - .Width / 2
            .Top = dYVal - .Height / 2
        End With
    End With
End If
Locating Chart Items

Sometimes, however hard we try, the only way to get a chart looking exactly how we want it is to add drawing objects to it, such as rectangles, lines, arrows and so on. As soon as we do that, we hit the problem of trying to identify where in the drawing object coordinate space an item on the chart is located, such as the top middle of a specific column in a column chart.

That level of positional information cannot be obtained through the Excel object model, but can be obtained by calling on the long-disused XLM function GET.CHART.ITEM. This function has the following parameters:

\[
\text{GET.CHART.ITEM}(x\_y\_index, \text{point\_index}, \text{item\_text})
\]

Where:

- \( x\_y\_index \) is 1 to return the x position and 2 to return the y position.
- \( \text{point\_index} \) depends on the item we’re looking at, but is a number from 1 to 8 to identify a specific vertex within the item. For example, 2 is the upper middle of any rectangular item, such as a column in a column chart.
- \( \text{item\_text} \) identifies the item we’re interested in, such as “Plot” for the plot area, or “S2P4” for the fourth data point in the second series in the chart.

The full list of available parameters can be found in the XLM Macros help file available for download from the Microsoft Web site at http://support.microsoft.com/?kbid=128175. The only caveat with using GET.CHART.ITEM is that the chart must be active for it to work. The code in Listing 15-3 moves an arrow on a chart to be from the top-left corner of the inside of the plot area (using normal VBA positioning) to the top middle of the third column of a column chart, resulting in the chart shown in Figure 15-16.
Listing 15-3 Using GET.CHART.ITEM to Locate a Chart Item’s Vertices

Private Sub cmdMoveArrow_Click()

    Dim rngActive As Range
    Dim dXVal As Double
    Dim dYVal As Double
    Dim chtChart As Chart

    Set rngActive = ActiveCell

    'We have to activate the chart to use GET.CHART.ITEM
    Me.ChartObjects(1).Activate

    'Find the XY position of the middle top of the third column
    'in the data series,
    'returned in XLM coordinates
    dXVal = ExecuteExcel4Macro("GET.CHART.ITEM(1,2,""S1P3""*)")
    dYVal = ExecuteExcel4Macro("GET.CHART.ITEM(2,2,""S1P3""*)")

    'Get the Chart
    Set chtChart = Me.ChartObjects(1).Chart
    With chtChart

        'Convert the XLM coordinates to Drawing Object coordinates
        'The x values are the same, but the y values need to be
        'flipped
        dYVal = .ChartArea.Height - dYVal

        'Move and size the Arrow
        .Shapes("linArrow").Left = .PlotArea.InsideLeft
        .Shapes("linArrow").Top = .PlotArea.InsideTop
        .Shapes("linArrow").Width = dXVal - .Shapes("linArrow").Left
        .Shapes("linArrow").Height = dYVal - .Shapes("linArrow").Top
    End With

    rngActive.Activate

End Sub
Calculating Reasonable Axis Scales

Often when we're controlling charts through VBA, we need to set our own values for the axis scales. The code in Listing 15-4 calculates tidy Minimum, Maximum and MajorUnit values. It is a different algorithm than the one Excel uses to determine chart axis scales, but is one that we have found to give pleasant-looking results.

Listing 15-4  Function to Calculate Reasonable Chart Axes Scales

```vba
Public Type CHART_SCALE
    dMin As Double
    dMax As Double
    dScale As Double
End Type

Public Function ChartScale(ByVal dMin As Double, ByVal dMax As Double) As CHART_SCALE
    Dim dPower As Double, dScale As Double
    'Check if the max and min are the same
    If dMax = dMin Then
        dScale = dMax
        dMax = dMax * 1.01
    End If
```
dMin = dMin * 0.99
End If

'Check if dMax is bigger than dMin - swap them if not
If dMax < dMin Then
    dScale = dMax
    dMax = dMin
    dMin = dScale
End If

'Make dMax a little bigger and dMin a little smaller
If dMax > 0 Then
    dMax = dMax + (dMax - dMin) * 0.01
Else
    dMax = dMax - (dMax - dMin) * 0.01
End If
If dMin > 0 Then
    dMin = dMin - (dMax - dMin) * 0.01
Else
    dMin = dMin + (dMax - dMin) * 0.01
End If

'What if they are both 0?
If (dMax = 0) And (dMin = 0) Then dMax = 1

'This bit rounds the maximum and minimum values to
'reasonable values to chart.
'Find the range of values covered
dPower = Log(dMax - dMin) / Log(10)
dScale = 10 ^ (dPower - Int(dPower))

'Find the scaling factor
Select Case dScale
Case 0 To 2.5
    dScale = 0.2
Case 2.5 To 5
    dScale = 0.5
Case 5 To 7.5
    dScale = 1
Case Else
    dScale = 2
End Select
'Calculate the scaling factor (major unit)
dScale = dScale * 10 ^ Int(dPower)

'Round the axis values to the nearest scaling factor
ChartScale.dMin = dScale * Int(dMin / dScale)
ChartScale.dMax = dScale * (Int(dMax / dScale) + 1)
ChartScale.dScale = dScale

End Function

---

**Conclusion**

Although Excel’s charting engine has a relatively poor reputation among users, most of that is due to a lack of knowledge about how to exploit the engine, rather than a lack of features. Yes, we would like to see significant improvements in the quality of the graphics, proper support for true 3D contour and XYZ scatter plots and a general overhaul of the user interface to make the advanced techniques shown in this chapter much more discoverable for the average user.

However, after we’ve spent the time to explore the charting engine and fully understand the techniques introduced here, we realize that the limits of Excel’s charting capabilities are to be found in our imagination and creativity, rather than with Excel.
Symbols
2D charts, 522
. (dot) operator, 613
! (exclamation point) character, 660
/ (forward slash) character, 242
# character, 550
? (question mark) character, 212
? wildcard, 507
* wildcard, 507

