WinDriver v6.20 User's Guide

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Chapter 1

WinDriver Overview

In this chapter you will explore the uses of WinDriver, and learn the basic steps of creating your driver.

1.1 Introduction to WinDriver

WinDriver is a development toolkit that dramatically simplifies the difficult task of creating device drivers and hardware access applications. WinDriver includes a wizard and code generation features that automatically detect your hardware and generate the driver to access it from your application. The driver and application you develop using WinDriver is source code compatible between all supported operating systems (WinDriver currently supports Windows 98/Me/NT/2000/XP/CE/CE.NET/Server 2003, Linux, Solaris and VxWorks.). The driver is binary compatible between Windows 98/Me/NT/2000/XP/Server 2003. Bus architecture support includes PCI/CardBus/ISA/ISAPnP/EISA/CompactPCI and USB. WinDriver provides a complete solution for creating high performance drivers that handle interrupts and I/O at optimal rates.

Don't let the size of this manual fool you. WinDriver makes developing device drivers an easy task that takes hours instead of months. Most of this manual deals with the features that WinDriver offers to the advanced user. However, most developers will find that reading this chapter and glancing through the DriverWizard and function reference chapters is all they need to successfully write their driver.

WinDriver supports USB and PCI chipsets from all vendors. Enhanced support is offered for PLX, Altera, Marvell, AMCC, QuickLogic, Cypress, STMicroelectronics, Texas Instruments and National Semiconductors chipsets. A special chapter is dedicated to developers of drivers for USB devices and PCI cards who are using USB and PCI chips from these vendors. The final chapters of this manual explain how to tune your driver code to achieve optimal performance, with special emphasis on the Kernel PlugIn feature of WinDriver. This feature allows the developer to write and debug the entire device driver in user mode, and later drop performance critical parts into kernel mode. In this way the driver achieves optimal kernel-mode performance, while the developer need not sacrifice the ease of user-mode development.

Visit Jungo's web site at `http://www.jungo.com` for the latest news about WinDriver and other driver development tools that Jungo offers.

Good luck with your project!

1.2 Background

1.2.1 The Challenge

In protected operating systems such as Windows, Linux and Solaris, a programmer cannot access hardware directly from the application level (user mode), where development work is usually done. Hardware can only be accessed from within the operating system itself (kernel mode or Ring-0), utilizing software modules called device drivers. In order to access a custom hardware device from the application level, a programmer must do the following:

- Learn the internals of the operating system he is working on (Windows 98/Me/NT/2000/XP/CE/CE.NET/Server 2003, Linux, Solaris and VxWorks).
- Learn how to write a device driver.
- Learn new tools for developing/debugging in kernel mode (DDK, ETK, DDI/DKI).
- Write the kernel-mode device driver that does the basic hardware input/output.
- Write the application in user mode that accesses the hardware through the device driver written in kernel mode.
- Repeat the first four steps for each new operating system on which the code should run.

1.2.2 The WinDriver Solution

Easy Development: WinDriver enables Windows programmers to create PCI/CardBus/ISA/ISAPnP/EISA/CompactPCI and USB -based device drivers in an extremely short time. WinDriver allows you to create your driver in the familiar user-mode environment, using MSDEV, Visual C/C++, Borland Delphi, Borland C++, Visual Basic, GCC or any other 32-bit compiler. You do not need to have any device driver knowledge, nor do you have to be familiar with operating system internals, kernel programming, the DDK, ETK or DDI/DKI.

Cross Platform: The driver created with WinDriver will run on Windows 98/Me/NT/2000/XP/CE/CE.NET/Server 2003, Linux, Solaris and VxWorks. In other words—write it once, run it on many platforms.

Friendly Wizards: DriverWizard (included) is a graphical diagnostics tool that lets you write to, and read from, the hardware before writing a single line of code. The hardware is diagnosed with just a few clicks of the mouse: memory ranges are read, registers are toggled and interrupts are checked. Once the device is operating to your satisfaction, DriverWizard creates the skeletal driver source code, giving access functions to all the resources on the hardware.

Kernel-Mode Performance: WinDriver's API is optimized for performance. For drivers that need kernel-mode performance, WinDriver offers the Kernel PlugIn. This powerful feature enables you to create and debug your code in user mode and run the performance-critical parts of your code (such as the interrupt handling or access to I/O mapped memory ranges) in kernel mode, thereby achieving kernel-mode performance (zero performance degradation). This unique feature allows the developer to run user-mode code in the OS kernel without having to learn how the kernel works. There is no need to use the Kernel PlugIn when working with Windows CE or VxWorks, since there is no separation between user and kernel modes in these operating systems. This enables you to achieve optimal performance from user-mode code.

1.3 How Fast Can WinDriver Go?

For PCI drivers, you can expect the same throughput using the WinDriver Kernel PlugIn as when using a custom kernel driver. Throughput is constrained only by the limitations of your operating system and hardware. A rough estimate of the

throughput you can obtain using the Kernel PlugIn is about 100,000 interrupts per second.

1.4 Conclusion

Using WinDriver, a developer need only do the following to create an application that accesses the custom hardware:

- Start DriverWizard and detect the hardware and its resources.
- Automatically generate the device driver code from within DriverWizard.
- Call the generated functions from the user-mode application.

The new hardware access application will run on all Windows platforms (including Windows CE), on Linux, on Solaris and on VxWorks (just recompile).

1.5 WinDriver Benefits

- Easy user-mode driver development.
- Kernel PlugIn for high-performance drivers.
- Friendly DriverWizard allows hardware diagnostics without writing a single line of code.
- Automatically generates the driver code for the project in C, Delphi (Pascal) or Visual Basic.
- Support for any PCI/CardBus/ISA/ISAPnP/EISA/CompactPCI and USB device, regardless of manufacturer.
- Enhanced support for PLX/Altera/Marvell/AMCC/QuickLogic PCI chips allows the developer to disregard the PCI chip details.
- Enhanced support for Cypress, STMicroelectronics, Texas Instruments and National Semiconductors USB controllers, hiding from the developer the USB implementation details.

- Applications are binary-compatible across Windows 98/Me/NT/2000/XP/Server 2003.
- Applications are source code compatible across Windows 98/Me/NT/2000/XP/CE/CE.NET/Server 2003, Linux, Solaris and VxWorks.
- Can be used with common development environments, including MSDEV, Visual C/C++, Borland Delphi, Borland C++, Visual Basic, GCC or any other 32-bit compiler.
- No DDK, ETK, DDI or any system-level programming knowledge required.
- Supports I/O, DMA, interrupt handling and access to memory-mapped cards.
- Supports multiple CPU and multiple PCI bus platforms.
- Support for 64-bit PCI data transfers.
- Includes dynamic driver loader.
- Comprehensive documentation and help files.
- Detailed examples in C, Delphi and Visual Basic.
- Two months of free technical support.
- No runtime fees or royalties.

1.6 WinDriver Architecture

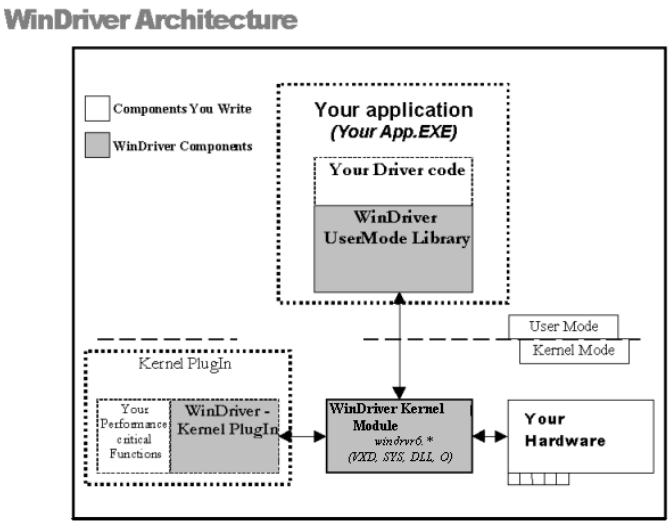


Figure 1.1: WinDriver Architecture

For hardware access, your application calls one of the WinDriver functions from the WinDriver user-mode library (**windrvr.h**). The user-mode library calls the WinDriver kernel, which accesses the hardware for you through the native calls of the operating system.

WinDriver's design minimizes performance hits on your code, even though it is running in user mode. However, some hardware drivers have high performance requirements that cannot be achieved in user mode. This is where WinDriver's edge sharpens. After easily creating and debugging your code in user mode, you may drop the performance-critical modules of your code (such as a hardware interrupt handler) into the WinDriver Kernel PlugIn without changing them at all. Now, WinDriver kernel calls this module from kernel mode, thereby achieving maximal performance. This allows you to program and debug in user mode, and still achieve kernel performance where needed. In Windows CE and VxWorks there is no separation between user mode and kernel mode; therefore, you may achieve optimal performance directly from user mode, without needing to use the Kernel PlugIn in these operating systems.

1.7 What Platforms Does WinDriver Support?

WinDriver supports Windows 98/Me/NT/2000/XP/CE/CE.NET/Server 2003, Linux, Solaris and VxWorks. The same source code will run on all supported platforms. The executable you create will operate on Windows 98/Me/NT/2000/XP/Server 2003. Even if your code is meant only for one of these operating systems, using WinDriver will give you the flexibility to move your driver to another operating system without needing to change your code.

1.8 Limitations of the Different Evaluation Versions

All the evaluation versions of WinDriver are full featured. No functions are limited or crippled in any way. The evaluation version of WinDriver varies from the registered version in the following ways:

- Each time WinDriver is activated, an **Un-registered** message appears.
- When using the DriverWizard, a dialog box with a message stating that an evaluation version is being run appears on every interaction with the hardware.
- In the Linux, Solaris, VxWorks and CE versions, the driver will remain operational for 60 minutes, after which time it must be restarted.
- The Windows evaluation version expires 30 days from the date of installation.

For more details please refer to appendix C.

1.9 How Do I Develop My Driver with WinDriver?

1.9.1 On Windows 98/Me/NT/2000/XP/Server 2003, Linux and Solaris

1. Start DriverWizard. Refer to Chapter 5 for details.
2. Diagnose your device using DriverWizard.
3. Let DriverWizard generate skeletal code for your driver.

4. Modify the code generated by DriverWizard to suit your application's needs.
5. Run and debug your driver in user mode.
6. If your code contains performance-critical sections, improve their performance. See Chapter 10 for details.

NOTE:
The code generated by DriverWizard is in fact a diagnostics program that contains functions that read and write to any resource detected or defined (including custom-defined registers), enables your card's interrupts, listens to them, access USB pipes and more.

1.9.2 On Windows CE

1. Plug your hardware into a Windows host machine.
2. Activate Visual C++ for CE on the host machine.
3. Diagnose your hardware using DriverWizard.
4. Let DriverWizard generate your driver's skeletal code.
5. Modify this code using Visual C++ to meet your specific needs.
6. Test and debug your code and hardware from the CE emulation running on the host machine.
7. If your code contains performance-critical sections, improve their performance. See Chapter 10 for details.

NOTE:
ISAPnP is not supported under Windows CE.

TIP
If you cannot plug your hardware into your NT machine, you may still use DriverWizard by manually entering all your resources into it. Let DriverWizard generate your code and then test it on your hardware using a serial connection. After verifying that the generated code works properly, modify it to meet your specific needs. You may also use (or combine) any of the sample files for your driver's skeletal code.

1.9.3 On VxWorks

1. Plug your hardware into a Windows host machine.
2. Diagnose your hardware using DriverWizard for Windows. Refer to Chapter 5 for details.
3. Let DriverWizard generate your driver's skeletal code and project makefile for Tornado.
4. Move the code to your tornado environment and compile it.
5. Modify this code using tornado development environment, or any other 32-bit development environment, to meet your specific needs.

1.10 What Does the WinDriver Toolkit Include?

- A printed version of this manual
- Two months of free technical support (Phone/Fax/Email)
- WinDriver modules
- The WinDriver CD
  - Utilities
  - Chipset support APIs
  - Sample files

1.10.1 WinDriver Modules

- WinDriver (**WinDriver\include**) – the general purpose hardware access toolkit. The main files here are:
  - **windrvr.h**: the WinDriver API, data structures and constants are defined in this header file.
  - **wdu_lib.h**: contains definitions of the USB user-mode logic interface.
  - **windrvr_int_thread.h**: contains definitions of interrupt wrapper functions to simplify interrupt handling.

  - **windrvr_events.h**: contains functions to implement event handling and PnP notifications.
  - **wdlib.h**: contains API definitions of the USB HID extended support.
  - **utils.h**: OS specific implementation of threads and events.
  - **status_strings.h**: error strings conversion from numerical return value.

- DriverWizard (**Start Menu | Programs | WinDriver | DriverWizard**) – a graphical tool that diagnoses your hardware and enables you to easily generate code for your driver (refer to Chapter 5 for details).
- Graphical Debugger (**Start Menu | Programs | WinDriver | Debug Monitor**) – a graphical debugging tool that collects information about your driver as it runs; on Linux, Solaris, WinCE and VxWorks you can use the console version of this program (refer to Chapter 7 for details).
- WinDriver distribution package (**WinDriver\redist**) – the files you include in the driver distribution to customers.
- WinDriver Kernel PlugIn (**WinDriver\kerplug**) – the files and samples needed to create a Kernel PlugIn for WinDriver.
- This manual (**Start Menu | Programs | WinDriver**) – the full WinDriver manual (this document) in PDF, Windows Help and HTML formats.

1.10.2 Utilities

- **PCI_SCAN.EXE** (**\WinDriver\util\pci_scan.exe**) – used to obtain a list of the PCI cards installed and the resources allocated for each of them.
- **PCI_DUMP.EXE** (**\WinDriver\util\pci_dump.exe**) – used to obtain a dump of all the PCI configuration registers of the PCI cards installed.
- **USB_DIAG.EXE** (**\WinDriver\util\usb_diag.exe**) – provides a list of the USB devices installed and identifies the resources allocated for each one of them and the resources used to access them.

The CE version includes:

- **\REDIST\... \X86EMU\WINDRVR_CE_EMU.DLL**: DLL that communicates with the WinDriver kernel—for the x86 HPC emulation mode of Windows CE.

- **\REDIST\... \X86EMU\WINDRVR_CE_EMU.LIB:** an import library that is used to link with WinDriver applications that are compiled for the x86 HPC emulation mode of Windows CE.

1.10.3 WinDriver's Specific Chipset Support

These are APIs that support the major PCI bridge chipsets and USB Controllers, for even faster code development. Among others enhanced support is included for:

- WinDriver PLX APIs (for the 9030, 9050, 9052, 9054, 9060, 9080, 9056 and 9656 PCI bridges) – under the respective directory, e.g., **WinDriver\plx\9050**.
- WinDriver Marvell APIs (for the Marvell GT64 PCI bridges) – **WinDriver\marvell\gt64**.
- WinDriver AMCC APIs (for the AMCC S5933 PCI bridges) – **WinDriver\amcc**.
- WinDriver ALTERA (for Altera PCI cores) – **WinDriver\altera**.
- WinDriver QuickLogic APIs (for the QuickLogic PCI bridges) – **WinDriver\QuickLogic**.
- WinDriver Cypress APIs (for the Cypress EZ-USB controllers) – **WinDriver\cypress**.
- WinDriver STMicroelectronics APIs (for the ST7 and ST9 chips) – **WinDriver\st**.
- WinDriver Texas Instruments APIs (for the TUSB3410, TUSB3210, TUSB2136, TUSB5052 chips) – **WinDriver\ti**.

Each of the directories above includes the following subdirectories:

- **\lib** – the special chipset API for the enhanced support chip, written using the WinDriver API.
- **\xxx_diag** - a sample diagnostics application, which was written using the special library functions available for the chipsets; This application can be compiled and executed as-is (**xxx_diag** i.e., **p9054_diag.c** for the PLX 9054 chip).

Refer to Chapter 8 for details.

1.10.4 Samples

Here you will find the source code for the utilities listed earlier, along with other samples that demonstrate how to perform the various driver tasks. Find the sample closest to the driver you need and use it to jump-start your driver development process:

- WinDriver samples (**WinDriver\samples**) – samples that demonstrate different common drivers.
- WinDriver for PLX/Altera/Marvell/AMCC/QuickLogic/Cypress/STMicroelectronics/TI samples (e.g., **WinDriver\PLX\p9054_diag** or **WinDriver\Cypress\bulk_sample** etc.) – source code of the diagnostics applications for the specific chipsets that WinDriver supports.

1.11 Can I Distribute the Driver Created with WinDriver?

Yes. WinDriver is purchased as a development toolkit, and any device driver created using WinDriver may be distributed royalty free in as many copies as you wish. See the license agreement (**WinDriver\docs\license.txt**) for more details.

1.12 Identifying the Right Tool for Your Development

Jungo offers two driver development products: WinDriver and KernelDriver.

WinDriver is designed for monolithic type user-mode drivers. It enables you to access your hardware directly from within your user-mode application, without writing a kernel-mode device driver. Using WinDriver you can either access your hardware directly from your application (in user mode) or write a DLL that you can call from many different applications.

In addition, WinDriver provides a complete solution for high-performance drivers. Using WinDriver's Kernel PlugIn, you can drop your user-mode code into the kernel and reach full kernel-mode performance.

A driver created with WinDriver runs on Windows 98/Me/NT/2000/XP/Server 2003, Linux, Solaris, VxWorks and Windows CE/CE.NET. Typically, a developer without any previous driver knowledge can get a driver running in a matter of a few hours (compared to several weeks with a kernel-mode driver).

KernelDriver is intended for creating standard operating system internal drivers that require hardware access and that must communicate with the operating system or must be implemented in the kernel.

A driver created with KernelDriver can run on Windows 98/Me/NT/2000/XP/Server 2003. KernelDriver dramatically simplifies the difficult task of creating kernel-mode device drivers, by providing a hardware access API in the kernel mode, which is portable across the supported operating systems.

Chapter 2

Understanding Device Drivers

This chapter provides you with a general introduction to device drivers and takes you through the structural elements of a device driver.

2.1 Device Driver Overview

Device drivers are the software segments that provides an interface between the operating system and the specific hardware devices such as terminals, disks, tape drives, video cards and network media. The device driver brings the device into and out of service, sets hardware parameters in the device, transmits data from the kernel to the device, receives data from the device and passes it back to the kernel, and handles device errors.
A driver acts like a translator between the device and programs that use the device. Each device has its own set of specialized commands that only its driver knows. In contrast, most programs access devices by using generic commands. The driver, therefore, accepts generic commands from a program and then translates them into specialized commands for the device.

2.2 Classification of Drivers According to Functionality

There are numerous driver types, differing in their functionality. This subsection briefly describes three of the most common driver types.

2.2.1 Monolithic Drivers

Monolithic drivers are device drivers that embody all the functionality needed to support a hardware device. A monolithic driver is accessed by one or more user applications, and directly drives a hardware device. The driver communicates with the application through I/O control commands (IOCTLs) and drives the hardware using calls to the different DDK, ETK, DDI/DKI functions.

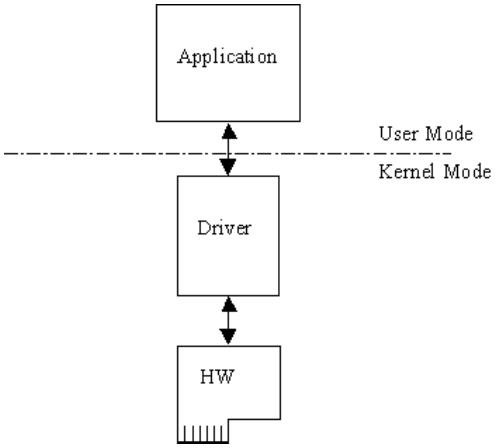


Figure 2.1: Monolithic Drivers

Monolithic drivers are supported in all operating systems including all Windows platforms and all Unix platforms.

2.2.2 Layered Drivers

Layered drivers are device drivers that are part of a stack of device drivers that together process an I/O request. An example of a layered driver is a driver that intercepts calls to the disk and encrypts/decrypts all data being transferred to/from the disk. In this example, a driver would be hooked on to the top of the existing driver and would only do the encryption/decryption.

Layered drivers are sometimes also known as filter drivers, and are supported in all operating systems including all Windows platforms and all Unix platforms.

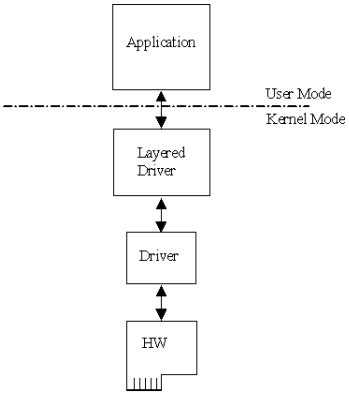


Figure 2.2: Layered Drivers

2.2.3 Miniport Drivers

A Miniport driver is an add-on to a class driver that supports miniport drivers. It is used so the miniport driver does not have to implement all of the functions required of a driver for that class. The class driver provides the basic class functionality for the miniport driver.
A class driver is a driver that supports a group of devices of common functionality, such as all HID devices or all network devices.

Miniport drivers are also called miniclass drivers or minidrivers, and are supported in the Windows NT (or 2000) family, namely Windows NT/2000/XP and Server 2003.

Windows NT/2000/XP/Server 2003 provide several driver classes (called ports) that

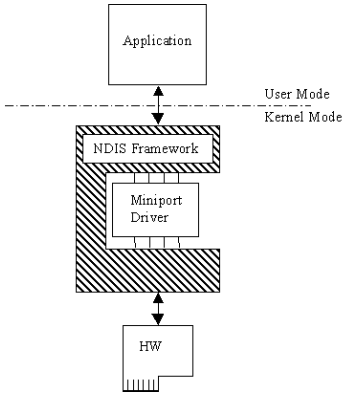


Figure 2.3: Miniport Drivers

handle the common functionality of their class. It is then up to the user to add only the functionality that has to do with the inner workings of the specific hardware.

The NDIS miniport driver is one example of such a driver. The NDIS miniport framework is used to create network drivers that hook up to NT's communication stacks, and are therefore accessible to common communication calls used by applications. The Windows NT kernel provides drivers for the various communication stacks and other code that is common to communication cards. Due to the NDIS framework, the network card developer does not have to write all of this code, only the code that is specific to the network card he is developing.

2.3 Classification of Drivers According to Operating Systems

2.3.1 WDM Drivers

WDM (Windows Driver Model) drivers are kernel-mode drivers within the Windows NT and Windows 98 operating system families. Windows NT family includes Windows NT/2000/XP/Server 2003, and Windows 98 family includes Windows 98 and Windows Me.
WDM works by channeling some of the work of the device driver into portions of the code that are integrated into the operating system. These portions of code handle all

of the low-level buffer management, including DMA and Plug and Play (Pnp) device enumeration.
WDM drivers are PnP drivers that support power management protocols, and include monolithic drivers, layered drivers and miniport drivers.

2.3.2 VxD Drivers

VxD drivers are Windows 95/98/Me Virtual Device Drivers, often called VxDs because the filenames end with the .vxd extension. VxD drivers are typically monolithic in nature. They provide direct access to hardware and privileged operating system functions. VxD drivers can be stacked or layered in any fashion, but the driver structure itself does not impose any layering.

2.3.3 Unix Device Drivers

In the classic Unix driver model, devices belong to one of three categories: character (char) devices, block devices and network devices. Drivers that implement these devices are correspondingly known as char drivers, block drivers or network drivers. Under Unix, drivers are code units linked into the kernel that run in privileged kernel mode. Generally, driver code runs on behalf of a user-mode application. Access to Unix drivers from user-mode applications is provided via the file system. In other words, devices appear to the applications as special device files that can be opened.

Unix device drivers are either layered or monolithic drivers. A monolithic driver can be perceived as a one-layer layered driver.

2.3.4 Linux Device Drivers

Linux device drivers are based on the classic Unix device driver model. In addition, Linux introduces some new characteristics.

Under Linux, a block device can be accessed like a character device, as in Unix, but also has a block-oriented interface that is invisible to the user or application.

Traditionally, under Unix, device drivers are linked with the kernel, and the system is brought down and restarted after installing a new driver. Linux introduces the concept of a dynamically loadable driver called a module. Linux modules can be loaded or removed dynamically without requiring the system to be shut down. A Linux driver can be written so that it is statically linked or written in a modular form that allows

it to be dynamically loaded. This makes Linux memory usage very efficient because modules can be written to probe for their own hardware and unload themselves if they cannot find the hardware they are looking for.

Like Unix device drivers, Linux device drivers are either layered or monolithic drivers.

2.3.5 Solaris Device Drivers

Solaris device drivers are also based on the classic Unix device driver model. Like Linux drivers, Solaris drivers may be either statically linked with the kernel or dynamically loaded and removed from the kernel.

Like Unix and Linux device drivers, Solaris device drivers are either layered or monolithic drivers.

2.4 The Entry Point of the Driver

Every device driver must have one main entry point, like the `main()` function in a C console application. This entry point is called `DriverEntry()` in Windows and `init_module()` in Linux. When the operating system loads the device driver, this driver entry procedure is called.

There is some global initialization that every driver needs to perform only once when it is loaded for the first time. This global initialization is the responsibility of the `DriverEntry()`/`init_module()` routine. The entry function also registers which driver callbacks will be called by the operating system. These driver callbacks are operating system requests for services from the driver. In Windows, these callbacks are called *dispatch routines*, and in Linux they are called *file operations*. Each registered callback is called by the operating system as a result of some criteria, such as disconnection of hardware, for example.

2.5 Associating the Hardware to the Driver

Operating systems differ in how they link a device to its driver.
In Windows, the link is performed by the INF file, which registers the device to work with the driver. This association is performed before the `DriverEntry()` routine is called. The operating system recognizes the device, looks up in its database which

INF file is associated with the device, and according to the INF file, calls the driver's entry point.
In Linux, the link between a device and its driver is defined in the `init_module()` routine. The `init_module()` routine includes a callback which states what hardware the driver is designated to handle. The operating system calls the driver's entry point, based on the definition in the code.

2.6 Communicating with Drivers

A driver can create an instance, thus enabling an application to open a handle to the driver through which the application can communicate with it.
The applications communicate with the drivers using a file access API (Application Program Interface). Applications open a handle to the driver using `CreateFile()` call (in Windows), or `open()` call (in Linux) with the name of the device as the file name. In order to read from and write to the device, the application calls `ReadFile()` and `WriteFile()` (in Windows), or `read()`, `write()` in Linux. Sending requests is accomplished using an I/O control call, called `DeviceIoControl()` (in Windows), and `ioctl()` in Linux. In this I/O control call, the application specifies:

- The device to which the call is made (by providing the device's handle).
- An IOCTL code that describes which function this device should perform.
- A buffer with the data on which the request should be performed.

The IOCTL code is a number that the driver and the requester agree upon for a common task.

The data passed between the driver and the application is encapsulated into a structure. In Windows, this structure is called an I/O Request Packet (IRP), and is encapsulated by the I/O Manager. This structure is passed on to the device driver, which may modify it and pass it down to other device drivers.

Chapter 3

WinDriver USB Overview

This chapter explores the basic characteristics of the USB bus and introduces WinDriver USB's features and architecture.

3.1 Introduction to USB

USB (Universal Serial Bus) is an industry standard extension to the PC architecture for attaching peripherals to the computer. The Universal Serial Bus was originally developed in 1995 by leading PC and telecommunication industry companies, such as Intel, Compaq, Microsoft and NEC. USB was developed to meet several needs. Among them were the needs for an inexpensive and widespread connectivity solution for peripherals in general and for computer telephony integration in particular, an easy-to-use and flexible method of reconfiguring the PC, and a solution for adding a large number of external peripherals.

The USB interface meets these needs. A single USB port can be used to connect up to 127 peripheral devices. USB also supports Plug and Play installation and hot swapping. USB 1.1 supports both isochronous and asynchronous data transfers and has dual speed data transfer: 1.5 Mbps (megabits per second) for low-speed USB devices and 12 Mbps for high-speed USB devices (much faster than the original serial port). Cables connecting the device to the PC can be up to five meters (16.4 feet) long. USB includes built-in power distribution for low power devices and can provide limited power (up to 500 mA of current) to devices attached on the bus.

Because of these benefits, USB is enjoying broad market acceptance today.

USB 2.0 supports a signalling rate of 480 Mbps, 40 times faster than USB 1.1. USB 2.0 is fully forward- and backward-compatible with USB 1.1 and uses existing cables and connectors.

USB 2.0 supports connections with PC peripherals that provide expanded functionality and require wider bandwidth. In addition, it can handle a larger number of peripherals simultaneously.

USB 2.0 enhances the user's experience of many applications, including interactive gaming, broadband Internet access, desktop and Web publishing, Internet services and conferencing.

3.2 WinDriver USB Benefits

- External connection, maximizing ease of use
- Self identifying peripherals supporting automatic mapping of function to driver and configuration
- Dynamically attachable and re-configurable peripherals
- Suitable for device bandwidths ranging from a few Kbps to hundreds of Mbps
- Supports isochronous as well as asynchronous transfer types over the same set of wires
- Supports simultaneous operation of many devices (multiple connections)
- Supports USB 2.0 (Hi-Speed) devices for the operating systems that officially support this specification
- Guaranteed bandwidth and low latencies; appropriate for telephony, audio, etc. (isochronous transfer may use almost entire bus bandwidth)
- Flexibility: supports a wide range of packet sizes and a wide range of data rates
- Robustness: built-in error handling mechanism and dynamic insertion and removal of devices with no delay observed by the user
- Synergy with PC industry
- Optimized for integration in peripheral and host hardware

- Low-cost implementation, therefore suitable for development of low-cost peripherals
- Low-cost cables and connectors
- Uses commodity technologies
- Built-in power management and distribution
- Specific library support for custom USB HID devices

3.3 USB Components

USB Host: The USB host computer is where the USB host controller is installed and where the client software/device driver runs. The USB host controller is the interface between the host and the USB peripherals. The host is responsible for detecting the attachment and removal of USB devices, managing the control and data flow between the host and the devices, providing power to attached devices and more.

USB Hub: A USB device that allows multiple USB devices to attach to a single USB port on a USB host. Hubs on the back plane of the hosts are called root hubs. Other hubs are called external hubs.

USB Function: A USB device that can transmit or receive data or control information over the bus and that provides a function. Compound devices provide multiple functions on the USB bus.

3.4 Data Flow in USB Devices

During the operation of a USB device, data flows between the client software and the device. The data is transferred via pipes that run between memory buffers of the software on the host and endpoints on the device.

A uniquely identifiable entity on a USB device, an endpoint is the source or terminus of the data that flows from or to the device. Each USB device, logical or physical, has a collection of independent endpoints. Each endpoint has the following attributes: bus access frequency, bandwidth requirement, endpoint number, error handling mechanism, maximum packet size that can be transmitted or received, transfer type and direction (into or out of the device).

A pipe is a logical component that represents an association between an endpoint on the USB device and software on the host. Data is moved to and from a device through a pipe. A pipe can be either a stream pipe or a message pipe, depending on the type of data transfer used in the pipe. Stream pipes handle interrupt, bulk and isochronous transfers, while message pipes support the control transfer type. The different USB transfer types are discussed below:

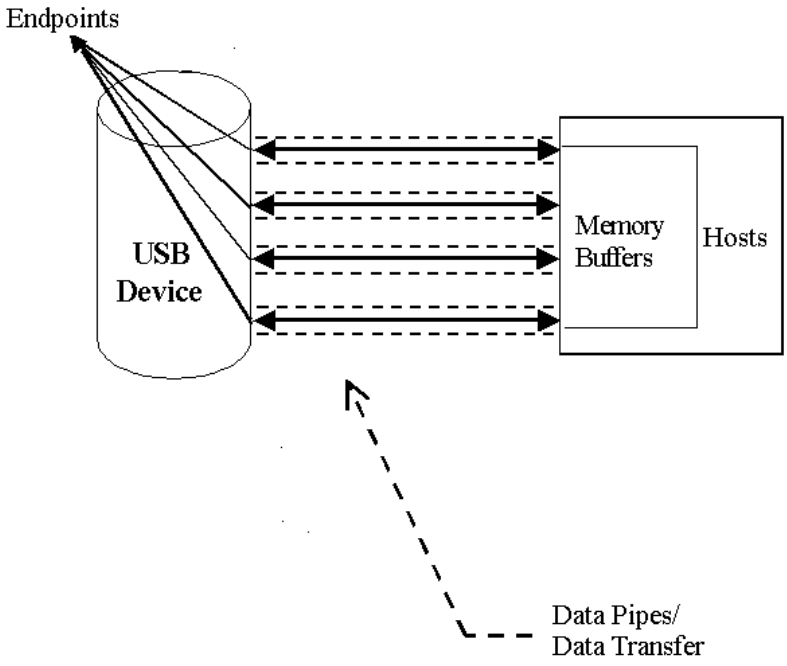


Figure 3.1: USB Endpoints

3.5 USB Data Exchange

The USB standard supports two kinds of data exchange between a host and a device: functional data exchange and control exchange.

Functional data exchange is used to move data to and from the device. There are

three types of data transfers: bulk transfers, interrupt transfers and isochronous transfers.

Control exchange is used to configure a device when it is first attached and can also be used for other device-specific purposes, including control of other pipes on the device. Control exchange takes place via a control pipe, mainly the default Pipe 0, which always exists. The control transfer consists of a setup stage (in which a setup packet is sent from the host to the device), an optional data stage and a status stage.

More information on how to implement the control transfer by sending setup packets can be found in Chapter 9, which deals with WinDriver implementation issues.

The screen shot below depicts a USB device with one bidirectional control and three functional data transfer pipes/endpoints:

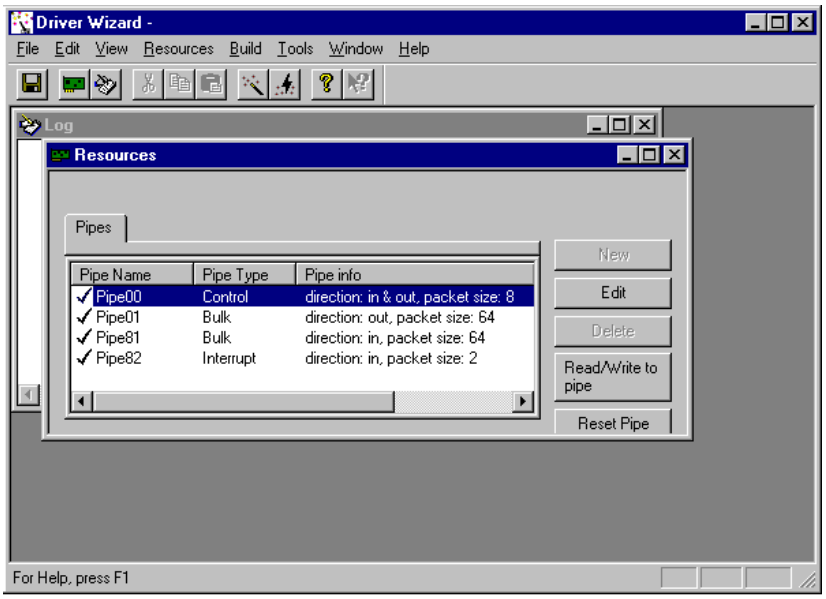


Figure 3.2: USB Pipes

3.6 USB Data Transfer Types

The USB device (function) communicates with the host by transferring data through a pipe between a memory buffer on the host and an endpoint on the device. USB provides for four different transfer types. A type is selected for a specific endpoint according to the requirements of the device and the software. The transfer type of a specific endpoint is determined in the endpoint descriptor.

Data transfer types provided for by the USB specification are as follows:

Control Transfer is mainly intended to support configuration, command and status operations between the software on the host and the device. Each USB device has at least one control pipe (default pipe), which provides access to the configuration, status and control information. The control pipe is a bidirectional pipe. Control transfer is bursty, non-periodic communication. Control transfer has a robust error detection, recovery and retransmission mechanism and retries are made without the involvement of the driver. Control transfer is used by low-speed and high-speed devices.

Isochronous Transfer is most commonly used for time-dependent information, such as multimedia streams and telephony. The transfer is periodic and continuous. The isochronous pipe is unidirectional and a certain endpoint can either transmit or receive information. Bidirectional isochronous communication requires two isochronous pipes, one in each direction. USB guarantees the isochronous transfer access to the USB bandwidth (that is it reserves the required amount of bytes of the USB frame) with bounded latency and guarantees the data transfer rate through the pipe unless there is less data transmitted. Up to 90% of the USB frame can be allocated to periodic transfers (isochronous and interrupt transfers). If, during configuration, there is not sufficient bus time available for the requester isochronous pipe, the configuration is not established. Since timeliness is more important than correctness in these types of transfers, no retries are made in case of error in the data transfer. However, the data receiver can determine that an error occurred on the bus. Isochronous transfer can be used only by high-speed devices.

Interrupt Transfer is intended for devices that send and receive small amounts of data infrequently or in an asynchronous time frame. An interrupt transfer type guarantees a maximum service period and a that delivery will be re-attempted in the next period if there is an error on the bus. The interrupt pipe, like the isochronous pipe, is unidirectional. The bus access time period (1-255 ms for high-speed devices and 10-255 ms for low-speed devices) is specified by the

endpoint of the interrupt pipe. Although the host and the device can only count on the time period specified by the endpoint, the system can provide a shorter period (up to 1 ms).

Bulk Transfer is non-periodic, large packet, bursty communication. Bulk transfer typically supports devices that transfer large amounts of non-time sensitive data, and that can use any available bandwidth, such as printers and scanners. Bulk transfer allows access to the bus on an "as-available" basis, guarantees the data transfer but not the latency, and provides an error check mechanism with retries attempts. If part of the USB bandwidth is not being used for other transfers, the system will use it for bulk transfer. Like the other stream pipes (isochronous and interrupt), the bulk pipe is also unidirectional. Bulk transfer can only be used by high-speed devices.

3.7 USB Configuration

Before the USB function (or functions, in a compound device) can be operated, the device must be configured. The host does the configuring by acquiring the configuration information from the USB device. USB devices report their attributes by descriptors. A descriptor is the defined structure and format in which the data is transferred. A complete description of the USB descriptors can be found in Chapter 9 of the USB Specification (see `http://www.usb.org` for the full specification).

It is best to view the USB descriptors as a hierarchical structure with four levels:

- The Device level
- The Configuration level
- The Interface level (this level may include an optional sub-level called alternate settings)
- The Endpoint level

There is only one device descriptor for each USB device. Each device has one or more configurations, each configuration has one or more interfaces, and each interface has zero or more endpoints.

Device Level: The device descriptor includes general information about the USB device, that is, global information for all of the device configurations. The

device descriptor identifies, among other things, the device class (HID device, hub, locator device, etc.), subclass, protocol code, vendor ID, device ID and more. Each USB device has one device descriptor.

Configuration Level: A USB device has one or more configuration descriptors. Each descriptor identifies the number of interfaces grouped in the configuration and the power attributes of the configuration (such as self-powered, remote wakeup, maximum power consumption and more). Only one configuration can be loaded at a given time. For example, an ISDN adapter might have two different configurations, one that presents it with a single interface of 128 Kbps and a second that presents it with two interfaces of 64 Kbps each.

Interface Level: The interface is a related set of endpoints that present a specific functionality or feature of the device. Each interface may operate independently. The interface descriptor describes the number of the interface, the number of endpoints used by this interface and the interface-specific class, subclass and protocol values when the interface operates independently. In addition, an interface may have alternate settings. The alternate settings allow the endpoints or their characteristics to be varied after the device is configured.

Endpoint Level: The lowest level is the endpoint descriptor that provides the host with information regarding the data transfer type of the endpoint and the bandwidth of each endpoint (the maximum packet size of the specific endpoint). For isochronous endpoints, this value is used to reserve the bus time required for the data transfer. Other attributes of the endpoints are their bus access frequency, their endpoint number, their error handling mechanism and their direction.

Seems complicated? Not at all! WinDriver automates the USB configuration process. The included DriverWizard and USB diagnostics application scan the USB bus, detect all USB devices and their configurations, interfaces, settings and endpoints, and enable the developer to pick the desired configuration before starting driver development.

WinDriver identifies the endpoint transfer type as determined in the endpoint descriptor. The driver created with WinDriver contains all configuration information acquired at this early stage.

3.8 WinDriver USB

WinDriver USB enables developers to quickly develop high-performance drivers for USB-based devices, without having to learn the USB specifications or the OS internals. Using WinDriver USB, developers can create USB drivers without having to use the DDK, and without having to be familiar with Microsoft's WDM (Win32 Driver Module).

The driver code developed with WinDriver USB is binary compatible with Windows 98, Windows Me, Windows 2000, Windows XP and Windows Server 2003.

The source code will be code compatible with all other operating systems supported by WinDriver USB, including Linux and Windows CE. For an up-to-date list of operating systems supported by WinDriver USB, please visit Jungo's web site at: http://www.jungo.com.

WinDriver USB encapsulates the USB specification and architecture, letting you focus on your application logic. WinDriver USB features DriverWizard, with which you can detect your hardware, configure it and test it before writing a single line of code. DriverWizard first leads you through the configuration procedure, where you can choose the desired configuration, interface and alternate setting through a friendly graphical user interface. After detecting and configuring your USB device, you can then test it, listen to pipes, write and read packets and ensure that all your hardware resources function as expected. WinDriver USB is a generic tool kit that supports all USB devices from all vendors and with all types of configurations.

After your hardware is diagnosed, DriverWizard automatically generates your device driver source code in C, Delphi or Visual Basic. WinDriver USB provides user-mode APIs to your hardware, which you can call from within your application. The WinDriver USB API is specific to your USB device and includes USB-unique operations such as reset-pipe and reset-device. Along with the device API, WinDriver USB creates a diagnostics application, which just needs to be compiled and run. You can use this application as your skeletal driver to jump-start your development cycle. If you are a VB or a Delphi programmer, you will find that the WinDriver USB API is also supported in VB and Delphi, giving you everything you need to develop your driver in VB and Delphi.

DriverWizard also automates the creation of an INF file, if needed. An INF file is a text file used by the Plug and Play mechanisms of Windows 98/Me/2000/XP/Server 2003 to load the driver for a newly installed piece of hardware or to replace an existing driver. The INF file includes all necessary information about the device(s) and the files to be installed. INF files are required for pieces of hardware that identify themselves, such as USB and PCI. In some cases, the INF file of your specific device

is included in the INF files that are shipped with the operating system. In other cases, you will need to create an INF file for your device. WinDriver automates this process for you. More information on how to create your own INF file with DriverWizard can be found in Chapter 5, which explains the DriverWizard. Instructions for installing INF files can be found in Chapter 14, which illustrates how to distribute your driver.

With WinDriver USB, all development is done in user mode, using familiar development and debugging tools and your favorite compiler (such as MSDEV, Visual C/C++, Borland Delphi, Borland C++ or Visual Basic).

3.9 WinDriver USB Architecture

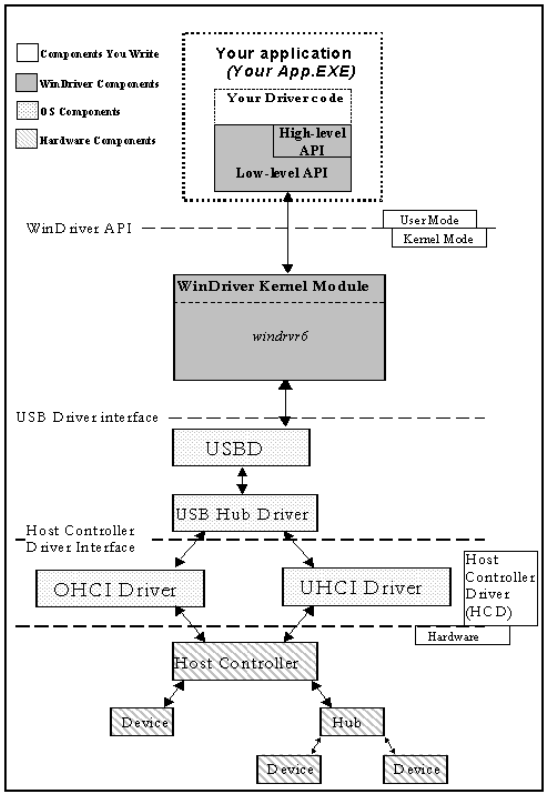


Figure 3.3: WinDriver USB Architecture

To access your hardware, your application makes calls to the WinDriver kernel module using functions from the WinDriver USB API. . The high-level functions make use of the low-level functions, which use IOCTLs to enable communication between the WinDriver kernel module and your user-mode application. The WinDriver kernel module accesses your USB device resources through the native operating system calls.

There are two layers responsible for abstracting the USB device to the USB device driver. The upper one is the USB Driver layer (including the USB Driver (USBD)

and USB Hub Driver) and the lower one is the Host Controller Driver layer (HCD). The division of duties between the HCD and USBD is not defined, and is operating system dependent. Both HCD and USBD are software interfaces and components of the operating system, where the HCD layer represents a lower level of abstraction.

The HCD is the software layer that provides an abstraction of the host controller hardware while the USBD provides an abstraction of the USB device and the data transfer between the host software and the function of the USB device.

The USBD communicates with its clients (the specific device driver for example) through the USB Driver Interface. At the lower level, the USBD and USB Hub Driver implement the hardware access and data transfer by communicating with the HCD using the host controller driver interface.

The USB Hub Driver is responsible for identifying the addition and removal of devices from a particular hub. Once the Hub Driver receives a signal that a device was attached or detached, it uses additional host software and the USB driver to recognize and configure the device. The software implementing the configuration can include the hub driver, the device driver and other software.

WinDriver USB abstracts the configuration procedure and hardware access described above for the developer. With WinDriver USB API, developers can do all the hardware-related operations without having to master the lower levels of implementing these activities.

3.10 Which Drivers Can I Write with WinDriver USB?

Almost all monolithic drivers (drivers that need to access specific USB devices) can be written with WinDriver USB. In cases where a standard driver needs to be written, e.g., NDIS driver, SCSI driver, Display driver, USB to Serial port drivers, USB layered drivers, etc., use KernelDriver USB (also from Jungo).

For quicker development time, select WinDriver USB over KernelDriver USB wherever possible.

3.11 WinDriver Extension for Custom USB HID Devices

WinDriver has a new feature to support the development of drivers for custom USB HID devices. This extension provides user level libraries and DLLs that enable the application developer to access his custom USB HID device without needing to write device drivers at all. The WinDriver extension for custom USB HID devices uses the standard USB HID class drivers that are part of the operating system, providing developers with an easy-to-use API and significantly shortening the amount of time needed to develop support for custom HID USB devices. Because WinDriver extension for custom USB HID devices exploits the standard HID support provided with the operating system, no kernel-level driver need be developed, resulting in hassle free distribution and maintenance of your application.
There are several differences between WinDriver extension for custom USB HID devices and classic WinDriver:

- User-mode DLL vs. kernel-mode driver
- Different API (WDL_ vs. WD_)
- Usage of HID class driver vs. usage of custom WinDriver USB driver
- Distribution issues (**wdlib.dll** vs. **windrvr6.sys**)

The WinDriver extension for custom USB HID devices uses a user-level DLL to provide support for HID. Throughout this manual, certain sections may differ between classic WinDriver and the WinDriver extension for custom USB HID devices. If you are developing using the WinDriver extension for custom USB HID devices, be sure to refer to the sections directed at that product.

Chapter 4

Installing WinDriver

This chapter takes you through the WinDriver installation process, and shows you how to verify that your WinDriver is properly installed. The last section discusses the uninstall procedure.

4.1 System Requirements

4.1.1 For Windows 98/Me

- An x86 processor
- Any 32-bit development environment supporting C, VB or Delphi

4.1.2 For Windows NT/2000/XP/Server 2003

- An x86 processor
- Any 32-bit development environment supporting C, VB or Delphi
- Windows NT: Service Pack 3 or higher (Service Pack 6 is recommended)

4.1.3 For Windows CE

- An x86 Windows CE target platform

  or

  A MIPS / ARM Windows CE target platform. This option is available for Windows CE 4.x (.NET)

- Windows NT/2000/XP/Server 2003 host development platform

- Microsoft eMbedded Visual C++ with a corresponding target SDK

  or

  Microsoft Platform Builder with corresponding BSP (Board Support Package) for the target platform

4.1.4 For Linux

- Linux 2.2, 2.4 or 2.6

- An x86 processor

- A GCC compiler for WinDriver installation and for Kernel PlugIn

  NOTE:
  The GCC compiler must be the same version as the running kernel

- Any 32-bit development environment supporting C (such as GCC) for user mode

4.1.5 For Solaris

- Solaris 8.0/9.0

- 64-bit or 32-bit kernel on SPARC platform
  or
  32-bit kernel on x86 platform

- Any development environment supporting C (such as GCC)

- WinDriver 5.22 is still provided for Solaris 2.6/7.0 32-bit kernel on Intel x86 platform.

NOTE:
If you have chosen a development environment other than GCC, make sure *libgcc* is installed on your computer. You may download it from http://www.sunfreeware.com.
Set the LD_LIBRARY_PATH to the location of your *libgcc*, a probable location would be:
LD_LIBRARY_PATH= **/usr/local/lib:/usr/local/lib/sparcv9**

4.1.6 For VxWorks

- VxWorks 5.4
- Windows host development platform
- Tornado 2.0 IDE
- Target Platform running a processor that has a BSP (Board Support Package) compatible with the list of CPU/BSP combinations supported by DriverBuilder

  For an up-to-date list see: http://www.jungo.com/db-vxworks.html#platforms

  For information on BSP compatibility, please contact your nearest WindRiver Systems support representative.

4.2 WinDriver Installation Process

The WinDriver CD contains all versions of WinDriver for all the different operating systems. The CD's root directory contains the Windows 98/Me and NT/2000/XP/Server 2003 version. This will automatically begin when you insert the CD into your CD drive. The other versions of WinDriver are located in subdirectories, i.e., **\Linux, \Wince** and so on.

4.2.1 WinDriver Installation Instructions for Windows 98, Me, NT, 2000, XP and Server 2003

NOTE:
You must have administrative privileges in order to install WinDriver on Windows 98, Me, NT, 2000, XP and Server 2003.

1. Insert the WinDriver CD into your CD-ROM drive.
   (When installing WinDriver by downloading it from Jungo's web site instead of using the WinDriver CD, double click the downloaded WinDriver file (**WDxxx.EXE**) in your download directory, and go to Step 3).

2. Wait a few seconds until the installation program starts automatically. If for some reason it does not start automatically, double-click the file **WDxxx.EXE** (where xxx is the version number) and click the **Install WinDriver** button.

3. Read the license agreement carefully, and click **Yes** if you accept its terms.

4. Choose the destination location in which to install WinDriver.

5. In the **Setup Type** screen, choose one of the following:

   - **Typical** – to install all WinDriver modules (generic WinDriver toolkit + specific chipset APIs)
   - **Compact** – to install only the generic WinDriver toolkit
   - **Custom** – to choose which modules of WinDriver to install; you may choose which APIs will be installed

6. After the installer finishes copying the required files, choose whether to view the quick-start guides.

7. You will be prompted to reboot your computer.

The following steps are for registered users only:

In order to register your copy of WinDriver with the license you received from Jungo, follow the steps below:

1. Activate DriverWizard GUI (**Start | Programs | WinDriver | DriverWizard**).

2. Select the **Register WinDriver** option from the **File** menu and insert the license string you received from Jungo. Click the **Activate License** button.

3. To activate source code you developed during the evaluation period, please refer to `WD_License` function reference in Section A.1.9.

4.2.2 Installing WinDriver CE

Installing WinDriver CE when Building New CE-based Platforms

The following instructions apply to platform developers who build WinCE kernel images using Windows CE Platform Builder:

> **NOTE:**
> We recommend that you read Microsoft's documentation and understand the Windows CE and device driver integration procedure before you perform the installation.

1. Run Microsoft **Platform Builder** and open your platform.
2. Select **Open Build Release Directory** from the **Build** menu.
3. Copy the WinDriver CE kernel file
   \WinDriver\redist\TARGET_CPU\windrvr6.dll
   to the **%_FLATRELEASEDIR%** subdirectory on your development platform (should be the current directory in the new command window).
4. Append the contents of the file
   \WinDriver\samples\wince_install\PROJECT_WD.REG
   to the file **PROJECT.REG** in the **%_FLATRELEASEDIR%** subdirectory.

   > **NOTE:**
   > On non-x86 platforms, for PCI only: make sure you copy the lines specified for PCI from **PROJECT_WD.REG** to **PROJECT.REG**, after removing the comment marks, and inserting the card specific information.

5. Append the contents of the file
   \WinDriver\samples\wince_install\PROJECT_WD.BIB
   to the file **PROJECT.BIB** in the **%_FLATRELEASEDIR%** subdirectory.

   This step is only necessary if you want the WinDriver CE kernel file (**windrvr6.dll**) to be a permanent part of the Windows CE image (**NK.BIN**). This would be the case if you were transferring the file to your target platform using a floppy disk. If you prefer to have the file **windrvr6.dll** loaded on demand via the CESH/PPSH services, you need not carry out this step until you build a permanent kernel.
6. Select **Make Image** from the **Build** menu and name the new image **NK.BIN**.

7. Download your new kernel to the target platform and initialize it either by selecting **Download/Initialize** from the **Target** menu or by using a floppy disk.
8. Restart your target CE platform. The WinDriver CE kernel will automatically load.
9. Compile and run the sample programs to make sure that WinDriver CE is loaded and is functioning correctly. (See Section 4.4, which describes how to check your installation.)

Installing WinDriver CE when Developing Applications for CE Computers

The following instructions apply to driver developers who do not build the WinCE kernel, but only download their drivers, built using Microsoft eMbedded Visual C++, to a ready-made WinCE platform:

1. Insert the WinDriver CD into your Windows host CD drive.
2. Exit from the auto installation.
3. Double click the **Cd_setup.exe** file found in the **\Wince** directory on the CD. This will copy all needed WinDriver files to your host development platform.
4. Copy the WinDriver CE kernel file
   \WinDriver\redist\TARGET_CPU\windrvr6.dll
   to the **\WINDOWS** subdirectory of your target CE computer.
5. Use the Windows CE Remote Registry Editor tool (**ceregedt.exe**) or the Pocket Registry Editor (**pregedt.exe**) on your target CE computer to modify your registry so that the WinDriver CE kernel is loaded appropriately. The file **\WinDriver\samples\wince_install\PROJECT_WD.REG** contains the appropriate changes to be made.
6. Restart your target CE computer. The WinDriver CE kernel will automatically load. You will have to do a warm reset rather than just suspend/resume (use the reset or power button on your target CE computer).
7. Compile and run the sample programs (see Section 4.4, which describes how to check your installation) to make sure that WinDriver CE is loaded and is functioning correctly.

4.2.3 WinDriver Installation Instructions for Linux

Preparing the System for Installation

In Linux, kernel modules must be compiled with the same header files that the kernel itself was compiled with. Since WinDriver installs the kernel module **windrvr6.o**, it must compile with the header files of the Linux kernel during the installation process.

Therefore, before you install WinDriver for Linux, verify that the Linux source code and the file **versions.h** are installed on your machine:

Install linux kernel source code

- If you have yet to install Linux, please choose **Custom** installation when performing the installation and then choose to install the source code.
- If Linux is already installed on the machine, you must check to see if the Linux source code was installed. You can do this by looking for linux in the **/usr/src** directory. If the source code is not installed, you can either reinstall Linux with the source code, as described above, or you can install the source code by following these steps:

  1. Login as super user.
  2. Type:
     /$ rpm -i /<source location>/ <Linux distributor>/RPMS/kernel-source-<version number>
     (For example: to install the source code from the Linux installation CD-ROM, for RedHat 7.1, type:
     /$ rpm -i /mnt/cdrom/RedHat/RPMS/ kernel-source-2.4.2.-2.i386rpm)

     > **TIP**
     > If you do not have an RPM with the source code, you may download it from: http://rpmfind.net/linux/RPM/.

Install version.h

- The file **version.h** is created when you first compile the Linux kernel source code. Some distributions provide a compiled kernel without the file **version.h**. Look under **/usr/src/linux/include/linux/** to see if you have this file. If you do not, please follow these steps:

1. Type:
   `/$ make xconfig`
2. Save the configuration by choosing **Save and Exit**.
3. Type:
   `/$ make dep`.

Before proceeding with the installation, you must also make sure that you have a linux symbolic link. If you do not, please create one by typing:
`/usr/src$ ln -s <target kernel>/ linux`
(For example: for Linux 2.4 kernel type:
`/usr/src$ ln -s linux-2.4/ linux`)

Installation

1. Insert the WinDriver CD into your Linux machine CD drive or copy the downloaded file to your preferred directory.
2. Change directory to your preferred installation directory (your home directory, for example):
   `/$ cd ~`
3. Extract the file **WDxxxLN.tgz** (where xxx is the version number):
   `~$ tar xvzf /<file location>/WDxxxLN.tgz`
   For example:
   - From a CD:
     `~$ tar xvzf /mnt/cdrom/LINUX/WDxxxLN.tgz`
   - From a downloaded file:
     `~$ tar xvzf /home/username/WDxxxLN.tgz`
4. Change directory to WinDriver (this directory is created by tar):
   `~$ cd WinDriver/`
5. Install WinDriver:
   (a) `~/WinDriver$ make`
   (b) Become super user:
   `~/WinDriver$ su`
   (c) Install the driver:
   `~/WinDriver# make install`

6. Create a symbolic link so that you can easily launch the DriverWizard GUI
   ```
   ~/WinDriver$ ln -s
   <full path to WinDriver>/WinDriver/wizard/wdwizard/
   usr/bin/wdwizard
   ```
7. Change the read and execute permissions on the file **wdwizard** so that ordinary users can access this program.
8. Change the user and group ids and give read/write permissions to the device file **/dev/windrvr6** depending on how you wish to allow users to access hardware through the device.
9. You can now start using WinDriver to access your hardware and generate your driver code!

The following steps are for registered users only

In order to register your copy of WinDriver with the license you received from Jungo, follow the steps below:

1. Activate the DriverWizard GUI:
   ```
   ~/WinDriver/wizard$ ./wdwizard
   ```
2. Select the **Register WinDriver** option from the **File** menu and insert the license string you received from Jungo.
3. Click the **Activate License** button.
4. To register source code you developed during the evaluation period, please refer to `WD_License` function reference [A.1.9].

Restricting Hardware Access on Linux

CAUTION:
Since **/dev/windrvr6** gives direct hardware access to user programs, it may compromise kernel stability on multi-user Linux systems. Please restrict access to the DriverWizard and the device file **/dev/windrvr6** to trusted users.

For security reasons the WinDriver installation script does not automatically perform the steps of changing the permissions on **/dev/windrvr6** and the DriverWizard executable (**wdwizard**).

4.2.4 WinDriver Installation Instructions for Solaris

Installation of WinDriver should be performed by the system administrator logged in as root, or with root privileges, since the WinDriver installation process includes installation of the kernel module **windrvr6**.

1. Insert your CD into your Solaris machine CD drive or copy the downloaded file to your preferred directory.
2. Change directory to preferred installation directory (your home directory, for example):
   `/$ cd ~`
3. Copy the file **WDxxxSLS.tgz** to the current directory (here 'xxx' stands for the version number—500, for example):
   `~$ cp /home/username /WDxxxSLS.tgz /`
4. Extract the file:
   `~$ gunzip -c WDxxxSLS.tgz | tar xvf -`
5. Change directory to WinDriver.
6. Install WinDriver:
   The installation requires you to determine on which PCI card you will be working, by defining the device's Vendor ID and Device ID (hexadecimal values). There are two different ways to do this and install the driver:
   - Modify the installation file before performing the installation and then install WinDriver:
     (a) Open the file **install_windrvr** for editing, and change the default Vendor ID and default Device ID to your PCI card's identification values.
     (b) Install WinDriver:
     `~/WinDriver# ./install_windrvr`
   - Use the Command Line to change your device's identification values and install the driver in one step, by typing:
     `~/WinDriver# VENDOR_ID=XXXX DEVICE_ID=XXXX ./install_windrvr`

> **NOTE:**
> From version 5.x and above this directory is created by tar, but in versions preceding 5.x the WinDriver directory is not created by the extraction. Therefore, when working with versions preceding 5.x (version 4.33, for example) first create a directory (e.g., WinDriver) before proceeding with the installation.
> (`/$ mkdir ~/WinDriver`)

The following three steps are optional:

7. Create a symbolic link so that you can easily launch the DriverWizard GUI:
   `~/WinDriver# ln -s ~/WinDriver/wizard/wdwizard /usr/bin/wdwizard`
8. Change the read and execute permissions on the file **wdwizard** so that ordinary users can access this program.
9. Change the user and group ids and give read/write permissions to the device file **/dev/windrvr6** depending on how you wish to allow users to access hardware through the device.
10. You can now start using WinDriver to access your hardware and generate your driver code!

The following steps are for registered users only:

In order to register your copy of WinDriver with the license you have received from Jungo, please follow the steps below:

1. Activate the DriverWizard GUI:
   `~/WinDriver/wizard$ ./wdwizard`
2. Select the **Register WinDriver** option from the **File** menu and insert the license string you received from Jungo.
3. Click the **Activate License** button.
4. To register source code you developed during the evaluation period, please refer to `WD_License` function reference [A.1.9].

Restricting Hardware Access on Solaris

> **CAUTION:**
> Since **/dev/windrvr6** gives direct hardware access to user programs, it may compromise kernel stability on multi-user Solaris systems. Please restrict access to DriverWizard and the device file **/dev/windrvr6** to trusted users.
>
> For security reasons the WinDriver installation script does not automatically perform the steps of changing the permissions on **/dev/windrvr6** and the DriverWizard executable (**wdwizard**).

4.2.5 DriverBuilder Installation Instructions for VxWorks

The following describes the installation of DriverBuilder for VxWorks. DriverBuilder development environment works with Tornado 2 for Windows only (on x86 platform). Drivers generated using version 5.x and above of DriverBuilder will run on Intel x86 BSPs (pc486, pcPentium and pcPentiumPro), PPC 821/860 with MBX821/860 and PPC 750 (IBM PPC 604) with MCP750. For an up-to-date list see: `http://www.jungo.com/db-vxworks.html#platforms`.

Installation:

1. Download DriverBuilder for VxWorks.
2. Change drive to the preferred root drive for DriverBuilder. For example:
   `\> c:\`
3. Unpack the file you downloaded:
   `\> unzip -d DBxxxVX.zip c:\` (Here 'xxx' stands for the version number, e.g., 500.)

   > **NOTE:**
   > The extraction creates a directory called DriverBuilder and then places all of the DriverBuilder installation files in it. If working with a version prior to 5.00, you will have to create a directory for DriverBuilder manually, and then perform the extraction. For example:
   > `\> c:\cd_vxworks` and unpack the file to it:
   > `\> unzip -d DBxxxVX.zip c:\db_vxworks`

NOTE:
In WinDriver, samples for VxWorks have the .out extension, e.g., **pci_diag.out**. To invoke these programs, use Windsh to load them, and execute the routine xxx_main. For example:

wddebug.out : wddebug_main **pci_diag.out** : pci_diag_main

TIP
DriverBuilder is based on Jungo's WinDriver product line. You can save time by downloading the Windows version of WinDriver and using its graphical development environment for fast hardware validation and automatic code generation. If you choose to do so, follow these steps:

1. Download and install DriverBuilder for VxWorks.
2. Download and install WinDriver for Windows. *Don't skip this part.*
3. Create a shortcut on your desktop to DriverWizard (**C:\WinDriver\wizard\wdwizard.exe**) so that you can easily launch and develop your driver using the GUI DriverWizard.

4.3 Upgrading Your Installation

To upgrade to a new version of WinDriver on Windows, follow the steps outlined in Section 4.2.1, which illustrates the process of installing WinDriver for Windows 98/Me/NT/2000/XP/Server 2003. You can either choose to overwrite the existing installation or install to a separate directory.

After installation, start DriverWizard and enter the new license string, if you have received one. This completes the upgrade of WinDriver.

To upgrade your source code, pass the new license string as a parameter to `WD_License`. Please refer to `WD_License` function reference [A.1.9] for more details.

The procedure for upgrading your installation on other operating systems is the same as the one described above. Please check the respective installation sections for installation details.

4.4 Checking Your Installation

4.4.1 On Your Windows, Linux and Solaris Machines

1. Start DriverWizard by choosing **Programs |WinDriver | DriverWizard** from the **Start** menu.
2. Make sure that your WinDriver license is installed (see Section 4.2, which explains how to install WinDriver). If you are an evaluation version user, you do not need to install a license.
3. For PCI cards – Insert your card into the PCI bus, and verify that DriverWizard detects it.
4. For ISA cards – Insert your card into the ISA bus, configure DriverWizard with your card's resources and try to read/write to the card using DriverWizard. (Not relevant for Solaris)

4.4.2 On Your Windows CE Machine

1. Start DriverWizard on your Windows host machine by choosing **Programs | WinDriver | DriverWizard** from the **Start Menu**.
2. Make sure that your WinDriver license is installed. If you are an evaluation version user, you do not need to install a license.
3. For PCI/USB devices – Plug your device into the computer, and verify that DriverWizard detects it.
4. For ISA cards – Insert your card into the ISA bus, configure DriverWizard with your card's resources and try to read/write to the card using DriverWizard.
5. Activate Visual C++ for CE.
6. Load one of the WinDriver samples, e.g., **\WinDriver\samples\speaker\speaker.dsw**.
7. Set the target platform to x86em in the Visual C++ WCE configuration toolbar.
8. Compile and run the speaker sample. The Windows host machine's speaker should be activated from within the CE emulation environment.

NOTE:
ISAPnP is not supported under Windows CE.

4.4.3 On VxWorks

1. In x86 only: Make sure MMU is set to basic support (**hardware/memory/MMU/MMU Mode**).
2. Load DriverBuilder, download the object file: (**DriverBuilder \redist\eval\intelx86\PENTIUM\windrvr6.o**).
3. Initialize DriverBuilder from the WindShell:

```
=> drvrInit()

function returned (return value = 0)

 =>
```

4. Run a sample driver.
   Load **C:\DriverBuilder \samples\pci_diag\PENTIUM\pci_diag.out** from the WindShell:

```
=> pci_diag_main()
```

5. Scan the PCI bus, open cards and access them.

4.5 Uninstalling WinDriver

This section will help you to uninstall either the evaluation or registered version of WinDriver.

4.5.1 Uninstalling WinDriver from Windows 98, Me, NT, 2000, XP and Server 2003

1. Close any open WinDriver applications, including DriverWizard, the DebugMonitor log and any user-specific applications.
2. If you created a Kernel PlugIn driver:
   - If your created Kernel PlugIn driver is currently installed, uninstall it by running:

  - For a SYS Kernel PlugIn driver:
    `wdreg -name <Kernel PlugIn name> uninstall`
  - For a VXD Kernel PlugIn driver use the **-vxd** flag:
    `wdreg -vxd -name <Kernel PlugIn name> uninstall`

> **NOTE:**
> The Kernel PlugIn name should be specified without the *.sys/vxd extension.

- Erase your Kernel PlugIn driver.

3. For all Windows platforms, with the exception of Windows NT and Windows 98/Me using **windrvr6.vxd**:

   - Uninstall any Plug-and-Play devices (USB/PCI) registered to work with WinDriver.
     - On Windows 2000/XP/Server 2003 run:
       `wdreg -inf <path to the device-specific *inf file> uninstall`
     - On Windows 98/Me uninstall (Remove) the device from the Device Manager.
   - Verify that there are no *.inf files that register your device(s) with WinDriver (**windrvr6.sys**) in the **%windir%\inf** directory or **%windir%\inf\other** directory (Windows 98/Me).

4.

> **NOTE:**
> It is recommended not to uninstall the WinDriver kernel module (**windrvr6.sys/vxd**), since WinDriver is designed as a generic driver module and may be used by other drivers in the system. To successfully terminate your usage of WinDriver without uninstalling the WinDriver kernel module, simply skip this step and proceed to the steps below.

   This step is optional and we recommend you skip it, as explained in the note above.

   - To uninstall **windrvr6.sys** on Windows 98/Me/2000/XP/Server 2003 run:
     `wdreg -inf <path to windrvr6.inf> uninstall`

> **NOTE:**
> **windrvr6.sys** should reside in the same directory as **windrvr6.inf** when running this command.

To uninstall **windrvr6.sys** on Windows NT 4.0 run:
`wdreg uninstall`
To uninstall **windrvr6.vxd** on Windows 98/Me run:
`wdreg -vxd uninstall`

- Erase the following files if they exist:
  - Windows 98/Me/NT/2000/XP/Server 2003:
    %windir%\system32\drivers\windrvr6.sys
  - Windows 98/Me:
    %windir%\system\vmm32\windrvr6.vxd

5. This step is required only for computers on which the entire WinDriver tool-kit has been installed.
   - Uninstall the WinDriver tool-kit using the uninstall shield:
     Start | Settings | Control Panel | Add/Remove Programs
   - Erase the **\WinDriver** directory.
   - Erase WinDriver's entry in the start menu:
     On Windows 2000, for example: **Start | Settings | Task Bar | Advanced | Advanced | All Users | Start Menu | Programs | WinDriver**
6. Remove WinDriver DLLs.

   We recommend not to perform this step, since removing the DLLs will effect other WinDriver based applications that may be running in the system.
   Erase the following DLL files if they exist:
   %windir%\system32\wd_utils.dll
   %windir%\system32\wdlib.dll
7. Reboot the computer.

4.5.2 Uninstalling WinDriver from Linux

> **NOTE:**
> You must be logged in as root to perform the uninstall procedure.

1. Verify that the WinDriver module is not being used by another program:
   - View a list of modules and the programs using each of them:
     `/# /sbin/lsmod`
   - Close any applications that are using the WinDriver module.
   - Unload any modules that are using the WinDriver module:
     `/sbin# rmmod`
2. Unload the WinDriver module:
   `/sbin# rmmod windrvr6`
3. Remove the old device node in the **/dev** directory:
   `/# rm -rf /dev/windrvr6`
4. If you created a Kernel PlugIn, remove it as well.
5. Remove the file **.windriver.rc** from the **/etc** directory:
   `/# rm -rf /etc/.windriver.rc`
6. Remove the file **.windriver.rc** from **$HOME**:
   `/# rm -rf $HOME/.windriver.rc`
7. If you created a symbolic link to DriverWizard, delete the link using the command:
   `/# rm -f /usr/bin/wdwizard`
8. Delete the WinDriver installation directory using the command:
   `/# rm -rf ~/WinDriver`

4.5.3 Uninstalling WinDriver from Solaris

NOTE:
You must be logged in as root to perform the uninstall procedure.

1. Change directory to WinDriver.
2. If you created a Kernel PlugIn, remove it by following these steps:
   ```
   # /usr/sbin/rem_drv kpname
   # rm /kernel/drv/sparcv9/kpname
   # rm /kernel/drv/kpname.conf
   ```

3. Run the following uninstallation script:
   `~/WinDriver# ./remove_windrvr`

4. If you created a symbolic link to DriverWizard, delete the link:
   `# rm -f /usr/bin/wdwizard`

5. Delete the WinDriver installation directory, after changing the directory to the one above WinDriver:
   `# rm -rf ~/WinDriver`

4.5.4 Uninstalling DriverBuilder for VxWorks

1. Delete the DriverBuilder installation directory (**C:\DriverBuilder**, for example) using Windows Explorer.

2. If you created any shortcuts to DriverWizard on your desktop, delete them.

Chapter 5

Using DriverWizard

5.1 An Overview

DriverWizard (included in the WinDriver toolkit) is a GUI-based diagnostics and driver generation tool that allows you to write to and read from the hardware, before writing a single line of code. The hardware is diagnosed through a Graphical User Interface—memory ranges are read, registers are toggled and interrupts are checked. Once the card is operating to your satisfaction, DriverWizard creates the skeletal driver source code, with functions to access all your hardware resources.

If you are developing a driver for a card which is based on one of the supported USB or PCI chipsets (PLX 9030, 9050, 9052, 9054, 9056, 9060, 9080, 9656, IOP 480, Marvell gt64, Altera, QuickLogic PBC/QuickPCI, AMCC 5933, STMicroelectronics ST7, ST9, TI TUSB3410, TUSB3210, TUSB2136, TUSB5052 and the Cypress EZ-USB family), we recommend you read Chapter 8, which explains WinDriver's enhanced support for specific chipsets, before starting your driver development.

DriverWizard can be used to diagnose your hardware and can generate an INF file for hardware running under Windows 98/Me/2000/XP/Server 2003 (an INF file should not be generated for hardware running under Windows NT). Avoid using DriverWizard to generate code for a card based on one of the supported PCI chipsets, as DriverWizard generates generic code which will have to be modified according to the specific functionality of the card in question. Preferably, use the complete source code libraries and sample applications (supplied in the package) tailored to the various PCI chipsets.

DriverWizard is an excellent tool for two major phases in your HW/Driver development:

Hardware diagnostics: After the hardware has been built, insert the hardware into the appropriate slot (PCI/CardBus/ISA/ISAPnP/EISA/CompactPCI) or attach your USB device to the USB port on your machine, and use DriverWizard to verify that the hardware is performing as expected.

Code generation: Once you are ready to build your code, let DriverWizard generate your driver code for you.

The code generated by DriverWizard is composed of the following elements:

Library functions for accessing each element of your device's resources (memory ranges, I/O ranges, registers and interrupts).

A 32-bit diagnostics program in console mode with which you can diagnose your device. This application utilizes the special library functions described above. Use this diagnostics program as your skeletal device driver.

A project workspace that you can use to automatically load all of the project information and files into your development environment. In WinDriver Linux and WinDriver Solaris, DriverWizard generates the makefile for the relevant operating system.

5.2 DriverWizard Walkthrough

To use DriverWizard:

1. **Attach your hardware to the computer:**
   If it's a PCI/CardBus/ISA/ISAPnP/EISA/CompactPCI card, attach it to the appropriate slot in your computer. If it's a USB device, attach it to the USB port on your computer.
   OR
   You have the option of using DriverWizard to generate code for a virtual PCI device. In this case use DriverWizard without attaching a device.

2. **Run DriverWizard and select your device:**

(a) Click **Start | Programs | WinDriver | DriverWizard** or double click the DriverWizard icon on your desktop.

(b) Click **OK** on the initial screen.

(c) Click **Next** in the **Choose Your Project** dialog box.

(d) Select your **PnP Device** from the list of devices detected by DriverWizard. For non-PnP cards, select **ISA**. For code generation for a non-attached device, select **PCI: VIRTUAL DEVICE**.

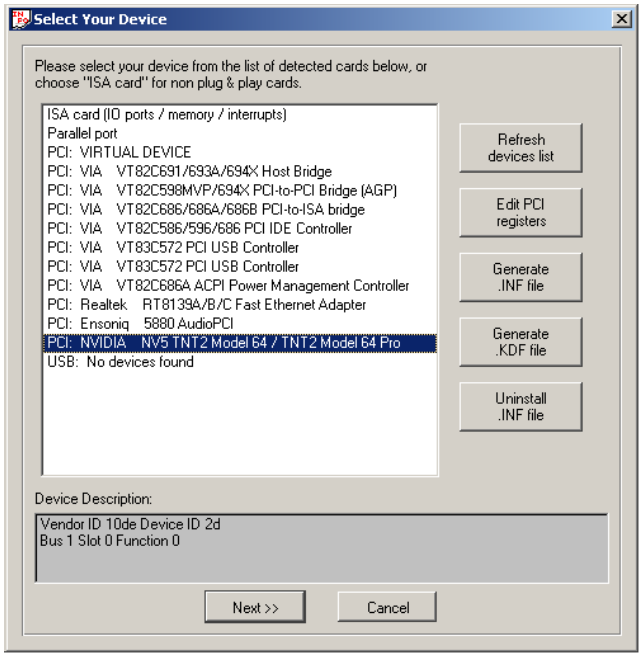


Figure 5.1: Selection of PnP Device

NOTE:
On Windows 98, if you do not see your USB device in the list, reconnect it and make sure the **New Hardware Found**/**Add New Hardware** wizard appears for your device. Do not close the dialog box until you have generated an INF for your device using the steps below.

3. **Choose if to use the WinDriver extension for custom USB HID devices:** (This step is for USB HID devices only. Developers working with PCI/CardBus/ISA/ISAPnP/EISA/CompactPCI cards should skip this step).

   If the selected device is a USB HID device, DriverWizard will ask you if you want to use the WinDriver extension for custom USB HID devices. Select **Yes** to continue using the WinDriver extension for custom USB HID devices, and **No** to use classic WinDriver support for USB devices. The differences between classic WinDriver support for USB devices and WinDriver extension for custom USB HID devices are explained in Section 3.11.

   If the WinDriver extension for custom USB HID devices is used, some of the following steps of the DriverWizard will be omitted entirely.

4. **Generate an INF file for DriverWizard:**
   Whenever developing a driver for a Plug and Play Windows operating system (i.e., Windows 98, Me, 2000, XP or Server 2003) you are required to install an INF file for your device. This file will register your Plug and Play device to work with the **windrvr6.sys** driver. The file generated by the DriverWizard in this step should later be distributed to your customers using Windows 98/Me/2000/XP/Server 2003, and installed on their PCs.
   The INF file you generate here is also designed to enable DriverWizard to diagnose your device (for example, when no driver is installed for your PCI/USB device). As explained earlier, this is required only when using WinDriver to support a Plug and Play device (PCI/USB) on a Plug and Play system (Windows 98/Me/2000/XP/Server 2003). Additional information concerning the need for an INF file is explained in Section 14.4.1.

   If you do not need to generate an INF file, skip this step and proceed to the next one.

   To generate the INF file with the DriverWizard, follow the steps below:

   (a) In the **Select Your Device** screen, click the **Generate .INF file** button or click **Next**.

   (b) DriverWizard will prompt you for information about your device: Vendor ID, Device/Product ID, Device Class, etc. Enter the required details in the dialog box that appears.

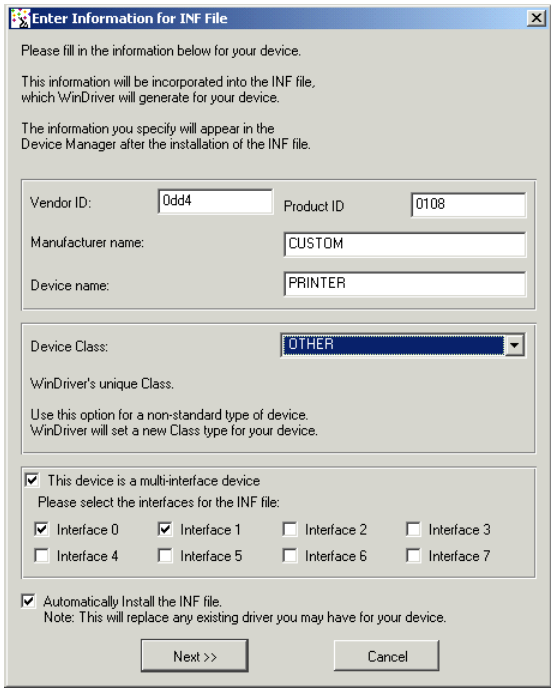


Figure 5.2: DriverWizard INF File Information

(c) For USB devices with multiple interfaces, check the box stating that this is a multiple-interface device, then select the interfaces for the INF file. You have the option of generating a separate INF file for each interface, or a single INF file for some or all of the interfaces.

> **NOTE:**
> For USB devices with multiple interfaces, you must identify all the interfaces supported for DriverWizard to work properly.

(d) When you're done, click **Next** and choose the directory in which you wish to store the generated INF file. DriverWizard will then automatically generate the INF file for you.
On **Windows 2000/XP/Server 2003** you can choose to automatically install the INF file from the DriverWizard by checking the **Automatically Install the INF file** option in the DriverWizard's INF generation dialog

box. On **Windows 98/Me** you must install the INF file manually, using Windows **Add New Hardware Wizard** or **Upgrade Device Driver Wizard**, as explained in Section 14.4. If the automatic INF file installation on Windows 2000/XP/Server 2003 fails, DriverWizard will notify you and provide manual installation instructions for this OS as well.

(e) When the INF file installation completes, select and open your device from the list in the **Select Your Device** screen.

5. **Uninstall the INF file of your device:**
   You can use the **Uninstall** option to uninstall the INF file of your PnP device (PCI/USB). Once you uninstall the INF file, the device will no longer be registered to work with the **windrvr6.sys**, and the INF file will be deleted from the Windows root directory.