A
accelerator keys, controls, 310
Access
deleting data, 474
further resources, 476
inserting data, 469
object model, 635
retrieving data from, 465
running a report using Excel data, 636
updating data, 471
Access data sources, connecting to, 461
Access Relationship window, 447
Accessing Excel application object from an automation add-in, 766
accessing data
connecting to data sources, 457-458
Access, 461
error handling, 462
data manipulation operations, 464-465
deleting data, 473
inserting data, 468
retrieving data, 467
updating data, 470-471
technology, 435
Activate event, 416
ActiveDocument, referencing, 622
ActiveX controls, 101
ActiveX Data Objects, 454-455
connecting to data sources, 457-458
Access, 461
data manipulation operations, 464-473
error handling, 462
connection pooling, 461
ConnectionString property, 460
data manipulation operations, 464
data retrieval, 464
further resources, 476
recordsets, creating structured
ranges, 493
technology defined, 455
ActiveX DLLs
complex case—two-way
communication, 693-696
creating a new project, 688-689
creating front loaders, 735-741
displaying a VB6 form in Excel, 698-703
Hello World, 688
in-process communication, 719
justification of use
code protection, 704
custom collection support, 716-717
OOP, 714
resource files, 718
VB6 forms, 705-710, 713-714
out-of-process communication, 720
simple case—one-way communication, 690-692
using resource files to load icons, 726-730
adding bitmaps to the resource file, 731
using bitmaps located in the resource file, 733-735
add-in command bar definition table, 247
Add-in Designer, 747-751
AddinInstance object, 755
Advanced tab, 752
load behavior, 751
add-ins
Add-in Designer, 749-751
Advanced tab, 752
load behavior, 751
application-specific add-ins, 19-20
121-124, 127
automation add-ins, 765
accessing Excel application object from, 786
DError automation add-in, 765
OOM Add-ins
Excel interaction, 755-757
installing, 753-754
development/maintenance, 110
function library add-ins, 112, 115
creating names and descriptions, 117
equivalent UDF, 113
general add-ins, 120
general-purpose, 17
Hello World, 745-747
installation requirements, 879
installing using the object model, 882
managed, 775, 795
multi-application, 764
practical example, 130, 131, 136-139
runtime, 111
shutdown, 112
Index 887

startup, 110
structure, 18
worksheets, 18
AddInInstall event, 758
AddInInstance object (Add-in
Designer), 755
ADO (ActiveX Data Objects), 454-455
connecting to data sources, 457-458
Access, 461
data manipulation operations, 464-473
element handling, 462
connection pooling, 461
ConnectionString property, 460
data manipulation operations, 464
data retrieval, 464
further resources, 476
recordsets, creating structured
ranges, 493
technology defined, 455
ADO Connection object, bypassing, 472
ADO object model, 456
ADsPath, 875
advanced filter criteria range, 510
Advanced Filter feature (Excel), 504-506
Alias clause, 266
Alt+A shortcut key, 572
Alt+V shortcut key, 563
API calls, 259
API
documentation, 256
functions, 266
application shutdown code, 398
application tier, 42
application-specific add-ins, 19, 121
structure, 20
table-driven approach to UI worksheet
management, 122-124, 127
applications, 13
add-ins, 17-20, 749. See also add-ins
API calls, 260
automation, 619, 722
codeless, 14-15
communication
in-process communication, 719
out-of-process communication, 720
creating instances of Office
applications, 627
data access code, 453
deployment, 546
design considerations, 13
development
change control, 67
preparing for release, 863
worksheet, 4
development best practices
code commenting, 47-51
code readability, 51-52
VBA, 54-58
dictator applications, 20-22, 143
customizing the UI, 153-158
requirements of, 23
startup and shutdown, 144-147, 150-152
structure, 24, 143
distributing, 883
Help files, 863-864
creating, 863-865
displaying from VBA, 870-872
writing content, 869
organization best practices, 44
creating procedures, 46
functional decomposition, 45
applications (cont.)
  packaging
  installation location, 877
  installation mechanisms, 881
  installation requirements, 879-880
  performance, 597-598
  optimization, 593-596
  PerfMon utility, 589-591
  Run mode versus Break mode, 545
  security, 873
  checking network groups, 873-875
  macro security, 875-877
  self-automated workbooks, 15-16
  structure best practices
    one-workbook versus the n-workbook application, 42
  separation of data/UI from code, 44
  separation of logical tiers, 42
  tiers, 43
  VBA, code validation, 740
  arguments
    declaring explicitly, 63
    validating, 64
  array formulas, 510-513, 531
  arrays
    control arrays (VB6), 707-710, 713-714
    hard-coding array bounds, 58
    looping, 58
    variant arrays, 614
  Arrows icon, 235
  artificial keys, 451-452
  As Double variable, 615
  assemblies, 776
  assertions, 584-592
  atomic values, 439
  attributes (XML), 822
  auto-expanding charts, 525
  auto-instantiation, 363
  automation, 619
  Access, 636
  Excel from a VB6 EXE, 721-728
  Outlook, 644-645
  PowerPoint and MSGraph, 641
  Word, 638-639
  automation add-ins, 765
  accessing Excel application object
    from, 766
  IfError automation add-in, 765
  installation requirements, 881
  axes (charts), 522, 536