   If you do not need to uninstall an INF file, skip this step and proceed to the next one.

   (a) In the **Select Your Device** screen, click the **Uninstall .INF file** button.

   (b) Select the INF file to be removed.

6. **Select your USB device's alternate setting:**
   (This step is for USB devices only. Developers working with PCI/CardBus/ISA/ISAPnP/EISA/CompactPCI cards should skip this step).

   Choose the desired **alternate setting** from the list. (Note that DriverWizard reads all the supported devices' alternate settings and displays them. For USB devices with only one alternate setting configured, DriverWizard automatically selects the detected alternate setting and therefore the **Select Device Interface** dialog box will not be displayed.)

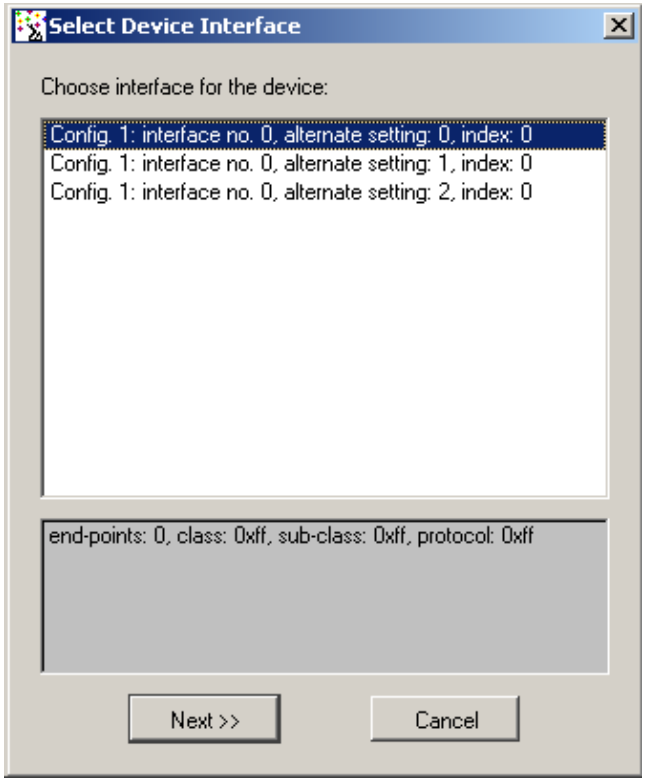


Figure 5.3: USB Device Configuration

7. **Diagnose your device:**
   Before writing your device driver, it is important to make sure your hardware is working as expected. Use DriverWizard to diagnose your hardware. All of your activity will be logged in the DriverWizard log so that you may later analyze your tests:

   (a) Define and test your PCI device's I/O and memory ranges, registers and interrupts:

   - DriverWizard will automatically detect your Plug and Play hardware's resources (I/O ranges, memory ranges and interrupts). You can define the registers manually.

- For non-Plug and Play hardware, define your hardware's resources manually.
- Read and write to the I/O ports, memory space and your defined registers.

> **NOTE:**
> You have the option to check the **Auto Read** box from the **Register Information** window. The registers that are marked with the **Auto Read** option will automatically be read with any register read/write operation performed from the Wizard (the read results will be displayed in the wizard's Log window).

- 'Listen' to your hardware's interrupts.

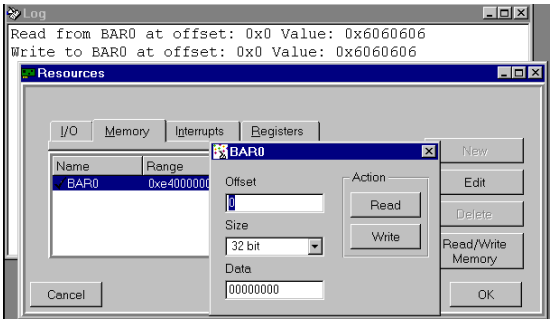


Figure 5.4: PCI Diagnostics Screen

(b) Test your USB device's pipes:
DriverWizard shows the pipe detected according to the selected configuration\interface\alternate setting. In order to perform USB data transfers follow the steps given below:

i. Select the desired pipe.
ii. For a control pipe (a bidirectional pipe), click **Read/Write to Pipe**. A new dialog box will appear, allowing you to select a standard USB request (see Figure 5.5) or enter a custom request. Once you select a standard USB request, the setup packet array is automatically filled and the request description is displayed in the dialog box. For a custom request, you are required to enter a setup packet and write operation data. The setup packet should be eight bytes long (little

endian) and should conform to the USB specification parameters (bmRequestType, bRequest, wValue, wIndex, wLength).

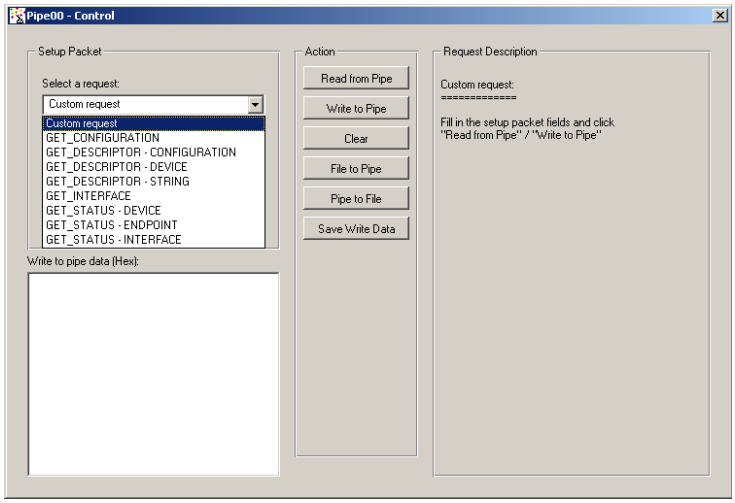


Figure 5.5: USB Request List

> **NOTE:**
> More detailed information on the standard USB requests, on how to implement the control transfer and how to send setup packets can be found in Sections 9.3 and 9.4.

iii. For an input pipe (moves data from device to host) click **Listen to Pipe**. To successfully accomplish this operation with devices other than HID, you need to first verify that the device sends data to the host. If no data is sent after listening for a short period of time, DriverWizard will notify you that the **Transfer Failed**.

iv. To stop reading, click **Stop Listen to Pipe**.

v. For an output pipe (moves data from host to device), click **Write to Pipe**. A new dialog box will appear (see Figure 5.6), asking you to enter the data to write. The DriverWizard log will contain the result of the operation.

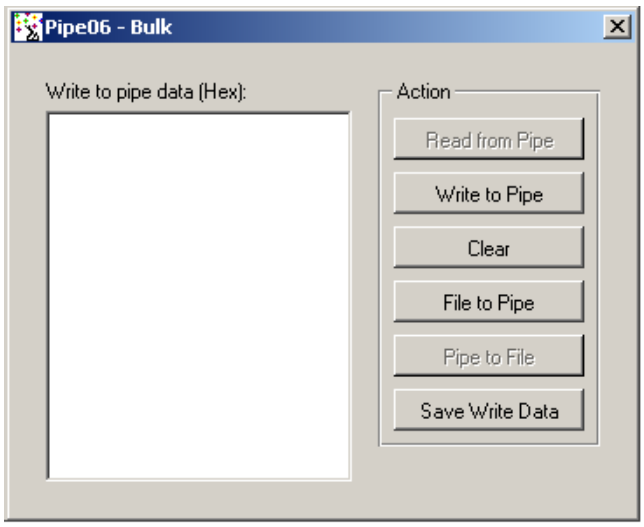


Figure 5.6: Write to Pipe

8. **Generate the skeletal driver code:**

   (a) Select **Generate Code** from the **Build** menu, or click **Next** in the **Define and Test Resources for Your Device** dialog box.

Figure 5.7: Generate Code Option

   (b) Select **WinDriver** in the **Choose Type of Driver** dialog box. Selecting the **KernelDriver** option will generate kernel source code designed for full kernel-mode drivers. See the KernelDriver documentation or the Jungo web site (`http://www.jungo.com`) for more details. (Note that this dialog box appears only when both WinDriver and KernelDriver are installed on your machine.)

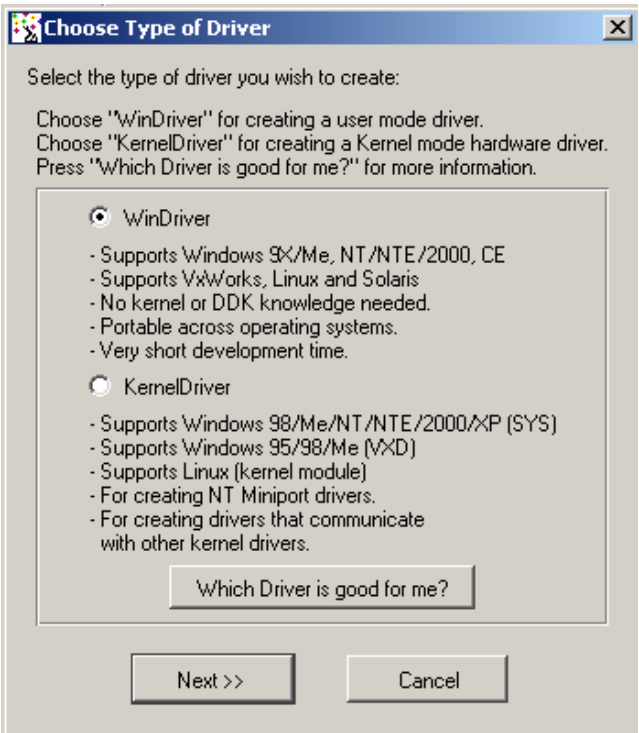


Figure 5.8: Select Driver Type

(c) Next, the **Select Code Generation Options** dialog box will appear. Choose the language in which the code will be generated and the desired development environment for the various operating systems.

(d) Click **Next** and indicate whether you wish to handle Plug and Play and power management events from within your driver code and whether you wish to generate Kernel PlugIn code.

> **NOTE:**
> In order to work with a Kernel PlugIn, you must have an appropriate Microsoft DDK installed on your computer before you generate Kernel PlugIn code.

(e) Save your project (if required) and click **OK** to open your development environment with the generated driver.

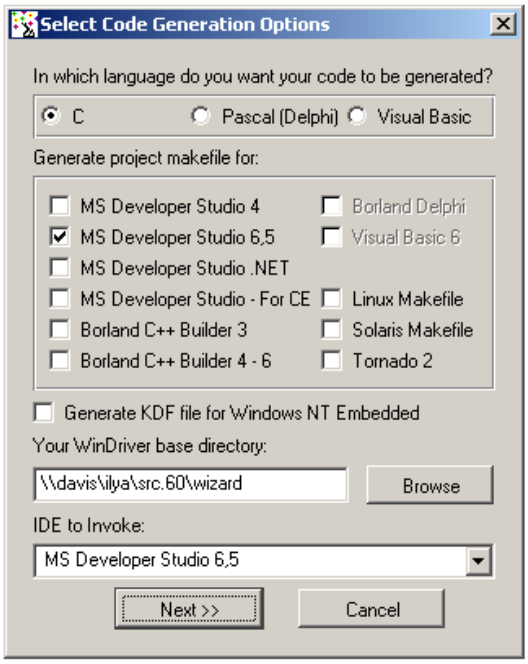


Figure 5.9: Options for Generating Code

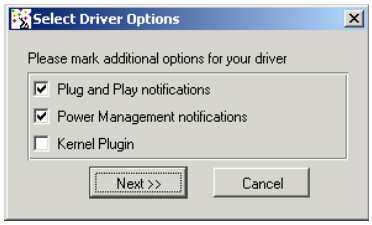


Figure 5.10: Notification Events

(f) For USB only - close DriverWizard.

9. **Compile and run the generated code:**

   - Use this code as a starting point for your device driver. Modify where

needed to perform your driver's specific functionality.

- The source code DriverWizard creates can be compiled with any 32-bit compiler, and will run on all supported platforms (Windows 98/Me/NT/2000/XP/CE/CE.NET/Server 2003, Linux, Solaris and VxWorks) without modification.

5.3 DriverWizard Notes

5.3.1 Sharing a Resource

If you want more than one driver to share a single resource, you must define that resource as shared:

1. Select the resource.
2. Right click on the resource.
3. Select **Share** from the menu.

NOTE:
New interrupts are set as **Shared** by default. If you wish to define an interrupt as unshared, follow Steps 1 and 2, and select **Unshared** in Step 3.

5.3.2 Disabling a Resource

During your diagnostics, you may wish to disable a resource so that DriverWizard will ignore it and not create code for it.

1. Select the resource.
2. Right click on the resource name.
3. Choose **Disable** from the menu.

5.3.3 Logging WinDriver API Calls

You have the option to log all the WinDriver API calls using the DriverWizard, with the API calls input and output parameters. You can select this option by selecting the **Log API calls** option from the **Tools** menu or by clicking on the **Log API calls** toolbar icon in the DriverWizard's opening window.

5.3.4 DriverWizard Logger

The wizard logger is the empty window that opens along with the **Device Resources** dialog box when you open a new project. The logger keeps track of all of the input and output during the diagnostics stage, so that you may analyze your device's physical performance at a later time. You can save the log for future reference. When saving the project, your log is saved as well. Each log is associated with one project.

5.3.5 Automatic Code Generation

After you have finished diagnosing your device and have ensured that it runs according to your specifications, you are ready to write your driver.

Generating the Code

Choose **Generate Code** from the **Build** menu. DriverWizard will generate the source code for your driver, and place it along with the project file (**xxx.wdp**, where "xxx" is the project name). The files are saved in a directory DriverWizard creates for every development environment and operating system selected in the **Generate Code** dialog box.

Generated PCI Code

In the source code directory you now have a new **xxxlib.h** file. It states the interface for the new functions that DriverWizard created for you and the source of these functions, **xxxlib.c**, where your device-specific API is implemented. In addition, you will find the sample function `main` in the file **xxxdiag.c**.

The code generated by DriverWizard is composed of the following elements and files, where "xxx" represents your project name:

- Library functions for accessing each element of your card's resources (memory ranges, I/O ranges, registers, interrupts and the USB pipes):

  xxx_lib.c Here you can find the implementation of the hardware-specific API (found in **xxx_lib.h**), using the standard WinDriver API.

  xxx_lib.h This is the header file of the diagnostics program. Here you can find the hardware-specific API created by DriverWizard. You should include this file in your source code in order to use this API.

- A general PCI utility library:

A diagnostics program with which you can diagnose your card. This console application utilizes the special library functions that were created for your device by DriverWizard. Use this diagnostics program as your skeletal device driver.

pci_diag_lib.c This is the source code of the diagnostics program DriverWizard creates.

- A list of all files created can be found at **xxx_files.txt**.

After creating your code, compile it with your favorite Win32 compiler, and see it work!

Change the function `main` of the program so that the functionality fits your needs.

Generated USB Code

In the source code directory you now have a new USB application that uses your USB devices and demonstrates PnP events and read/write functionality for it. In addition, the source code demonstrates handling of multiple (identical) USB devices. The USB application will have the same name as was specified for the project, together with the respective .c and .h files.

When using the WinDriver extension for custom USB HID device, the generated application will be a standard Windows application that can read to and written from your custom USB HID device.

Compiling the Generated Code

For Windows 98, Me, NT, 2000, XP, CE and Server 2003 (Using MSDEV):

1. For Windows platforms, DriverWizard generates the project files (for MSDEV 4, 5, 6 and 7 (.NET), Borland C/C++ Builder, Visual Basic and Delphi). After code generation, the chosen IDE (Integrated Development Environment) will be launched automatically. You can then immediately compile and run the generated code.

Visual Basic or Delphi Code Generation

This will generate Visual Basic or Delphi project and files, similar to the MSDEV projects generated for PCI and USB in the above sections.

For Linux and Solaris:

1. DriverWizard creates a makefile for your project.
2. Compile the source code using the makefile generated by DriverWizard.
3. Use any compilation environment to build your code, preferably GCC.

For Other OSs or IDEs:

1. Create a new project in your IDE (Integrated development environment).
2. Include the source files created by DriverWizard in your project.
3. Compile and run the project.
4. The project contains a working example of the custom functions that DriverWizard created for you. Use this example to create the functionality you want.

Chapter 6

Developing a Driver

This chapter takes you through the WinDriver driver development cycle.

NOTE:
WinDriver provides a special set of APIs to further shorten development time for those who use one of the supported chipsets (PLX/Altera/Marvell/AMCC/QuickLogic/Cypress/STMicroelectronics/TI) for their USB or PCI bridge. If this applies to you, read the following overview and then jump straight to Chapter 8.

6.1 Using the DriverWizard to Build a Device Driver

- Use DriverWizard to diagnose your card. Read/write to the I/O, memory ranges, and/or registers that your card supports and to the pipes of your USB device. Verify that your device operates as expected.
- Use DriverWizard to generate skeletal code for your device in C, Delphi or Visual Basic. Refer to Chapter 5 for details about DriverWizard.
- If you are using one of the supported chipsets (PLX 9030, 9050, 9052, 9054, 9056, 9060, 9080, 9656, IOP 480, Marvell gt64, Altera, QuickLogic PBC/QuickPCI, AMCC 5933, STMicroelectronics ST7, ST9, TI TUSB3410, TUSB3210, TUSB2136, TUSB5052 and the Cypress EZ-USB family) as your USB or PCI chipsets, we recommend that you use the specific sample code

provided for your chip as your skeletal driver code. For more details regarding WinDriver's enhanced support for specific PCI and USB chipsets, please refer to Chapter 8.

NOTE:
The WinDriver PLX 9050 library is fully compatible with PLX 9052.

- Use any 32-bit compiler (such as MSDEV, Visual C/C++, Borland Delphi, Borland C++, Visual Basic, GCC) to compile the skeletal driver you need.
- For Linux and Solaris, use any compilation environment, preferably GCC to build your code.
- That is all you need do to create your user-mode driver. If you discover that better performance is needed, please refer to Chapter 10 for details on performance improvement.

Please see Appendix A for a detailed function and structure reference for WinDriver. See Chapter 9 to learn how to perform operations that DriverWizard cannot automate.

6.2 Writing the Device Driver Without the DriverWizard

There may be times when you choose to write your driver directly without using DriverWizard. Sometimes you may be compelled to do so, for example, when working with VxWorks without using Windows as a host, since DriverBuilder does not provide the DriverWizard utility. In either case, proceed according to the steps outlined below, or choose a sample that most closely resembles what your driver should do, and modify it. For further information on VxWorks, please refer to Sections 4.2.5 and 4.4.3.

1. Copy the file **windrvr.h** to your source code directory.
2. Add the following line to the source code:

```
#include "windrvr.h"
```

6.2.1 PCI/ISA Drivers

1. Call `WD_Open` [A.1.2] at the beginning of your program to get a handle for WinDriver.
2. Call `WD_Version` [A.1.3] to make sure that the WinDriver version installed is up to date.
3. For PCI cards:
   (a) Call `WD_PciScanCards` [A.2.2]to get a list of the PCI cards installed.
   (b) Choose your card.
   (c) Call `WD_PciGetCardInfo` [A.2.3].
4. For ISAPnP cards:
   (a) Call `WD_IsapnpScanCards` [A.2.5] to get a list of the ISAPnP cards installed.
   (b) Choose your card.
   (c) Call `WD_IsapnpGetCardInfo` [A.2.6].
5. For ISA (non-PnP) cards: fill in your card information (I/O, memory & interrupts) in the WD_CARD structure.
6. Call `WD_CardRegister` [A.2.8] to open a handle to your device with the desired configuration.
7. Now you can use `WD_Transfer` [A.2.10] to perform I/O and memory transfers.
8. If the card uses interrupts, call `WD_IntEnable` [A.3.2]. Now you can wait for interrupts using `WD_IntWait` [A.3.3].
9. To finish, call `WD_CardUnregister` [A.2.9], and at the end call `WD_Close` [A.1.4].

6.2.2 USB Drivers

1. Call `WDU_Init` [A.6.1] at the beginning of your program to initialize WinDriver for your USB device and wait for the device-attach callback. The relevant device information will be provided in the attach callback.

2. Once the attach callback is received, you can start using one of the `WDU_Transfer` [A.6.7] functions family to send and receive data.
3. To finish, call `WDU_Uninit` [A.6.6] to un-register from the device.

6.3 Writing Using the WinDriver Extension for Custom USB HID Devices

If you wish to use the WinDriver extension for custom USB HID devices to develop applications without the DriverWizard, proceed according to the steps outlined below, or choose a sample that most closely resembles what your application should do, and modify it.

1. Ensure that **windriver/include** is on your include path.
2. Add the following lines to the source code:

```
#include <windows.h>
#include "wdlib.h"
```

3. Add **windriver/lib/wdlib.lib** to your project:
4. Call `WDL_Init` [A.10.3] at the beginning of your program to get a handle for the USB HID device.
5. Call `WDL_Version` [A.10.2] to make sure that the WinDriver version installed is up to date.
6. Call the `WDL_` functions to perform read/write, etc.
7. To finish, call `WDL_Close` [A.10.4] to close your device.

6.4 Developing in Visual Basic and Delphi

The entire WinDriver API can be used when developing drivers in Visual Basic and Delphi.

Using DriverWizard

DriverWizard can be used to diagnose your hardware and verify that it is working properly before you start coding. DriverWizard's automatic source code generator generates code in C, Delphi and Visual Basic only.

To create your driver code in C, Delphi or Visual Basic, please refer to Chapter 5.

Samples

Samples for drivers written using the WinDriver API in Delphi or Visual Basic can be found in:

1. **\WinDriver\delphi\samples**
2. **\WinDriver\vb\samples**

Use these samples as a starting point for your own driver.

Kernel PlugIn

Delphi and Visual Basic cannot be used to create a Kernel PlugIn. Developers using WinDriver with Delphi or VB in user mode must use C when writing their Kernel PlugIn.

Creating your Driver

The method of development in Visual Basic is the same as the method in C using the automatic code generation feature of DriverWizard.

Your work process should be as follows:

- Use DriverWizard to easily diagnose your hardware.
- Verify that it is working properly.
- Generate your driver code.
- Integrate the driver into your application.
- You may find it useful to use the WinDriver samples to get to know the WinDriver API and as your skeletal driver code.

6.5 Testing on Windows CE

Emulation

If your Windows host development workstation already has the target hardware plugged in, you can use the x86 HPC software emulator to test your driver. Generate the code as usual using DriverWizard, or from scratch as described earlier in this chapter. When compiling the code, use the Visual C++ WCE Configuration toolbar to select the x86em target platform. You will need to link the import library **WinDriver\redist\x86emu\windrvr_ce_emu.lib** with your application program objects.

Chapter 7

Debugging Drivers

The following sections describe how to debug your hardware access application code.

7.1 User-Mode Debugging

- Since WinDriver is accessed from user mode, we recommend that you first debug your code using your standard debugging software.
- When the Debug Monitor is activated, WinDriver's kernel module performs verification of the validity of the memory ranges when using `WD_Transfer` [A.2.10], i.e. it verifies that the reading/writing from/to the memory is in the range that is defined for the card.
- Use DriverWizard to check values of memory and registers in the debugging process.
- When developing for Windows CE: If you are using the WinDbg debugger from Microsoft to connect to your target platform via a serial (COM1) port, you can use the DEBUGMSG macro inside your user-mode driver code to send printf-style debugging output to the debugger window. Refer to the following locations for more information:
  - **\WINCE210\PUBLIC\COMMON\DDK\INC\DBGPRINT.H**
  - **\WINCE210\PUBLIC\COMMON\OAK\DEMOS\DBGSAMP1**

The ETK documentation also includes detailed documentation on using WinDbg for user mode or driver debugging.

7.2 Debug Monitor

Debug Monitor is a powerful graphical- and console-mode tool for monitoring all activities handled by the WinDriver kernel (**windrvr6.sys/windrvr6.vxd/windrvr6.dll/windrvr6.o**). You can use this tool to monitor how each command sent to the kernel is executed.

Debug Monitor has two modes: graphical mode and console mode. The following sections explain how to operate Debug Monitor in both modes.

7.2.1 Using Debug Monitor in Graphical Mode

Applicable for Windows 98, Me, NT, 2000, XP, Server 2003, Linux and Solaris. You may also use Debug Monitor to debug your CE driver code running on CE emulation on Windows NT. For VxWorks and CE targets use Debug Monitor in console mode.

1. Run the Debug Monitor using one the following three ways:

   - The Debug Monitor is available as **wddebug_gui** in the **\WinDriver\util** directory.
   - The Debug Monitor can be launched from the **Tools** menu in DriverWizard.
   - In Windows, use **Start | Programs | WinDriver | Debug Monitor** to start Debug Monitor.

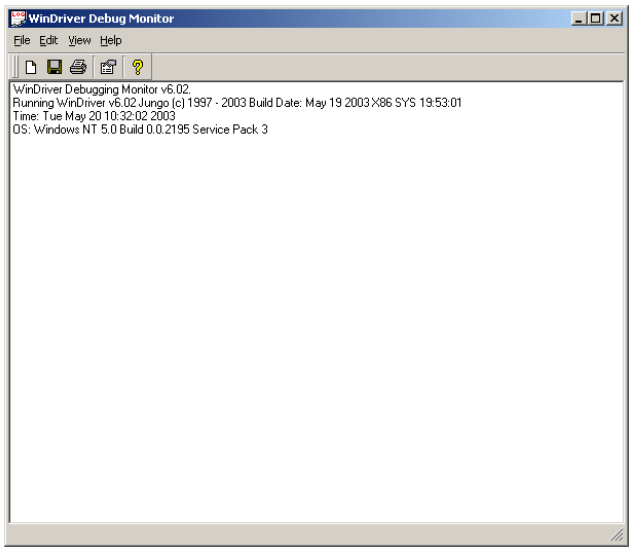


Figure 7.1: Start Debug Monitor

2. Activate and set the trace level using either the **View | Debug Options** menu or the **Change Status** button.

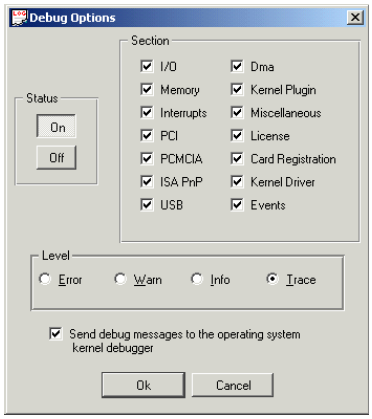


Figure 7.2: Set Trace Options

- **Status** – Set trace on or off.
- **Section** – Choose what part of the WinDriver API you would like to monitor. If you are developing a PCI card and experiencing problems with your interrupt handler, select the **Int** and **PCI** check boxes. USB developers should select the **USB** check box. KernelDriver users should select the **Ker_drv** check box to monitor communication between their custom kernel-mode drivers (developed using KernelDriver) and the WinDriver kernel.

  TIP
  Choose carefully those sections that you would like to monitor. Checking more options than necessary could result in an overflow of information, making it harder for you to locate your problem.

- **Level** – Choose the level of messages you want to see for the resources defined.

  Error is the lowest level of trace, resulting in minimum output to the screen.

  Trace is the highest level of tracing, displaying every operation the WinDriver kernel performs.

- Select the **Send WinDriver Debug Messages To Kernel Debugger** check box if you want debugging messages to be sent to an external kernel debugger as well.
  This option enables you to send to an external kernel debugger all the debug information that is received from WinDriver's kernel module (which calls `WD_DebugAdd()` [A.1.6] in your code).
  Now run your application, reproduce the problem, and view the debug information in the external kernel debugger's log.
  Windows users can use Microsoft's WinDbg tool, for example, which is freely supplied in the NT DDK and through Microsoft's web site (Microsoft Debugging Tools page).

3. Once you have defined what you want to trace and on what level, click **OK** to close the **Modify Status** window.

4. Activate your program (step-by-step or in one run).

5. Watch the monitor screen for errors or any unexpected messages.

7.2.2 Using Debug Monitor in Console Mode

This tool is available in all supported operating systems. To use it, run:
`\WinDriver\util>` **`wddebug`**
with the appropriate switches.
For a list of switches that can be used with Debug Monitor in console mode, type:
`\>` **`wddebug`**
To see activity logged by the Debug Monitor, type:
`\>` **`wddebug dump`**.

Using Debug Monitor on Windows CE

On Windows CE, Debug Monitor is only available in console mode. You first need to start a Windows CE command window (**CMD.EXE**) on the Windows CE target computer and then run the program **WDDEBUG.EXE** inside this shell.

Using Debug Monitor on VxWorks

On VxWorks, Debug Monitor is only available in console mode. However, because of the special syntax of the Tornado WindShell, we show a sample session with Tornado II IDE below, where we first load the debug monitor, then set the options and then run it to capture information.

```
-> ld < wddebug.out
Loading wddebug.out |
value = 10893848 = 0xa63a18
-> wdddebug

-> wddebug_main "on", "trace", "all"
Debug level (4) TRACE, Debug sections (0xffffffff) ALL ,
Buffer size 16384
value = 0 = 0x0
-> wddebug_main "dump"
WDDEBUG v5.00 Debugging Monitor.
Running DriverBuilder V5.00 Jungo (c) 2001 evaluation copy
Time: THU JAN 01 01:06:56 2001
OS: VxWorks
Press CTRL-BREAK to exit
```

Please note the following:

- The Debug Monitor object binary module is called **wddebug.out**.
- The main program entry point is called `wddebug_main`.
- The arguments are enclosed in double quotes and are separated by commas. This syntax is required by WindShell.

Chapter 8

Using the Enhanced Support for PCI and USB Chipsets

This chapter is relevant to projects using one of the chipsets for which WinDriver offers enhanced support. These currently include PLX 9030, 9050, 9052, 9054, 9056, 9060, 9080, 9656, IOP 480, Marvell gt64, Altera, QuickLogic PBC/QuickPCI, AMCC 5933, STMicroelectronics ST7, ST9, TI TUSB3410, TUSB3210, TUSB2136, TUSB5052 and the Cypress EZ-USB family. WinDriver supports all other PCI and USB chipsets via DriverWizard and the standard WinDriver API.

8.1 Overview

In addition to the standard WinDriver API described in the earlier chapters, WinDriver also offers a custom API for specific chipsets—currently PLX 9030, 9050, 9052, 9054, 9056, 9060, 9080, 9656, IOP 480, Marvell gt64, Altera, QuickLogic PBC/QuickPCI, AMCC 5933, STMicroelectronics ST7, ST9, TI TUSB3410, TUSB3210, TUSB2136, TUSB5052 and the Cypress EZ-USB family.

The following is an overview of the development process when using WinDriver's chipset-specific PCI API:

1. Run the custom diagnostics program to diagnose your card.

2. Locate the diagnostics program for your card. See **\WinDriver\chip_vendor \chip_name\xxxdiag\xxxdiag.c**
3. Use the source code for this diagnostics program as your skeletal device driver.
4. Modify the code to suit your application.
5. If the user-mode driver you have created in the above steps contains parts that require enhanced performance (an interrupt handler, for example), please refer to Chapter 11, which explains the WinDriver's Kernel PlugIn. There you learn how to move parts of your source code to WinDriver's Kernel PlugIn, thereby eliminating any calling overhead, and achieving maximal performance.

8.2 What is the PCI Diagnostics Program?

The diagnostics program is a ready-to-run sample diagnostics application for certain PCI chipsets. The diagnostics program accesses the hardware via WinDriver's chipset-specific APIs (**xxxLIB.C**). It is written as a console-mode application, and not as a GUI application, to simplify the understanding of the source code of the diagnostics program. This will help you learn how to properly use the API for your card.

This application can be used as your skeletal device driver. If your driver is not a console-mode application, just remove the printf calls from the code. You may replace them with MessageBox if you wish.

You may find **xxx_DIAG.C** helpful as both an example of how to use your card's API and as a useful diagnostics utility.

8.3 Using Your PCI Chipset Diagnostics Program

8.3.1 Introduction

The custom diagnostics program (**xxx_DIAG.EXE**) accesses the hardware using WinDriver. Therefore, WinDriver must be installed before xxx_DIAG is run.

Once WinDriver is running, you may run xxx_DIAG by clicking on **Start | Programs | WinDriver | Samples | Chip_name Diagnostics**.

The application will first try to locate the card with the default VendorID and DeviceID assigned by your PCI chip vendor, e.g., for PLX 9054 VendorID=0x10b5 and DeviceID=0x9054. If such a card is found you will get a **Your PCI Card Found** message (**PLX 9054 Card Found**). If you have programmed your EEPROM to load a different VendorID/DeviceID, then at the main menu you will have to choose your card (option **Locate/Choose** your board in the main menu).

8.3.2 Main Menu Options

Scan PCI Bus

Displays all the cards present on the PCI bus and their resources (I/O ranges, Memory ranges, Interrupts, VendorID / DeviceID). This information may be used to choose the card you need to access.

Locate/Choose Your Board

Chooses the active card that the diagnostics application will use. Enter the VendorID/DeviceID of the card you want to access when prompted. If there are multiple cards with the same VendorID/DeviceID, you will be asked to choose one of them.

PCI Configuration Registers

This option is available only after choosing an active card. A list of the PCI configuration registers and their read values are displayed. These are general registers common to all PCI cards. In order to write to a register, enter its number and then the value to write to it.

Your PCI Local Registers

This option is available only after choosing an active card. A list of your PCI registers and their read values is displayed. In order to write to a register, enter the register number and then enter the value to write to it.

Access Memory Ranges on the Board

This option is available only after choosing an active card. Use this option carefully. Accessing memory ranges accesses the local bus on your card. If you access an invalid local address, or if you have any problem with your card (such as a problem with the IRDY# signal), the CPU may hang. The IRDY# signal is the initiator ready signal that indicates that the initiator is ready to perform a data transfer.

- In order to access a local region, first toggle the active mode between BYTE/WORD/DWORD, to fit the hardware you are accessing.
- In order to read from a local address, choose **Read from Board**. You will then be asked for the local address from which to read.
- In order to write to a local address, choose **Write to Board**. You will then be asked for the local address to which to write, and the data to be written.

In both reading and writing from the board, the address you supply will be also used to set the base address register.

Enable/Disable Interrupts (Where Available)

This option will appear only if the card was set to open with interrupts. Choosing this item toggles the interrupt status (Enable/Disable). When interrupts are disabled, interrupts that the card generates are not intercepted by the application. If interrupts are generated by the hardware while the interrupts are disabled by the application, the computer may hang.

Access EEPROM Device (Where Available)

The EEPROM access is part of the added functionality for several chipsets (e.g. PLX9050/54/56/9656). It enables reading and writing from the EEPROM located on the development board. The EEPROM is used to hold the configuration of the device, i.e. the initial state of the PCI configuration registers. By writing to the EEPROM you can change the vendor ID and device ID of the device as well as the amount of resources it requests at boot time.
The EEPROM access option provides basic read/write access to the serial configuration EEPROM. This is available only after choosing an active card. This option assumes that the configuration EEPROM has initialized the configuration register.

- In order to read from an EEPROM location, choose **Read a Byte from Serial EEPROM**. You will then be asked for the address of the location from which to read.
- In order to write to an EEPROM location, choose **Write a Byte to Serial EEPROM**.You will then be asked for the address to which to write, and the data to be written.

NOTE:
Resolution of delay time is based on PC timer tick, or approximately 55 milliseconds.

8.4 Creating Your Driver Without Using the PCI Diagnostics Code

1. Add **xxxLIB.C** to your project or your make file.
2. Include xxxlib.h in your driver source code.

> **NOTE:**
> You will find the source code for **xxx_DIAG.EXE** in your **\WinDriver\chip_vendor\chip_name\xxx_diag** directory. Double-click the **dsw** file (which contains the project environment used to compile this code) in this directory to start your MSDEV with the proper settings for a project. You may use this as your skeletal code.

3. Call `Pxxx_Open` at the beginning of your code to get a handle to your card.
4. After locating your card, you may read/write to memory, enable/disable interrupts, access your EEPROM, and more using the following functions (please note that some of these functions are not available to all PCI chipsets or have different prototypes):

   - `xxx_IsAddrSpaceActive`
   - `xxx_GetRevision`
   - `xxx_ReadReg`
   - `xxx_WriteReg`
   - `xxx_ReadSpaceBlock`
   - `xxx_WriteSpaceBlock`
   - `xxx_ReadSpaceByte`
   - `xxx_ReadSpaceWord`
   - `xxx_ReadSpaceDWord`
   - `xxx_WriteSpaceByte`
   - `xxx_WriteSpaceWord`
   - `xxx_WriteSpaceDWord`
   - `xxx_ReadBlock`
   - `xxx_WriteBlock`
   - `xxx_ReadByte`

- `xxx_ReadWord`
- `xxx_ReadDWord`
- `xxx_WriteByte`
- `xxx_WriteWord`
- `xxx_WriteDWord`
- `xxx_IntIsEnabled`
- `xxx_IntEnable`
- `xxx_IntDisable`
- `xxx_DMAOpen`
- `xxx_DMAClose`
- `xxx_DMAStart`
- `xxx_DMAIsDone`
- `xxx_EEPROMRead`
- `xxx_EEPROMWrite`
- `xxx_ReadPCIReg`
- `xxx_WritePCIReg`

5. Call `xxx_Close` before end of code to close your card.

NOTES:

- You may be able to shorten the development process by using one of the sample drivers included with WinDriver as your skeletal code.
- APIs may vary slightly between PCI chips. Please refer to the sample code of the target chipset for specific implementation.

Sample Code

Sample uses of WinDriver for all PCI chipsets are supplied with the WinDriver toolkit.

You may find the WinDriver samples under **\WinDriver\samples** and the WinDriver for PLX/Altera/Marvell/AMCC/QuickLogic/Cypress/STMicroelectronics/TIsamples under **\WinDriver\chip_vendor**. Each directory contains **files.txt** that describes the various samples included.

Each sample is located in its own directory. For your convenience, we have supplied a **dsp** file alongside each **.c** file, so that users of Microsoft's Developers Studio may double click the **dsp** file and have the whole environment ready for compilation. Those using other win32 compilers must include the **.c** files in their stand-alone console projects, and include **xxx_lib.c** in their projects. Linux and Solaris users may use the makefile provided.

You may use the source of the diagnostic program described earlier to learn your particular PCI chipset's API usage.

8.5 WinDriver's Specific PCI Chipset API Function Reference

Use this section as a quick reference to WinDriver's specific PCI API functions.

Advanced users may find more functionality in WinDriver's API.

All the functions outlined in Chapter A, the WinDriver function reference, are implemented in the respective **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

For more detailed information, please refer to the sample code implementation of the target chipset.

8.5.1 xxx_CountCards ()

Returns the number of cards on the PCI bus that match the given VendorID and DeviceID.

This value can then be used when calling `xxx_Open` to select a board to open. Normally, only one board is in the bus, and this function will return 1.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Returns the number of matching PCI cards found.

EXAMPLE

```
nCards = P9054_CountCards( 0x10b5, 0x9054 );
```

8.5.2 xxx_Open()

Used to open a handle to your card. If several cards with identical PCI chips are installed, the specific card to open may be specified by using `xxx_CountCards` before using `xxx_Open`, and then calling open with a specific card number.

If Open is successful, the function returns **True** and a handle to the card.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

TRUE if successful.

EXAMPLE

```
if (!P9054_Open( &hPlx, 0x10b5, 0x9054, 0,
   P9054_OPEN_USE_INT ))

{

  printf("Error opening device\n");

}
```

8.5.3 xxx_Close()

Closes WinDriver device. Must be called when the driver is no longer in use.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

EXAMPLE

```
P9054_Close(hPLX);
```

8.5.4 xxx_IsAddrSpaceActive()

Checks if the specified address space is enabled. The enabled address spaces are determined by the EEPROM, which sets the memory ranges requests at boot time.

Use this function after calling `xxx_Open` to make sure that the address space that your driver is going to use is enabled.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

TRUE if address space is enabled.

EXAMPLE

```
if ( !P9054_IsAddrSpaceActive(hPlx, P9054_ADDR_SPACE2) )
{
  printf ("Address space2 is not active!\n");
}
```

8.5.5 xxx_GetRevision()

Returns your PCI chipset silicon revision.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Returns the silicon revision.