B
  backdrops, 153-155
  Before setting (CommandBarControl
    objects), 218
  Begin Group setting
    (CommandBarControl
      objects), 217
  best practices
    application development
      change control, 67
      code commenting, 47-51
      code readability, 51-52
      including Excel object library in
        variable declarations, 621
      qualifying property and method
        calls, 622
      VBA, 54-58
      versioning, 623
    application organization, 44
    creating procedures, 46
    functional decomposition, 45
    application structure
      one-workbook versus the
        n-workbook application, 42
separation of data/UI from code, 44
separation of logical tiers, 42
command bar design, 199-200
constants, 58
variables, 55-57
best routines (optimization), 599
binding
   early versus late, 60-62, 625
   optimization, 612
bit-masks, 276
bitmaps, 233
as CommandBarButton icons, 235
bookmarks, 638
borders, 94-96
Break in Class Module setting, 546
Break mode, 545
Break on All Errors setting, 545
Break on Unhandled Errors setting, 546
break points, 550-552
browsing for folders, 286-287
browsing to regsvr32.exe, 753
buffers, 280
business logic (userforms), 300
business logic tier, 42
ByRef, 63
ByVal, 63
C
C API, 652
example worksheet function, 679
Excel4 function, 672
parameters, 673
functions, 674
xlCoerce function, 675
xlGetName function, 675
XLOPER data type, 667, 669-670
C strings, 658
calculated fields, 500
adding alongside a query table, 501
parameters, 500
call stack, 591
Call Stack window, 560
callback functions (XLL)
   xlAddInManagerInfo function, 664
   xlAutoClose function, 664
   xlAutoOpen function, 663
   xlAutoRegister function, 666
callbacks, 287, 283
   interacting with the Windows File Picker dialog, 288
cascading-data-validation lists, 90-91
caspol, 804-805
catching errors, 406
cell comments, 86
central error handler, 405, 408-414
central error control, 67
changing
to a UNC path, 281
userform window styles, 317
width of the Name drop-down list, 271
window icon, 272
window styles, 273
chart sheets, naming conventions, 38
Chart Wizard, 519
charts
   auto-expanding, 525
   axes, 522
   calculating reasonable axis scales
      (VBA), 541
   combining chart types, 519-521
   complex axis scale, 536
charts (cont.)  
coordinate systems, 528  
error bars, 533  
linking to data with defined names, 523-530  
locating chart items (VBA), 539  
PowerPoint, 642  
step charts, 533  
time-series data, 527  
working with VBA, 537  
charts (userforms), 321  
circular references, 514-515  
class instancing types, 714  
class modules, 167  
creating objects, 168-169  
Collection objects, 172-178  
raising events, 182-188  
trapping events, 179-181  
structure  
methods, 171  
property procedures, 170  
userforms, 304  
classes  
error handling, 415  
GlobalMultiUse classes, 716  
polyorphic, 308-309, 372  
userforms, 303  
client-server databases, 437  
Close button, disabling (userforms), 320  
code  
defensive coding, 63  
executing in the Immediate window, 559  
execution points, 553  
organizing, 45  
prefixes, 31  
readability, 51  
grouping lines, 52  
line continuation, 53  
reuse, 361  
code comments, 47  
internal, 49  
misake avoidance, 51  
module-level, 47  
procedure-level, 48  
code-created userforms, 336, 340, 343  
code templates, 110  
codelss applications, 14-15  
Collection object, 612  
Collection objects  
creating, 172-178  
custom collection classes, 177  
columns, foreign keys, 440, 446  
COM (Component Object Model), 619  
Object, 624  
COM Add-ins, 747  
adding menu items to Excel, 758  
checking for, 750  
Command Bar Event Hooks, 758  
custom toolbar faces, 762  
Excel interaction, 755  
OnAddInUpdate event, 756  
OnBeginShutdown event, 757  
OnConnection event, 755  
OnDisconnection event, 757  
OnStartupComplete event, 756  
Terminate event, 757  
Hello World, 748  
installation requirements, 880  
installing, 753-754  
jutification for, 761  
Managed COM Add-ins, 774  
Paste Special Bar, 762  
permanent menus, 759-760  
separate threading, 764  
temporary menus, 761
COM DLLs, Managed, 774
combo boxes, 308
ComboBox control, 309, 352
Command Bar Control Events, 237
custom toolbars, 229
Paste Special toolbar, 240
Command Bar Event Hooks, 758
command bars, 23
custom, 158
adding custom menus/submenus to the Worksheet Menu Bar, 224-225
designing:
best practices, 198-200
table-driven command bars, 201-202, 206-215
managed workbooks, 789
practical example, 247
CommandBar objects
IsMenubar setting, 208
Position setting, 207
Protection setting, 209
Visible setting, 208
CommandBarButton objects, 235
CommandBarControl objects
Before setting, 218
Begin Group setting, 217
Control ID setting, 211
Control Style setting, 214
Control Type setting, 213
Face ID setting, 215
List setting, 220
ListRange setting, 220
OnAction setting, 211
Parameter setting, 219
Shortcut Text setting, 218
State setting, 220
Tag setting, 219
Tool tip setting, 218
comments, 47
internal, 49
mismatch avoidance, 51
module-level, 47
procedure-level, 48
compatibility, Office versions, 623
Component Object Model. See COM
Component One's Doc-to-Help web site, 863
conditional compilation constants, 549
conditional formatting, 92
calling out error conditions, 96-98
dynamic tables, 93-95, 151
connecting to data sources, 457-458
Access, 481
error handling, 482
Excel, 480
connection strings, 457-460
consolidating data, 502-504
constants
best practices, 58
conditional compilation constants, 549
defined in the command bar definition table, 204
finding values, 257
including in VBA module, 258
named constants, 72
naming conventions, 31
Control Array Demo form, 710
control arrays, 341
Control Caption columns, 206
core events, trapping, 244
Control ID setting
(CommandBarControl objects), 211
Control Style setting (CommandBarControl objects), 214
Control Type setting (CommandBarControl objects), 213
controlling applications from Excel Access, 636
Outlook, 644-645
performance, 632
PowerPoint and MSGraph, 641
Word, 638-639
controls, 39, 99
ActiveX controls, 101
assigning event handler classes, 342
Custom Toolbar, 227
drag-and-drop operations, 357
form controls, 100
hooking, 238
MultiPage control, 356
userforms, 306
accelerator keys, 330
ComboBox, 352
data binding, 311
data validation, 313
event handling, 311
layering, 309
locking versus disabling, 323
naming, 309
positioning, 309-310
Windows Common Controls, 355-357
z-order, 309
converting pixels to points, 262
values to VBA, 258
coordinate systems, 528, 537
copy, 356
CopyFromRecordset method, 467
CopyPicture method, 321
COUNTA() function, 525
COUNTIF() function, 511
CREATEOBJECT function, 627, 631
CreateParameter method, 473
creating cell comments, 86
COM Add-in projects, 747-748
custom toolbars, 226
dynamic tables, 93-95
front loaders, 735-741
Help project files, 865
compiling, 868
No Help Available topic files, 867
topics, 868
upgrading project options, 865
writing content, 869
IFError automation add-in, 705
instances, 627
menu items, 759
objects, 167-169
Collection objects, 172-178
raising events, 182-188
trapping events, 179-181
procedures, 46
query tables, 495
resource files, 730
special effects with borders, 84
strong names, 801
structured ranges, 493
styles, 80-82
tables, 85
toggle classes, 187-188
Web services, 844-846
XLL projects, 652, 655-666
XML XSD files, 825
criteria range, 598
Ctrl+G shortcut key, 556
Ctrl+L shortcut key, 560
culture (.NET framework), 809-810
custom collection classes, 177
custom collections, 716-717
custom document properties, 140, 163
custom drop-down pane, 354
custom errors, 400
custom icons, 232-235
custom interfaces
defining, 363
implementing, 364-366
use of, 366-367
Custom Toolbar, controls, 227
custom wizards, 333
customizing dictator application UI
backdrops, 153-155
custom command bars, 158
cut, copy, and paste, 156
cut, 156
dancing ants, 526
DAO (Data Access Objects), 636
DAO Database object, 636
data
access, 455
accessing
connecting to data sources, 457-458, 461-462
data manipulation operations, 464-473
Advanced Filter feature (Excel), 504-505
array formulas, 510
defined, 444
filtering, 508
inserting, 468
linking charts to, 523-530
normalization, 438-445
plot data, 530
retrieving, 464-466
structured ranges, 492
time-series, 527
types, 660
unstructured ranges, 492
updating, 470
data access and storage tier, 43
data access code, 453
Data Access Objects (DAO), 636
data binding
controls (userforms), 311
data consolidation, 502-504
data manipulation operations, 464
Data Type Specifier, 31
data types
OPER, 671
XLOPER, 667, 670
memory management, 675
xtype member, 669
data validation, 89
cascading lists, 90-91
controls (userforms), 313
unique entries, 89
data-validation list, 449
data-base, 509
database functions, 509
databases, 435
client-server, 437
disclosed, 437
justification for, 436
primary keys, 438
relational, 437
second normal form, 441
SQL Server, 459
third normal form, 443
DAVERAGE() function, 509
Debug mode, 150, 546
conditional compilation constants, 549
Stop statement, 548
Debug Assert method, 581
Debug Print statement, 536
debugging, 545
assertions, 581
Break in Class Module setting, 546
Break on All Errors setting, 545
Break on Unhandled Errors setting, 546
Call Stack window, 560
conditional compilation constants, 550
Immediate window, 556
Debug Print statement, 536
executing code, 558
Locals window, 573
advanced features, 576
basic features, 575
Quick Watch window, 572
Set Next Statement command, 555
shortcut keys, 552, 583-584
Step Into command, 552
Step Out command, 554
Step Over command, 554
Step to Cursor command, 554
stepping into code, 553
test harnesses, 578-581
User-Defined Debug mode, 547
Watch window, 561, 564
arrays, UDTs, and classes, 570-572
Watch Context option, 567
Watch Type setting, 567-568
watch types, 565
worksheet functions, 682
XLL projects, 655
debugging errors, 408
declarations, 6, 257
Declare statements, 256
declaring, 63
default instances, 303
default interfaces, 360
default VSTO templates, 760
defensive coding, 63
Define Name dialog, 526
defined names
linking data to charts, 523-530
named constants, 72
named formulas, 76
named ranges, 73
naming conventions, 41
relative named ranges, 73
scope of, 77
defining custom interfaces, 363
DELETE statement (SQL), 473
deleting files to recycle bin, 284, 286
dependency checks, 144
derived data, 444
design-time version (ActiveX controls), 706
designing
custom interfaces, 364
command bars
best practices, 199-200
table-driven command bars, 201-202, 206-215
Excel applications, 13
Excel UI
borders, 84
cell comments, 86
cell formatting, 92-98
defensive coding, 63
defined names, 73
conditional formatting, 92-98
data validation, 99-101
default VSTO templates, 760
default instances, 303
default interfaces, 360
default VSTO templates, 760
defensive coding, 63
defined names, 73, 76-77
practical example, 101, 103-104
Define Name dialog, 526
defined names
linking data to charts, 523-530
named constants, 72
named formulas, 76
named ranges, 73
naming conventions, 41
relative named ranges, 73
scope of, 77
defining custom interfaces, 363
DELETE statement (SQL), 473
deleting files to recycle bin, 284, 286
dependency checks, 144
derived data, 444
design-time version (ActiveX controls), 706
designing
custom interfaces, 364
command bars
best practices, 199-200
table-driven command bars, 201-202, 206-215
Excel applications, 13
Excel UI
borders, 84
cell comments, 86
cell formatting, 92-98
defensive coding, 63
defined names, 73
conditional formatting, 92-98
data validation, 99-101
default VSTO templates, 760
default instances, 303
default interfaces, 360
default VSTO templates, 760
defensive coding, 63
defined names, 73, 76-77
practical example, 101, 103-104
rows and columns, 70
shapes, 88
styles, 78-83
tables, 85
wizard dialogs, 333
developers, 2
Excel, 3
VBA, 2
development add-ins, 110
device context, 292
disconnected recordsets, 486
dictator applications, 20-22
customizing the UI
backdrops, 153-155
custom command bars, 158
cut, copy and paste, 156
requirements of, 23
startup and shutdown, 144
crashes, 150
Debug Mode, 150-152
storing/restoring Excel settings, 145-147
structure, 24, 143
dictator applications, 143
dictionaries, 612
digital signatures, 875-877
disabling:
Close button (userforms), 320
COM Add-ins, 749
controls versus locking (userforms), 323
On Error Resume Next, 547
toolbar buttons, 194
Toolbar List command bar, 210
displaying
Help files from VBA, 870-872
Immediate window, 556
VB6 forms in Excel, 698-703
distributing applications, 883
DLLMain function, 662
DLLs, 694-696
Do...While loops, 50
DoCmd object, 636
document properties, 140
documents, range, 639
dot ( . ) operator, 613
downloading HTML Help Workshop, 864
drag-and-drop operations, 159, 357
drawing objects, 40
drop-down panes, 354
dynamic lists, 76
dynamic control event handling (dynamic userforms), 341
dynamic tables, 93-95
dynamic userforms, 336
code-created/table-driven userforms, 336-340, 343
dynamic control event handling and control arrays, 341
scroll regions, 340
subset userforms, 336
E
early binding, 60-62, 624-625
embedded objects, 40
EnableCancelKey property, 24
enabling:
COM Add-ins, 749
eroerror handlers, 394
capsulating
API calls, 259-260
userforms, 306
capsulation, 45
entry points, 253
EntryPoint subroutine, 420-421
enumerations, 35
advantages of, 36
naming conventions, 31
EOF property, 467
Err object, 392
error bars, 533
Error Check formula, 97
error handled command bar builder, 222
error handling, 391
accessing data sources, 462
central error handler, 408-414
classes and userforms, 415
complex error handler example, 405
enabling handlers, 394
Err object, 392
function return value, 426
On Error statement, 396
overview, 393
procedure error handlers, 404-405
raising custom errors, 400
re-throw system, 428
Resume statement, 399
scope, 394-395
simple error handler example, 402
starting and closing Outlook, 630
trivial procedures, 407
unhandled versus handled errors, 391
userforms, 417-421
VBA, 628
error log files, 408, 413
errors
calling out error conditions, 96-98
debugging, 408
trapping, 426
Type Mismatch errors, 359
EVALUATE() function, 532
event handlers, 342
event handling, 311
event hooks
functionality, 228
why use?, 277
events
Activate event, 416
Initialize event, 416
Terminate event, 416
XML, 835-840
Evil Type Coercion, 56
Excel
Advanced Filter feature, 504-505
applications
add-ins, 17-18
applications-specific add-ins, 19-20
codeless, 14-15
dictator applications, 20-24
distributing, 883
preparing for release, 863
self-automated workbooks, 15-16
controlling applications, 620
controlling applications from
Access, 636
Outlook, 644-645
performance, 632
PowerPoint and MSGraph, 641
Word, 638-639
dancing ants, 526
data processing features, 497
data-handling features, 491
developers, 2-3
keyboard functions, 274-277
menu items, 759
object model, 7
overview, 1
populating a Word document from, 633
power users, 2
retrieving holiday dates from Outlook calendar, 645
security, 872-877
supported versions, 9
user IDs, 279
VBA, 5
Web services, 843-844
creating, 845-846
functionality, 847-849
XML features, 825-827
Excel 2003, 494
Excel 97 SDK, 652
Excel UI designing
borders, 84
cell comments, 86
conditional formatting, 92-98
controls, 99-101
data validation, 89-91
defined names, 72-73, 76-77
practical example, 101-104
rows and columns, 70
shapes, 88
styles, 78-83
tables, 85
naming conventions
defined names, 41
embedded objects, 49
principles of good design, 69
Excel4 function, 672-673
exclamation point (!) character, 600
Execute method, 470
execution point indicator, 553
execution points, 553
exporting XML data, 833-834, 842
expressions
lvalue, 564
watch, 562
F
file-based databases, 437
files, deleting to recycle bin, 284-286
filtering data, 504-508
FindWindow function, 266
FindWindowEx function, 267
first normal form, 439
folders
browsing for, 286-287
special folders, 282-284
foreign keys, 440, 446
form controls, 100
form-based UI, 155
forms (VB6), 795
ActiveX control support, 706
control arrays, 707-710, 713-714
Forms toolbar, selecting controls, 99
forms, 305. See also userforms
formulas
array formulas, 510, 531
data validation, 99
Error Check formula, 97
named formulas, 76
Form_Load event procedure, 722
Form_QueryUnload event, 713
formulas (array formulas), 511-513
FP struct, 661
Frame control, 399
front loaders
creating, 735-741
structure, 736
Sub Main procedure, 741
function library add-ins, 112, 115
creating names and descriptions, 117
example UDF, 113
function return value, 426
function tables, 658-661
functional decomposition, 45
functionals, 17
functions, 36
C API, 674
xlCoerce function, 675
xlFree function, 674
dlGetName function, 675
charting, 530
database functions, 509
structure, 18
wrapped in On Error Resume Next statement, 398