8.5.6 xxx_ReadReg ()

Reads data from a specified register on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Data read from register (for `P9054_ReadReg` only).

8.5.7 xxx_WriteReg ()

Writes data to a specified register on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.8 xxx_ReadSpaceByte()

Reads a byte from address space on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Data read from the board.

8.5.9 xxx_ReadSpaceWord()

Reads a word from address space on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Data read from the board.

8.5.10 xxx_ReadSpaceDWord()

Reads a dword from address space on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Data read from the board.

8.5.11 xxx_WriteSpaceByte()

Writes a byte to address space on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.12 xxx_WriteSpaceWord()

Writes a word to address space on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.13 xxx_WriteSpaceDWord()

Writes a dword to address space on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.14 xxx_ReadSpaceBlock()

Reads a block from address space on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Data read from the board.

8.5.15 xxx_WriteSpaceBlock()

Writes a block to address space on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.16 xxx_ReadByte()

Reads a byte from memory on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Data read from the board.

8.5.17 xxx_ReadWord()

Reads a word from memory on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Data read from the board.

8.5.18 xxx_ReadDWord()

Reads a dword from memory on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Data read from the board.

8.5.19 xxx_WriteByte()

Writes a byte to memory on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.20 xxx_WriteWord()

Writes a word to memory on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.21 xxx_WriteDWord()

Writes a dword to memory on the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.22 xxx_ReadBlock()

Reads a block of memory from the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Data read from the board.

8.5.23 xxx_WriteBlock()

Writes a block of memory to the board.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.24 xxx_IntIsEnabled()

Checks whether interrupts are enabled.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

TRUE if interrupts are already enabled, e.g., if `P9054_IntEnable` was called.

8.5.25 xxx_IntEnable()

Enable interrupt processing.

NOTE:
All PCI chipsets use level-sensitive interrupts. Hence, you must edit the implementation of this function (found in your **\WinDriver\chip_vendor\chip_name \lib\xxx_lib.c** file) to fit your specific hardware.

The comments in this function indicate where changes must be inserted.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

TRUE if successful.

8.5.26 xxx_IntDisable()

Disable interrupt processing.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.27 xxx_DMAOpen()

Initializes the **WD_DMA** structure (see windrvr.h) and allocates a contiguous buffer.

WD_DMA structure

```
typedef struct {
  DWORD hDma;  // handle of dma buffer
  PVOID pUserAddr; // beginning of buffer
  DWORD dwBytes; // size of buffer
  DWORD dwOptions; // allocation options:

               // DMA_KERNEL_BUFFER_ALLOC, DMA_KBUF_BELOW_16M,
               // DMA_LARGE_BUFFER, DMA_ALLOW_CACHE,
               // DMA_KERNEL_ONLY_MAP, DMA_READ_FROM_DEVICE,
               // DMA_WRITE_TO_DEVICE

  DWORD dwPages; // number of pages in buffer
  DWORD hCard; // Handle of relevant card as received from
               // WD_CardRegister()
  WD_DMA_PAGE Page[WD_DMA_PAGES];

} WD_DMA, WD_DMA_V30;
```

The WD_DMA_PAGE structure is defined as follows:

```
typedef struct {
  KPTR pPhysicalAddr; // physical address of page
  DWORD dwBytes;  // size of page
} WD_DMA_PAGE, WD_DMA_PAGE_V30;
```

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

Return Value

Returns TRUE if DMA buffer allocation succeeds.

8.5.28 xxx_DMAClose()

Frees the DMA handle, and frees the allocated contiguous buffer.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.29 xxx_DMAStart()

Start DMA to or from the card.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.30 xxx_IsDMADone()

Used to test if DMA is done. (Use when QuickLogic PBC_DMAStart is called with fBlocking == FALSE.)

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

Return Value

Returns TRUE if DMA transfer has been completed.

8.5.31 xxx_PulseLocalReset()

Sends a reset signal to the card for a period of wDelay milliseconds.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

8.5.32 xxx_EEPROMRead()

Reads data from the EEPROM. Syntax and functionality may vary between different chipsets. Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file for exact syntax and usage.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Returns the data read.

8.5.33 xxx_EEPROMWrite()

Writes data to the EEPROM. Syntax and functionality may vary between different chipsets. Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file for your chipsets exact syntax and usage.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Returns TRUE if EEPROM write succeeds.

8.5.34 xxx_ReadPCIReg ()

Read data from the PCI configuration registers.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

Data read from configuration register.

8.5.35 xxx_WritePCIReg()

Write to the PCI configuration registers.

PROTOTYPE AND PARAMETERS

Please refer to the sample code implementation of the target chipset found in the **\WinDriver\chip_vendor\chip_name\lib\xxx_lib.c** file.

RETURN VALUE

None.

Chapter 9

Advanced Issues

This chapter contains instructions for performing operations that DriverWizard cannot automate. You do not have to read this chapter if you are using a chipset from PLX, Altera, Marvell, AMCC, QuickLogic, Cypress, STMicroelectronics, Texas Instruments and National Semiconductors.

WinDriver includes custom APIs built specifically for these PCI chipset vendors. These APIs save you from needing to learn both the PCI internals and the chipset data sheets. With these APIs, using a DMA function is as simple as calling a function, e.g., `P9054_DMAOpen`, `P9054_DMAStart`, etc.

9.1 Performing DMA

If you are not using a PCI chipset with enhanced support, the next sections will guide you through the steps of performing DMA via WinDriver's API.

You may also refer to `WD_DMALock`[A.2.12] and `WD_DMAUnlock`[A.2.13] in Chapter A.

There are two ways to perform DMA: **Contiguous Buffer DMA** and **Scatter/Gather DMA**. Scatter/Gather DMA is much more efficient than contiguous DMA. This method allows the PCI device to copy memory blocks from different addresses. This means that the transfer can be done directly to/from the user's buffer that is contiguous in virtual memory, but fragmented in the physical memory. If your PCI device does

not support Scatter/Gather, you will need to allocate a physically contiguous memory block, perform the DMA transfer to there, and then copy the data to your own buffer.

The programming of DMA is specific for different PCI devices. Normally, you need to program your PCI device with the Local address (on your PCI device), the Host address (the physical memory address on your PC) and the transfer count (size of block to transfer), and then set the register that initiates the transfer.

9.1.1 Scatter/Gather DMA

Sample DMA Implementation

The following is an outline of a DMA transfer routine for PCI devices that support Scatter/Gather DMA. More detailed examples can be found in:

- **\WinDriver\plx\9054\lib\p9054_lib.c**
- **\WinDriver\plx\9080\lib\p9080_lib.c**
- **\WinDriver\marvell\gt64\lib\gt64_lib.c**

```
BOOL DMA_routine(void *startAddress, DWORD transferCount,
 BOOL fIsRead)

{

  WD_DMA dma;

  int i;

  DWORD dwStatus;

  BZERO (dma);

  dma.pUserAddr = startAddress;

  dma.dwBytes = transferCount;

  dma.dwOptions = fIsRead ? DMA_READ_FROM_DEVICE : DMA_WRITE_TO_DEVICE;

  // Initialization of dma.hCard, value obtained from WD_CardRegister call:
```

```
  dma.hCard = cardReg.hCard;

  // lock region in memory
  dwStatus = WD_DMALock(hWD,&dma);
  if (dwStatus)
  {
    printf("Could not lock down buffer\n");
    return FALSE;
  }
  for(i=0;i!=dma.dwPages;i++)
  {
   // Program the registers for each page of the transfer
   My_DMA_Program_Page(dma.Page[i].pPhysicalAddr,
    dma.Page[i].dwBytes, fDir);
  }
  // write to the register that initiates the DMA transfer
  My_DMA_Initiate();
   // read register that tells when the DMA is done
  while(!My_DMA_Done());
  WD_DMAUnlock(hWD,&dma);
  return TRUE;

}
```

What Should You Implement?

- `My_DMA_Program_Page` – Set the registers on your device that are part of the chained list of transfer addresses.
- `My_DMA_Initiate` – Set the start bit on your PCI device to initiate the DMA.
- `My_DMA_Done` – Read the transfer ended bit on your PCI device.

Scatter/Gather DMA for Buffers Larger than 1 MB

The **WD_DMA** structure holds a list of 256 pages (see `WD_DMA_PAGES` definition in **windrvr.h**). The x86 CPU uses a page size of 4 KB, so 256 pages can hold 256*4 KB = 1 MB. Since the first and last page do not necessarily start (or end) on a 4096 byte boundary, 256 pages can hold 1 MB - 8 KB.

If you need to lock down a buffer larger than 1 MB, i.e., more than 256 pages, you will need the DMA_LARGE_BUFFER option.

When using the DMA_LARGE_BUFFER flag in `WD_DMALock` [A.2.12], dwPages is an input/output parameter. As an input to `WD_DMALock()` call, dwPages equals the maximum number of elements in an array of pages. On return from `WD_DMALock()`, dwPages equals the number of actual physical blocks. The returned dwPages may be smaller, because adjacent pages are returned as one block.

```
BOOL DMA_Large_routine(void *startAddress,
   DWORD transferCount, BOOL fIsRead)
{
  DWORD dwStatus;
  DWORD dwPagesNeeded = transferCount / 4096 + 2;
  // WD_DMA structure already has space for WD_DMA_PAGES
  // number of entries
  WD_DMA *pDma=calloc(sizeof(WD_DMA)+sizeof(WD_DMA_PAGE)*
     (dwPagesNeeded - WD_DMA_PAGES),1);
  pDma->pUserAddr = startAddress;
  pDma->dwBytes = transferCount;
  pDma->dwOptions = DMA_LARGE_BUFFER |
     (fIsRead ? DMA_READ_FROM_DEVICE : DMA_WRITE_TO_DEVICE);
  pDma->dwPages = dwPagesNeeded;
  // Initialization of dma.hCard, value obtained from WD_CardRegister call:
  dma.hCard = cardReg.hCard;
  // lock region in memory
  dwStatus = WD_DMALock(hWD,pDma);
  if (dwStatus)
  {
    printf("Could not lock down buffer\n");
  }
  else
  {
   // the returned pDma->dwPages may be smaller

   // the rest is the same as in the DMA_routine()
   // free the WD_DMA structure allocated
  }
  free (pDma);
}
```

9.1.2 Contiguous Buffer DMA

More detailed examples can be found at:

- **WinDriver\QuickLogic\lib\pbclib.c**
- **WinDriver\amcc\lib\amcclib.c**

Read Sequence

The following is a read sequence from the card to the motherboard's memory.

```
{
  WD_DMA dma;
  DWORD dwStatus;
  BZERO (dma);
  // allocate the DMA buffer (10000 bytes)
  dma.pUserAddr = NULL;
  dma.dwBytes = 10000;
  dma.dwOptions = DMA_KERNEL_BUFFER_ALLOC |
     (fIsRead ? DMA_READ_FROM_DEVICE : DMA_WRITE_TO_DEVICE);
  // Initialization of dma.hCard, value obtained from WD_CardRegister call:
  dma.hCard = cardReg.hCard;
  dwStatus = WD_DMALock(hWD, &dma);
  if (dwStatus)
  {
    printf("Failed allocating kernel buffer for DMA\n");
    return FALSE;
  }
  // transfer data from the card to the buffer
  My_Program_DMA_Transfer(dma.Page[0].pPhysicalAddr,
     dma.Page[0].dwBytes, fDir);
  // Wait for transfer to end
  while(!My_Dma_Done());
  // now the data is the buffer, and can be used
  UseDataReadFromCard(dma.pUserAddr);
  // release the buffer
  WD_DMAUnlock(hWD,&dma);
  return TRUE;
}
```

Write Sequence

The following is a write sequence from the motherboard's memory to the card.

```
{
```

```
  WD_DMA dma;
  DWORD dwStatus;
  BZERO (dma);
  //allocate the DMA buffer (10000 bytes)
  dma.pUserAddr = NULL;
  dma.dwBytes = 10000;
  dma.dwOptions = DMA_KERNEL_BUFFER_ALLOC |
     (fIsRead ? DMA_READ_FROM_DEVICE : DMA_WRITE_TO_DEVICE);
  // Initialization of dma.hCard, value obtained from WD_CardRegister call:
  dma.hCard = cardReg.hCard;
  dwStatus = WD_DMALock(hWD, &dma);
  if (dwStatus)
  {
    printf("Failed allocating kernel buffer for DMA\n");
    return FALSE;
  }
  // prepare data into buffer
  PrepareDataInBuffer(dma.pUserAddr);
  // transfer data from the buffer to the card
  My_Program_DMA_Transfer(dma.Page[0].pPhysicalAddr,
   LocalAddr);
  // Wait for transfer to end
  while(!My_Dma_Done());
  // release the buffer
  WD_DMAUnlock(hWD,&dma);
  return TRUE;
}
```

9.1.3 Performing DMA on SPARC

SPARC on Solaris supports DVMA (Direct Virtual Memory Access). Platforms that support DVMA perform transfers by providing the device with a virtual address rather than a physical address. With this memory access method, the platform translates device accesses to the provided virtual address into the proper physical addresses using a type of Memory Management Unit (MMU). The device transfers to and from a contiguous virtual image that can be mapped to dis-contiguous physical pages. Devices that operate in these platforms do not require Scatter/Gather DMA capability.

9.2 Handling Interrupts

Interrupts can be handled easily via DriverWizard. We recommend that you allow DriverWizard to generate the interrupt code for you, by defining (or auto-detecting) your hardware's interrupts. Use the following section to understand the code DriverWizard generates for you or to write your own interrupt handler.

9.2.1 General – Handling an Interrupt

1. A thread is created to handle incoming interrupts.
2. The thread runs an infinite loop that waits for an interrupt to occur.
3. When an interrupt occurs, the driver's interrupt handler code is called.
4. When the interrupt handler code returns, the wait loop continues.

The `WD_IntWait` function [A.3.3] puts the thread to sleep until an interrupt occurs. There is no CPU consumption while waiting for an interrupt. Once an interrupt occurs, it is first handled by the WinDriver kernel, then the `WD_IntWait` wakes up the interrupt handler thread and returns.

Since your interrupt thread runs in user mode, you may call any Windows API function, including file handling and GDI functions.

Simple interrupt handler routine for edge-triggered interrupts (normally ISA/EISA cards):

```
// interrupt structure
WD_INTERRUPT Intrp;
DWORD DLLCALLCONV wait_interrupt (PVOID pData)
{
 printf ("Waiting for interrupt");
 for (;;)
 {
  WD_IntWait (hWD, &Intrp);
  if (Intrp.fStopped)
    break; // WD_IntDisable called by parent

  // call your interrupt routine here
    printf ("Got interrupt %d\n", Intrp.dwCounter);
 }
```

```
  return 0;
}
void Install_interrupt()
{
  BZERO(Intrp);
  // put interrupt handle returned by WD_CardRegister
  Intrp.hInterrupt = cardReg.Card.Item[0].I.Int.hInterrupt;
  // no kernel transfer commands to do upon interrupt
  Intrp.Cmd = NULL;
  Intrp.dwCmds = 0;
  // no special interrupt options
  Intrp.dwOptions = 0;
  WD_IntEnable(hWD, &Intrp);
  if (!Intrp.fEnableOk)
  {
    printf ("Failed enabling interrupt\n");
    return;
  }
  printf ("starting interrupt thread\n");
  thread_handle = CreateThread (0, 0x1000,
    wait_interrupt, NULL, 0, &thread_id);
  // call your driver code here
  WD_IntDisable (hWD, &Intrp);
  WaitForSingleObject(thread_handle, INFINITE);
}
```

Simplified Interrupt Handling Using windrvr_int_thread.c

WinDriver provides the following convenience functions to further simplify the interrupt handling: `InterruptEnable` [A.2.14] and `InterruptDisable` [A.2.15]. Both functions are implemented in **\WinDriver\src\windrvr_int_thread.c** Please refer to the implementation of these functions for a better understanding of how this mechanism operates.
In the following example, we rewrote the code from Section 9.2.1 to use these convenience wrapper functions. This code was extracted from the sample program int_io.c, which can be found under **\WinDriver\samples\int_io**. Please refer to this file for the full listing.

```
VOID DLLCALLCONV interrupt_handler (PVOID pData)
{
   WD_INTERRUPT * pIntrp = (WD_INTERRUPT *) pData;
```

```
   // do your interrupt routine here
   printf ("Got interrupt %d\n", pIntrp->dwCounter);
}

...

int main()
{
   HANDLE hWD;
   WD_CARD_REGISTER cardReg;
   // interrupt structure
   WD_INTERRUPT *pIntrp;
   HANDLE thread_handle;
   ...
   hWD = WD_Open();
   BZERO(cardReg);
   cardReg.Card.dwItems = 1;
   cardReg.Card.Item[0].item = ITEM_INTERRUPT;
   cardReg.Card.Item[0].fNotSharable = TRUE;
   cardReg.Card.Item[0].I.Int.dwInterrupt = MY_IRQ;
   cardReg.Card.Item[0].I.Int.dwOptions = 0;
   ...
   WD_CardRegister (hWD, &cardReg);
   ...
   pIntrp = malloc(sizeof(WD_INTERRUPT));
   BZERO(*pIntrp);
   pIntrp->hInterrupt =
      cardReg.Card.Item[0].I.Int.hInterrupt;
   printf ("starting interrupt thread\n");
   // this calls WD_IntEnable() and creates an interrupt
   // handler thread

   ...
   dwStatus = InterruptEnable(&thread_handle, hWD, pIntrp,
       interrupt_handler, pIntrp))
   if (dwStatus)
     {
       printf ("failed enabling interrupt Status 0x%x - %s\n",
            dwStatus, Stat2Str(dwStatus));
     }
   else
     {
      // call your driver code here
      printf ("Press Enter to uninstall interrupt\n");
```

```
      fgets(line, sizeof(line), stdin);

      // this calls WD_IntDisable()
      InterruptDisable(thread_handle);
    }
  WD_CardUnregister(hWD, &cardReg);
  free(pIntrp);
  ....
}
```

In the above code, the function `interrupt_handler` serves as our interrupt handler, invoked once for every interrupt that occurs. In the simplified code for setting up interrupt handling, we call `InterruptEnable` [A.2.14]. This function spawns a thread, which in turn calls the function `interrupt_handler`. A pointer to this function is passed as the fourth parameter to `InterruptEnable`. Each time an interrupt occurs, the data pData, specified by the fifth parameter, is passed into the function.

9.2.2 ISA/EISA and PCI Interrupts

Generally, ISA/EISA interrupts are edge triggered, in contrast to PCI interrupts, which are level sensitive. This has many implications for how the interrupt handler routine is written.

Edge-triggered interrupts are generated once, when the physical interrupt signal goes from low to high. Therefore, exactly one interrupt is generated. This makes the Windows operating system call the WinDriver kernel interrupt handler that released the thread waiting on the `WD_IntWait` function [A.3.3]. No special action is needed in order to acknowledge this interrupt.

Level-sensitive interrupts are generated as long as the physical interrupt signal is high. If the interrupt signal is not lowered by the end of the interrupt handling by the kernel, the operating system will call the WinDriver kernel interrupt handler again, causing the PC to hang! To prevent such a situation, the interrupt must be acknowledged by the WinDriver kernel interrupt handler.

Transfer Commands at Kernel Level (Acknowledging the Interrupt)

Usually, interrupt handlers for PCI cards (level-sensitive interrupt handlers) need to perform transfer commands at the kernel to lower the interrupt level (acknowledge

the interrupt). The transfer commands should write to run-time registers of the PCI card, thus clearing a hardware interrupt.

To pass transfer commands to be performed in the WinDriver kernel interrupt handler before `WD_IntWait` [A.3.3] returns, you must prepare an array of commands (**WD_Transfer** structure), and pass it to the `WD_IntEnable` function [A.3.2].

For example, suppose the interrupt must be cleared by writing a 0 to interrupt command-status register, and this register is mapped to IO port dwAddr, then you could write:

```
WD_TRANSFER trans[2];
BZERO(trans);
trans[0].cmdTrans = RP_DWORD; // Read Port Dword
// Set address of IO port to write to:
trans[0].dwPort = dwAddr;
trans[1].cmdTrans = WP_DWORD; // Write Port Dword
// address of IO port to write to
trans[1].dwPort = dwAddr;
// the data to write to the IO port
trans[1].Data.Dword = 0;
Intrp.dwCmds = 2;
Intrp.Cmd = trans;
Intrp.dwOptions =
     INTERRUPT_LEVEL_SENSITIVE | INTERRUPT_CMD_COPY;
WD_IntEnable(hWD, &Intrp);
```

This sample performs a DWORD read command from the I/O address dwAddr, then writes to the same I/O port a value of "0".

The INTERRUPT_CMD_COPY option is used to retrieve the value read by the first transfer command, before the write command is issued. This is useful when you need to read the value of a register, and then write to it to lower the interrupt level. If you try to read this register after `WD_IntWait` [A.3.3] returns, it will already be "0" because the write transfer command was issued at kernel level.

```
DWORD DLLCALLCONV wait_interrupt(PVOID pData)
{
   printf("Waiting for interrupt\n");
   for (;;)
   {
      WD_TRANSFER trans[2];
      Intrp.dwCmds = 2;
      Intrp.Cmd = trans;
      WD_IntWait(hWD, &Intrp);
```

```
      if (Intrp.fStopped)
        break; // WD_IntDisable called by parent

      // call your interrupt routine here
        printf("Got interrupt %d. Value of register read %x\n",
          Intrp.dwCounter, trans[0].Data.Dword);
   }
   return 0;
}
```

Study the implementation of the interrupt handling in the **\WinDriver\src\windrvr_int_thread.c** file, and see that it uses code similar to that used above.

Improving the Interrupt Handling Rate on VxWorks

WinDriver for VxWorks (a.k.a. DriverBuilder) implements a call-back routine, which, if set by the user, is executed immediately when an interrupt is received, thus enabling you to speed up interrupt acknowledgment and processing. This routine is not needed on Windows 98/Me/NT/2000/XP/Server 2003, Linux and Solaris, since you can use the Kernel PlugIn feature to improve the interrupt handling rate on these platforms. See Section 11 or `http://www.jungo.com/kpi.html` for more information about the Kernel PlugIn.

To use the `windrvr_isr` routine:

1. Include the following declaration in your code:

   ```
   int (__cdecl *windrvr_isr)(void);
   ```

2. Set `windrvr_isr` to point to the interrupt handler routine that you wish to have performed immediately upon the arrival of an interrupt. For example:

   ```
   int __cdecl my_isr(void)
   {
      // Add code here in order to verify that the ISR is called.
      return TRUE; // If TRUE, continue regular handling of WinDriver;
                   // If FALSE, exit ISR.
   }

   extern int (__cdecl *windrvr_isr)(void);

   // after calling drvrInit()
   windrvr_isr = my_isr;
   ```

9.2.3 Interrupts in Windows CE

Windows CE uses a logical interrupt scheme rather than the physical interrupt number. It maintains an internal kernel table that maps the physical IRQ number to the logical IRQ number. Device drivers are expected to use the logical interrupt number when requesting interrupts from Windows CE. In this context, there are two approaches to interrupt mapping:

- In most of the x86 or MIPS platforms, all the physical interrupts except for some reserved ones are statically mapped using this simple mapping:

  logical interrupt = SYSINTR_FIRMWARE + physical interrupt

  Calling **WD_CardRegister** with the **INTERRUPT_CE_INT_ID** flag set, instructs WinDriver to follow this mapping. Otherwise, when **INTERRUPT_CE_INT_ID** flag is cleared, the developer must provide the mapped logical interrupt. Note that if you want to use a reserved interrupt value, you should modify this static map according to the following paragraph.

- On other platforms, with no such mapping, the developer should do one of the following:

  1. **NOTE:**
     This option can only be performed by the platform builder.

     Statically map the physical IRQ to a logical interrupt, and call **WD_CardRegister** with the logical interrupt and with the **INTERRUPT_CE_INT_ID** flag set. The static interrupt map is in the file **CFWPC.C** (located in the **%_TARGETPLATROOT%\KERNEL\HAL** directory).

     You will then need to rebuild the Windows CE image **NK.BIN** and download the new executable onto your target platform.

     Static mapping is helpful also in the case of using reserved interrupt mapping. Suppose your platform static mapping is:

     – **IRQ0**: Timer Interrupt
     – **IRQ2**: Cascade interrupt for the second PIC
     – **IRQ6**: The floppy controller
     – **IRQ7**: LPT1 (because the PPSH does not use interrupts)
     – **IRQ9**
     – **IRQ13**: The numeric coprocessor

An attempt to initialize and use any of these interrupts will fail. However, you may want to use one or more of these interrupts on occasion, such as when you do not want to use the PPSH, but you want to reclaim the parallel port for some other purpose.

To solve this problem, simply modify the file **CFWPC.C** (located in the **%_TARGETPLATROOT%\KERNEL\HAL** directory) to include code, as shown below, that sets up a value for interrupt 7 in the interrupt mapping table.

```
SETUP_INTERRUPT_MAP(SYSINTR_FIRMWARE+7,7);
```

Suppose you have a PCI card which was assigned IRQ9. Since WinCE does not map this interrupt by default, you will not be able to receive interrupts from this card. In this case, you will need to insert a similar entry for IRQ9.

```
SETUP_INTERRUPT_MAP(SYSINTR_FIRMWARE+9,9);
```

2. (On ARM platforms only) Register the device with the PCI bus driver, and call **WD_CardRegister** with the logical interrupt and with the **INTERRUPT_CE_INT_ID** flag cleared. Following this method will cause the PCI bus driver to perform the IRQ mapping and direct WinDriver to use it.

   The following registry example shows how to register your device with the PCI bus driver (can be added to your Platform.reg file).

```
[HKEY_LOCAL_MACHINE\Drivers\BuiltIn\PCI\Template\MyCard]
"Class"=dword:04
"SubClass"=dword:01
"ProgIF"=dword:00
"VendorID"=multi_sz:"1234","1234"
"DeviceID"=multi_sz:"1111","2222"
```

   For more information, refer to MSDN Library, under PCI Bus Driver Registry Settings section.

9.3 USB Control Transfers

9.3.1 USB Data Exchange

The USB standard supports two kinds of data exchange between the host and the device:

Functional data exchange is used to move data to and from the device. There are three types of data transfers: Bulk, Interrupt, and Isochronous transfers.

Control exchange is used to configure a device when it is first attached and can also be used for other device-specific purposes, including control of other pipes on the device. Control exchange takes place via a control pipe, mainly the default Pipe 0, which always exists.

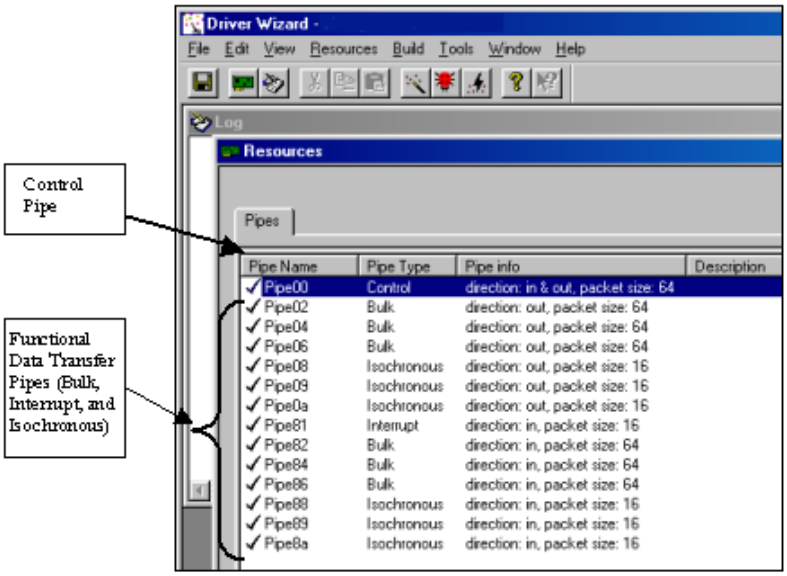


Figure 9.1: USB Data Exchange

9.3.2 More About the Control Transfer

The control transaction always begins with a setup stage. The setup stage is followed by zero or more control data transactions (data stage) that carry the specific information for the requested operation, and finally a status transaction completes the control transfer by returning the status to the host.

During the setup stage, an 8-byte setup packet is used to transmit information to the control endpoint of the device. The setup packet's format is defined by the USB specification.

A control transfer can be a read transaction or a write transaction. In a read transaction the setup packet indicates the characteristics and amount of data to be read from the device. In a write transaction the setup packet contains the command sent (written) to the device and the number of control data bytes that will be sent to the device in the data stage.

Refer to Figure 9.2 (taken from the USB specification) for a sequence of read and write transactions.
'(in)' indicates data flow from the device to the host.
'(out)' indicates data flow from the host to the device.

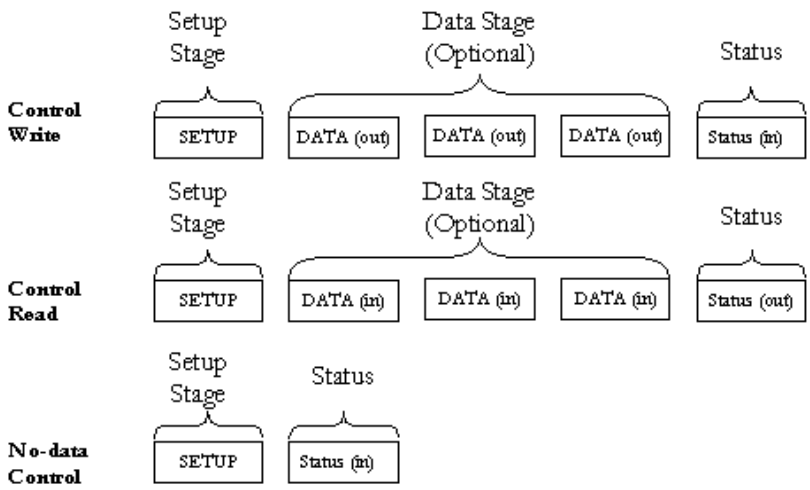


Figure 9.2: USB Read and Write

9.3.3 The Setup Packet

The setup packets (combined with the control data stage and the status stage) are used to configure and send commands to the device. Chapter 9 of the USB specification defines standard device requests. USB requests such as these are sent from the host to the device, using setup packets. The USB device is required to respond properly to these requests. In addition, each vendor may define device-specific setup packets to perform device-specific operations. The standard setup packets (standard USB device

requests) are detailed below. The vendor's device-specific setup packets are detailed in the vendor's data book for each USB device.

9.3.4 USB Setup Packet Format

The table below shows the format of the USB setup packet. For more information, please refer to the USB specification at `http://www.usb.org`.

Byte	Field	Description
0	bmRequest Type	Bit 7: Request direction (0=Host to device - Out, 1=Device to host - In). Bits 5-6: Request type (0=standard, 1=class, 2=vendor, 3=reserved). Bits 0-4: Recipient (0=device, 1=interface, 2=endpoint,3=other).
1	bRequest	The actual request (see next table).
2	wValueL	A word-size value that varies according to the request. For example, in the CLEAR_FEATURE request the value is used to select the feature, in the GET_DESCRIPTOR request the value indicates the descriptor type and in the SET_ADDRESS request the value contains the device address.
3	wValueH	The upper byte of the Value word.
4	wIndexL	A word-size value that varies according to the request. The index is generally used to specify an endpoint or an interface.
5	wIndexH	The upper byte of the Index word.
6	wLengthL	A word-size value that indicates the number of bytes to be transferred if there is a data stage.
7	wLengthH	The upper byte of the Length word.

9.3.5 Standard Device Request Codes

The table below shows the standard device request codes.

bRequest	Value
GET_STATUS	0
CLEAR_FEATURE	1
Reserved for future use	2
SET_FEATURE	3
Reserved for future use	4
SET_ADDRESS	5
GET_DESCRIPTOR	6
SET_DESCRIPTOR	7
GET_CONFIGURATION	8
SET_CONFIGURATION	9
GET_INTERFACE	10
SET_INTERFACE	11
SYNCH_FRAME	12

9.3.6 Setup Packet Example

This example of a standard USB device request illustrates the setup packet format and its fields. The setup packet is in Hex format.

The following setup packet is for a control read transaction that retrieves the device descriptor from the USB device. The device descriptor includes information such as USB standard revision, vendor ID and product ID.

GET_DESCRIPTOR (Device) Setup Packet

80	06	00	01	00	00	12	00

Setup packet meaning:

Byte	Field	Value	Description
0	BmRequest Type	80	8h=1000b bit 7=1 -> direction of data is from device to host. 0h=0000b bits 0..1=00 -> the recipient is the device.
1	bRequest	06	The Request is GET_DESCRIPTOR.
2	wValueL	00	
3	wValueH	01	The descriptor type is device (values defined in USB spec).
4	wIndexL	00	The index is not relevant in this setup packet since there is only one device descriptor.
5	wIndexH	00	
6	wLengthL	12	Length of the data to be retrieved: 18(12h) bytes (this is the length of the device descriptor).
7	wLengthH	00	

In response, the device sends the device descriptor data. A device descriptor of Cypress EZ-USB Integrated Circuit is provided as an example:

Byte No.	0	1	2	3	4	5	6	7	8	9	10
Content	12	01	00	01	ff	ff	ff	40	47	05	80

Byte No.	11	12	13	14	15	16	17
Content	00	01	00	00	00	00	01

As defined in the USB specification, byte 0 indicates the length of the descriptor, bytes 2-3 contain the USB specification release number, byte 7 is the maximum packet size for endpoint 00, bytes 8-9 are the Vendor ID, bytes 10-11 are the Product ID, etc.

9.4 Performing Control Transfers with WinDriver

WinDriver allows you to easily send and receive control transfers on Pipe00, while using DriverWizard to test your device. You can either use the API generated by

DriverWizard [5] for your hardware, or directly call the WinDriver `WDU_Transfer` [A.6.7] function from within your application.

9.4.1 Control Transfers with DriverWizard

1. Choose **Pipe00** and click **Read/Write To Pipe**.
2. You can either enter a custom setup packet, or use a standard USB request.
   - For a custom request: enter the required setup packet fields. For a write transaction that includes a data stage, enter the data in the **Write to pipe data (Hex)** field. Click **Read From Pipe** or **Write To Pipe** according to the required transaction (see Figure 9.3).

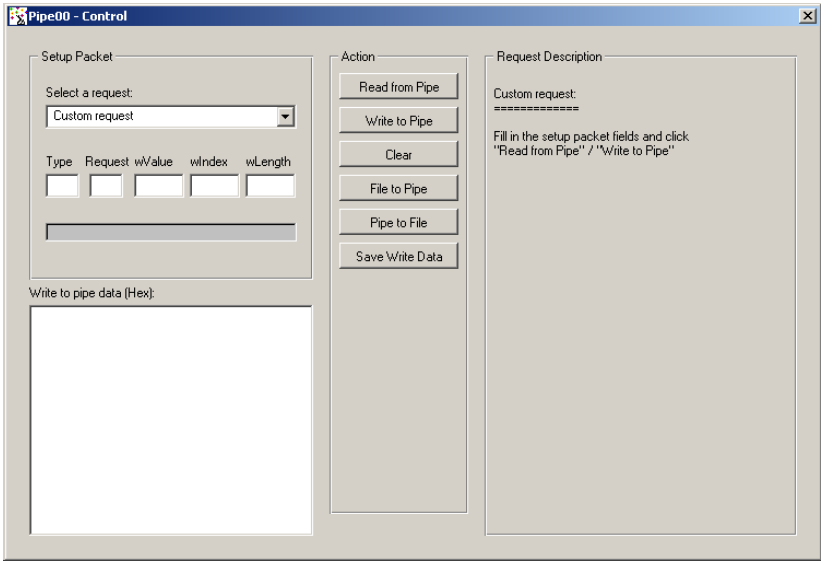


Figure 9.3: Custom Request

   - For a standard USB request: select a USB request from the request list, which includes **GET_CONFIGURATION, GET_DESCRIPTOR CONFIGURATION, GET_DESCRIPTOR DEVICE** and more (see Figure 9.4). Each standard USB request is described on the right hand of the dialog box when selected.

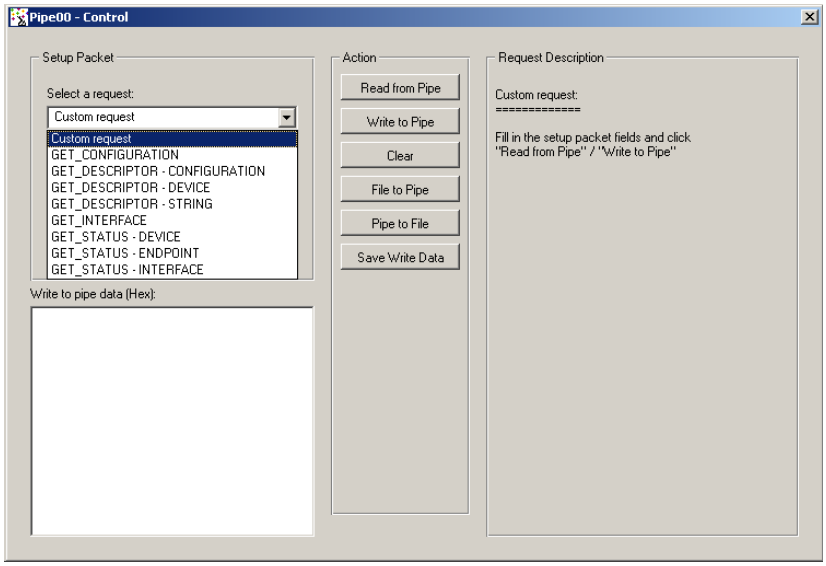


Figure 9.4: Request List

3. The device descriptor data retrieved from the device using the standard USB request **GET_DESCRIPTOR DEVICE** can be seen in the DriverWizard log screen (see Figure 9.5).

9.4.2 Control Transfers with WinDriver API

To perform a read or write transaction on the control pipe, you can either use the API generated by DriverWizard for your hardware, or directly call the WinDriver `WDU_Transfer` [A.6.7] function from within your application.

Fill the setup packet in the BYTE SetupPacket[8] array and call these functions to send setup packets on Pipe00 and to retrieve control and status data from the device.

- The following sample demonstrates how to fill the SetupPacket[8] variable with a GET_DESCRIPTOR setup packet:

```
setupPacket[0] = 0x80;  //BmRequstType
setupPacket[1] = 0x6;   //bRequest [0x6 == GET_DESCRIPTOR]
setupPacket[2] = 0;     //wValue
```

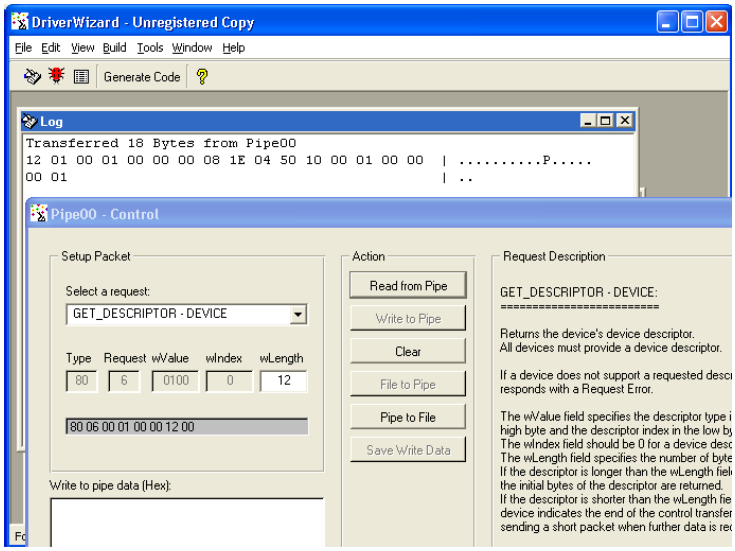


Figure 9.5: Log Screen

```
setupPacket[3] = 0x1;  //wValue [Descriptor Type: 0x1 == DEVICE ]
setupPacket[4] = 0;    //wIndex
setupPacket[5] = 0;    //wIndex
setupPacket[6] = 0x12; //wLength [Size for the returned buffer]
setupPacket[7] = 0;    //wLength
```

- The following sample demonstrates how to send a setup packet to the control pipe (a GET instruction; the device will return the information requested in the pBuffer variable):

```
WDU_TransferDefaultPipe(hDev, TRUE, 0, pBuffer, dwSize,
   bytes_transferred, &setupPacket[0], 10000);
```

- The following sample demonstrates how to send a setup packet to the control pipe (a SET instruction):

```
WDU_TransferDefaultPipe(hDev, FALSE, 0, NULL, 0, bytes_transferred,
   &setupPacket[0], 10000);
```

For further information regarding `WDU_TransferDefaultPipe`, please refer to Section A.6.9, and for further information regarding `WDU_Transfer`, please refer to Section A.6.7,

9.5 Support for 64-bit Operating Systems

NOTE:
Starting from version 6.02, WinDriver supports Solaris 8.0/9.0 64-bit kernels. Refer to Section 4.1.5 for the full list of Solaris platforms supported by WinDriver.