G
general add-ins, 120
General Options panel, 337
general-purpose add-ins, 17
structure, 18
GET.CHART.ITEM XLM function, 537-539
GetDC function, 263
getKeyState API function, 274
GetSetting, 18
GetSystemMetrics API function, 257
encapsulating, 260
finding screen resolution, 261
global scope, 30
GlobalMultiUse instancing type, 715
guard counters, 65
GUIDs, 624

H
handles, 259
finding Excel main window handle, 268
handling instances, 626
application availability, 632
creating new instances, 627
multiversion support, 631
referencing existing instances, 628
tidying up, 628
Hello World ActiveX DLL, 688
complex case—two-way communication, 693-696
creating a new project, 688
displaying a VB6 form in Excel, 696-703
simple case—one-way communication, 690-692
Hello World add-in, 745-747
Hello World Com Add-in, 748
Hello World managed workbook, 777, 780
Help files, 864
creating, 865
compiling, 868
No Help Available topic files, 867
topics, 868
updating project options, 865
displaying from VBA, 870-872
writing content, 869
hiding userforms, 305
Highlight method, 176
hOwner element, 293
HTML help files, 864
creating, 865
compiling, 868
No Help Available topic files, 867
topics, 868
updating project options, 865
displaying from VBA, 870-872
writing content, 869
HTML Help Workshop, 864
HWND, 264
hybrid VBA/VSTO solutions, 775, 796-799

I
Icon property procedure, 733
icons/mask method, 217
icons, 216
loading custom icons from files, 232-235
ID property, 238
ID/Tag combination, 238
IfError automation add-in, 765
IFERROR UDF, 113
IgnoreOtherApplications, 21
Immediate window, 556
Debug.Print statement, 556
executing code, 558
implementing
custom interface, 364-366
single-exit points, 401
implicit agreement, 374
implicit interfaces, 386
importing
text files, 494
XML data, 525, 533-534
in-process communication, 719
indexes,
Help files, 869
unique, 453
infinite loops, protecting against, 65
Initialize event, 188, 194, 416
INSERT statement (SQL), 468
inserting data, 468
ing restoration, 877
installing
COM Add-ins, 733-754
HEML Help Workshop, 864
installation location, 878
installation mechanisms, 881
installation requirements, 880
instances
handling, 628
application availability, 632
creating new instances, 627
multiversion support, 631
referencing existing instances, 629
tidying up, 628
instantiation, 194
auto-instantiation, 361
global class variables, 243
integralHeight property, setting to False, 329
intellectual property, 763
IntelliSense, 374
interfaces, 359
custom
defining, 363
implementing, 364-366
use of, 366-367
default, 360
implicit, 386
improving robustness, 373
polymorphic classes, 368-369, 372
progress bars, 575, 581
intermediate tables, 450
internal code comments, 49
intrusive validation, 313
IsAddin property, 18
IsEnabled setting, 211
IsMenuBar setting (CommandBar
objects), 208
IsNumeric() function, 311
IsTemporary setting, 211
iterating through a collection of different
object types, 373

J-K
joins, 405
K data type, 661
key columns, 438
keyboards, 274
testing to see if a key is held
down, 274
KeyDown, 311
KeyPress event, 311, 724
kill switches, 516

L
languages, VBA, 5
late binding, 60-62, 625
layering controls (userforms), 309
lcid, 867
leveraging .NET framework, 774
line continuation, 53
list boxes, splitter bars, 330
List feature (Excel 2003), 494
List range, 505
List setting (CommandBarControl
objects), 220
ListRange setting (CommandBarControl
objects), 220
LoadBehavior value, 751
loading custom icons from files, 232-235
Locals window, 573
advanced features, 576
basic features, 575
locking controls (userforms), 323
LOOKUP() function, 492
loops
arrays, 58
infinite, protecting against, 65
lvalue, 564

M
macro security, 875, 877
macro-optimization, 598
best routines, 599
nested loops, 600
VBA algorithms
binary search, 605
QuickSort routine, 602
sort and scan, 607
SORTSEARCH_INDEX udt, 608
Macromedia's RoboHelp, 863
maintaining add-ins, 110
Managed COM Add-ins, 774
managed COM DLLs, 774
managed Excel Add-ins, 795
managed workbooks, 775-776
default template, 780
Hello World managed workbook, 777, 780
ProExcel VSTO template, 781-784,
787-788
sharing command bars, 789, 793
Index 901

managing UI worksheets, 122
many to many relationships, 449
MAPIFolder object, 645
mapping XML maps, 830-831, 836
margin indicator bar, 551
masks, 215, 233
member variables, 35
memory leak, 259
memory management, 675
menus, adding a custom menu with
submenus to the Worksheet Menu
Bar, 224-225
methods (class modules), 171
micro-optimization, 609
Excel, 613-615
VBA, 610-612
Microsoft Excel
Advanced Filter feature, 504-505
applications
add-ins, 17-18
applications-specific add-ins, 19-20
codeless, 14-15
dictator applications, 20-24
distributing, 883
preparing for release, 863
self-automated workbooks, 15-16
controlling applications, 620
controlling applications from
Access, 630
Outlook, 644-645
performance, 632
PowerPoint and MSGraph, 641
Word, 638-639
dancing ants, 526
data processing features, 497
data-handling features, 491
developers, 2-3
keyboard functions, 274-277
menu items, 759
object model, 7
overview, 1
populating a Word document
from, 633
power users, 2
retrieving holiday dates from Outlook
calendar, 645
security, 872-877
supported versions, 9
user IDs, 279
VBA, 5
Web services, 843-844
creating, 845-846
functionality, 847-849
practical example, 850-854
XML features, 825-827
Microsoft Excel 2003, 494
Microsoft Excel-97 SDK, 652
Microsoft Excel UI
designing
borders, 84
cell comments, 86
conditional formatting, 92-98
controls, 99-101
data validation, 88-91
defined names, 72-73, 76-77
practical example, 101-104
rows and columns, 70
shapes, 88
styles, 78-83
tables, 85
naming conventions
defined names, 41
embedded objects, 40
principles of good design, 69
migrating from VBA to VSTO, 811
MISSING object library reference, 624
modeless userforms, 344
combining with menu items, 348
progress bars, 346
splash screens, 345
modifying
styles, 82
worksheet UI, 127
module definition file, 653
module-level code comments, 47
modules, organizing code, 45
mousers, 310
MSDN library, 256
MSForms toolbox, ComboBox control, 350
MSG, 277
msoBarPopup style, 324
MSQuery application, 495
MUI Pack, 808
multi-application add-ins, 764
MultiPage control, 334, 336
MultiUse instancing type, 715

N
.NET framework
assemblies, 776
culture, 809-810
interacting with Office, 773
leveraging, 774
runtime, 807
security policies, 800
terminology, 773
named constants, 72
named formulas, 76
named ranges, 73
Namespace object, 645
namespaces, 841-842
naming
controls, 389
conventions, 29
descriptive names, 32
Excel UI, 40
making exceptions, 41
prefixes, 31
sample, 30
subroutines and functions, 36
UDFs, 114
worksheets and chart sheets, 38
natural keys, 451-452
nested loops, 599
network groups, 873-875
New keyword, 627
NewEnum method, 716-717
nonkey columns, 438
normalization
of data, 438
when not to, 445
null-terminated C strings, 658

O
Object Browser, 574
Object Linking and Embedding (OLE), 619
object model, 7
object models
Access, 635
XML, 835-840
object-oriented programming (OOP), 5
objects
checking interface, 372
creating with class modules, 167-169
Collection objects, 172-178
raising events, 182-188
trapping events, 179-181

Office
creating instances of applications, 627
interacting with .NET framework, 773
Office FileDialog object, 286-287
Office object libraries, forward compatibility, 625
OfficeCodeBehind class, 777

OFFSET() function, 525
OLE (Object Linking and Embedding), 619
OLE DB, 455
providers
Microsoft Jet, 457
SQL Server, 458

On Error GoTo 0 statement, 398
On Error Goto <label>, 396
On Error Resume Next statement, 396

Paint objects, 6
optimization, 593-596
macro-optimization, 598
best routines, 599
binary search, 605
nested loops, 600
QuickSort routine, 602
sort and scan, 607
SORTSEARCH_INDEX udt, 608
micro-optimization, 609
Excel, 613-615
VBA, 610-612
Opt: Base 1 statement, 54
option buttons, changing to combo boxes, 308
Option Compare Text, 611
Option Explicit statement, 54
Option Private Module statement, 54
OptionSelected property procedure, 713
optType_Click event procedure, 713
out-of-process communication, 720
Outlook
starting and closing with error handling, 630

P
packaging applications
installation location, 877
installation mechanisms, 881
installation requirements, 879-880
panels (General Options panel), 337
Parameter setting (CommandBarControl objects), 219
Panels strings, 665, 669
paste, 156
Paste Special Bar COM Add-in, 762
Paste Special Bar VSTO Add-in, 795
Paste Special Command Bar, 239
PerfMon utility, 586
performance, 587–588
controlling applications from Excel, 632
macro-optimization, 598
best routines, 599
binary search, 605
nested loops, 600
QuickSort routine, 602
sort and scan, 607
SORTSEARCH_INDEX udt, 608
micro-optimization, 609
Excel, 611-615
VBA, 610-612
optimization, 593-596
PerfMon utility, 589-591
permanent assertions, 552
permanent menus (COM Add-ins), 759-760
pictures, 217
pivot caches, 488
pivot tables, 488-500
pixels
converting to points, 262
finding size of, 263
plot data, 530
points, converting pixels to, 262
polymorphic classes, 368-369, 372
populating
PowerPoint presentation from Excel data, 642
Word documents from Excel, 633
Word templates from Excel data, 630
popup menus (userforms), 324
Position setting (CommandBar objects), 307
positioning
controls (userforms), 309-310
userforms next to a cell, 325
power users, 2
PowerPoint
charts, 642
Slide object, 641
using Excel data, 641
prefixes, 31
primary axis, 522
primary keys, 458
natural versus artificial, 451-452
procedure error handlers, 404-405
procedure-level code comments, 48
procedures, 36
creating, 46
PerfMon calls, 590
trivial, 407
validating arguments before use, 64
ProExcel VSTO template, 781-783
program columns, 70
program rows, 70
programming
code comments, 47
code reuse, 361
debugging, 545
assertions, 581
Break in Class Module setting, 546
Break on All Errors setting, 545
Break on Unhandled Errors setting, 546
Call Stack window, 560
conditional compilation constants, 550
Immediate window, 556-558
Locals window, 573-576
Quick Watch window, 572
Set Next Statement command, 555
shortcut keys, 552-554, 583-584
stepping into code, 553