- WinDriver for Solaris 64-bit kernel supports both 32-bit and 64-bit applications. Note that 64-bit applications are more efficient.
- In general, DWORD is unsigned long. On 32-bit applications DWORD is a 32-bit variable and on 64-bit applications DWORD is a 64-bit variable. The exception is the transfer commands used in the `WD_Transfer` struct. In `WD_Transfer` struct DWORD stands for 32-bit and QWORD stands for 64-bit regardless of how the application was compiled. This exception was made for backward code compatibility and for compatibility between 32-bit and 64-bit applications.
- On 64-bit operating systems, 64-bit data transfers are performed directly. There is no need to use WinDriver `WD_Transfer` [A.6.7] function.

Chapter 10

Improving Performance

10.1 Overview

Once your user-mode driver has been written and debugged, you might find that certain modules in your code do not operate fast enough (for example: an interrupt handler or accessing I/O-mapped regions). If this is the case, try to improve performance in one of the following ways:

- Improve the performance of your user-mode driver.
- Move the performance-critical parts of your code into WinDriver's Kernel PlugIn.

NOTE:
Kernel PlugIn is of great use in PCI applications (e.g interrupt handling), and is not supported in USB applications.
Kernel PlugIn is not implemented under Windows CE and VxWorks,since there is no separation between kernel mode and user mode in these operating systems. As such, top performance can be achieved without using the Kernel PlugIn.

Use the following checklist to determine how to best improve the performance of your driver.

10.1.1 Performance Improvement Checklist

The following checklist will help you determine how to improve the performance of your driver:

Problem	**Solution**
1. ISA Card – accessing an I/O-mapped range on the card	Try to convert multiple calls to `WD_Transfer` to one call to `WD_MultiTransfer` (see Section 10.2.2 later in this chapter). • If this does not solve the problem, handle the I/O at kernel mode by writing a Kernel PlugIn (see the Kernel PlugIn-related chapters for details, Chapters 11 and 12).
2. PCI Card – accessing an I/O-mapped range on the card	First, try to change the card from I/O-mapped to memory-mapped by changing bit 0 of the address space PCI configuration register to 0 and then try the solutions for problem #3. You will probably need to reprogram the EPROM to initialize BAR0/1/2/3/4/5 registers with different values. • If this is not possible, try the solutions suggested for problem #1. • If this does not solve the problem, handle the I/O in kernel mode by writing a Kernel PlugIn (see the Kernel PlugIn-related chapters for details, Chapters 11 and 12).
3. Accessing a memory-mapped range on the card	Try to access memory without using `WD_Transfer`, and instead using direct access to memory-mapped regions (see Section 10.2.1 later in this chapter). • If this does not solve the problem, then there is a hardware design problem. You will not be able to increase performance by using any software design method, writing a Kernel PlugIn, or even by writing a full kernel driver.

4. Interrupt latency – missing interrupts, receiving interrupts too late	Handle the interrupts in kernel mode by writing a kernel PlugIn (see the Kernel PlugIn-related chapters for details, Chapters 11 and 12).
5. USB devices – slow transfer rate	To increase the transfer rate, try to increase the packet size by choosing a different device configuration.

10.2 Improving the Performance of a User-Mode Driver

As a general rule, transfers to memory-mapped regions are faster than transfers to I/O-mapped regions. The reason is that WinDriver enables the user to directly access the memory-mapped regions without calling the `WD_Transfer` function.

10.2.1 Using Direct Access to Memory-Mapped Regions

After registering a memory-mapped region using `WD_CardRegister` [A.2.8], two results are returned: dwTransAddr and dwUserDirectAddr.
The dwTransAddr result should be used as a base address when calling `WD_Transfer` [A.2.10] to read or write to the memory region. A more efficient way to perform memory transfers would be to use dwUserDirectAddr directly as a pointer, and then use it to access the memory-mapped range. This method enables you to read/write data to your memory-mapped region without any function calls overhead, i.e., zero performance degradation.

Whether you use `WD_Transfer` or dwUserDirectAddr, it is important to align the base address according to the size of the data type, especially when issuing string transfer commands. Otherwise, the transfers are split into smaller portions.
The easiest way to align data is to use basic types when defining a buffer, i.e.

```
BYTE buf[len];    // for BYTE transfers - not aligned
WORD buf[len];    // for WORD transfers - aligned on 2-byte boundary
UINT32 buf[len];  // for DWORD transfers - aligned on 4-byte boundary
UINT64 buf[len];  // for QWORD transfers - aligned on 8-byte boundary
```

10.2.2 Accessing I/O-Mapped Regions

The only way to transfer data on I/O-mapped regions is by calling a `WD_Transfer` function [A.2.10]. If you need to transfer a large buffer, the String (Block) Transfer

commands can be used. For example, `RP_SBYTE`, the Read Port String Byte command, will transfer a buffer of bytes to the I/O port. In such cases, the function calling overhead is negligible when compared to the block transfer time.

In a case where many short transfers are called, the function calling overhead may increase to such an extent that it causes overall performance degradation. This might happen if you need to call `WD_Transfer` more than 20,000 times per second.

Take for example a case in which a 1-MB block of data needs to be transferred word-by-word, and in each word that is transferred first the LOW byte is transferred to I/O port 0x300 and then the HIGH byte is transferred to I/O port 0x301.

Normally this would mean calling `WD_Transfer` 1 million times—byte 0 to port 0x300, byte 1 to port 0x301, byte 2 to port 0x300, byte 3 to port 0x301, etc. (`WP_BYTE` – Write Port Byte).

A quick way to save 50% of the function call overhead would be to call `WD_Transfer` with a `WP_SBYTE` (Write Port String Byte), with two bytes at a time. The first call would transfer byte 0 and byte 1 to ports 0x300 and 0x301, the second call would transfer byte 2 and byte 3 to ports 0x300 and 0x301, etc. This way, `WD_Transfer` will only be called 500,000 times to transfer the block.

The third method would be to prepare an array of 1000 `WD_TRANSFER` commands. Each command in the array would have a `WP_SBYTE` command that transfers two bytes at a time. Then you would call `WD_MultiTransfer` [A.2.11] with a pointer to the array of `WD_TRANSFER` commands. In one call to `WD_MultiTransfer`, 2000 bytes of data will be transferred. You will need only 500 calls to `WD_Transfer` to transfer the 1 MB of data. This is only 0.05% of the original number of calls to `WD_Transfer`. The trade-off in this case is between the number of calls to `WD_Transfer` and the memory that is used to setup the 500 `WD_TRANSFER` commands.

10.2.3 Performing 64-bit Data Transfers

NOTE:
The ability to perform actual 64-bit transfers is dependant on the existence of support for such transfers by the hardware, CPU, bridge, etc, and can be affected by any of these or their specific combination.

WinDriver supports 64-bit PCI data transfer on x86 platforms running 32-bit operating systems. If your PCI hardware (device and bus) is 64-bit, this feature will enable you

to utilize your hardware's broader bandwidth, even though your host operating system is only 32-bit.

This innovative technology makes possible data transfer rates previously unattainable on such platforms. Drivers developed using WinDriver will attain significantly better performance results than drivers written with the DDK or other driver development tools. To date, such tools do not enable 64-bit data transfer on x86 platforms running 32-bit operating systems. Jungo's benchmark performance testing results for 64-bit data transfer indicate a significant improvement of data transfer rates compared to 32-bit data transfer, guaranteeing that drivers developed with WinDriver and KernelDriver will achieve far better performance than 32-bit data transfer normally allows.

To perform 64-bit data transfers, please refer to `WD_Transfer()` function reference in Section A.2.10.

NOTE:
On 64-bit operating systems, 64-bit data transfers are performed directly. There is no need to use `WD_Transfer()`.

Chapter 11

Understanding the Kernel PlugIn

This chapter provides a description of the Kernel PlugIn feature of WinDriver.

NOTE:
The Kernel PlugIn can be very helpful for PCI/ISA driver development. It is does not support the USB API used beginning with version 6.0 of WinDriver.

11.1 Background

The creation of drivers in user mode imposes a fair amount of function call overhead from the kernel to user mode, which may cause performance to drop to an unacceptable level. In such cases, the Kernel PlugIn feature allows critical sections of the driver code to be moved to the kernel while keeping most of the code intact. Using WinDriver's Kernel PlugIn feature, your driver will operate without any degradation in performance.

The advantages of writing a Kernel PlugIn driver over a kernel-mode driver are:

- All the driver code is written and debugged in user mode.
- The code segments that are moved to kernel mode remain essentially the same and therefore no kernel debugging is needed.

- The parts of the code that will run in the kernel through the Kernel PlugIn are platform independent and therefore will run on every platform supported by WinDriver. A standard kernel-mode driver will run only on the platform it was written for.

Using WinDriver's Kernel PlugIn feature, your driver will operate without any performance degradation.

11.2 Do I Need to Write a Kernel PlugIn?

Not every performance problem requires you to write a Kernel PlugIn. Some performance problems can be solved in the user-mode driver by better utilization of the features that WinDriver provides. For further information, please refer to Chapter 10.

11.3 What Kind of Performance Can I Expect?

Since you can write your own interrupt handler in the kernel with the WinDriver Kernel PlugIn, you can expect to handle about 100,000 interrupts per second without missing any one of them.

11.4 Overview of the Development Process

Using the WinDriver Kernel PlugIn, the developer first develops and debugs the driver in user mode with the standard WinDriver tools. After identifying the performance-critical parts of the code (such as the interrupt handling or access to I/O-mapped memory ranges), the developer can drop these parts of the code into WinDriver's Kernel PlugIn, which runs in kernel mode, thereby eliminating calling overhead. This unique feature allows the developer to start with quick and easy development in user mode, and progress to performance oriented code only where needed. This unique architecture saves time and provides for virtually zero performance degradation.

11.5 The Kernel PlugIn Architecture

11.5.1 Architecture Overview

A driver written in user mode uses WinDriver's functions (`WD_xxx` functions) for device access. If a certain function in user mode needs to achieve kernel performance (the interrupt handler, for example), that function is moved to the WinDriver Kernel PlugIn. Generally it should be possible to move code that uses `WD_xxx` calls from the user mode to the kernel without modifications, seeing the same WinDriver API is supported both in the user mode and in the Kernel PlugIn.

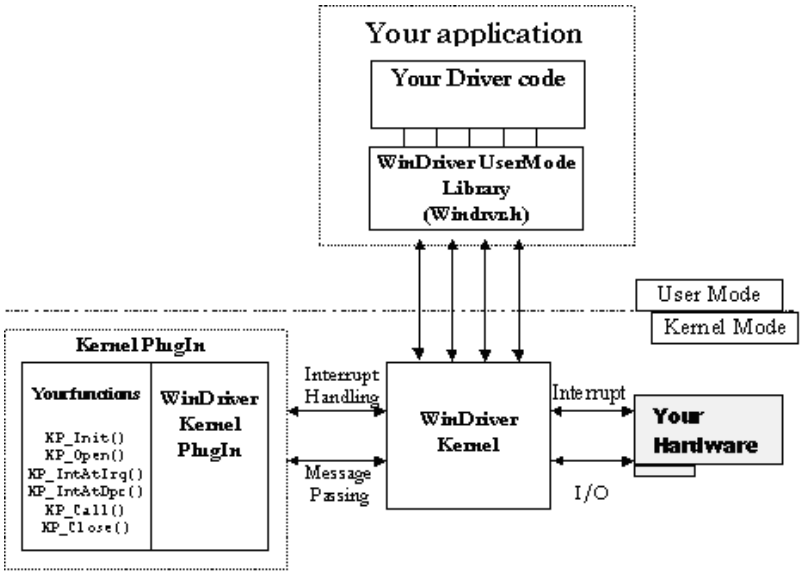


Figure 11.1: Kernel PlugIn Architecture

11.5.2 WinDriver Kernel and Kernel PlugIn Interaction

There are two types of interaction between the WinDriver kernel and the WinDriver Kernel PlugIn. They are:

Interrupt handling: When WinDriver receives an interrupt, by default it will activate the interrupt handler in user mode. However, if the interrupt was set to be handled by WinDriver Kernel PlugIn, then once WinDriver receives the interrupt, it is processed by the interrupt function in the kernel. This can be the same code that you wrote and debugged in the user-mode interrupt handler before, though some of the user-mode code should be modified. We recommend you rewrite the interrupt acknowledge and handling code in the Kernel PlugIn to utilize the flexibility offered by Kernel PlugIn (see Section 11.6.5).

Message passing: To execute functions in kernel mode (such as I/O processing functions), the user-mode driver simply passes a message to the WinDriver Kernel PlugIn. This message is mapped to a specific function, which is then executed in the kernel. This function can contain the same code as it did when it was written and debugged in user mode.

11.5.3 Kernel PlugIn Components

At the end of your Kernel PlugIn development cycle, your driver will have the following elements:

- User-mode driver – written with the `WD_xxx` functions
- WinDriver kernel – **windrvr6.sys**
- Kernel PlugIn (**<Your Kernel PlugIn Driver Name>.sys** or **<Your Kernel PlugIn Driver Name>.vxd**) – the element that contains the functionality that you have chosen to bring down to the kernel level

11.5.4 Kernel PlugIn Event Sequence

The following is a typical event sequence that covers all the functions that you can implement in your Kernel PlugIn:

Opening Handle from User Mode to Kernel PlugIn

Event/Callback	Notes
Event: Windows loads your Kernel PlugIn driver.	This takes place at boot time, by dynamic loading, or as instructed by the registry.

Callback: Your `KP_Init` Kernel PlugIn function is called [A.12.1].	`KP_Init` informs WinDriver of the name of your `KP_Open` routine [A.12.2]. WinDriver will call this routine when the application wishes to open your driver (when it calls `WD_KernelPlugInOpen` [A.11.1]).
Event: Your user-mode driver application calls `WD_KernelPlugInOpen`.	
Callback: Your `KP_Open` routine is called.	The `KP_Open` function is used to inform WinDriver of the names of all the callback functions that you have implemented in your Kernel PlugIn driver and to initiate the Kernel PlugIn driver, if needed.

Handling User-Mode Requests from the Kernel PlugIn

Event/Callback	Notes
Event: Your application calls `WD_KernelPlugInCall` [A.11.3].	Your application calls `WD_KernelPlugInCall` to run code in kernel mode (in the Kernel PlugIn driver). The application passes a message to the Kernel PlugIn driver. The Kernel PlugIn driver will select the function to execute according to the message sent.

Interrupt Handling – High IRQL Processing

Event/Callback	Notes
Callback: Your `KP_Call` [A.12.4] routine is called.	It executes code according to the message passed to it from user mode.
Event: Your hardware creates an interrupt.	

Callback: Your `KP_IntAtIrql` [A.12.8] routine is called (if the Kernel PlugIn interrupts are enabled).	`KP_IntAtIrql` runs at a high priority, and therefore should perform only the basic interrupt handling (such as lowering the HW interrupt signal). If more interrupt processing is needed, it is deferred to the `KP_IntAtDpc` [A.12.9] function. If your `KP_IntAtIrql` function returns TRUE, the `KP_IntAtDpc` function is called.

Interrupt Handling – Deferred Procedure Calls

Event/Callback	Notes
Event: `KP_IntAtIrql` [A.12.8] function returns TRUE.	Needs interrupt code to be processed as a deferred procedure call in the kernel.
Callback: `KP_IntAtDpc` [A.12.9] is called.	Processes the rest of the interrupt code, but at a lower priority than `KP_IntAtIrql`.
Event: `KP_IntAtDpc` returns a value greater than 0.	Needs interrupt code to be processed in user mode as well.
Callback: `WD_IntWait` [A.3.3] returns.	Execution resumes at the user-mode interrupt handler.

Plug and Play and Power Management

Event/Callback	Notes
Event: A Plug and Play or power management event occurred.	Your application registered to receive notifications of such events by calling `EventRegister` [A.8.2] (or the lower level `WD_EventRegister` function [A.9.2]) and used the hKernelPlugin field in the WD_EVENT structure that is passed to the function to request that the event will first be handled in the Kernel PlugIn. Thereafter, an event that matched the criteria set in `EventRegister`/`WD_EventRegister` occurred.

Callback: Your `KP_Event` [A.12.5] routine is called.	`KP_Event` receives information about the event that occurred.
Event: `KP_Event` returns TRUE.	The event needs to be processed in your user-mode application as well.
Callback: `WD_IntWait` [A.3.3] returns.	Execution resumes at your user-mode application event handler.

11.6 How Does Kernel PlugIn Work?

The following sections take you through the development cycle of a Kernel PlugIn under the assumption that you have already written and debugged your entire driver code in user mode, and have encountered a performance problem.

11.6.1 Minimal Requirements for Creating a Kernel PlugIn

When developing a driver using WinDriver's Kernel PlugIn, it is highly recommended to use two computers; set up one computer as your host, and the other as your target computer. The host computer is the computer on which you develop your driver, and the target computer is the computer on which you run your developed driver.

- To compile the kernel-mode driver you need the VC compiler (**cl.exe**, **rc.exe**, **link.exe** and **nmake.exe**).
- To create a Windows 98/Me/NT/2000/XP/Server 2003 driver (SYS) you need to install the corresponding DDK for the target operating system on your host machine.

  NOTE:
  If your developed driver is intended for a Windows 98/Me target PC, develop your driver on a Windows 2000 or above host PC.

- To compile the kernel-mode driver on Linux and Solaris, you need GCC, gmake or make.

NOTE:
The DDKs are available in the MSDN subscription from Microsoft. You can also order them from http://www.microsoft.com/whdc/ddk/winddk.mspx

11.6.2 Kernel PlugIn Implementation

Before You Begin

The functions described in this section are callback functions, implemented in the Kernel PlugIn driver, which are called when their calling event occurs. For example, `KP_Init` [A.12.1] is the callback function that is called when the driver is loaded. Any code that you want to execute upon loading should be in this function.

The name of your driver is given in `KP_Init`. For the other callback functions, it is the convention of this reference guide to mark these functions as `KP_` functions (e.g. `KP_Open`), as done, for example, in the KPTEST sample.
However, when developing a Kernel PlugIn driver you can also select different names for these callback functions. When generating Kernel PlugIn code with the DriverWizard, for example, the names of the callback functions (apart from `KP_Init`) will be derived from the driver name that you specified when generating the code and will begin with the prefix `KP_XXX`, where XXX is your driver name. For example, if your driver's name is MyDriver, then your Open callback will be called `KP_MyDriver_Open`, etc.

Write Your KP_INIT Function

Implement the following function in your kernel driver:

```
BOOL __cdecl KP_Init(KP_INIT *kpInit);
```

where `KP_INIT` is the following structure:

```
typedef struct {
   DWORD dwVerWD;    // version of the WinDriver Kernel PlugIn library
   CHAR cDriverName[12]; // returns the device driver name, up to 12 chars.
   KP_FUNC_OPEN funcOpen; // returns the KP_Open function
} KP_INIT;
```

This function is called once, when the driver is loaded. The KP_INIT structure should be filled with the name of your Kernel PlugIn and the address of your `KP_Open` function [A.12.2] (see example in **kptest.c**).

NOTE:
(1) The name that you choose for your Kernel PlugIn driver – by setting it in the cDriverName field of the KP_INIT structure in `KP_Init` [A.12.1] – should be the name of the driver that you wish to create – i.e., if you are creating a driver called **XXX.sys** or **XXX.vxd**, then you should set the name "XXX" in the cDriverName field of the KP_INIT structure.
(2) You should also verify that the driver name that is set in the user mode, in the pcDriverName field of the WD_KERNEL_PLUGIN structure that is passed to `WD_KernelPlugInOpen` [A.11.1], is identical to the driver name that was set in the cDriverName field of the KP_INIT structure in `KP_Init()`.

From the KPTEST sample:

```
BOOL __cdecl KP_Init(KP_INIT *kpInit)
{
   // Check if the version of the WinDriver Kernel
   // PlugIn library is the same version
   // as windrvr.h and wd_kp.h

   if (kpInit->dwVerWD!=WD_VER)
   {
     // You need to re-compile your Kernel PlugIn
     // with the compatible version of the WinDriver
     // Kernel PlugIn library windrvr.h and wd_kp.h

      return FALSE;
   }

   kpInit->funcOpen = KP_Open;
   strcpy (kpInit->cDriverName, "KPTEST");

   return TRUE;
}
```

Write Your KP_OPEN Function

Implement the `KP_Open` [A.12.2] function in the Kernel PlugIn file, where Kernel PlugIn is the name of your Kernel PlugIn driver (copied to kpInit->cDriverName in the `KP_Init` function [A.12.1]).

```
BOOL __cdecl KP_Open(KP_OPEN_CALL *kpOpenCall, HANDLE
hWD, PVOID pOpenData, PVOID *ppDrvContext);
```

This callback is called when the user-mode application calls the `WD_KernelPlugInOpen` function [A.11.1].

In the `KP_Open` function, define the callbacks that you wish to implement in the Kernel PlugIn.

The following is a list of the callbacks that can be implemented:

Callback Name	Functionality
`KP_Close` [A.12.3]	Called when the user-mode application calls the `WD_KernelPlugInClose` function [A.11.2].
`KP_Call` [A.12.4]	Called when the user-mode application calls the `WD_KernelPlugInCall` [A.11.3] function. This function is a message handler for your utility functions.
`KP_Event` [A.12.5]	Called when a Plug-and-Play or power management event occurred, if the user-mode application previously registered to listen to this event by calling the `EventRegister` [A.8.2] function (or the lower level `WD_EventRegister` function [A.9.2]) with a handle to the Kernel PlugIn (set in the hKerenlPlugIn field of the WD_EVENT structure that is passed to the function).
`KP_IntEnable` [A.12.6]	Called when the user-mode application calls the `WD_IntEnable` function [A.3.2] (which is also called from the higher level `InterruptEnable` function [A.2.14]) with a handle to the Kernel PlugIn (set in the hKernelPlugIn field of the WD_INTERRUPT structure that is passed to the function). This function should contain any initialization needed for your Kernel PlugIn interrupt handling.
`KP_IntDisable` [A.12.7]	Called when the user-mode application calls the `WD_IntDisable` [A.3.5] function (which is also called from the higher level `InterruptDisable` function [A.2.15]), if the interrupts were previously enabled with a handle to the Kernel PlugIn. This function should free any memory that was allocated in the `KP_IntEnable` [A.12.6] callback.
`KP_IntAtIrql` [A.12.8]	Called when WinDriver receives an interrupt (provided the interrupts were enabled with a handle to the Kernel PlugIn). This is the function that will handle your interrupt in kernel mode (additional handling can be performed in `KP_IntAtDpc` and also in the user mode).
`KP_IntAtDpc` [A.12.9]	Called if the `KP_IntAtIrql` callback [A.12.8] has requested deferred handling of the interrupt (by returning TRUE).

As indicated above, these handlers will be called (respectively) when the user-mode program opens/closes a Kernel PlugIn driver (`WD_KernelPlugInOpen`, `WD_KernelPlugInClose`), sends a message (`WD_KernelPlugInCall`), installs an interrupt where `hKernelPlugIn` in the `WD_INTERRUPT` struct passed to `InterruptEnable`/`WD_IntEnable` is the handle to the Kernel PlugIn driver opened with `WD_KernelPlugInOpen`, or registers an a Plug-and-Play or power management event where `hKernelPlugIn` in the `WD_EVENT` struct passed to `EventRegister`/`WD_EventRegister` is the handle to the Kernel PlugIn driver.

From the KPTEST sample:

```
BOOL __cdecl KP_Open(KP_OPEN_CALL *kpOpenCall, HANDLE hWD,
          PVOID pOpenData, PVOID *ppDrvContext)
{
   kpOpenCall->funcClose = KP_Close;
   kpOpenCall->funcCall = KP_Call;
   kpOpenCall->funcIntEnable = KP_IntEnable;
   kpOpenCall->funcIntDisable = KP_IntDisable;
   kpOpenCall->funcIntAtIrql = KP_IntAtIrql;
   kpOpenCall->funcIntAtDpc = KP_IntAtDpc;
   kpOpenCall->funcEvent = KP_Event;
   *ppDrvContext = NULL; // you can allocate memory here
   return TRUE;
}
```

Write the Remaining PlugIn Callbacks

Add your specific code inside the callback routines.

11.6.3 Sample/Generated Kernel PlugIn Driver Code

You can use the **DriverWizard** to generate a skeletal Kernel PlugIn driver for your device, and use it as the basis for your Kernel PlugIn driver development (recommended), or use the **Kernel PlugIn sample** (**KPTEST**), found under the **\WinDriver\kerplug** directory, as the basis for your Kernel PlugIn driver. Both the generated and sample code include a Kernel PlugIn driver project and a user-mode application that communicates with it.
Both the generated code and the KPTEST sample demonstrate communication between a user-mode application (**USERMODE.EXE** or **XXX_DIAG.EXE** - where

XXX is the generated driver name) and a Kernel PlugIn driver (**KPTEST.sys/vxd** or **XXX.sys/vxd**).
The generated/sample Kernel PlugIn code implements a message for getting the driver's version number to demonstrate how to pass data (messages) between the Kernel PlugIn driver and a user-mode WinDriver, as well as sample kernel interrupt handling code. [The KPTEST sample demonstrates ISA interrupt handling. The generated code will include sample interrupt code for the interrupt detected on your card (PCI or ISA). For PCI, you can define the information for acknowledging (clearing) the interrupt in the DriverWizard, before generating the code, so that the generated code will already utilize this information in the interrupt functions.]

TIP
We recommend that you build and run the sample/generated Kernel PlugIn project (and corresponding user-mode application) before writing your own Kernel PlugIn driver.

11.6.4 Directory Structure of the Sample/Generated Kernel PlugIn Driver Code

- The Kernel PlugIn **sample code** – **KPTEST** – can be found under the **\WinDriver\kerplug** directory and is comprised of the following files:
  - **\WinDriver\kerplug\lib** – Includes the files needed to link your Kernel PlugIn driver.
  - **\WinDriver\kerplug\kptest** – Contains a sample Kernel PlugIn driver, which includes both a kernel-mode Kernel PlugIn project and a user-mode project that communicates with it. This sample demonstrates how to pass data to/from the Kernel PlugIn and how to handle interrupts in the Kernel PlugIn (the sample is for ISA interrupts).

    The sample data exchange function gets the version of the WinDriver kernel module and passes it to the user level. This sample can be used as a basis for implementing I/O calls with the Kernel PlugIn.

    The sample interrupt handler implements an interrupt counter. The interrupt handler counts five interrupts and notifies the user mode on every fifth incoming interrupt. For more details, see **WinDriver\kerplug\kptest\files.txt**.

    The **kptest** directory includes the following files:
    - **kptest_com.h** contains common definitions between the Kernel PlugIn and user-mode projects, such as message names (for messages

that will be passed from the user mode and implemented in the Kernel PlugIn).

  * **\usermode\usermode.c** – The user-mode component of the driver (opens a handle to the Kernel PlugIn driver and communicates with it).
  * **\kermode\kermode.c** – The Kernel PlugIn driver.

- The **generated Kernel PlugIn code**, created by the **DriverWizard**, will also include a kernel-mode Kernel PlugIn project and a user-mode project that communicates with it, but for your specific hardware. The generated code demonstrates data passing between the user-mode and kernel-mode projects (using messages) and interrupt handling in the kernel in a similar way to the **KPTEST** sample, described above. With regards to the interrupts, you can use the DriverWizard to define read/write commands to be executed in `KP_IntAtIrql` [A.12.8] when an interrupt occurs, in which case the generated code will use the information that you defined within the `KP_IntAtIrql` implementation. This is specifically useful for setting up the information for acknowledging (clearing) PCI interrupts (which are level sensitive and must be cleared in the kernel immediately when they are received). The generated Kernel PlugIn code will be comprised of the following files (where XXX represents the name that you selected for the driver when generating the code and **kp_xxx** is the directory where you selected to save the code):

  – **\kp_xxx\kerplug** – The Kernel PlugIn project. This directory includes the following:

    * **kp_xxx.c** – The Kernel PlugIn driver.
    * **msdev** – This directory includes the project file and the makefile for the Kernel PlugIn project and will also contain the final SYS driver that will be created when building the Kernel PlugIn driver code (**kp_xxx.sys**).

  – **\kp_xxx\xxx_diag.c** – A diagnostics user-mode application that opens a handle to the Kernel PlugIn and communicates with it.

  – **\kp_xxx\xxx_lib.c** and **\kp_xxx\xxx_lib.h** – Library functions for communicating with your hardware (used from **xxx_diag.c**).

  – **\kp_xxx\msdev** – This directory includes the project and workspace files for the user-mode application and will also contain the final user-mode executable that will be created when building the generated user-mode application (**xxx.exe**).

– **kptest_com.h** – Contains common definitions between the Kernel PlugIn and user-mode projects, such as message names (for messages that will be passed from the user mode and implemented in the Kernel PlugIn).

11.6.5 Handling Interrupts in the Kernel PlugIn

Interrupts will be handled by the Kernel PlugIn if a handle to the Kernel PlugIn was passed to `WD_IntEnable` [A.3.2]/`InterruptEnable` [A.2.14] (which calls the lower level `WD_IntEnable` function) by the user-mode application when it enabled the interrupts. The handle is passed within the `hKernelPlugIn` member of the `WD_INTERRUPT` structure that is passed to the function. When WinDriver receives a hardware interrupt, it calls `KP_IntAtIrql`[A.12.8] (if Kernel PlugIn interrupts are enabled). If `KP_IntAtIrql` returns TRUE, the deferred `KP_IntAtDpc` [A.12.9] Kernel PlugIn function will be called, after `KP_IntAtIrql` returns. The return value of `KP_IntAtDpc` determines how many times (if at all) the user-mode interrupt handler routine will be executed.
In the KPTEST sample, for example, the Kernel PlugIn interrupt handler code counts five interrupts and notifies the user mode on every fifth interrupt, thus `WD_IntWait` [A.3.3] (in the user mode) will return on only one out of every five incoming interrupts. [`KP_IntAtIrql` returns TRUE every five interrupts to activate `KP_IntAtDpc`, and `KP_IntAtDpc` returns the number of accumulated deferred DPC calls from `KP_IntAtIrql`, so all at all the user-mode interrupt handler will be executed once for every 5 interrupts.]

Interrupt Handling in User Mode (Without Kernel PlugIn)

If the Kernel PlugIn interrupt handle is not enabled, then each incoming interrupt will cause `WD_IntWait` to return (see Figure 11.2).

Interrupt Handling in the Kernel (with the Kernel PlugIn)

To have the interrupts handled by the Kernel PlugIn, a handle to the Kernel PlugIn must be given as a parameter to the `WD_IntEnable` [A.3.2] function (or to the wrapper `InterruptEnable` function [A.2.14], which calls `WD_IntEnable` and `WD_IntWait` [A.3.3]). This enables the Kernel PlugIn interrupt handler.

If the Kernel PlugIn interrupt handler is enabled, then `KP_IntAtIrql` [A.12.8] will be called on each incoming interrupt. The code in the `KP_IntAtIrql` function is executed at HIGH IRQL. While this code is running, the system is halted, i.e., there will be no context switch and no lower-priority interrupts will be handled.

The code in the `KP_IntAtIrql` function is limited in the following ways:

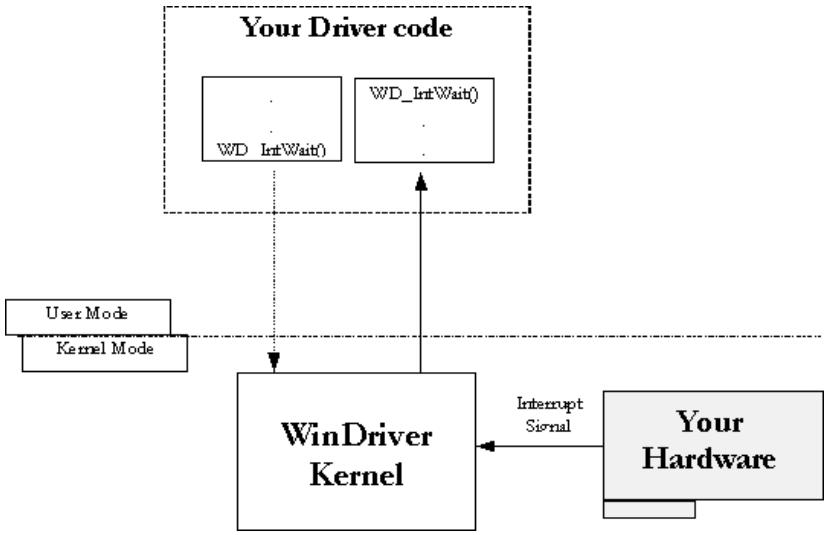


Figure 11.2: Interrupt Handling Without Kernel PlugIn

- It may only access non-pageable memory.
- It may only call the following functions:
  - `WD_Transfer` [A.2.10], `WD_MultiTransfer` [A.2.11] or `WD_DebugAdd` [A.1.6]
  - OS-specific functions (such as certain DDK functions on Windows) that can be called from HIGH IRQL
- It may not call `malloc`, `free` or any `WD_xxx` API other than `WD_Transfer`, `WD_MultiTransfer` or `WD_DebugAdd`.

Because of the aforementioned limitations, the code in `KP_IntAtIrql` should be kept to a minimum (such as clearing of level sensitive interrupts). Other code that you want to run in the interrupt handler should be implemented in `KP_IntAtDpc`, which is called after `KP_IntAtIrql` returns and does not face the same limitations as `KP_IntAtIrql`. [You can also leave some additional interrupt handling to the user mode, as explained in the manual].

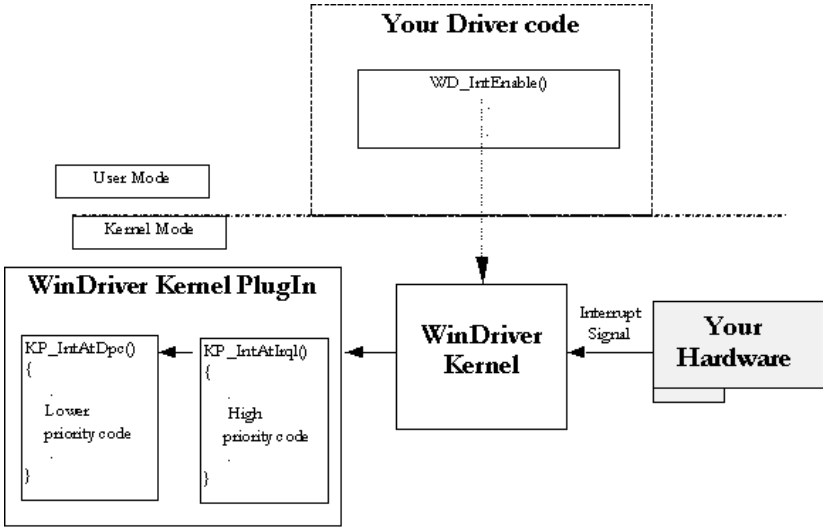


Figure 11.3: Interrupt Handling with the Kernel PlugIn

11.6.6 Message Passing

The WinDriver architecture enables a kernel-mode function to be called from the user mode by passing a message through the `WD_KernelPlugInCall` [A.11.3] function.
The messages are defined by the developer in a header file that is common to both the user-mode and kernel-mode plugin parts of the driver. In the generated DriverWizard code this header file will be called **KP_XXX_COM.H**. In the KPTEST sample this file is called **KPTEST_COM.H**.
Upon receiving the message from the user mode, WinDriver will execute the `KP_Call` [A.12.4] Kernel PlugIn callback function, which identifies the message that has been received and executes the relevant code for this message (as implemented in the Kernel PlugIn).

The generated/sample Kernel PlugIn code implement a message for getting the driver's version in order to demonstrate Kernel PlugIn data passing. The code that sets the version number in `KP_Call` is executed in the Kernel PlugIn whenever the Kernel PlugIn receives a relevant message from the user-mode application. You can see the definition of the message in the header file **KPTEST_COM.H/KP_XXX_COM.H**. The user-mode application (**USERMODE.EXE/ XXX_DIAG.EXE**) sends the

message to the Kernel PlugIn driver via the `WD_KernelPlugInCall` function [A.11.3].

Chapter 12

Writing a Kernel PlugIn

The easiest way to write a Kernel PlugIn driver is to use the **DriverWizard** to generate the Kernel PlugIn code for your hardware. Alternatively, you can use the sample Kernel PlugIn driver provided with WinDriver - **KPTEST** - which can be found under the **\WinDriver\kerplug** directory, as the basis for your Kernel PlugIn driver development.

The following is a step-by-step guide to creating your Kernel PlugIn driver.

12.1 Determine Whether a Kernel PlugIn is Needed

The Kernel PlugIn should be used only after your driver code has been written and debugged in user mode. This way, all of the logical problems of creating a device driver are solved in the user mode, where development and debugging are much easier.
Determine whether a Kernel PlugIn should be written by consulting Chapter 10, which explains how to improve the performance of your driver.

12.2 Windows 98/Me/NT/2000/XP/Server 2003 - Determine the Type of Driver to Develop (SYS or VXD)

Windows NT, Windows **2000**, Windows **XP** and Windows **Server 2003** support the development of **SYS** drivers.
Windows 98 and Windows **Me** support the development of both **SYS** and **VXD** drivers.
WinDriver can be used to develop a Kernel PlugIn driver of any of the supported driver types for each of the aforementioned operating systems. Please note that the generated DriverWizard code is targeted at the development of SYS drivers, however the **KPTEST** sample can be used as the basis for development of VXD Kernel PlugIn drivers for Windows 98/Me (see further explanations in section 12.8 below).
Keep in mind that the DDK is required for development of SYS drivers.

12.3 Prepare the User-Mode Source Code

1. Isolate the functions you need to move into the Kernel PlugIn.
2. Remove any platform-specific code from the functions. Use only functions that can also be used from the kernel.
3. Recompile your driver in the user mode.
4. Debug your driver in user mode again to see that your code still works after changes have been made.

NOTE:
Keep in mind that the kernel stack is relatively limited in size. Therefore, code that will be moved into the Kernel PlugIn should not contain static memory allocations. Use the `malloc()` function to allocate memory dynamically instead. This is especially important for large data structures.

NOTE:
If the user-mode code that you are porting to the kernel accesses memory addresses directly - using the user-mode mapping of the physical address, returned from `WD_CardRegister()` - note that in the kernel you will need to use the kernel mapping of the physical address instead (the kernel mapping is also returned by `WD_CardRegister()` - see section A.2.8).

12.4 Create a New Kernel PlugIn Project

You can use the **DriverWizard** to generate a new Kernel PlugIn project (and corresponding user-mode project) for your device (recommended), or use the **KPTEST** sample as the basis for your development. [You can also develop your code "from scratch", if you wish.]
If you select to use the **KPTEST** sample as the basis for your development, please follow these steps:

1. Make a copy of the **KPTEST** directory. For example, to create a new project called MyDrv, copy **\WinDriver\kerplug\kptest** to **\WinDriver\kerplug\MyDrv**.
2. Change all instances of "KPTEST" in all the files in your new directory to "MyDrv".
3. Change all occurrences of "KPTEST" in file names to "MyDrv".
4. Copy the **\WinDriver\kerplug\lib** directory or otherwise verify that your Kernel PlugIn driver is linked with this directory.

For a general description of the generated/sample code and it's structure, see sections 11.6.3 and 11.6.4.

12.5 Create a Handle to the WinDriver Kernel PlugIn

In your original user-mode source code, call `WD_KernelPlugInOpen` [A.11.1] at the beginning of your code and `WD_KernelPlugInClose` [A.11.2] before terminating. [The generated DriverWizard user-mode project and the the sample **\WinDriver\kerplug\usermode\usermode.c** file demonstrate how this should be done].

12.6 Set Interrupt Handling in the Kernel PlugIn

1. When calling `WD_IntEnable` [A.3.2] or `InterruptEnable` [A.2.14] (which calls `WD_IntEnable`), give the handle to the Kernel PlugIn that you received from opening the Kernel PlugIn. [This handle should be set in the `hKernelPlugIn` field of the `WD_INTERRUPT` struct that is passed to the function.] This is demonstrated in the generated DriverWizard Kernel PlugIn code and in the Kernel PlugIn KPTEST sample.

2. Move the source code in the user-mode interrupt handler to the Kernel PlugIn by moving some of it to `KP_IntAtIrql` [A.12.8] and some of it to `KP_IntAtDpc` [A.12.9]. [You can also modify the code to make it more efficient, due to the advantages of handling the interrupts directly in the kernel]. See Section 11.6.5 for an explanation of how to handle interrupts in the kernel.

12.7 Set I/O Handling in the Kernel PlugIn

1. Move your I/O handling code (if needed) from user mode to `KP_Call` [A.12.4].

2. To activate the kernel code that performs the I/O handling from the user mode, call `WD_KernelPlugInCall` [A.11.3] with a handle to the Kernel PlugIn and a relevant message for each of the different functionalities you need. Create a different message for each functionality.

3. Define these messages in the file **KP_XXX_COM.H** or **KPTEST_COM.H** (if you used the KPTEST sample as the basis for your driver). This header file is common to both the kernel and user-mode projects and should contain the message definitions (IDs) and data structures used to communicate between kernel mode and user mode.

12.8 Compile Your Kernel PlugIn Driver

12.8.1 Windows - Compiling the Generated DriverWizard Kernel PlugIn Code

When generating the Kernel PlugIn code with the DriverWizard, the generated code will include a workspace (**.dsw**) file that enables you to easily build and compile a

SYS Kernel PlugIn driver from Microsoft Developer Studio (MSDEV), by following these steps:

1. Make sure that the BASEDIR environment variable is set to point to the directory in which the DDK for the target platform is installed (i.e., the DDK of the OS for which you wish to create your driver; For example, if you are creating a driver for Windows XP, the BASEDIR environment variable should be set to point to the directory in which the Windows XP DDK is located).

2. Start Microsoft Developer Studio (MSDEV) and do the following:

   (a) From your driver project directory, open the generated workspace file – **\base_dir\msdev\xxx_diag.dsw**, where 'base_dir' is the directory in which you saved the driver project generated by the DriverWizard (the default location is **\WinDriver\wizard\my_projects**) and 'xxx' is the driver name you selected.
   Please note that The DriverWizard automatically starts the MSDEV as part of the code generation process (i.e. when you finish generating the code the generated workspace file will automatically be opened in MSDEV).

   (b) Select the active configuration for your target platform: From the **Build** menu, choose **Select Active Configuration...**, and choose the desired configuration.

   > **NOTE:**
   > The active configuration must correspond with the target OS for which you are building the driver. For example, for Windows 2000 select either **Win32 win2k free** (release mode) or **Win32 win2k checked** (debug mode).

   (c) Build your driver - Press the **F7** key or start the process from the **Build** menu.

> **NOTE:**
> This method supports compilation of **SYS** Kernel PlugIn drivers only. To compile the generated Kernel PlugIn code as a **VXD** driver (on Windows 98/Me), you can use the **compile.bat** and **kptest.mak** files from the KPTEST sample, as explained in section 12.8.2.

NOTE:
On **Windows 98/Me**, the generated code cannot be built into a SYS driver using the method described above. You can, however, build a SYS driver for a target Windows 98/Me PC with Windows NT/2000/XP/Server 2003 (i.e. build the code on a PC running Windows NT/2K/XP/Server 2003 for a target Windows 98/Me OS and then use the driver that was created on Windows 98/Me).

12.8.2 Windows - Compiling a KPTEST Based Kernel PlugIn Driver

If you have used the sample Kernel PlugIn code - **KPTEST** - as the basis for your Kernel PlugIn driver, follow the instructions below for building the driver. If you have changed the driver name, replace any references to 'kptest' below with the new driver name that you selected:

- If you are building a **SYS** driver, set the BASEDIR environment variable to the location of the DDK library for the target OS.
- To build a **VXD** driver, comment-out or remove the following line in **\WinDriver\kerplug\kptest\kermode\compile.bat**:
  `nmake %1 /f kptest.mak`
- Run the **\WinDriver\kerplug\kptest\kermode\compile.bat** utility (which uses the **\WinDriver\kerplug\kermode\kptest.mak** makefile) to build the driver.
- Build the user-mode application that communicates with the Kernel PlugIn (**usermode.exe**). You can build the executable from the MSDEV IDE – simply open the **\WinDriver\kerplug\kptest\usermode\kptest_user.dsw** workspace file and build the user-mode project – **kptest_user.dsp**.

12.8.3 Compiling Under Linux

1. Open a shell terminal.
2. Change directory to the path where you generated the source code for the Kernel PlugIn module (e.g., **/home/user/WinDriver/wizard/my_projects**):
   `cd /home/user/WinDriver/wizard/my_projects`
3. Change directory to the Kernel Plugin makefile path:
   `cd kerplug/linux`

4. Build the module (using the **`make`** command).
5. Move to the directory that holds the makefile for the sample user-mode diagnostics application:
   `cd ../../linux`
6. Compile the sample diagnostics program (using the **`make`** command).

12.8.4 Compiling Under Solaris

1. Open a shell terminal.
2. Change directory to the path where you generated the source code for the Kernel PlugIn module (e.g., **/home/user/WinDriver/wizard/my_projects**):
   `cd /home/user/WinDriver/wizard/my_projects`
3. Change directory to the Kernel Plugin makefile path:
   `cd kerplug/solaris`
4. Build the module (using the **`make`** command).
5. Move to the directory that holds the makefile for the sample user-mode diagnostics application:
   `cd ../../solaris`
6. Compile the sample diagnostics program (using the **`make`** command).

NOTE:
Both the Kernel PlugIn module and the user-mode application that drives it need to be compiled in 64-bit mode. The makefile provided by WinDriver uses the CC and LD environment variables without specifically declaring them. You may therefore need to set these variables to fit your specific compiler and linker with the corresponding flags.
For example, to compile with gcc you may need to set the CC and LD variables as follows:
For the compilation of the Kernel PlugIn module:
$ export LD="gcc -m64 –melf64_sparc -nostdlib"
$ export CC="gcc -m64 -isystem /usr/include/"
For the compilation of the user-mode application:
$ export LD="gcc -m64"
$ export CC="gcc -m64"

12.9 Install Your Kernel PlugIn Driver

12.9.1 On Win32 Platforms

1. Copy the files to the appropriate locations:

   - **Windows NT/2000/XP/Server 2003**: Copy the **MyDrv.sys** driver that was created to the **%windir%\system32\drivers** directory (e.g., **C:\WINNT\system32\drivers** - on WinNT/2000, or **C:\Windows\system32\drivers** - on Windows XP/Server2003).
   - **Windows 98/Me**: If you created a SYS driver (**MyDrv.sys**), copy the driver to the **%windir%\system32\drivers** directory (e.g., **C:\Windows\system32\drivers**).
     If you created a VXD driver (**MyDrv.vxd**), copy the driver to the **%windir%\system\VMM32** directory (e.g., **C:\Windows\system\VMM32**).

   NOTE:
   If your developed Kernel PlugIn driver is intended for a Windows 98/Me target PC, develop your driver on a Windows 2000 or above host PC.

2. Register/Load your driver, using the **wdreg** (or **wdreg_gui**) utility - on Windows NT/2000/XP/Server 2003, or using the **wdreg16** utility - on Windows 98/Me:

   NOTE:
   (1) In the following instructions, "NAME" stands for your Kernel PlugIn driver's name, without the .sys or .vxd extension.
   (2) For Windows 98/Me, replace references to "wdreg" below with "wdreg16".
   See Section 13.2.2, for more information regarding the WDREG utility.

   - To install a SYS driver, run:
     `\WinDriver\util> wdreg -name NAME install`
   - To install a VXD driver (note the **-vxd** flag), run:
     `\WinDriver\util> wdreg -vxd -name NAME install`

NOTE:
Kernel PlugIn drivers, with the exception of SYS drivers on Windows 98/Me, are dynamically loadable, and thus do not require a reboot in order to load.

12.9.2 On Linux

1. Copy the newly created driver to the modules directory:
   `kptest/kermode/LINUX#` **`cp kptest_module.o /lib/modules/misc/`**
2. Insert the module into the kernel:
   `kptest/LINUX#` **`/sbin/insmod kptest_module`**

12.9.3 On Solaris

Installation of the Kernel PlugIn Driver should be performed by the system administrator logged in as root, or with root privileges (become a super user).

1. Copy the newly created driver to the drivers' directory:
   `kptest/SOLARIS#` **`cp kptest /kernel/drv/sparcv9`** (on 64-bit platforms)
   `kptest/SOLARIS#` **`cp kptest /kernel/drv`** (on 32-bit platforms)
2. Copy this file to the drivers' directory:
   `kptest#` **`cp kptest.conf /kernel/drv`**
3. Install the driver:
   `kptest/SOLARIS#` **`add_drv kptest`**

NOTE:
Additional useful commands:

- **`modinfo`** - lists the loaded kernel modules.
- **`rem_drv`** - removes the kernel module.

Chapter 13

Dynamically Loading Your Driver

13.1 Why Do You Need a Dynamically Loadable Driver?

When adding a new driver, you may be required to reboot the system in order for it to load your new driver into the system. WinDriver is a dynamically loadable driver, which enables your customers to start your application immediately after installing it, without needing to reboot. You can dynamically load your driver whether you have created a user-mode or a kernel-mode driver.

NOTE:
In order to successfully UNLOAD your driver, make sure there are no open handles from WinDriver applications or Kernel PlugIns.

13.2 Windows NT/2000/XP/Server 2003 and 98/Me

13.2.1 Windows Driver Types

Two types of driver files are used by WinDriver, both are supported by the WDREG utility:

- WDM (Windows Driver Model) drivers: Files with the extension ".SYS" on Win98/Me/2000/XP/Server 2003, e.g. **windrvr6.sys**.
  WDM drivers are installed via the installation of an INF file (see below).
- Non-WDM / Legacy drivers: All driver files for WinNT4; Files with the extension ".VXD" on Win98/Me; All KernelPlugin driver files. For example, **windrvr6.vxd**, **MyKPDriver.sys**

13.2.2 The WDREG Utility

WinDriver provides a utility for dynamically loading and unloading your driver, which replaces the slower manual process using Windows' Device Manager (which can still be used for the device INF). For **Windows 2000/XP/Server 2003**, this utility is provided in two forms: **wdreg** and **wdreg_gui**. Both utilities can be found under the **\WinDriver\util** directory, can be run from the command line, and provide the same functionality. The difference is that **wdreg_gui** displays installation messages graphically, while **wdreg** displays them in console mode.
For **Windows 98/Me** the **wdreg16** utility is provided.
This section describes the usage of **wdreg**/ **wdreg_gui**/**wdreg16** on Windows operating systems.

NOTE:
The explanations and examples below refer to **wdreg**, but for **Windows 2000/XP/Server 2003** you can replace any references to **wdreg** with **wdreg_gui**. For **Windows 98/Me**, replace the references to **wdreg** with **wdreg16**.

NOTE:
On **Windows 98/Me** you can only use **wdreg16** to install the **windrvr6.sys** WDM driver, by installing **windrvr6.inf** (or use **wdreg16** to install the non-WDM **windrvr6.vxd** driver), but you **cannot** use **wdreg16** to install any other INF files.

Below

- **Non-WDM drivers** (windrvr6.vxd / windrvr6.sys on Windows NT 4.0 / Kernel PlugIn drivers):

  Usage: **`WDREG [-vxd] [-file <filename>] [-name <drivername>] [-startup <level>] [-silent] [-log <logfile>] Action [Action ...]`**
  wdreg supports several basic OPTIONS from which you can choose one, some, or none:

-startup : Specifies when to start the driver. Requires one of the following arguments:

- **boot**: Indicates a driver started by the operating system loader, and should only be used for drivers that are essential to loading the OS (for example, Atdisk).
- **system**: Indicates a driver started during OS initialization.
- **automatic**: Indicates a driver started by the Service Control Manager during system startup.
- **demand**: Indicates a driver started by the Service Control Manager on demand (i.e., when your device is plugged in).
- **disabled**: Indicates a driver that cannot be started.

> **NOTE:**
> The default setting for the **-startup** option is **automatic**.

-name – Relevant only for Kernel PlugIn drivers (by default the **wdreg** commands relate to the windrvr6 service). Sets the symbolic name of the driver. This name is used by the user-mode application to get a handle to the driver. You must provide the driver's symbolic name (*without* the *.sys/*.vxd extension) as an argument with this option. The argument should be equivalent to the driver name as set in the `KP_Init()` [A.12.1] function of your Kernel PlugIn project: `strcpy (kpInit->cDriverName , XX_DRIVER_NAME)`.

-file – Relevant only for Kernel PlugIn. **wdreg** allows you to install your driver in the registry under a different name than the physical file name. This option sets the file name of the driver. You must provide the driver's file name (*without* the *.sys/*.vxd extension) as an argument.
wdreg looks for the driver in the Windows installation directory (**<WINDIR>\system32\drivers** for SYS drivers, **<WINDIR>\system\VMM32** for VxD drivers). Therefore, you should verify that the driver file is located in the correct directory before attempting to install the driver.
Usage: `\> wdreg -name <Your new driver name> -file <Your original driver name> install`

-vxd – Used to load a VxD driver on Windows 98/Me. Does not require any arguments.
Use this option when installing windrvr6.vxd on Windows 98/Me or when installing a Kernel PlugIn VxD driver on Windows 98/Me. Note that this flag is irrelevant for wdreg16.

-silent – Suppresses the display of messages of any kind.

-log <logfile> – Logs all messages to the specified file.

- ACTIONS
  wdreg supports several basic ACTIONS:

  create – Instructs Windows to load your driver next time it boots, by adding your driver to the registry.

  delete – Removes your driver from the registry so that it will not load on next boot.

  start – Dynamically loads your driver into memory for use. You must create your driver before starting it.

  stop – Dynamically unloads your driver from memory.

  > **NOTE:**
  > In order to successfully stop the windrvr6.sys/vxd service, you must first close any open handles to the this service (such as closing open WinDriver applications). **wdreg** will display a relevant warning message if you attempt to stop the service when there are still open handles to it.

- Shortcuts
  wdreg supports a few shortcut operations for your convenience:

  install – Creates and starts your driver.
  This is the same as first using the wdreg **`stop`** action and then the wdreg **`start`** action.
  (if an older version exists), or:

  The same as using the wdreg **`create`** action and then the wdreg **`start`** action.
  (otherwise).

  uninstall – Unloads your driver from memory and removes it from the registry so that it will not load on next boot.
  This is the same as first using the wdreg **`stop`** action and then the wdreg **`delete`** action.

NOTE:
Remember that in order to successfully stop the WinDriver service, there cannot be any open handles to the windrvr6.sys/vxd service (such as open WinDriver applications). This is also true for the **install** and **uninstall** shortcuts, since both commands include stopping the WinDriver service. **wdreg** will display a relevant warning message if you attempt to stop the service when there are still open handles to the windrvr6.sys/vxd service.

- **WDM drivers** (windrvr6.sys on Windows 98/Me/2000/XP/Server 2003):

NOTE:
(1) As specified above, on **Windows 98/Me** you can only use **wdreg16** to install the **windrvr6.sys** WDM driver, by installing **windrvr6.inf** (or use **wdreg16** to install the non-WDM **windrvr6.vxd** driver), but you **cannot** use **wdreg16** to install any other INF files.
(2) This section is **not relevant** for **Kernel PlugIn** drivers, since these are not WDM drivers and are not installed via an INF file.

Usage: `WDREG -inf <filename> [-silent] [-log <logfile>] [install | uninstall | enable | disable]`
wdreg supports several basic OPTIONS from which you can choose one, some, or none:

-inf – The path of the INF file to be dynamically installed.

-silent – Suppresses the display of messages of any kind.

-log <logfile> – Logs all messages to the specified file.

- ACTIONS
wdreg supports several basic ACTIONS:

install – Installs the inf file, copies the relevant files to their target locations, dynamically loads the driver specified in the inf file name by replacing the older version (if needed).

uninstall – Removes your driver from the registry so that it will not load on next boot.

enable – Enables your driver.

disable – Disables your driver, i.e. dynamically unloads it, but the driver will reload after system boot.

NOTE:
In order to successfully disable/uninstall WinDriver, you must first close any open handles to the windrvr6.sys service - Which includes closing any open WinDriver applications and uninstalling (from the Device Manager or using **wdreg**) any PCI/USB devices that are registered to work with the windrvr6.sys service (or otherwise removing such devices). **wdreg** will display a relevant warning message if you attempt to stop the service when there are still open handles to the windrvr6.sys service, and will enable you to select whether to close all open handles and Retry, or Cancel and reboot the PC to complete the command's operation.

13.2.3 Dynamically Loading/Unloading WINDRVR6

When using WinDriver, you develop a user-mode application that controls and accesses your hardware by using the generic driver **WINDRVR6.SYS** or **WINDRVR6.VXD** (WinDriver's kernel module). Therefore, you might want to dynamically load and unload the driver **WINDRVR6.SYS** (or **WINDRVR6.VXD**) - which you can do using **wdreg**. In addition, in WDM-compatible operating systems, you also need to dynamically load INF files for your Plug and Play devices. **wdreg** enables you to do so automatically on Windows 2000, XP and Server 2003. This section includes example implementations that are based on the detailed description of **wdreg** contained in the previous section.
Example implementations:

- To start **WINDRVR6.SYS** on Windows NT:
  `\> wdreg install`
  which is equivalent to:
  `\> wdreg create start`
- To start **WINDRVR6.SYS** on Windows 98/Me/2000/XP/Server 2003:
  `\> wdreg -inf [path to windrvr6.inf] install`
  which loads the **windrvr6.inf** file and starts the **windrvr6.sys** service.
- To load **WINDRVR6.VXD** on Windows 98/Me, use the -vxd flag:
  `\> wdreg -vxd install`
- To load an INF file named **device.inf**, located under the **c:\tmp** directory, on Windows 2000/XP/Server 2003:
  `\> wdreg -inf c:\tmp\device.inf install`

To unload the driver, use the same commands, but simply replace *install* in the samples above with *uninstall*.

13.2.4 Dynamically Loading/Unloading Your Kernel PlugIn Driver

If you have used WinDriver to develop a Kernel PlugIn driver, you must load your Kernel PlugIn after loading the WinDriver generic driver **WINDRVR6.SYS** or **WINDRVR6.VXD**.
When uninstalling your driver, you should unload your Kernel PlugIn driver before unloading **WINDRVR6.SYS** or (**WINDRVR6.VXD**).

NOTE:
Kernel PlugIns for Windows 98 are not dynamically loaded, they require reboot after the initial loading. Kernel PlugIns for all other Windows platforms are dynamically loaded, i.e. they do not require reboot.

To load/unload your Kernel PlugIn driver (**[Your driver name].SYS/[Your driver name].VXD**) use the **wdreg** command as described above for WINDRVR6, with the addition of the ”name” flag, after which you must add the name of your Kernel PlugIn driver.

NOTE:
You should **not** add the *.sys/*.vxd extension to the driver name.

Example implementations:

- To load a Kernel PlugIn driver called **KPTest.SYS**, execute:
  `\> wdreg -name KPTest install`
- To load a Kernel PlugIn driver called **KPTest.VXD**, execute:
  `\> wdreg -vxd -name KPTest install`
- To load a Kernel PlugIn driver called MPEG_Encoder, with file name MPEGENC.SYS, execute:
  `\> wdreg -name MPEG_Encoder -file MPEGENC install`
- To load a Kernel PlugIn driver called MPEG_Encoder, with file name MPEGENC.VXD, execute:
  `\> wdreg -vxd -name MPEG_Encoder -file MPEGENC install`

- To uninstall a Kernel PlugIn driver called KPTest.SYS, execute:
  `\> wdreg -name KPTest uninstall`
- To uninstall a Kernel PlugIn driver called MPEG_Encoder, with file name MPEGENC.SYS, execute:
  `\> wdreg -name MPEG_Encoder -file MPEGENC uninstall`

13.3 Linux

- To dynamically load WinDriver on Linux, execute:
  `/sbin$ insmod -f /lib/modules/misc/windrvr6.o`
- To dynamically unload WinDriver, execute:
  `/sbin$ rmmod windrvr6`
- In addition, you can use the **wdreg** script under Linux to install (load) **windrvr6.o**.
  Example usage: To load your driver, execute:
  `\> wdreg <driver name.extension>`

13.4 Solaris

- After initial installation you may dynamically load WinDriver on Solaris by executing:
  `/usr/sbin# add_drv windrvr6`
- To dynamically unload WinDriver, execute:
  `/usr/sbin# rem_drv windrvr6`

Chapter 14

Distributing Your Driver

Read this chapter in the final stages of driver development. It will guide you in preparing your driver for distribution.

NOTE:
For **Windows 2000/XP/Server 2003**, all references to **wdreg** in this chapter can be replaced with **wdreg_gui**, which offers the same functionality but displays GUI messages instead of console-mode messages.
For **Windows 98/Me**, all references to **wdreg** should be replaced with **wdreg16**.
For more information regarding the **wdreg** utility, see Chapter 13 above.

14.1 Getting a Valid License for WinDriver

To purchase a WinDriver license, complete the order form, found under **\WinDriver\docs\order.txt**, and fax or email it to Jungo. Complete details are included on the order form. Alternatively, you can order WinDriver on-line. Visit `http://www.jungo.com` for more details.

In order to install the registered version of WinDriver and to activate driver code that you have developed during the evaluation period on the development machine, please follow the installation instructions found in Section 4.2 above.

14.2 Windows 98/Me and Windows 2000/XP/Server 2003

Distributing the driver you created is a multi-step process. First, create a distribution package that includes all the files required for the installation of the driver on the target computer. Second, install the driver on the target machine. This involves installing **windrvr6.sys** and **windrvr6.inf**, installing the specific INF file for your device (for Plug and Play hardware – PCI/USB), and installing your Kernel PlugIn driver (if you have created one). Finally, you need to install and execute the hardware control application that you developed with WinDriver. These steps can be performed using **wdreg** utility.

NOTE:

- This section refers to distribution of SYS files. On **Windows 98/Me** you can also choose to install **windrvr6.vxd** instead (although we do not recommend this). Should you select to do so, follow the installation instructions in Section 14.3 below.
- For the distribution of drivers developed with the WinDriver extension for custom USB HID devices, please refer to Section 14.5 (this section does not refer to distribution of these drivers).

14.2.1 Preparing the Distribution Package

Your distribution package should include the following files:

- Your hardware control application/DLL.
- **windrvr6.sys** (get this file from the WinDriver package under the **\WinDriver\redist** directory).
- **windrvr6.inf** (get this file from the WinDriver package under the **\WinDriver\redist** directory).
- **wd_utils.dll** (get this file from the WinDriver package under the **\WinDriver\redist** directory. It should be copied to the **%windir%\system32** directory on the target computer).

- An INF file for your device (required for PCI and USB devices).
  You can generate this file with the DriverWizard, as explained in Section 5.2.
- Your Kernel PlugIn driver – **<KP driver name>.sys/vxd** – if you have created such a driver.

14.2.2 Installing Your Driver on the Target Computer

NOTE:
The user must have administrative privileges on the target computer in order to install your driver.

Follow the instructions below in the order specified to properly install your driver on the target computer:

- **Preliminary Steps:**
  - To avoid reboot, before attempting to install the driver make sure that there are no open handles to the **windrvr6.sys/vxd** service. This includes verifying that there are no open applications that use this service and that there are no connected PCI/USB devices that are registered to work with **windrvr6.sys** - i.e., no INF files that point to this driver are currently installed for any of the PCI/USB devices connected to the PC, or the INF file is installed but the device is disabled. This may be relevant, for example, when upgrading a driver developed with an earlier version of WinDriver (version 6.0 and later only, since previous versions used a different module name).
    You should therefore either disable or uninstall all PCI/USB devices that are registered to work with WinDriver from the Device Manager (**Properties | Uninstall**, **Properties | Disable** or **Remove** - on Win98/Me), or otherwise disconnect the device(s) from the PC. If you do not do this, attempts to install the new driver using **wdreg** will produce a message that instructs the user to either uninstall all devices currently registered to work with WinDriver, or reboot the PC in order to successfully execute the installation command.
  - **Windows 2000**: Due to Windows 2000's INF selection algorithm, if there are PCI/USB drivers, developed with an older version of WinDriver installed on the target computer, we also recommend that you delete any old INF files that Windows/WinDriver may have created for the PCI/USB

devices that you wish to handle with WinDriver, otherwise an older INF file may be installed, causing the older version of WinDriver to become active (see further explanations in Section 14.4). These files are stored in the **%windir%\inf** directory. You can search the INF directory for a device's vendor ID and device/product ID in this INF directory to locate the file(s) associated with the relevant device(s).

- **Installing WinDriver's kernel module:**

  1. Copy **windrvr6.sys** and **windrvr6.inf** to the same directory.
  2. Use the utility **wdreg**/**wdreg16** to install WinDriver's kernel module on the target computer.

     On Windows 2000/XP/Server 2003 type from the command line:
     \> wdreg -inf <path to windrvr6.inf> install
     On Windows 98/Me type from the command line:
     \> wdreg16 -inf <path to windrvr6.inf> install
     For example, if **windrvr6.inf** and **windrvr6.sys** are in the **d:\MyDevice** directory on the target computer, the command should be:
     \> wdreg -inf d:\MyDevice\windrvr6.inf install
     You can find the executable of **wdreg** in the WinDriver package under the **\WinDriver\util** directory. For a general description of this utility and its usage, please refer to Chapter 13 above.

     NOTE:
     wdreg is an interactive utility. If it fails, it will display a message instructing the user how to overcome the problem. In some cases the user may be asked to reboot the computer.

     CAUTION:
     When distributing your driver, take care not to overwrite a newer version of **windrvr6.sys** with an older version of the file in Windows drivers directory (**%windir%\system32\drivers**). You should configure your installation program (if you are using one) or your INF file so that the installer automatically compares the time stamp on these two files and does not overwrite a newer version with an older one.

- **Installing the INF file for your device** (registering your Plug-and-Play device with windrvr6.sys):

  – **Windows 2000/XP/Server 2003**: Use the utility **wdreg** to automatically load the INF file.

To automatically install your INF file on **Windows 2000/XP/Server 2003** and update Windows Device Manager, run **wdreg** with the **`install`** command:
`\> wdreg -inf <path to your INF file> install`

> **NOTE:**
> On **Windows 2000**, if another INF file was previously installed for the device, which registered the device to work with the Plug-and-Play driver used in earlier versions of WinDriver remove any INF file(s) for the device from the **%windir%\inf** directory before installing the new INF file that you created. This will prevent Windows from automatically detecting and installing an obsolete file. You can search the INF directory for the device's vendor ID and device/product ID to locate the file(s) associated with the device.

– **Windows 98/Me**: Install the INF file manually using Windows **Add New Hardware Wizard** or **Upgrade Device Driver Wizard**, as outlined in detail in Section 14.4 below.

14.2.3 Installing Your Kernel PlugIn on the Target Computer

> **NOTE:**
> The user must have administrative privileges on the target computer in order to install your Kernel PlugIn driver.

If you have created a Kernel PlugIn driver, follow the additional instructions below:

1. Copy your Kernel PlugIn driver (**<KP driver name>.sys/vxd**) to Windows drivers directory on the target computer (**%windir%\system32\drivers** for SYS drivers, **\Windows\system\VMM32** for VXD drivers).

2. Use the utility **wdreg** to add your Kernel PlugIn driver to the list of device drivers Windows loads on boot. Use the following installation command:
   To install a **SYS** Kernel PlugIn Driver:
   `\> wdreg -name <Your driver name, without the *.sys extension> install`
   If you have created a **VXD** Kernel PlugIn driver, use the **-vxd** flag in the installation command:
   `\> wdreg -vxd -name <Your driver name, without the *.vxd extension> install`

You can find the executable of **wdreg** in the WinDriver package under the **\WinDriver\util** directory. For a general description of this utility and its usage, please refer to Chapter 13 above (see specifically Section 13.2.4 for Kernel PlugIn installation).

14.3 Windows 98/Me and NT 4.0

NOTE:
For Windows 98/Me, this section refers to the distribution of **windrvr6.vxd** files only. Should you select to install **windrvr6.sys** instead, follow the installation instructions for Windows 98/Me and 2000/XP/Server 2003 in Section 14.2 above.

Distributing the driver you created is a multi-step process. First, create a distribution package that includes all the files required for installation of the driver on the target computer. Second, install WinDriver's generic driver (**windrvr6.sys/windrvr6.vxd**). If you have created a Kernel PlugIn driver, install it on the target computer as well. Finally, you need to install and execute the hardware control application you developed with WinDriver on the target computer. The following subsections describe this process in detail.

14.3.1 Preparing the Distribution Package

Your distribution package should include the following files:

- Your hardware control application/DLL.
- **windrvr6.sys** for Windows NT or **windrvr6.vxd** for Windows 98/Me (get this file from the WinDriver package under the **\WinDriver\redist** directory).
- **wd_utils.dll** (get this file from the WinDriver package under the **\WinDriver\redist** directory. It should be copied to the **%windir%\system32** directory on the target computer).
- Your Kernel PlugIn driver – **<driver name>.sys** or **<driver name>.vxd** – if you have created such a driver.

14.3.2 Installing Your Driver on the Target Computer

NOTE:
The user must have administrative privileges on the target computer in order to install your driver.

Follow the instructions below in the order specified to properly install your driver on the target computer:

1. Make sure that there are no open handles to **windrvr6.sys/vxd**.
2. Copy the file **windrvr6.sys/windrvr6.vxd** to Windows drivers directory on the target computer:
   - Windows NT target computers – Copy **windrvr6.sys** to **%windir%\system32\drivers**.
   - Windows 98/Me target computers – Copy **windrvr6.vxd** to **%windir%\system\VMM32**.
3. Use the utility **wdreg** to add **windrvr6.sys/windrvr6.vxd** to the list of device drivers Windows loads on boot.
   - Windows NT – Use the following installation command:
     `\> wdreg install`
   - Windows 98/Me – Use the -vxd flag in the installation command:
     `\> wdreg -vxd install`

   By default **wdreg** installs **windrvr6.sys** on Windows NT, 98, Me, 2000, XP and Server 2003, therefore you need to use the **-vxd** flag in order to install **windrvr6.vxd** on Windows 98/Me.

   You can find the executable of **wdreg** in the WinDriver package under the **\WinDriver\util** directory. For a general description of this utility and its usage, please refer to Chapter 13 above.

14.3.3 Installing Your Kernel PlugIn on the Target Computer

NOTE:
The user must have administrative privileges on the target computer in order to install your Kernel PlugIn driver.

If you have created a Kernel PlugIn driver, follow the additional instructions below:

1. Copy your Kernel PlugIn driver (**<driver name>.sys** or **<driver name>.vxd**) to Windows drivers installation directory on the target computer (**%windir%\system32\drivers** for SYS drivers, **\Windows\system\VMM32** for VXD drivers)

   CAUTION:
   When distributing your driver, take care not to overwrite a newer version of **windrvr6.sys** or **windrvr6.vxd** with an older version of the file in the Windows drivers directory (**%windir%\system32\drivers** for **windrvr6.sys** on Windows NT, or **%windir%\system\VMM32** for **windrvr6.vxd** on Windows 98/Me). You should configure your installation program (if you are using one) so that the installer automatically compares the time stamp on these two files and does not overwrite a newer version with an older one.

2. Use the utility **wdreg** to add your Kernel PlugIn driver to the list of device drivers Windows loads on boot.

   - Windows NT – Use the following installation command:
     `\> wdreg -name [Your driver name] install`
   - Windows 98/Me – Use the following installation command:
     `\> wdreg -vxd -name [Your driver name] install`

   You can find the executable of **wdreg** in the WinDriver package under the **\WinDriver\util** directory. For a general description of this utility and its usage, please refer to Chapter 13 above (see specifically Section 13.2.4).

14.4 Creating an INF File

Device information (INF) files are text files that provide information used by the Plug and Play mechanism in Windows 98/Me/2000/XP/Server 2003 to install software that supports a given hardware device. INF files are required for hardware that identifies itself, such as USB and PCI. An INF file includes all necessary information about a device and the files to be installed. When hardware manufacturers introduce new products, they must create INF files to explicitly define the resources and files required for each class of device.

In some cases, the INF file for your specific device is supplied by the operating system. In other cases, you will need to create an INF file for your device. WinDriver's

DriverWizard can generate a specific INF file for your device. The INF file is used to notify the operating system that WinDriver now handles the selected device.

For USB devices, you will not be able to access the device with WinDriver (either from the DriverWizard or from the code) without first registering the device to work with **windrvr6.sys**. This is done by installing an INF file for the device. The DriverWizard will offer to automatically generate the INF file for your device.

You can use the DriverWizard to generate the INF file on the development machine - as explained in Section 5.2 of the manual - and then install the INF file on any machine to which you distribute the driver, as explained in the following sections.

14.4.1 Why Should I Create an INF File?

- To enable the DriverWizard to access USB devices.
- To stop the Windows **Found New Hardware Wizard** from popping up after each boot.
- To ensure that the operating system can initialize the PCI configuration registers on Windows 98/Me/2000/XP/Server 2003.
- To ensure that the operating system can assign physical addresses to a USB device.
- To load the new driver created for the device. An INF file must be created whenever developing a new driver for Plug and Play hardware that will be installed on a Plug and Play system.
- To replace the existing driver with a new one.

14.4.2 How Do I Install an INF File When No Driver Exists?

NOTE:
You must have administrative privileges in order to install an INF file on Windows 98, Me, 2000, XP and Server 2003.

- **Windows 2000/XP/Server 2003**:
  On Windows 2000/XP/Server 2003 you can use the **wdreg** utility with the **`install`** command to automatically install the INF file:
  `\> wdreg -inf <path to the INF file> install`

See Section 13.2.2 of the manual for more information.
On the development PC, you can have the INF file automatically installed when selecting to generate the INF file with the DriverWizard, by checking the **Automatically Install the INF file** option in the DriverWizard's INF generation window (see Section 5.2).

It is also possible to install the INF file manually on Windows 2000/XP/Server 2003, using either of the following methods:

- Windows **Found New Hardware Wizard**: This wizard is activated when the device is plugged in or, if the device was already connected, when scanning for hardware changes from the Device Manager.
- Windows **Add/Remove Hardware Wizard**: Right-click the mouse on **My Computer**, select **Properties**, choose the **Hardware** tab and click on **Hardware Wizard...**.
- Windows **Upgrade Device Driver Wizard**: Select the device from the **Device Manager** devices list, select **Properties**, choose the **Driver** tab and click the **Update Driver...** button. On Windows XP and Windows Server 2003 you can choose to upgrade the driver directly from the Properties list.

In all the manual installation methods above you will need to point Windows to the location of the relevant INF file during the installation.
We recommend using the **wdreg** utility to install the INF file automatically, instead of installing it manually.

- **Windows 98/Me**:
  On **Windows 98/Me** you need to install the INF file for your PCI/USB device manually, either via Windows **Add New Hardware Wizard** or **Upgrade Device Driver Wizard**, as explained below:

  - Windows **Add New Hardware Wizard**:

    NOTE:
    This method can be used if no other driver is currently installed for the device or if the user first uninstalls (removes) the current driver for the device. Otherwise, Windows **New Hardware Found Wizard**, which activates the **Add New Hardware Wizard**, will not appear for this device.

    1. To activate the Windows **Add New Hardware Wizard**, attach the hardware device to the computer or, if the device is already connected, scan for hardware changes (**Refresh**).

2. When Windows **Add New Hardware Wizard** appears, follow its installation instructions. When asked, point to the location of the INF file in your distribution package.

– Windows **Upgrade Device Driver Wizard**:

1. Open Windows Device Manager: From the **System Properties** window (right-click on **My Computer** and select **Properties**) select the **Device Manager** tab.
2. Select your device from the **Device Manager** devices list, choose the **Driver** tab and click the **Update Driver** button.
   To locate your device in the Device Manager, select **View devices by connection**. For PCI devices, navigate to **Standard PC | PCI bus | <your device>**. For USB devices, navigate to **Standard PC | PCI bus | PCI to USB Universal Host Controller (or any other controller you are using - OHCI/EHCI) | USB Root Hub | <your device>**.
3. Follow the instructions of the **Upgrade Device Driver Wizard** that opens. When asked, point to the location of the INF file in your distribution package.

14.4.3 How Do I Replace an Existing Driver Using the INF File?

NOTE:
You must have administrative privileges in order to replace a driver on Windows 98, Me, 2000, XP and Server 2003.

1. On **Windows 2000**, if you wish to upgrade the driver for PCI/USB devices that have been registered to work with earlier versions of WinDriver, we recommend that you first delete from Windows INF directory (**%windir%\inf**) any previous INF files for the device, to prevent Windows from installing an old INF file in place of the new file that you created. Look for files containing your device's vendor and device IDs and delete them.

2. Install your INF file:

   - On **Windows 2000/XP/Server 2003** you can automatically install the INF file:
     You can use the **wdreg** utility with the `install` command to automatically install the INF file on Windows 2000/XP/Server 2003:

```
\> wdreg -inf <path to INF file> install
```

See Section 13.2.2 of the manual for more information.

On the development PC, you can have the INF file automatically installed when selecting to generate the INF file with the DriverWizard, by checking the **Automatically Install the INF file** option in the DriverWizard's INF generation window (see Section 5.2).

It is also possible to install the INF file manually on Windows 2000/XP/Server 2003, using either of the following methods:

- Windows **Found New Hardware Wizard**: This wizard is activated when the device is plugged in or, if the device was already connected, when scanning for hardware changes from the Device Manager.
- Windows **Add/Remove Hardware Wizard**: Right-click on **My Computer**, select **Properties**, choose the **Hardware** tab and click on **Hardware Wizard...**.
- Windows **Upgrade Device Driver Wizard**: Select the device from the **Device Manager** devices list, select **Properties**, choose the **Driver** tab and click the **Update Driver...** button. On Windows XP and Windows Server 2003 you can choose to upgrade the driver directly from the Properties list.

In the manual installation methods above you will need to point Windows to the location of the relevant INF file during the installation. If the installation wizard offers to install an INF file other than the one you have generated, select **Install one of the other drivers** and choose your specific INF file from the list.

We recommend using the **wdreg** utility to install the INF file automatically, instead of installing it manually.

- On **Windows 98/Me** you need to install the INF file manually via Windows **Add New Hardware Wizard** or **Upgrade Device Driver Wizard**, as explained below:
  - Windows **Add New Hardware Wizard**:

    NOTE:
    This method can be used if no other driver is currently installed for the device or if the user first uninstalls (removes) the current driver for the device. Otherwise, the Windows **Found New Hardware Wizard**, which activates the **Add New Hardware Wizard**, will not appear for this device.

    (a) To activate the Windows **Add New Hardware Wizard**, attach the hardware device to the computer or, if the device is already

connected, scan for hardware changes (Refresh).

(b) When Windows **Add New Hardware Wizard** appears, follow its installation instructions. When asked, specify the location of the INF file in your distribution package.

– Windows **Upgrade Device Driver Wizard**:

(a) Open Windows Device Manager: From the **System Properties** window (right click on **My Computer** and select **Properties**) select the **Device Manager** tab.

(b) Select your device from the **Device Manager** devices list, open it, choose the **Driver** tab and click the **Update Driver** button. To locate your device in the Device Manager, select **View devices by connection**. For PCI devices, navigate to **Standard PC | PCI bus | <your device>**. For USB devices, navigate to **Standard PC | PCI bus | PCI to USB Universal Host Controller (or any other controller you are using - OHCI/EHCI) | USB Root Hub | <your device>**.

(c) Follow the instructions of the **Upgrade Device Driver Wizard** that opens. Locate the INF in your distribution package when asked.

14.5 The WinDriver Extension for Custom USB HID Devices

Distribution of applications developed using the WinDriver extension for custom USB HID devices is simple. You need only copy the **WinDriver/redist/wdlib.dll** file together with your application/DLL to the **%windir%\system32** directory on the target computer.