User-Define Debug mode, 547

Watch window, 561, 564-572

worksheet functions, 692

XLL projects, 655

defensive coding, 63

naming conventions, 30
descriptive names, 32

Excel UI, 40

making exceptions, 41
prefixes, 31
sample, 30

worksheets and chart sheets, 38

VB6, 687

ActiveX DLL projects, 688-696
displaying VB6 form in Excel,

698-701

VBA, 5

progress bars, 346, 375, 381

properties (userforms), 306

property procedures (class
modules), 170

Protection setting (CommandBar
objects), 209

providers

Microsoft Jet, 457
OLE DB, 455
SQL Sever, 458

public scope, 30

Q

query tables, 494

adding a calculated field, 501
cautions, 495
limitations, 497
refresingh, 496

question mark (?) character, 212

Quick Watch window, 572

R

raising custom errors, 400

raising events, 182-183

creating trigger classes, 187-188

family relationship problem, 184-186
ranges, named, 73

re-throw system of error handling, 428

readability (code), 51

grouping lines, 52

fine continuation, 53

recordsets, 467

creating structured ranges, 493
disconnected, 486

recycle bin, deleting files, 284-286

referencing

ActiveDocument, 622

adding to an object library

Office object library, 625

Word object library, 620

Excel from VB6, 695

existing instances, 629

multiversion support, 631

referential integrity, 445, 451

refreshing query tables, 496

regsvr32.exe, browsing to, 753

unique indexes, 453

relationships, 445

many to many, 449

natural versus artificial keys, 451-452

referential integrity, 451

relationships, 449

unique indexes, 453

relationships, 445

many to many, 449

one to many, 448
relationships (cont.)
  one to one, 447
  referential integrity, 451
relative named ranges, 73
resolution (screen), 261
resolutions (userforms), 327
resource files, 718
creating, 730
loading icons, 729-730
adding bitmaps to the resource file, 731
using bitmaps located in the resource file, 733-735
restoring Excel settings during shutdown, 147
Resume <Labels> statement, 400
Resume Next statement, 400
Resume statement, 399
retrieving data, 464-466
RHS, 371
right-click command bars, 230
root element (XML), 822
routines
general-purpose add-ins, 17
group routines in application-specific modules, 624
Run mode, 545
runtime add-ins, 111
runtime version (ActiveX controls), 706
S
satellite DLL, 753
SaveSetting, 18
saving application versions, 67
schema, mapping to worksheets, 832
schema definition files (XML), 820
scope
defined names, 77
class error handling, 394-395
variables, 30, 59
screen resolution, 261
userform concerns, 327
scroll regions (dynamic userforms), 340
second normal form, 441
secondary axis, 522
security
  checking network groups, 873-875
  COM Add-ins, 763
  Excel, 872-873
  macro security, 875-877
  VSTO, 811
  VSTO security model, 799-801
caspol, 804-805
strong names, 800-802
SELECT statement (SQL), 405
self-automated workbooks, 15-16
SendKeys, 16
separate threading, 764
Series() function, 523
Set Next Statement command, 555
setting
  basic watches, 562
  break points, 551
shapes, 88
  sharing command bars (managed workbooks), 789, 793
SHBrowseForFolder function, 293
sheet-based UI, 155
shortcut keys (debugging), 583-584
Step Into command, 552
Step Out command, 554
Step Over command, 554
Step to Cursor command, 554
Shortcut Text setting
(CommandBarControl objects), 218
ShowWindowsInTaskBar, 23
shutdown
add-ins, 112
dictator applications, 144
Debug Mode, 150-152
handling crashes, 150
storing/restoring Excel settings, 145-147
single exit point principle, 401
size
converting pixels to points, 262
device contexts, 262
userforms, 328
sorting routines, 367
SORTSEARCH_INDEX udt, 608
source data, defined names, 525
special folders, 282-284
splash screens, showing at startup, 345
splitter bars, 330
Spy++ utility, 264
SQL (Structured Query Language), 437
data retrieval, 464
DELETE statement, 473
further resources, 474-476
INSERT statement, 487
SELECT statement, 485
UPDATE statement, 470
Standard EXE (VB6), 735
startup
add-ins, 110
dictator applications, 144
Debug Mode, 150-152
storing/restoring Excel settings, 145
State setting (CommandBarControl objects), 220
statements, Resume statements, 399
step charts, 533
Step Out command, 554
Step Over command, 554
step through code, 552
Step to Cursor command, 554
stepping into code, 553
storage
resource files (VB6), 718
toolbar customizations, 148
strings, byte-counted, 669
strong names, 800
creating, 801
trusting, 802-803
structure
class modules
methods, 171
property procedure, 170
dictator applications, 143
front loader applications, 736
Structured Query Language. See SQL
structured ranges, 492
creating, 493
Style Includes option, 82
styles (windows), 273
adding Style drop down to the
toolbar, 83
advantages, 78
creating, 80-82
modifying, 82
userforms, 316
Sub Main procedure, 742
subroutines, 36
subset userforms, 336
sum of digits, 513
SUMIF() function, 511
T

tab orders, 310
table of contents (Help files), 869

table-driven command bars, 201
command bar definition table, 202
Command Bar Name column, 206
Control Style setting, 214
Control Type setting, 213
Face ID setting, 215
Position setting, 207
Protection setting, 209
settings, 211
table-driven command bar builder, 201
table-driven userforms, 336, 340, 343
tables, 85, 435. See also databases
dynamic, 91, 95
first normal form, 439
foreign keys, 440
function tables, 658-661
intermediate, 450
many to many relationships, 449
one to many relationships, 448
one to one relationships, 447
pivot tables, 498
calculated fields, 500
primary keys, 438
query tables, 494
second normal form, 441
third normal form, 443
Tag property, 238
Tag setting (CommandBarControl objects), 219

templates, 191
installation requirements, 879
temporary menus (COM Add-ins), 761
Terminate event, 398, 416, 757
Terminate method, 185
test harnesses, 578-579, 581
testing for key presses, 276-277
Thawte, 876
third normal form, 443
time-series data, scrolling and
zooming, 527
Timer, 609
toolbar customizations, 148
Toolbar List command bar,
disabling, 210
toolbars
custom, 226
custom faces (COM Add-ins), 762
custom icons, 230
custom right-click command bars, 230
disabling buttons, 194
Tooltip setting (CommandBarControl objects), 218
top-level windows, 266
trapping
control events, 244
errors, 426
events, 179-181
trigger classes, 187-188
trivial procedures, 407
troubleshooting, 546. See also debugging
calling out error conditions, 96-98
type library, 627
Type Mismatch errors, 359
Type Name() function, 372
Type Of function, 372
type_text data types, 660