14.6 Windows CE

The distribution process involves installing WinDriver's kernel DLL file **windrvr6.dll** and the hardware control application that you developed with WinDriver on the target CE platform/computer. The installation instructions below refer only to the installation of **windrvr6.dll** on the target platform/computer.

1. Install WinDriver's kernel DLL file on the target computer:

- For WinDriver applications developed for target CE computers:
  Copy **windrvr6.dll** from the **\WinDriver\redist\TARGET_CPU** directory to the **Windows** directory on your target Windows CE computer.
- When building new CE platforms:
  Copy **windrvr6.dll** from the **\WinDriver\redist\TARGET_CPU** directory to the **%_FLATRELEASEDIR%** directory and then append the contents of the supplied file **PROJECT_WD.BIB** to the file **PROJECT.BIB**. This will make the WinDriver kernel file a permanent part of the Windows CE kernel **NK.BIN**. Then use **MAKEIMG.EXE** to build the new Windows CE kernel **NK.BIN**. This process is similar to the process of installing WinDriver CE with Platform Builder, as described in section 4.2.2.

2. Add WinDriver to the list of device drivers Windows CE loads on boot:

- For WinDriver applications developed for target CE computers:
  Modify the registry according to the entries documented in the file **PROJECT_WD.REG**. This can be done using the Windows CE Pocket Registry Editor on the hand-held CE computer or by using the Remote CE Registry Editor Tool supplied with the Windows CE Platform SDK. You will need to have Windows CE Services installed on your Windows Host System to use the Remote CE Registry Editor Tool.
- When building new CE platforms:
  The required registry entries are made by appending the contents of the file **PROJECT_WD.REG** to the Windows CE ETK configuration file **PROJECT.REG** before building the Windows CE image using **MAKEIMG.EXE**.

  NOTE:
  On non-x86 platforms, for PCI only: Make sure you copy the lines specified for PCI from **PROJECT_WD.REG** to **PROJECT.REG**, after removing the comment marks and inserting the card specific information.

14.7 Linux

The Linux kernel is continuously under development and kernel data structures are subject to frequent changes. To support such a dynamic development environment and still have kernel stability, the Linux kernel developers decided that kernel modules

must be compiled with header files identical to those with which the kernel itself was compiled. They enforce this by including a version number in the kernel header files that is checked against the version number encoded into the kernel. This forces Linux driver developers to facilitate recompilation of their driver based on the target system's kernel version.

14.7.1 WinDriver Kernel Module

Since **windrvr6.o** is a kernel module, it must be recompiled for every kernel version on which it is loaded. To facilitate this, we supply the following components to insulate the WinDriver kernel module from the Linux kernel:

- **windrvr_gcc_v2.a and windrvr_gcc_v3.a:** compiled object code for the WinDriver kernel module. **windrvr_gcc_v2.a** is used for kernels compiled with gcc v2.x.x, and **windrvr_gcc_v3.a** is used for kernels compiled with gcc v3.x.x.
- **linux_wrappers.c/h:** wrapper library source code files that bind the WinDriver kernel module to the Linux kernel.
- **linux_common.h and windrvr.h:** header files required for building the WinDriver kernel module on the target.
- **wdusb_linux.c:** used by WinDriver to utilize the USB stack. Even though this is a USB file, it is also required for PCI/ISA drivers.

You need to distribute these components along with your driver source code or object code. We suggest that you adapt our makefile from the **WinDriver/redist** directory to compile and insert the module **windrvr6.o** into the kernel. Note that this makefile calls the **wdreg** utility shell script that we supply under the **WinDriver/util** directory. You should understand how this works and adapt it to your own needs.

NOTE:
If the makefile provided with WinDriver is used with no modifications, the **wdreg** utility also needs to be copied to the target, along with **setup_inst_dir**. Both are supplied under the **WinDriver/util** directory.

14.7.2 Your User-Mode Hardware Control Application/DLL

Since the user-mode hardware control application/DLL does not have to be matched against the kernel version number, you are free to distribute it as binary code (if you wish to protect your source code from unauthorized copying) or as source code.

CAUTION:
If you select to distribute your source code, make sure you do not distribute your WinDriver license string, which is used in the code.

14.7.3 Kernel PlugIn Modules

Since the Kernel PlugIn module (if you have creates such a module) is a kernel module, it also needs to be matched against the active kernel's version number. This means recompilation for the target system. It is advisable to supply the Kernel PlugIn module source code to your customers so that they can recompile it. You can also use the same makefile that you used to recompile and install the WinDriver kernel module to build and insert any Kernel PlugIn modules that you distribute.

14.7.4 Installation Script

We suggest that you supply an installation shell script that copies your driver executables/DLL to the correct locations (perhaps **/usr/local/bin**) and then invokes **make** or **gmake** to build and install the WinDriver kernel module and any Kernel PlugIn modules.

14.8 Solaris

For Solaris, you need to supply the following to allow the client to enable target installation of your driver:

- WinDriver's kernel module: The files **windrvr6** and **windrvr6.conf** implement the WinDriver kernel module.
- User-mode hardware control application/DLL: Your user-mode hardware control application/DLL binaries.

- Kernel PlugIn module: If you used a Kernel PlugIn module, you should supply the relevant files, e.g., **mykp** and **mykp.conf**
- An installation script : We suggest that you supply an installation shell script that copies your driver executables to the correct locations (perhaps **/usr/local/bin**) and then installs the WinDriver kernel. You may adapt the utility script **install_windrvr6** (found under the **WinDriver** directory on the development machine) to your purposes.

14.9 VxWorks

For VxWorks, you need to supply the following to allow the client to enable target installation of your driver:

- WinDriver's kernel module: The file **windrvr6.o** implements the WinDriver kernel module.
- Your hardware control application/DLL: the source code or the binaries of your hardware control application/DLL (**your_drv.out**, for example)

Your client will need to incorporate all these files into the VxWorks embedded image. There are two steps involved here:

1. **windrvr6.o** and **your_drv.out** have to be built into the VxWorks image.

   In the Tornado II Project's build specification for the VxWorks image, specify **windrvr6.o** and **your_drv.out** as **EXTRA_MODULES** under the **MACROS** tab, and copy these files under the appropriate target directory tree. Rebuild the project. These files should now be included in the image.

2. The `drvrInit` routine should be called during startup to initialize **windrvr6.o**. Your driver's startup routine may also need to be called.

   Add code to **usrAppInit.c** (found under the Tornado II project directory) so that it will call drvrInit—WinDriver's initialization routine—and your driver application's startup routine. Of course, you will need to rebuild the VxWorks image after modifying **usrAppInit.c**.

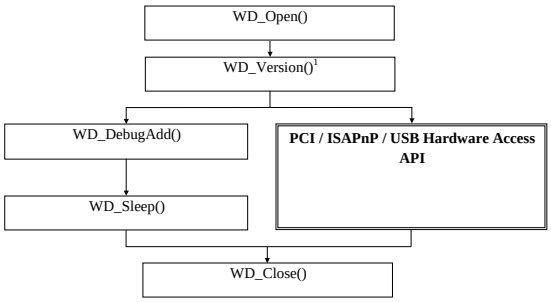
Appendix A

Function Reference

A.1 General Use

A.1.1 Calling Sequence WinDriver - General Use

The following is a typical calling sequence for the WinDriver API.



NOTES:

(1) We recommend calling the WinDriver function `WD_Version` [A.1.3] after calling `WD_Open` [A.1.2] and before calling any other WinDriver function. Its purpose is to return the WinDriver kernel module (windrvr) version number, thus providing the means to verify that your application is version compatible with the WinDriver kernel module.

(2) `WD_DebugAdd` [A.1.6] and `WD_Sleep` [A.1.8] can be called anywhere after `WD_Open`.

(3) Visual Basic and Delphi programmers should note that this Function Reference is C-oriented.
WinDriver Visual Basic and Delphi codes have been written as closely as possible to the C code, to enable maximal compatibility for all users.
Most of the APIs have a single implementation that can be used from a C, VB or Delphi application. However, some of the WinDriver functions require a specific implementation for VB and Delphi. Please refer to the relevant Delphi/Visual Basic samples and include files:

1. **\WinDriver\delphi**
2. **\WinDriver\vb**

A.1.2 WD_Open()

PURPOSE

• Opens a handle to access the WinDriver kernel module. The handle is used by all WinDriver APIs, and therefore must be called before any other WinDriver API is called.

PROTOTYPE

```
HANDLE WD_Open();
```

PARAMETERS

None

RETURN VALUE

The handle to the WinDriver kernel module.
If device could not be opened, returns INVALID_HANDLE_VALUE.

REMARKS

If you are a registered user, please refer to `WD_License()` [A.1.9] function reference to see an example of how to register your license.

EXAMPLE

```
HANDLE hWD;

hWD = WD_Open();
if (hWD==INVALID_HANDLE_VALUE)
{
   printf("Cannot open WinDriver device\n");
}
```

A.1.3 WD_Version()

PURPOSE

• Returns the version number of the WinDriver kernel module currently running.

PROTOTYPE

```
DWORD WD_Version(HANDLE hWD, WD_VERSION *pVer);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pVer	WD_VERSION *	
❑ dwVer	DWORD	Output
❑ cVer[100]	CHAR	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pVer	`WD_VERSION` elements:
dwVer	The version number.
cVer[100]	Version info string.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_VERSION ver;

BZERO(ver);
WD_Version(hWD, &ver);
printf("%s\n", ver.cVer)
if (ver.dwVer<WD_VER)
{
   printf("Error - incorrect WinDriver version\n");
}
```

A.1.4 WD_Close()

PURPOSE

• Closes the access to the WinDriver kernel module.

PROTOTYPE

```
void WD_Close(HANDLE hWD);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].

REMARKS

This function must be called when you finish using WinDriver kernel module.

EXAMPLE

```
WD_Close(hWD);
```

A.1.5 WD_Debug()

PURPOSE

• Sets debugging level for collecting debug messages.

PROTOTYPE

```
DWORD WD_Debug(HANDLE hWD, WD_DEBUG *pDebug);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pDebug	WD_DEBUG *	Input
❑ dwCmd	DWORD	Input
❑ dwLevel	DWORD	Input
❑ dwSection	DWORD	Input
❑ dwLevelMessageBox	DWORD	Input
❑ dwBufferSize	DWORD	Input

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pDebug	`WD_DEBUG` elements:
dwCmd	Debug command: Set filter, Clear buffer, etc. For more details please refer to DEBUG_COMMAND in **windrvr.h**.
dwLevel	Used for dwCmd=DEBUG_SET_FILTER. Sets the debugging level to collect: Error, Warning, Info, Trace. For more details please refer to DEBUG_LEVEL in **windrvr.h**.

dwSection	Used for dwCmd=DEBUG_SET_FILTER. Sets the sections to collect: IO, Mem, Int, etc. Use S_ALL for all. For more details please refer to DEBUG_SECTION in **windrvr.h**.
dwLevelMessageBox	Used for dwCmd=DEBUG_SET_FILTER. Sets the debugging level to print in a message box. For more details please refer to DEBUG_LEVEL in **windrvr.h**.
dwBufferSize	Used for dwCmd=DEBUG_SET_BUFFER. The size of buffer in the kernel.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_DEBUG dbg;

BZERO(dbg);
dbg.dwCmd = DEBUG_SET_FILTER;
dbg.dwLevel = D_ERROR;
dbg.dwSection = S_ALL;
dbg.dwLevelMessageBox = D_ERROR;

WD_Debug(hWD, &dbg);
```

A.1.6 WD_DebugAdd()

PURPOSE

• Sends debug messages to the debug log. Used by the driver code.

PROTOTYPE

```
DWORD WD_DebugAdd(HANDLE hWD, WD_DEBUG_ADD *pData);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pData	WD_DEBUG_ADD *	
❑ dwLevel	DWORD	Input
❑ dwSection	DWORD	Input
❑ pcBuffer	CHAR [256]	Input

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pData	`WD_DEBUGADD` elements:
dwLevel	Assigns the level in the Debug Monitor, in which the data will be declared. If dwLevel is 0, D_ERROR will be declared. For more details please refer to DEBUG_LEVEL in **windrvr.h**.
dwSection	Assigns the section in the Debug Monitor, in which the data will be declared. If dwSection is 0, S_MISC section will be declared. For more details please refer to DEBUG_SECTION in **windrvr.h**.
pcBuffer	The string to copy into the message log.

Return Value

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

Example

```
WD_DEBUG_ADD add;

BZERO(add);
add.dwLevel = D_WARN;
add.dwSection = S_MISC;
sprintf(add.pcBuffer, "This message will be displayed in "
   "the debug monitor\n");
WD_DebugAdd(hWD, &add);
```

A.1.7 WD_DebugDump()

PURPOSE

• Retrieves debug messages buffer.

PROTOTYPE

```
DWORD WD_DebugDump(HANDLE hWD, WD_DEBUG_DUMP *pDebugDump);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pDebug	WD_DEBUG_DUMP *	Input
❑ pcBuffer	PCHAR	Input/Output
❑ dwSize	DWORD	Input

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pDebugDump	`WD_DEBUG_DUMP` elements:
pcBuffer	Buffer to receive debug messages
dwSize	Size of buffer in bytes

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
char buffer[1024];
WD_DEBUG_DUMP dump;
dump.pcBuffer=buffer;
dump.dwSize = sizeof(buffer);
WD_DebugDump(hWD, &dump);
```

A.1.8 WD_Sleep()

PURPOSE

• Delays execution for a specific duration of time.

PROTOTYPE

```
DWORD WD_Sleep(HANDLE hWD, WD_SLEEP *pSleep);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pSleep	WD_SLEEP *	
❑ dwMicroSeconds	DWORD	Input
❑ dwOptions	DWORD	Input

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pSleep	WD_SLEEP elements:
dwMicroSeconds	Sleep time in microseconds - 1/1,000,000 of a second.
dwOptions	A bit mask flag: • SLEEP_NON_BUSY - If set, delays execution without consuming CPU resources. (Not relevant for under 17,000 micro seconds. Less accurate than busy sleep). Default - Busy sleep.

Return Value

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

Remarks

Example usage: to access slow response hardware.

Example

```
WD_Sleep slp;

BZERO(slp);
slp.dwMicroSeconds = 200;
WD_Sleep(hWD, &slp);
```

A.1.9 WD_License()

PURPOSE

• Transfers the license string to the WinDriver kernel module and returns information regarding the license type of the specified license string.

PROTOTYPE

```
DWORD WD_License(HANDLE hWD, WD_LICENSE *pLicense);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pLicense	WD_LICENSE *	
❑ cLicense[]	CHAR	Input
❑ dwLicense	DWORD	Output
❑ dwLicense2	DWORD	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pLicense	`WD_LICENSE` elements:
cLicense[]	A buffer to contain the license string that is to be transferred to the WinDriver kernel module. If an empty string is transferred, then WinDriver kernel module returns the current license type to the parameter dwLicense.
dwLicense	Returns the license type of the specified license string (cLicnese). The return value is a mask of license type flags, defined as an enum in **windrvr.h**. 0 = Invalid license string. Additional flags for determining the license type will be returned in dwLicense2, if needed.

dwLicense2	Returns additional flags for determining the license type, if dwLicense could not hold all the relevant information (otherwise - 0).

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

When using a registered version, this function must be called before any other WinDriver API call, apart from `WD_Open()`, in order to register the license from the code.

Example usage: Add registration routine to your application.

EXAMPLE

```
DWORD RegisterWinDriver()
{
   HANDLE hWD;
   WD_LICENSE lic;
   DWORD dwStatus = WD_INVALID_HANDLE;

   hWD = WD_Open();
   if (hWD!=INVALID_HANDLE_VALUE)
   {
      BZERO(lic);
      // replace the following string with your license string
      strcpy(lic.cLicense, "12345abcde12345.CompanyName");
      dwStatus = WD_License(hWD, &lic);
      WD_Close(hWD);
   }

   return dwStatus;
}
```

A.1.10 WD_LogStart()

PURPOSE

• Opens a log file.

PROTOTYPE

```
DWORD WD_LogStart(const char *sFileName, const char *sMode)
```

PARAMETERS

Name	Type	Input/Output
➢ sFileName	const char *	Input
➢ sMode	const char *	Input

DESCRIPTION

Name	Description
sFileName	Name of log file to be opened.
sMode	Type of access permitted. For example, when NULL or **w**, opens an empty file for writing. If the given file exists, its contents are destroyed. When **a**, opens for writing at the end of the file (appending).

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

Once a log file is opened, all API calls are logged in this file. You may add your own printouts to the log file by calling `WD_LogAdd` [A.1.12].

A.1.11 WD_LogStop()

PURPOSE

• Closes a log file.

PROTOTYPE

```
VOID WD_LogStop()
```

PARAMETERS

None

RETURN VALUE

None

A.1.12 WD_LogAdd()

PURPOSE

• Adds user printouts into log file.

PROTOTYPE

```
VOID DLLCALLCONV WD_LogAdd(const char *sFormat[, argument ]...)
```

PARAMETERS

Name	Type	Input/Output
➢ sFormat	const char *	Input
➢ argument		Input

DESCRIPTION

Name	Description
sFormat	Format-control string
argument	Optional arguments

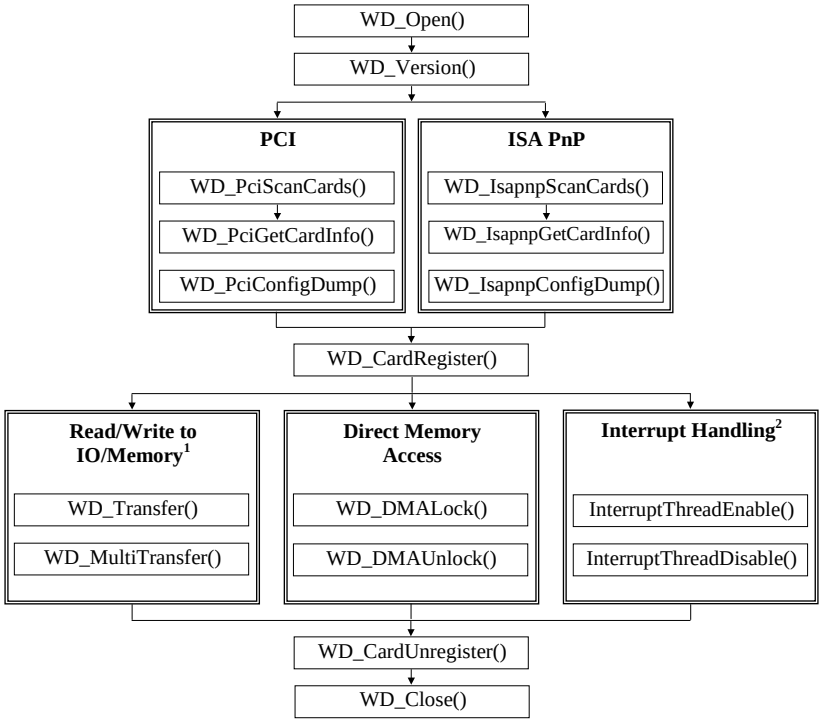
RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.2 PCI/ISA

A.2.1 Calling Sequence WinDriver - PCI/ISA

The following is a typical calling sequence for the PCI/ISA drivers.



NOTES:

(1) For memory transfers, instead of using `WD_Transfer` and `WD_MultiTransfer`, it is recommended to use the direct user-mode pointer received from `WD_CardRegister` [A.2.8].

(2) `WD_IntEnable`, `WD_IntWait`, `WD_IntCount` and `WD_IntDisable` compose the above `InterruptEnable` and `InterruptDisable` functions and can be called separately instead. For more details, please refer to Section A.3.

(3) `WD_DebugAdd` and `WD_Sleep` can be called everywhere after `WD_Open`. For more details, please refer to Section A.1.

A.2.2 WD_PciScanCards()

PURPOSE

• Detects PCI devices installed on the PCI bus, which conform to the input criteria (VendorID and/or DeviceID), and returns the number and location (bus, slot and function) of the detected devices.

PROTOTYPE

```
DWORD WD_PciScanCards(HANDLE hWD,
   WD_PCI_SCAN_CARDS *pPciScan);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pPciScan	WD_PCI_SCAN_CARDS *	
❑ searchId	WD_PCI_ID	
❖ dwVendorId	DWORD	Input
❖ dwDeviceId	DWORD	Input
❑ dwCards	DWORD	Output
❑ cardId	Array of WD_PCI_ID	
❖ dwVendorId	DWORD	Output
❖ dwDeviceId	DWORD	Output
❑ cardSlot	Array of WD_PCI_SLOT	
❖ dwBus	DWORD	Output
❖ dwSlot	DWORD	Output
❖ dwFunction	DWORD	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pPciScan	WD_PCI_SCAN_CARDS elements:
searchId	WD_PCI_ID elements:
searchId.dwVendorId	Required PCI Vendor ID to detect. If 0, detects devices from all vendors.
searchId.dwDeviceId	Required PCI Device ID to detect. If 0, detects all devices.
dwCards	Number of devices detected.
cardId	WD_PCI_ID elements:
cardId.dwVendorId	Vendor IDs of the detected devices (corresponding to the required Vendor ID defined in searchId.dwVendorId).
cardId.dwDeviceId	Device IDs of the detected devices (corresponding to the required Device ID defined in searchId.dwDeviceId).
cardSlot	WD_PCI_SLOT elements:
cardSlot.dwBus	Bus number of detected device.
cardSlot.dwSlot	Slot number of detected device.
cardSlot.dwFunction	Function number of detected device.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_PCI_SCAN_CARDS pciScan;
DWORD cards_found;
WD_PCI_SLOT pciSlot;

BZERO(pciScan);
pciScan.searchId.dwVendorId = 0x12bc;
pciScan.searchId.dwDeviceId = 0x1;
WD_PciScanCards(hWD, &pciScan);
if (pciScan.dwCards>0) // Found at least one device
{
   // use the first card found
   pciSlot = pciScan.cardSlot[0];
```

```
}
else
{
   printf("No matching PCI devices found\n");
}
```

A.2.3 WD_PciGetCardInfo()

PURPOSE

• Retrieves PCI device's resource information (i.e., Memory ranges, I/O ranges, Interrupt lines).

PROTOTYPE

```
DWORD WD_PciGetCardInfo(HANDLE hWD,
   WD_PCI_CARD_INFO *pPciCard);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pPciCard	WD_PCI_CARD_INFO *	
❑ pciSlot	WD_PCI_SLOT	
❖ dwBus	DWORD	Input
❖ dwSlot	DWORD	Input
❖ dwFunction	DWORD	Input
❑ Card	WD_CARD	
❖ dwItems	DWORD	Output
❖ Item	Array of WD_ITEMS	
✧ item	DWORD	Output
✧ fNotSharable	DWORD	Output
✧ I	union	
♦ Mem	struct	
→ dwPhysicalAddr	DWORD	Output
→ dwBytes	DWORD	Output
→ dwTransAddr	DWORD	N/A
→ dwUserDirectAddr	DWORD	N/A
→ dwCpuPhysicalAddr	DWORD	N/A
→ dwBar	DWORD	Output
♦ IO	struct	
→ dwAddr	DWORD	Output
→ dwBytes	DWORD	Output
→ dwBar	DWORD	Output

♦ Int	struct	
→ dwInterrupt	DWORD	Output
→ hInterrupt	DWORD	Output
→ dwOptions	DWORD	N/A
♦ Bus	struct	
→ dwBusType	WD_BUS_TYPE	Output
→ dwBusNum	DWORD	Output
→ dwSlotFunc	DWORD	Output

DESCRIPTION

Name	**Description**
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pPciCard	WD_PCI_CARD_INFO elements:
pciSlot	WD_PCI_SLOT elements:
pciSlot.dwBus	PCI bus number of device.
pciSlot.dwSlot	PCI slot number of device.
pciSlot.dwFunction	PCI function num of device.
Card	WD_CARD elements:
dwItems	Number of items detected on device.
Item	WD_ITEMS elements:
item	Type of item. Can be ITEM_MEMORY, ITEM_IO, ITEM_INTERRUPT or ITEM_BUS.
fNotSharable	If true, only one application at a time can access the mapped memory range, or monitor this card's interrupts.
I	Specific data according to "Item".
I.Mem	Describes ITEM_MEMORY.
I.Mem.dwPhysicalAddr	First address of physical memory range.
I.Mem.dwBytes	Length of range in bytes.
I.Mem.dwBar	Base Address Register number of PCI card.
I.IO	Describes ITEM_IO.
I.IO.dwAddr	First address of I/O range.
I.IO.dwBytes	Length of range in bytes.
I.IO.dwBar	Base Address Register number of PCI card.
I.Int	Describes ITEM_INTERRUPT.
I.Int.dwInterrupt	Physical number of interrupt request (IRQ).
I.Bus	Describes ITEM_BUS.

I.Bus.dwBusType	Used to save type of device from the WD_BUS_TYPE options (i.e., ISA/ISAPnP/PCI) and in this case - WD_BUS_PCI.
I.Bus.dwBusNum	Bus number of the specific PCI device.
I.Bus.dwSlotFunc	Slot and Function. This value is a combination of the slot number and the function number: The lower three bits represent the function number and the remaining bits represent the slot number. For example: a value of 0x80 (<=> 10000000 binary) corresponds to a function number of 0 (lower 3 bits: 000) and a slot number of 0x10 (remaining bits: 10000).

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_PCI_CARD_INFO pciCardInfo;
WD_CARD Card;

BZERO(pciCardInfo);
pciCardInfo.pciSlot = pciSlot;
WD_PciGetCardInfo(hWD, &pciCardInfo);
if (pciCardInfo.Card.dwItems!=0) // At least one item was found
{
   Card = pciCardInfo.Card;
}
else
{
   printf("Failed fetching PCI card information\n");
}
```

A.2.4 WD_PciConfigDump()

PURPOSE

• Reads/Writes from/to the PCI configuration registers of a selected PCI device.

PROTOTYPE

```
DWORD WD_PciConfigDump(HANDLE hWD,
   WD_PCI_CONFIG_DUMP *pConfig);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pConfig	WD_PCI_CONFIG_DUMP *	
❑ pciSlot	WD_PCI_SLOT	
❖ dwBus	DWORD	Input
❖ dwSlot	DWORD	Input
❖ dwFunction	DWORD	Input
❑ pBuffer	PVOID	Input/Output
❑ dwOffset	DWORD	Input
❑ dwBytes	DWORD	Input
❑ fIsRead	DWORD	Input
❑ dwResult	DWORD	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pConfig	WD_PCI_CONFIG_DUMP elements:
pciSlot	WD_PCI_SLOT elements:
pciSlot.dwBus	PCI bus number of card.
pciSlot.dwSlot	PCI slot number of card.
pciSlot.dwFunction	PCI function number of card.

pBuffer	A pointer to the data that will either: 1. Be written to the PCI configuration registers. 2. Be read from the PCI configuration registers.
dwOffset	The offset of the specific register/s in PCI configuration space to read/write from/to.
dwBytes	Number of bytes read/written from/to buffer.
fIsRead	If TRUE - read from PCI configuration registers. If FALSE - write to PCI configuration registers.
dwResult	1. PCI_ACCESS_OK - read/write ok. 2. PCI_ACCESS_ERROR - failed reading/writing. 3. PCI_BAD_BUS - bus does not exist. 4. PCI_BAD_SLOT - slot or Function does not exist.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_PCI_CONFIG_DUMP pciConfig;
WORD aBuffer[2];

BZERO(pciConfig);
pciConfig.pciSlot.dwBus = 0;
pciConfig.pciSlot.dwSlot = 3;
pciConfig.pciSlot.dwFunction = 0;
pciConfig.pBuffer = aBuffer;
pciConfig.dwOffset = 0;
pciConfig.dwBytes = sizeof(aBuffer);
pciConfig.fIsRead = TRUE;

WD_PciConfigDump(hWD, &pciConfig);
if (pciConfig.dwResult!=PCI_ACCESS_OK)
{
   printf("No PCI card in Bus 0, Slot 3\n");
}
else
{
   printf("Card in Bus 0, Slot 3 has Vendor ID %x "
      "Device ID %x\n", aBuffer[0], aBuffer[1]);
}
```

A.2.5 WD_IsapnpScanCards()

PURPOSE

• Detects ISA PnP devices installed on the ISA PnP bus that conform to the input criteria (VendorID and/or Serial Device Number), and returns the number and location (bus, slot and function) of the detected devices.

PROTOTYPE

```
DWORD WD_IsapnpScanCards(HANDLE hWD,
   WD_ISAPNP_SCAN_CARDS *pIsapnpScan);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pIsapnpScan	WD_ISAPNP_SCAN_CARDS *	
❑ searchId	WD_ISAPNP_CARD_ID	
❖ cVendor[8]	CHAR	Input
❖ dwSerial	DWORD	Input
❑ dwCards	DWORD	Output
❑ Card	Array of WD_ISAPNP_CARD	
❖ cardId	WD_ISAPNP_CARD_ID	
✧ cVendor[8]	CHAR	Output
✧ dwSerial	DWORD	Output
❖ dwLogicalDevices	DWORD	Output
❖ bPnPVersionMajor	BYTE	Output
❖ bPnPVersionMinor	BYTE	Output
❖ bVendorVersionMajor	BYTE	Output
❖ bVendorVersionMinor	BYTE	Output
❖ cIdent	CHAR [36]	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pIsapnpScan	WD_ISAPNP_SCAN_CARDS elements:
searchId	WD_ISAPNP_CARD_ID elements:
searchId.cVendor[8]	Required ISA PnP Vendor ID to detect. If 0, detects devices from all vendors.
searchId.dwSerial	Required ISA PnP serial device number to detect. If 0, detects all devices.
dwCards	Number of devices detected.
Card	WD_ISAPNP_CARD elements.
cardId	WD_ISAPNP_CARD_ID elements - vendor ID and serial number of device found.
cardId.cVendor[8]	Vendor ID.
cardId.dwSerial	Serial number of device.
dwLogicalDevices	Number of logical devices on device.
bPnPVersionMajor	ISA PnP version major.
bPnPVersionMinor	ISA PnP version minor.
bVendorVersionMajor	Vendor version major.
bVendorVersionMinor	Vendor version minor.
cIdent	WD_ISAPNP_ANSI - the ASCII device identification string.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_ISAPNP_SCAN_CARDS isapnpScan;
DWORD Cards_found
WD_ISAPNP_CARD isapnpCard;

BZERO(isapnpScan);
// CTL009e - Sound Blaster ISA PnP Card
strcpy(isapnpScan.searchId.cVendorId, "CTL009e");
isapnpScan.searchId.dwSerial = 0;
```

```
WD_IsapnpScanCards(hWD, &isapnpScan);
if (isapnpScan.dwCards>0) // Found at least one device
{
   // Take the first card found
   isapnpCard = isapnpScan.Card[0];
}
else
{
   printf("No matching ISA PnP devices found\n");
}
```

A.2.6 WD_IsapnpGetCardInfo()

PURPOSE

• Retrieves ISA PnP device resources information (i.e., Memory ranges, IO ranges, Interrupts).

PROTOTYPE

```
DWORD WD_IsapnpGetCardInfo(HANDLE hWD,
   WD_ISAPNP_CARD_INFO *pIsapnpCard);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pIsapnpCard	WD_ISAPNP_CARD_INFO *	
❑ cardId	WD_ISAPNP_CARD_ID	
❖ cVendor	CHAR[8]	Input
❖ dwSerial	DWORD	Input
❑ dwLogicalDevice	DWORD	Input
❑ clogicalDevice	CHAR [8]	Output
❑ dwCompatibleDevices	DWORD	Output
❑ CompatibleDevices	CHAR [10][8]	Output
❑ cIdent	CHAR [36]	Output
❑ Card	WD_CARD	
❖ dwItems	DWORD	Output
❖ Item	Array of WD_ITEMS	
✧ item	DWORD	Output
✧ fNotSharable	DWORD	Output
✧ I	union	
♦ Mem	struct	
→ dwPhysicalAddr	DWORD	Output
→ dwBytes	DWORD	Output
→ dwTransAddr	DWORD	N/A
→ dwUserDirectAddr	DWORD	N/A
→ dwCpuPhysicalAddr	DWORD	N/A
→ dwBar	DWORD	Output

♦ IO	struct	
→ dwAddr	DWORD	Output
→ dwBytes	DWORD	Output
→ dwBar	DWORD	Output
♦ Int	struct	
→ dwInterrupt	DWORD	Output
→ hInterrupt	DWORD	Output
→ dwOptions	DWORD	N/A
♦ Bus	struct	
→ dwBusType	WD_BUS_TYPE	Output
→ dwBusNum	DWORD	Output
→ dwSlotFunc	DWORD	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pIsapnpCard	WD_ISAPNP_CARD_INFO elements:
cardId	WD_ISAPNP_CARD_ID elements:
cardId.cVendor	Required ISA plug and play Vendor ID for which information is required.
cardId.dwSerial	Required ISA plug and play serial device number for which information is required.
dwLogicalDevice	Number of the logical device for which information is required.
clogicalDevice	WD_ISAPNP_COMP_ID - a string of 8 characters for the ASCII code of the logical device ID found.
dwCompatibleDevices	Number of compatible devices found.
CompatibleDevices	WD_ISAPNP_COMP_ID - an array of the compatible devices' IDs.
cIdent	WD_ISAPNP_ANSI - the ASCII device identification string.
Card	WD_CARD elements:
dwItems	Number of items detected on device.
Item	WD_ITEMS elements:
item	Type of item. Can be ITEM_MEMORY, ITEM_IO, ITEM_INTERRUPT or ITEM_BUS.

fNotSharable	If true, only one application at a time can access the mapped memory range or monitor this card's interrupts.
I	Specific data according to "Item".
I.Mem	Describes ITEM_MEMORY.
I.Mem.dwPhysicalAddr	First address of physical memory range.
I.Mem.dwBytes	Length of range in bytes.
I.Mem.dwBar	Base Address Register number of PCI card.
I.IO	Describes ITEM_IO.
I.IO.dwAddr	First address of I/O range.
I.IO.dwBytes	Length of range in bytes.
I.IO.dwBar	Base Address Register number of PCI card.
I.Int	Describes ITEM_INTERRUPT.
I.Int.dwInterrupt	Physical number of interrupt request (IRQ).
I.Bus	Describes ITEM_BUS.
I.Bus.dwBusType	Used to save type of device from the WD_BUS_TYPE options (i.e., ISA/ISAPnP/PCI) and in this case - WD_BUS_EISA.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_ISAPNP_CARD_INFO isapnpCardInfo;
WD_CARD Card;

BZERO(isapnpCardInfo);
// from WD_IsapnpScanCard():
isapnpCardInfo.CardId = isapnpCard;
isapnpCardInfo.dwLogicalDevice = 0;

WD_IsapnpGetCardInfo(hWD, &isapnpCardInfo);
// At least one item was found.
if (isapnpCardInfo.Card.dwItems!=0)
   Card = isapnpCardInfo.Card;
else
   printf("Failed fetching ISA PnP card information\n");
```

A.2.7 WD_IsapnpConfigDump()

PURPOSE

• Reads/Writes from/to the ISA PnP configuration registers of a selected ISA PnP device.

PROTOTYPE

```
DWORD WD_IsapnpConfigDump(HANDLE hWD,
   WD_ISAPNP_CONFIG_DUMP *pConfig);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pConfig	WD_ISAPNP_CONFIG_DUMP *	
❑ cardId	WD_ISAPNP_CARD_ID	
❖ cVendor	CHAR[8]	Input
❖ dwSerial	DWORD	Input
❑ dwOffset	DWORD	Input
❑ fIsRead	DWORD	Input
❑ bData	BYTE	Input/Output
❑ dwResult	DWORD	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pConfig	WD_ISAPNP_CONFIG_DUMP elements.
cardId	WD_ISAPNP_CARD_ID elements:
cardId.cVendor	Required ISA plug and play Vendor ID for the required device.
cardId.dwSerial	Required ISA plug and play serial device number for the required device.
dwOffset	The offset of the specific register/s in ISA PnP configuration space to read/write from/to.

fIsRead	If TRUE - read from ISA PnP configuration registers. If FALSE - write to ISA PnP configuration registers.
bData	The data that will either: 1. Be written to the ISA PnP configuration registers 2. Be read from the ISA PnP configuration registers.
dwResult	0 - ISAPNP_ACCESS_OK - read/write ok. 1 - ISAPNP_ACCESS_ERROR - failed reading/writing. 2 - ISAPNP_BAD_ID - device does not exist.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_ISAPNP_CONFIG_DUMP isapnpConfig;

BZERO(isapnpConfig);
// from WD_IsapnpScanCard():
isapnpConfig.CardId = isapnpCard;
isapnpConfig.dwOffset = 0;
isapnpConfig.fIsRead = TRUE;
WD_IsapnpConfigDump(hWD, &isapnpConfig);
if (isapnpConfig.dwResult!=ISAPNP_ACCESS_OK)
{
   printf("No ISA PnP device specified slot\n");
}
else
{
   printf("ISA PnP config in offest 0 =\%x\n",
      isapnpConfig.bData);
}
```

A.2.8 WD_CardRegister()

PURPOSE

• Maps the physical memory ranges to be accessed by kernel-mode processes and user-mode applications.
• Checks whether an I/O or Memory resource was previously exclusively registered.
• Saves data regarding interrupt request (IRQ) number and interrupt type (edge triggered or level sensitive) in internal data structures to be used by `InterruptEnable` [A.2.14] or `WD_IntEnable` [A.3.2].

PROTOTYPE

```
DWORD WD_CardRegister(HANDLE hWD, WD_CARD_REGISTER *pCardReg);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pCardReg	WD_CARD_REGISTER *	
❑ Card	WD_CARD	
❖ dwItems	DWORD	Input
❖ Item	Array of WD_ITEMS	
✧ item	DWORD	Input
✧ fNotSharable	DWORD	Input
✧ I	union	
♦ Mem	struct	
→ dwPhysicalAddr	DWORD	Input
→ dwBytes	DWORD	Input
→ dwTransAddr	DWORD	Output
→ dwUserDirectAddr	DWORD	Output
→ dwCpuPhysicalAddr	DWORD	Output
→ dwBar	DWORD	Input
♦ IO	struct	
→ dwAddr	DWORD	Input
→ dwBytes	DWORD	Input
→ dwBar	DWORD	Input
♦ Int	struct	

→ dwInterrupt	DWORD	Input
→ dwOptions	DWORD	Input
→ hInterrupt	DWORD	Output
♦ Bus	WD_BUS	
→ dwBusType	WD_BUS_TYPE	Input
→ dwBusNum	DWORD	Input
→ dwSlotFunc	DWORD	Input
❑ fCheckLockOnly	DWORD	Input
❑ hCard	DWORD	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pCardReg	WD_CARD_REGISTER elements:
Card	WD_CARD elements:
dwItems	Number of items detected on device.
Item	WD_ITEMS elements:
item	Can be ITEM_MEMORY, ITEM_IO, ITEM_INTERRUPT or ITEM_BUS.
fNotSharable	If true, only one application at a time can access the mapped memory range, or monitor this card's interrupts.
I	Specific data according to "item".
I.Mem	Describes ITEM_MEMORY.
I.Mem.dwPhysicalAddr	First address of physical memory range.
I.Mem.dwBytes	Length of range in bytes.
I.Mem.dwTransAddr	Maps the physical memory address received by dwPhysicalAddr and dwBytes (in WD_XxxGetCardInfo) for kernel-mode processes. Used by `WD_Transfer` [A.2.10].
I.Mem.dwUserDirectAddr	Maps the physical memory address received by dwPhysicalAddr and dwBytes (in WD_XxxGetCardInfo) for user-mode applications (enabling direct access from user mode).
I.Mem.dwCpuPhysicalAddr	Translates device's memory address from bus specific values into CPU values.
I.Mem.dwBar	Base Address Register number of PCI card.

I.IO	Describes ITEM_IO.
I.IO.dwAddr	First address of I/O range.
I.IO.dwBytes	Length of range in bytes.
I.IO.dwBar	Base Address Register number of PCI card.
I.Int	Describes ITEM_INTERRUPT.
I.Int.dwInterrupt	Physical number of interrupt request (IRQ).
I.Int.dwOptions	A bit mask flag: • INTERRUPT_LEVEL_SENSITIVE - If set, the interrupt is Level Sensitive. Default - Interrupt is Edge-Triggered (Received from WD_XxxGetCardInfo). • INTERRUPT_CE_INT_ID - On Windows CE (unlike other operating systems), there is an abstraction of the physical interrupt number to a logical one. Setting this bit will instruct WinDriver to refer to the interrupt in dwInterrupt as a logical interrupt number and convert it to a physical interrupt number.
I.Int.hInterrupt	Returns an interrupt handle to use with `InterruptEnable` [A.2.14] or `WD_IntEnable` [A.3.2].
I.Bus	Describes ITEM_BUS.
I.Bus.dwBusType	Used to save type of device from the WD_BUS_TYPE options (i.e., ISA/ISAPnP/PCI) 1 = ISA; 2 = EISA; 5 = PCI.
I.Bus.dwBusNum	Bus number of the specific device.
I.Bus.dwSlotFunc	Slot and Function.
fCheckLockOnly	When set to TRUE - checks whether certain resources were already locked when asking for an exclusive resource.
hCard	Handle to card used by `WD_CardUnregister` [A.2.9]. 0 when card registration fails.

Return Value

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

Example

```
WD_CARD_REGISTER cardReg;
BZERO(cardReg);
cardReg.Card.dwItems = 1;
cardReg.Card.Item[0].item = ITEM_IO;
cardReg.Card.Item[0].fNotSharable = TRUE;
cardReg.Card.Item[0].I.IO.dwAddr = 0x378;
cardReg.Card.Item[0].I.IO.dwBytes = 8;
WD_CardRegister(hWD, &cardReg);
if (cardReg.hCard==0)
{
   printf("Failed locking device\n");
   return FALSE;
}
```

A.2.9 WD_CardUnregister()

PURPOSE

• Unregisters a device and frees the resources allocated to it.

PROTOTYPE

```
DWORD WD_CardUnregister(HANDLE hWD, WD_CARD_REGISTER *pCardReg);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pCardReg	WD_CARD_REGISTER *	
❑ Card	WD_CARD	N/A
❑ fCheckLockOnly	DWORD	N/A
❑ hCard	DWORD	Input

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
hCard	Handle of device to unregister received from `WD_CardRegister` [A.2.8].