U

UDFs (User-Defined Functions), 111
critical details, 119
dead bugs add-ins, 113
IFERROR, 113
making appear native, 114
naming conventions, 114
unregistering, 116
VBA, 120
UIS (user interface support) layer, 301-304
ulFlags element, 293
UNC paths, 281
unique indexes, 453
unobtrusive validation, 313
unstructured ranges, 492
UPDATE statement (SQL), 470
updating data, 470
User-Defined Debug mode, 547
User-Defined Functions. See UDFs
user-defined types, 35, 454
naming conventions, 31
user IDs, finding, 279
user interface support (UIS) layer, 301
user-interface tier, 42
user32.exe, 256
userforms, 299
business logic, 300
controls, 306
accelerator keys, 310
ComboBox, 352
data binding, 311
data validation, 313
event handling, 311
layering, 309
naming, 309
positioning, 308-310
Windows Common Controls, 355-357
default instances versus classes, 303
disabling the Close button, 320
displaying graphics, 321
dynamic userforms, 336
code-created/table-driven userforms, 336, 340, 343
dynamic control event handling and control arrays, 341
scroll regions, 340
subset userforms, 336
error handling, 415
demo, 417-421
exposing properties and methods, 306
hiding versus unloading, 305
locking versus disabling controls, 323
modeless, 344
combining with menu items, 348
progress bars, 346
splash screens, 345
popup menus, 324
positioning next to a cell, 325
property procedures, 307
restorable, 328
responding to resolutions, 327
simplicity, 299
splitter bars, 330
UIS layer, 301-304
window styles, 316
wizard dialogs, 332
creating, 334
design rules, 333
validating data (userform controls), 313
values
atomic, 439
converting to VBA, 258
variables
best practices, 55-57
value, 564
variables (cont.)
member variables, 35
naming conventions, 31
scope, 30, 59
storing handles, 259
variant arrays, 614
VB.NET. See VSTO (Visual Studio Tools for Office)
VB.NET, creating Web services, 845-846
VB6 (Visual Basic 6), 687
activeX DLL projects, 688-689
code protection, 704
complex case—two-way communication, 693-696
custom collections, 717
displaying a VB6 form in Excel, 698-703
OOP, 714
resource files, 718
simple case—one-way communication, 690-692
taking advantage of VB6 forms, 705-710, 713-716
taking advantage of VB6 front loaders, 705-710, 713-716
taking advantage of VB6 front loaders creating, 735-741
structure, 736
Sub Main procedure, 741
VB6 front loaders
creating, 735-741
structure, 736
VB6 Resource Editor, 729
VBA, 5
advanced filtering, 505
applications, code validation, 740
charts, 537
calculating reasonable axes scales, 541
Collection object, 612
debugging
break points, 550
Step Out command, 554
Step Over command, 554
step through code, 552
Step to Cursor command, 554
stepping into code, 552
developers, 2
displaying Help files, 870-872
displaying Help files, 870-872
event handling, 628
error handling, 391, 628
error handling, 391, 628
Hybrid VBA/VSTO solutions, 796-799
Hybrid VBA/VSTO solutions, 796-799
locating chart items, 539
locating chart items, 539
migrating to VSTO, 811
modifying worksheet UI, 127
naming conventions, 32
Object Browser, 574
Object Browser, 574
programming, best practices, 54-58
programming, best practices, 54-58
self-automated workbooks, 15-16
self-automated workbooks, 15-16
Stop statement, 548
Stop statement, 548
UDFs, 119-120
UDFs, 119-120
VBA References dialog, 692
VBA References dialog, 692
VBE (Visual Basic Editor), 545
VBE (Visual Basic Editor), 545
Add-in Manager dialog, 751
Add-in Manager dialog, 751
conditional compilation constants, 549
conditional compilation constants, 549
VBE Error Trapping setting, 546
VBE Error Trapping setting, 546
VBE Object Browser, msoControlType enumeration members, 213
VBE Object Browser, msoControlType enumeration members, 213
VBE Tools Control Nudger toolbar, 310
VBE Tools Control Nudger toolbar, 310
VeriSign, 876
VeriSign, 876
version checks (dictator applications), 144
version checks (dictator applications), 144
virtual function table, 624
virtual function table, 624
Visible setting (CommandBar objects), 208
Visible setting (CommandBar objects), 208
Visual Basic Editor. See VBE
Visual Basic Editor. See VBE
Visual Studio .NET, 771
including XSD files in projects, 853
VSTO (Visual Studio Tools for Office), 763, 771
application links, 806
functional gaps, 806
global solutions, 807-808
hybrid VBA/VSTO solutions, 796-799
managed Excel add-ins, 795
managed workbooks, 776
default template, 780
Hello World, 777, 780
ProExcel template, 781-784, 787-788
sharing command bars, 789, 793
migrating from VBA, 811
Office versions, 812
overview, 771-772
security, 811
security model, 799-801
caspdl, 904-905
strong names, 800-802
vTable, 824

Web sites
assistance, 11
authors', 11
Component One’s Doc-to-Help, 863
downloading ADO, 458
Macromedia’s RoboHelp, 863
MSDN library, 256
Thawte, 876
VeriSign, 876
Windows
classes, 264
finding, 266
finding related windows, 267
hWid, 264
icons, changing, 272
messages, 270
special folders, 282-284
structures, 277
styles, 273
userforms, 316
top-level windows, 266
Windows API
documentation, 256
functions, 266
Windows Common Controls, 355-357
WithEvents objects, 238
wizard dialog, 332
code-created/table-driven, 336
creating, 334
design rules, 333
WM_PAINT message, 271
WM_SETICON message, 272
Word
controlling from Excel, 620
creating new instances of, 627
populating a document from Excel, 633
Word object library, 620
WordArt (userforms), 321
workbooks
linking to XML schema, 826
managed, 775-776
default template, 780
Hello World, 777, 780
ProExcel VSTO template, 781-784, 787-788
sharing command bars, 789, 793
templates, 191
Worksheet Menu Bar, adding custom menu with submenus, 224-225
worksheets
add-ins, 18
controls, 99
ActiveX controls, 101
form controls, 100
as a declarative programming language, 6
debugging functions, 682
example function, 679
naming conventions, 38
registering/unregistering custom functions, 676-678
UI
modifying, 127
utility code, 124
UI settings, 122-123
XLL-based, why create?, 651
wrapper procedures, test harness, 578
X-Z
xlAddInManagerInfo function, 664
xlAutoAdd function, 666
xlAutoClose function, 664
xlAutoFree function, 666
xlAutoOpen function, 663
xlAutoRegister function, 666
xlAutoRemove function, 666
xlcal.h file, 671
xlCoerce function, 675
xlFree function, 674
xlGetName function, 675
XLL, 652
callback functions
xlAddInManagerInfo function, 664
xlAutoClose function, 664
xlAutoOpen function, 663
xlAutoRegister function, 666
creating projects, 652, 655
structure, 657
callback functions, 663-666
DLLMain function, 662
function table, 658-661
XLL-based worksheets, why create?, 651
XLOPER data type, 665-667
C++ keyword clash, 683
containing arrays, 670
memory management, 675
dtype member, 669
XML, 819
elements, 822
events, 835-840
example file, 821
example XSD file, 823
Excel 2003’s XML features, 825
sample model, 827
exporting/importing data, 833-834
maps, 830-831, 836
namespaces, 841-842
object model, 835-840
overview, 820-821
preventing importing, 840
schema definitions, 820
support in previous Excel versions, 841
Web services, 843-844
creating, 845-846
functionality, 847-849
practical example, 850-854
XSD files, 828-829
XML functions, 532
XML Source task pane, 825
XMLDataQuery method, 839
XMLMapQuery method, 839
XPath, 838
XSD (XML schema definition) files, 823, 828-829
including in Visual Studio .NET projects, 853
XML maps, 830-831
XY series, 535
z-order (controls), 309