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_CardUnregister(hWD, &cardReg);
```

A.2.10 WD_Transfer()

PURPOSE

• Executes a single read/write instruction to an I/O port or to a memory address.

PROTOTYPE

```
DWORD WD_Transfer(HANDLE hWD, WD_TRANSFER *pTrans);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pTrans	WD_TRANSFER *	
❑ cmdTrans	DWORD	Input
❑ dwPort	DWORD	Input
❑ dwBytes	DWORD	Input
❑ fAutoinc	DWORD	Input
❑ dwOptions	DWORD	Input
❑ Data	union	
❑ Data.Byte	BYTE	Input/Output
❑ Data.Word	WORD	Input/Output
❑ Data.Dword	DWORD	Input/Output
❑ Data.Qword	QWORD	Input/Output
❑ Data.pBuffer	PVOID	Input/Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pTrans	WD_TRANSFER elements:

cmdTrans	Command of operation (WD_TRANSFER_CMD; please refer to **windrvr.h** for implementation). Should be typed in the following format: <dir><p>_<string><size> • dir - R for read, W for write. • p - P for I/O port, M for memory. • String - S for string, none for single transfer. • Size - BYTE, WORD, DWORD or QWORD.
dwPort	For an I/O transfer - port address received from I.IO.dwAddr in `WD_CardRegister` [A.2.8]. For a memory transfer - kernel-mode virtual memory address received from I.Mem.dwTransAddr in `WD_CardRegister`.
dwBytes	Used in string transfers - number of bytes to transfer.
fAutoinc	fAutoinc Used in string transfers - If TRUE, I/O or memory address should be incremented for transfer. If FALSE, all data is transferred to the same port/address.
dwOptions	Must be 0.
Data	The data to be translated.
Data.Byte	Used for 8-bit transfers.
Data.Word	Used for 16-bit transfers.
Data.Dword	Used for 32-bit transfers
Data.Qword	Used for 64-bit transfers
Data.pBuffer	Used in string transfers - the pointer to the buffer with the data to read/write from/to.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

- 64-bit data transfers (QWORD) are available only for memory read/write string operations.

  64-bit data transfers (QWORD) require 64-bit enabled PCI device, 64-bit PCI bus, and an x86 CPU running under any of the operating systems supported by WinDriver. (Note: 64-bit data transfers performed with `WD_Transfer` do not require 64-bit operating system/CPU).

- When using `WD_Transfer`, it is important to align the base address according to the size of the data type, especially when issuing string transfer commands. Otherwise, the transfers are split into smaller portions.
  The easiest way to align data is to use basic types when defining a buffer, i.e.

  BYTE buf[len]; // for BYTE transfers - not aligned
  WORD buf[len]; // for WORD transfers - aligned on 2-byte boundary
  UINT32 buf[len]; // for DWORD transfers - aligned on 4-byte boundary
  UINT64 buf[len]; // for QWORD transfers - aligned on 8-byte boundary

EXAMPLE

```
WD_TRANSFER Trans;
BYTE read_data;

BZERO(Trans);
Trans.cmdTrans = RP_BYTE; //Read Port BYTE
Trans.dwPort = 0x210;
WD_Transfer(hWD, &Trans);
read_data = Trans.Data.Byte;
```

A.2.11 WD_MultiTransfer()

PURPOSE

• Executes a multiple read/write instruction to an I/O port or a memory address.

PROTOTYPE

```
DWORD WD_MultiTransfer(HANDLE hWD,
   WD_TRANSFER *pTransArray, DWORD dwNumTransfers);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pTransArray	Array of WD_TRANSFER *	
❑ cmdTrans	DWORD	Input
❑ dwPort	DWORD	Input
❑ dwBytes	DWORD	Input
❑ fAutoinc	DWORD	Input
❑ dwOptions	DWORD	Input
❑ Data	union	
❑ Data.Byte	BYTE	Input/Output
❑ Data.Word	WORD	Input/Output
❑ Data.Dword	DWORD	Input/Output
❑ Data.Qword	QWORD	Input/Output
❑ Data.pBuffer	PVOID	Input/Output
➢ dwNumTransfers	DWORD	Input

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pTransArray	WD_TRANSFER elements:

cmdTrans	Command of operation (WD_TRANSFER_CMD; please refer to **windrvr.h** for implementation). Should be typed in the following format: <dir><p>_<string><size> • dir - R for read, W for write. • p - P for I/O port, M for memory. • String - S for string, none for single transfer. • Size - BYTE, WORD, DWORD or QWORD.
dwPort	For an I/O transfer - port address received from I.IO.dwAddr in `WD_CardRegister` [A.2.8]. For a memory transfer - kernel-mode virtual memory address received from I.Mem.dwTransAddr in `WD_CardRegister`.
dwBytes	Used in string transfers - number of bytes to transfer.
fAutoinc	fAutoinc Used in string transfers: If TRUE, I/O or memory address should be incremented for transfer. If FALSE, all data is transferred to the same port/address.
dwOptions	Must be 0.
Data	The data to be translated.
Data.Byte	Used for 8-bit transfers.
Data.Word	Used for 16-bit transfers.
Data.Dword	Used for 32-bit transfers.
Data.Qword	Used for 64-bit transfers.
Data.pBuffer	Used in string transfers - the pointer to the buffer with the data to read/write from/to.
dwNumTransfers	Number of commands in array.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

See `WD_Transfer` [A.2.10] remarks.

NOTE:
This function is not supported in Visual Basic.

EXAMPLE

```
WD_TRANSFER Trans[4];
DWORD dwResult;
char *cData = "Message to send\n";

BZERO(Trans);
Trans[0].cmdTrans = WP_WORD; //Write Port WORD
Trans[0].dwPort = 0x1e0;
Trans[0].Data.Word = 0x1023;

Trans[1].cmdTrans = WP_WORD;
Trans[1].dwPort = 0x1e0;
Trans[1].Data.Word = 0x1022;

Trans[2].cmdTrans = WP_SBYTE; //Write Port String BYTE
Trans[2].dwPort = 0x1f0;
Trans[2].dwBytes = strlen(cdata);
Trans[2].fAutoinc = FALSE;
Trans[2].dwOptions = 0;
Trans[2].Data.pBuffer = cData;

Trans[3].cmdTrans = RP_DWORD; //Read Port Dword
Trans[3].dwPort = 0x1e4;

WD_MultiTransfer(hWD, &Trans, 4);
dwResult = Trans[3].Data.Dword;
```

A.2.12 WD_DMALock()

PURPOSE

• Enables Contiguous Buffer or Scatter Gather DMA.
• Locks a physical memory region and returns a list of the corresponding physical addresses.
• For Contiguous Buffer DMA - returns a mapping of the physical address of the allocated buffer to both kernel and user-mode virtual address space.

PROTOTYPE

```
DWORD WD_DMALock(HANDLE hWD, WD_DMA *pDma);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pDma	WD_DMA *	
❑ hDma	DWORD	Output
❑ pUserAddr	PVOID	Input/Output
❑ pKernelAddr	KPTR	Output
❑ dwBytes	DWORD	Input
❑ dwOptions	DWORD	Input
❑ dwPages	DWORD	Input/Output
❑ hCard	DWORD	Input
❑ Page	Array of WD_DMA_PAGE	
❖ pPhysicalAddr	KPTR	Output
❖ dwBytes	DWORD	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pDma	WD_DMA elements.
hDma	Handle of DMA buffer to be used by `WD_DMAUnlock` [A.2.13]. Returns 0 if failed.
pUserAddr	Pointer to the user-mode virtual memory. Input in the case of Scatter Gather and output in the case of contiguous buffer DMA.
pKernelAddr	Kernel mapping of kernel allocated buffer. Relevant only for Contiguous Buffer DMA (dwOptions = DMA_KERNEL_BUFFER_ALLOC).
dwBytes	Size of buffer.

dwOptions	A bit mask flag: • DMA_KERNEL_BUFFER_ALLOC: If set - Allocates contiguous buffer in physical memory. Default - Scatter Gather. • DMA_KBUF_BELOW_16M: Relevant only if DMA was set to contiguous (above). If set - Physical address will be allocated within the first 16MB of the main memory. • DMA_LARGE_BUFFER: Relevant only if DMA is set to Scatter Gather (above). If set - Enables locking more than 1MB. • DMA_ALLOW_CACHE: Allow caching of the memory for contiguous memory allocation on Windows NT/2000/XP/Server 2003 (Not recommended! See remark below.) • DMA_KERNEL_ONLY_MAP: Relevant only if DMA was set to contiguous option with DMA_KERNEL_BUFFER_ALLOC flag. If set - the mapping of the allocated buffer is to the kernel only, not to the user mode. • DMA_READ_FROM_DEVICE: When set, the memory pages are locked to be read from, indicating writing to device. • DMA_WRITE_TO_DEVICE: When set, the memory pages are locked to be written to, indicating reading from device. **Note:** Set either DMA_READ_FROM_DEVICE or DMA_WRITE_TO_DEVICE but not both.
dwPages	Number of pages. Returns 1 if DMA is set to contiguous. In case of DMA_LARGE_BUFFER it is used as an input and an output parameter (otherwise only output), describing the size of the page array; Please refer to the remark regarding dwPages in this section.
hCard	Handle of relevant card as received from `WD_CardRegister()` [A.2.8].
Page	WD_DMA_PAGE - Array of pages.
pPhysicalAddr	Pointer to the physical address.
dwBytes	Size of page.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

- WinDriver supports both Scatter/Gather and Contiguous DMA under Windows 98/Me/NT/2k/XP/CE/Server 2003, Linux, Solaris and VxWorks.
  On Linux, Scatter/Gather DMA is only supported for 2.4 kernels and above (since the 2.2 Linux kernels require a patch to support this type of DMA).

- To access the allocated DMA buffer from your application, do NOT use the physical memory address (`dma.Page[i].pPhysicalAddr`) directly.
  To access the memory from a user-mode application, use the user-mode virtual mapping of the address - `dma.pUserAddr`.
  For Contiguous Buffer DMA, to access the memory from a kernel application (e.g. when using the Kernel PlugIn) or using WinDriver's API (e.g. `WD_Trasnfer()`), use the kernel mapping of the physical address, which is returned by `WD_DMALock()` in `dma.pKernelAddr`.

- The DMA_ALLOW_CACHE flag allocates cached DMA buffers on Windows NT/2000/XP/Server 2003. However, in order to prevent memory corruptions, DMA buffers generally should be non-cached. Therefore, we recommend that you avoid using this flag.

- On Solaris, the user buffer address and size must be aligned on system memory page boundary. Use the aligned memory allocation function, `valloc` (similar to `malloc`, except the allocated memory blocks are aligned). On SPARC platforms, the virtual page size is usually 8 KB, and on x86 platforms, it is 4 KB.

- When using the DMA_LARGE_BUFFER flag, dwPages is an input/output parameter. As an input to a `WD_DMALock()` call, dwPages equals the maximum number of elements in an array of pages. On return from `WD_DMALock()`, dwPages equals the number of actual physical blocks. The returned dwPages may be smaller, because adjacent pages are returned as one block.

EXAMPLE

The following code demonstrates Scatter/Gather DMA allocation:

```
WD_DMA dma;
DWORD dwStatus;
PVOID pBuffer = malloc(20000);

BZERO(dma);
dma.dwBytes = 20000;
dma.pUserAddr = pBuffer;
dma.dwOptions = fIsRead ? DMA_READ_FROM_DEVICE : DMA_WRITE_TO_DEVICE;
// Initialization of dma.hCard, value obtained from WD_CardRegister call:
dma.hCard = cardReg.hCard;
dwStatus = WD_DMALock(hWD, &dma);
if (dwStatus)
{
   printf("Could not lock down buffer\n");
}
else
{
   // On successful return dma.Page has the list of
   // physical addresses.
   // To access the memory from your user mode
   // application, use dma.pUserAddr.
}
```

EXAMPLE

The following code demonstrates contiguous kernel buffer DMA allocation:

```
WD_DMA dma;
DWORD dwStatus;

BZERO(dma);
dma.dwBytes = 20 * 4096; // 20 pages
dma.dwOptions = DMA_KERNEL_BUFFER_ALLOC |
   ( fIsRead ? DMA_READ_FROM_DEVICE : DMA_WRITE_TO_DEVICE);
// Initialization of dma.hCard, value obtained from WD_CardRegister call:
dma.hCard = cardReg.hCard;
dwStatus = WD_DMALock(hWD, &dma);
if (dwStatus)
{
  printf("Failed allocating kernel buffer for DMA\n");
```

```
}
else
{
   // On return dma.pUserAddr holds the user mode virtual
   // mapping of the allocated memory and dma.pKernelAddr
   // holds the kernel mapping of the physical memory.
   // dma.Page[0].pPhysicalAddr points to the allocated
   // physical address.
}
```

A.2.13 WD_DMAUnlock()

PURPOSE

• Unlocks a DMA buffer.

PROTOTYPE

```
DWORD WD_DMAUnlock(HANDLE hWD, WD_DMA *pDMA);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pDMA	WD_DMA *	
❑ hDma	DWORD	Input
❑ pUserAddr	PVOID	N/A
❑ pKernelAddr	KPTR	N/A
❑ dwBytes	DWORD	N/A
❑ dwOptions	DWORD	N/A
❑ dwPages	DWORD	N/A
❑ Page	Array of WD_DMA_PAGE	N/A

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pDMA	WD_DMA elements:
hDma	Handle of DMA buffer received by `WD_DMALock` [A.2.12].

Return Value

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

Example

```
WD_DMAUnlock(hWD, &DMA);
```

A.2.14 InterruptEnable()

PURPOSE

• Call a callback function upon interrupt reception. A convenient function for setting up interrupt handling.

PROTOTYPE

```
DWORD InterruptEnable(HANDLE *phThread, HANDLE hWD,
   WD_INTERRUPT *pInt, INT_HANDLER_FUNC func, PVOID pData);
```

PARAMETERS

Name	Type	Input/Output
➢ phThread	HANDLE *	Output
➢ hWD	HANDLE	Input
➢ pInt	WD_INTERRUPT *	
❑ hInterrupt	HANDLE	Input
❑ dwOptions	DWORD	Input
❑ Cmd	WD_TRANSFER *	Input
❑ dwCmds	DWORD	Input
❑ kpCall	WD_KERNEL_PLUGIN_CALL	
❖ hKernelPlugIn	DWORD	Input
❖ dwResult	DWORD	N/A
❑ fEnableOk	DWORD	N/A
❑ dwCounter	DWORD	N/A
❑ dwLost	DWORD	N/A
❑ fStopped	DWORD	N/A
➢ func	INT_HANDLER_FUNC	Input
➢ pData	PVOID	Input

DESCRIPTION

Name	Description
phThread	Returns the handle of the spawned interrupt thread to be used by `InterruptDisable` [A.2.15].
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pInt	WD_INTERRUPT elements:
hInterrupt	Handle of interrupt internal data structure received by I.Int.hInterrupt in `WD_CardRegister` [A.2.8].
dwOptions	A bit mask flag. May be "0" for no option, or: • INTERRUPT_CMD_COPY: if set, the WinDriver kernel will copy the data received from the read commands that were used to acknowledge the interrupt, back to the user mode. The data will be available when function is called.
Cmd	An array of data transfer commands (`WD_TRANSFER` *) to perform in kernel mode upon receipt of hardware interrupts. These commands are needed for acknowledging level sensitive interrupts (for more details refer to the ISA_PCI interrupts section). If no data transfer commands are needed, this should be set to NULL. (For details regarding the transfer commands refer to `WD_Transfer` [A.2.10].)
dwCmds	Number of transfer commands in Cmd array.
kpCall	WD_KERNEL_PLUGIN_CALL elements:
hKernelPlugIn	Handle to Kernel PlugIn returned from `WD_KernelPlugInOpen` [A.11.1].
func	The interrupt handling function that will be called once at every interrupt occurrence. INT_HANDLER_FUNC is defined in windrvr_int_thread.h.
pData	The pointer that is passed to the interrupt handling function as an argument.
Return Value	TRUE if enabling the interrupt succeeded.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

- Implemented in **\WinDriver\src\windrvr_int_thread.c**.
- `WD_IntEnable`, `WD_IntWait`, `WD_IntCount` and `WD_IntDisable` compose the above `InterruptEnable` and `InterruptDisable` functions and can be called separately instead. For more details, please refer to Section A.3.
- To improve the PCI interrupt handling rate on Windows 98/Me/NT/2000/XP/Server 2003, Linux and Solaris, consider using WinDriver's Kernel PlugIn feature (see Section "Understanding the Kernel PlugIn"). On VxWorks, you can use the `windrvr_isr` callback function (see Section "Improving the Interrupt Handling Rate on VxWorks").

EXAMPLE

```
VOID DLLCALLCONV interrupt_handler(PVOID pData)
{
   WD_INTERRUPT *pIntrp = (WD_INTERRUPT *)pData;
   // do your interrupt routine here

   printf("Got interrupt %d\n", pIntrp->dwCounter);
}

....
main()
{
   WD_CARD_REGISTER cardReg;
   WD_INTERRUPT Intrp;
   HANDLE hWD, thread_handle;

   ....
   hWD = WD_Open();
   BZERO(cardReg);
   cardReg.Card.dwItems = 1;
   cardReg.Card.Item[0].item = ITEM_INTERRUPT;
   cardReg.Card.Item[0].fNotSharable = TRUE;
```

```
   cardReg.Card.Item[0].I.Int.dwInterrupt = MY_IRQ;
   cardReg.Card.Item[0].I.Int.dwOptions = 0;
   ....
   WD_CardRegister(hWd, &cardReg);
   ....
   PVOID pdata = NULL;
   BZERO (Intrp);
   Intrp.hInterrupt = cardReg.Card.Item[0].I.Int.hInterrupt;
   Intrp.Cmd = NULL;
   Intrp.dwCmds = 0;
   Intrp.dwOptions = 0;
   printf("starting interrupt thread\n");
   pData = &Intrp;
   if (!InterruptEnable(&thread_handle, hWD, &Intrp,
      interrupt_handler, pdata))
   {
      printf ("failed enabling interrupt\n")
   }
   else
   {
      printf("Press Enter to uninstall interrupt\n");
      fgets(line, sizeof(line), stdin);
      // this calls WD_IntDisable()
      InterruptDisable(thread_handle);
   }
   WD_CardUnregister(hWD, &cardReg);
   ....
}
```

A.2.15 InterruptDisable()

PURPOSE

• A convenient function for shutting down interrupt handling.

PROTOTYPE

```
DWORD InterruptDisable(HANDLE hThread);
```

PARAMETERS

Name	Type	Input/Output
➢ hThread	HANDLE	Input

DESCRIPTION

Name	Description
phThread	The handle of the spawned interrupt thread which was created by `InterruptEnable` [A.2.14].

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

- Implemented in **\WinDriver\src\windrvr_int_thread.c**.
- `WD_IntEnable`, `WD_IntWait`, `WD_IntCount` and `WD_IntDisable` compose the above InterruptEnable and InterruptDisable functions and can be called separately instead. For more details, please refer to Section A.3.

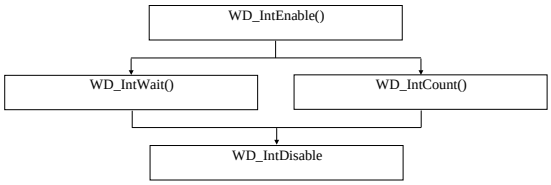
EXAMPLE

```
main()
{
   ....
   if (!InterruptEnable(&thread_handle, hWD, &Intrp,
      interrupt_handler, pData))
   {
      printf("failed enabling interrupt\n"');
   }
   else
   {
      printf("Press Enter to uninstall interrupt\n");
      fgets(line, sizeof(line), stdin);
      // this calls WD_IntDisable()
      InterruptDisable(thread_handle);
   }
   ....
}
```

A.3 PCI/ISA - Low Level Functions

A.3.1 Calling Sequence WinDriver - Low Level

The following is a typical calling sequence of the WinDriver API, used for servicing interrupts. The `InterruptEnable` and `InterruptDisable` functions enable interrupt handling in a more convenient manner.



A.3.2 WD_IntEnable()

PURPOSE

• Register an internal interrupt service routine (ISR) to be called upon interrupt.

PROTOTYPE

```
DWORD WD_IntEnable(HANDLE hWD, WD_INTERRUPT *pInterrupt);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pInterrupt	WD_INTERRUPT *	
❑ hInterrupt	HANDLE	Input
❑ dwOptions	DWORD	Input
❑ Cmd	WD_TRANSFER *	Input
❑ dwCmds	DWORD	Input
❑ kpCall	WD_KERNEL_PLUGIN_CALL	
❖ hKernelPlugIn	HANDLE	Input

❖ dwMessage	DWORD	N/A
❖ pData	PVOID	N/A
❖ dwResult	DWORD	N/A
❑ fEnableOk	DWORD	Output
❑ dwCounter	DWORD	N/A
❑ dwLost	DWORD	N/A
❑ fStopped	DWORD	N/A

DESCRIPTION

Name	Description
HWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pInterrupt	WD_INTERRUPT elements:
hInterrupt	Handle of interrupt to enable. The handle is returned by `WD_CardRegister` [A.2.8] in I.Int.hInterrupt.
dwOptions	A bit mask flag. May be 0 for no option, or: • INTERRUPT_CMD_COPY: if set, the WinDriver kernel will copy the data received from the read commands that were used to acknowledge the interrupt, back to the user mode. The data will be available when `WD_IntWait` [A.3.3] returns.
Cmd	An array of data transfer commands (`WD_TRANSFER` *) to perform in kernel mode upon receipt of hardware interrupts. These commands are needed for acknowledging level sensitive interrupts (for more details refer to the ISA_PCI interrupts section). If no data transfer commands are needed, this should be set to NULL. (For details regarding the transfer commands refer to `WD_Transfer` [A.2.10].)
dwCmds	Number of transfer commands in Cmd array.
kpCall	WD_KERNEL_PLUGIN_CALL elements:
hKernelPlugIn	Handle to Kernel PlugIn returned from `WD_KernelPlugInOpen` [A.11.1].
fEnableOk	Returns TRUE if `WD_IntEnable` [A.3.2] succeeded.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

(1) For more information regarding interrupt handling please refer to ISA_PCI interrupts section, Section 9.2.2.
(2) kpCall is relevant for Kernel PlugIn implementation.

EXAMPLE

```
WD_INTERRUPT Intrp;
WD_CARD_REGISTER cardReg;

BZERO(cardReg);
cardReg.Card.dwItems = 1;
cardReg.Card.Item[0].item = ITEM_INTERRUPT;
cardReg.Card.Item[0].fNotSharable = TRUE;
cardReg.Card.Item[0].I.Int.dwInterrupt = 10; // IRQ 10
 // INTERRUPT_LEVEL_SENSITIVE - Set to level sensitive
 // interrupts, otherwise should be 0.
 // ISA cards are usually edge triggered while PCI cards
 // are usually level sensitive.
cardReg.Card.Item[0].I.Int.dwOptions =
   INTERRUPT_LEVEL_SENSITIVE;
cardReg.fCheckLockOnly = FALSE;
WD_CardRegister(hWD, &cardReg);
if (cardReg.hCard == 0)
   printf("Could not lock device\n");
else
{
   BZERO(Intrp);
   Intrp.hInterrupt =
      cardReg.Card.Item[0].I.Int.hInterrupt;
   Intrp.Cmd = NULL;
   Intrp.dwCmds = 0;
   Intrp.dwOptions = 0;
   WD_IntEnable(hWD, &Intrp);
}
if (!Intrp.fEnableOk)
{
   printf("failed enabling interrupt\n");
```

```
}
```

EXAMPLE

For another example please refer to **<WinDriver>\Samples\pci_diag\pci_lib.c**.

A.3.3 WD_IntWait()

PURPOSE

• Wait until an interrupt is received or disabled and exit.

PROTOTYPE

```
DWORD WD_IntWait(HANDLE hWD, WD_INTERRUPT *pInterrupt);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pInterrupt	WD_INTERRUPT *	
❑ hInterrupt	HANDLE	Input
❑ dwOptions	DWORD	N/A
❑ Cmd	WD_TRANSFER *	N/A
❑ dwCmds	DWORD	N/A
❑ kpCall	WD_KERNEL_PLUGIN_CALL	N/A
❑ fEnableOk	DWORD	N/A
❑ dwCounter	DWORD	Output
❑ dwLost	DWORD	Output
❑ fStopped	DWORD	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pInterrupt	WD_INTERRUPT elements:
hInterrupt	Handle of interrupt, returned by `WD_CardRegister` [A.2.8] in I.Int.hInterrupt.
dwCounter	Number of interrupts received.
dwLost	Number of interrupts that were acknowledge in kernel mode but not yet handled in user mode.

fStopped	Returns zero if an interrupt occurred. Returns INTERRUPT_STOPPED if an interrupt was disabled while waiting. Returns INTERRUPT_INTERRUPTED if while waiting for an interrupt, `WD_IntWait` [A.3.3] was interrupted without an actual hardware interrupt.

Return Value

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

Remarks

INTERRUPT_INTERRUPTED status can occur on Linux and Solaris if the application that waits on the interrupt is stopped (e.g. by pressing CTRL+Z).

Example

```
for (;;)
{
   WD_IntWait(hWD, &Intrp);
   if (Intrp.fStopped)
      break;

   ProcessInterrupt(Intrp.dwCounter);
}
```

A.3.4 WD_IntCount()

PURPOSE

• Retrieve the count number of interrupts since `WD_IntEnable` [A.3.2] was called.

PROTOTYPE

```
void WD_IntCount(HANDLE hWD, WD_INTERRUPT *pInterrupt);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pInterrupt	WD_INTERRUPT *	
❑ hInterrupt	HANDLE	Input
❑ dwOptions	DWORD	N/A
❑ Cmd	WD_TRANSFER *	N/A
❑ dwCmds	DWORD	N/A
❑ kpCall	WD_KERNEL_PLUGIN_CALL	N/A
❑ fEnableOk	DWORD	N/A
❑ dwCounter	DWORD	Output
❑ dwLost	DWORD	Output
❑ fStopped	DWORD	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pInterrupt	WD_INTERRUPT elements:
hInterrupt	Handle of interrupt, returned by `WD_CardRegister` [A.2.8] in I.Int.hInterrupt.
dwCounter	Number of interrupts received.
dwLost	Number of interrupts not yet handled.
fStopped	Returns TRUE if interrupt was disabled while waiting.

Return Value

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

Example

```
DWORD dwNumInterrupts;

WD_IntCount(hWD, &Intrp);
dwNumInterrupts = Intrp.dwCounter;
```

A.3.5 WD_IntDisable()

PURPOSE

• Disable interrupt processing.

PROTOTYPE

```
DWORD WD_IntDisable(HANDLE hWD, WD_INTERRUPT *pInterrupt);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pInterrupt	WD_INTERRUPT	
❑ hInterrupt	HANDLE	Input
❑ dwOptions	DWORD	N/A
❑ Cmd	WD_TRANSFER *	N/A
❑ dwCmds	DWORD	N/A
❑ kpCall	WD_KERNEL_PLUGIN_CALL	N/A
❑ fEnableOk	DWORD	N/A
❑ dwCounter	DWORD	N/A
❑ dwLost	DWORD	N/A
❑ fStopped	DWORD	N/A

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pInterrupt	WD_INTERRUPT elements:
hInterrupt	Handle of interrupt, returned by `WD_CardRegister` [A.2.8] in I.Int.hInterrupt.

Return Value

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

Example

```
WD_IntDisable(hWD, &Intrp);
```

A.4 USB

A.4.1 Calling Sequence for WinDriver USB

The USB API provided as part of WinDriver is designed to support event-driven transfers between your user-mode USB application and USB devices. This is in contrast to earlier versions, in which USB devices were initialized and controlled using a specific sequence of function calls.

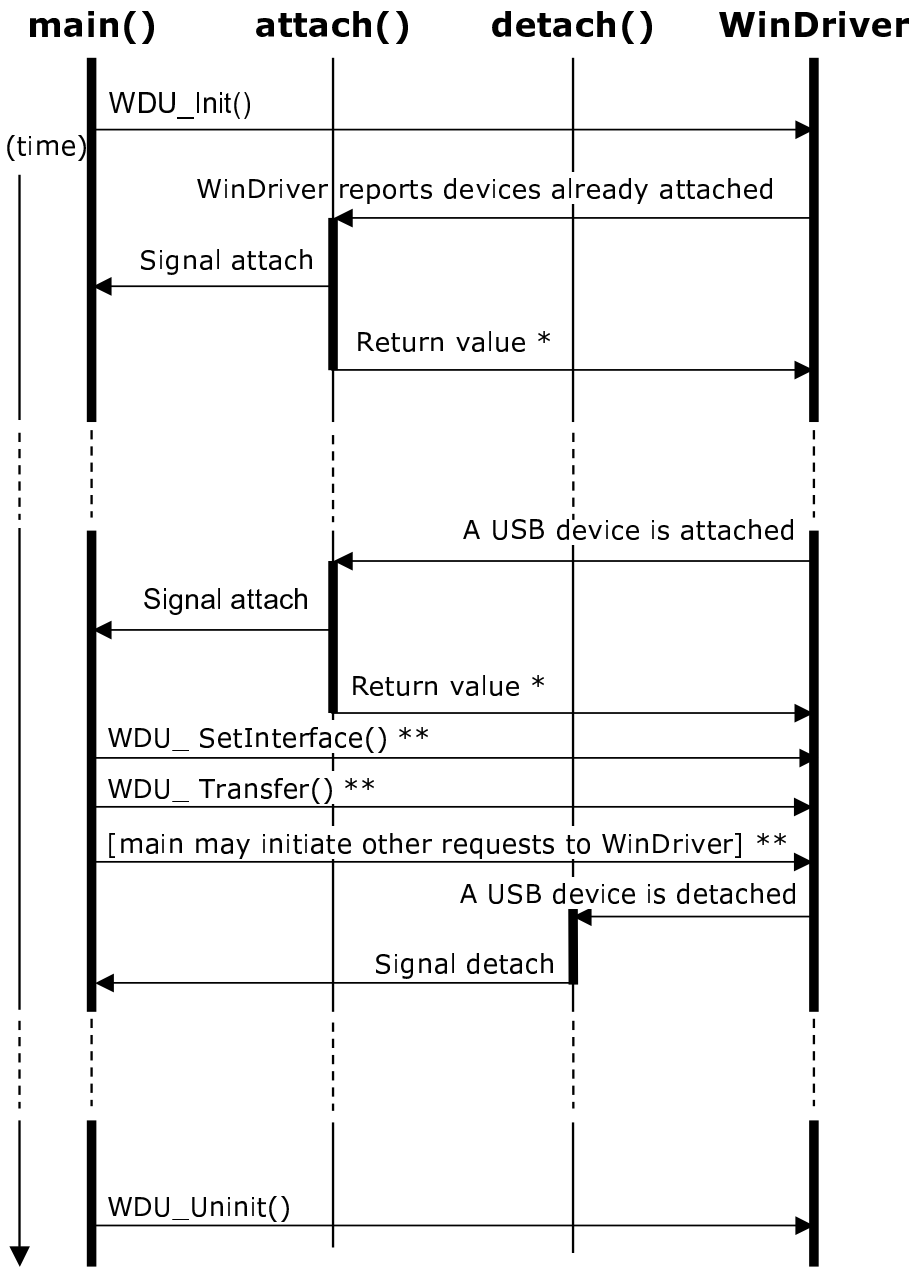
You can implement the three user callback functions specified in the next section: `WDU_ATTACH_CALLBACK` [A.5.1], `WDU_DETACH_CALLBACK` [A.5.2] and `WDU_POWER_CHANGE_CALLBACK` [A.5.3] (at the very least `WDU_ATTACH_CALLBACK`). These functions are used to notify your application when a relevant system event occurs, such as the attaching or detaching of a USB device. For best performance, minimal processing should be done in these functions.

Your application calls `WDU_Init` [A.6.1] and provides the criteria according to which the system identifies a device as relevant or irrelevant. The `WDU_Init` function must also pass pointers to the user callback functions.

Your application then simply waits to receive a notification of an event. Upon receipt of such a notification, processing continues. Your application may make use of any functions defined in the high- or low-level APIs below. The high-level functions, provided for your convenience, make use of the low-level functions, which in turn use IOCTLs to enable communication between the WinDriver kernel module and your user-mode application.

When exiting, your application calls `WDU_Uninit` [A.6.6] to stop listening to devices matching the given criteria and to un-register the notification callbacks for these devices.

The following figure depicts the calling sequence described above. Each vertical line represents a function or process. Each horizontal arrow represents a signal or request, drawn from the initiator to the recipient. Time progresses from top to bottom.



- If the WD_ACKNOWLEDGE flag was set in the call to WDU_Init(), the attach() callback should return TRUE if the function accepts control of the device, or FALSE otherwise.

** only possible if attach() returned TRUE

▬ indicates active function or process

-- represents discontinuity in time

The following piece of meta-code can serve as a framework for your user-mode application's code:

```
attach()
{
   ...
   if this is my device
      set the desired alternate setting
      signal main() about the attachment of this device
      return TRUE;
   else
      return FALSE;
}

detach()
{
   ...
   signal main() about the detachment of this device
   ...
}

main()
{
   WDU_Init(...);

   ...
   while (...)
   {
      wait for new devices

      ...

      issue transfers

      ...
   }
   ...
   WDU_Uninit();
}
```

A.4.2 Upgrading to WinDriver v6.X

The USB API provided as part of WinDriver v6.X is designed to support event-driven transfers between your user-mode USB application and USB devices. This is in contrast to earlier versions, in which USB devices were initialized and controlled using a specific sequence of function calls.

As a result of this change, you will need to modify your USB applications that were designed to interface with earlier versions of WinDriver to ensure that they will work with WinDriver v6.X on all supported platforms and not only on Microsoft Windows. You will have to reorganize your application's code so that it conforms with the framework illustrated by the piece of meta-code provided in Section A.4.1.

In addition, the functions that collectively define the USB API have been changed. The new functions, described in the next few sections, provide an improved interface between user-mode USB applications and the WinDriver kernel module. Note that the new functions receive their parameters directly, unlike the old functions, which received their parameters using a structure.

The table below lists the legacy functions in the left column and indicates in the right column which function or functions replace(s) each of the legacy functions. Use this table to quickly determine which new functions to use in your new code.

High Level API

This function...	*has been replaced by...*
WD_Open() WD_Version() WD_UsbScanDevice()	WDU_Init() [A.6.1]
WD_UsbDeviceRegister()	WDU_SetInterface() [A.6.2]
WD_UsbGetConfiguration()	WDU_GetDeviceInfo() [A.6.4]
WD_UsbDeviceUnregister()	WDU_Uninit() [A.6.6]

Low Level API

This function...	*has been replaced by...*
WD_UsbTransfer()	WDU_Transfer() [A.6.7] WDU_TransferDefaultPipe() [A.6.9] WDU_TransferBulk() [A.6.10] WDU_TransferIsoch() [A.6.11] WDU_TransferInterrupt() [A.6.12]
(USB_TRANSFER_HALT option)	WDU_HaltTransfer() [A.6.13]
WD_UsbResetPipe()	WDU_ResetPipe() [A.6.14]
WD_UsbResetDevice() WD_UsbResetDeviceEx()	WDU_ResetDevice() [A.6.15]

A.5 USB - User Callback Functions

NOTE:
Some of the functions described below take as parameters structures that are comprised of several elements. These structures, indicated by (†), are described in Section A.7.

A.5.1 WDU_ATTACH_CALLBACK()

PURPOSE

• WinDriver calls this function when a new device, matching the given criteria, is attached, provided it is not yet controlled by another driver.
This callback is called once for each matching interface.

PROTOTYPE

```
typedef BOOL (DLLCALLCONV *WDU_ATTACH_CALLBACK)(WDU_DEVICE_HANDLE hDevice,
   WDU_DEVICE *pDeviceInfo, PVOID pUserData);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ pDeviceInfo	WDU_DEVICE * [A.7.3]	Input (†)
➢ pUserData	PVOID	Input

DESCRIPTION

Name	Description
hDevice	A unique identifier for the device/interface
pDeviceInfo	Pointer to device configuration details; Valid until the end of the function
pUserData	Pointer that was passed to `WDU_Init` [A.6.1] (in the event table); Points to the user-mode data for the attach function

Return Value

If the WD_ACKNOWLEDGE flag was set in the call to `WDU_Init` [A.6.1] (within the dwOptions parameter), the callback function should check if it wants to control the device, and if so - return TRUE (otherwise - return FALSE).
If the WD_ACKNOWLEDGE flag was not set in the call to `WDU_Init`, then the return value of the callback function is insignificant.

A.5.2 WDU_DETACH_CALLBACK()

PURPOSE

• WinDriver calls this function when a controlled device has been detached from the system.

PROTOTYPE

```
typedef void (DLLCALLCONV *WDU_DETACH_CALLBACK)(WDU_DEVICE_HANDLE hDevice,
   PVOID pUserData);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ pUserData	PVOID	Input

DESCRIPTION

Name	Description
hDevice	A unique identifier for the device/interface
pUserData	Pointer that was passed to `WDU_Init` [A.6.1] (in the event table); Points to the user-mode data for the attach function

RETURN VALUE

None

A.5.3 WDU_POWER_CHANGE_CALLBACK()

PURPOSE

• WinDriver calls this function when a controlled device has changed its power settings.

PROTOTYPE

```
typedef BOOL (DLLCALLCONV *WDU_POWER_CHANGE_CALLBACK)(WDU_DEVICE_HANDLE hDevice,
   DWORD dwPowerState, PVOID pUserData);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ dwPowerState	DWORD	Input
➢ pUserData	PVOID	Input

DESCRIPTION

Name	Description
hDevice	A unique identifier for the device/interface
dwPowerState	Number of the power state selected
pUserData	Pointer that was passed to `WDU_Init` [A.6.1] (in the event table); Points to the user-mode data for the attach function

RETURN VALUE

TRUE/FALSE. Currently there is no significance to the return value.

REMARKS

This callback is supported only in Windows operating systems, starting from Windows 2000.

A.6 USB - Functions

NOTE:
Some of the functions described below take as parameters structures that are comprised of many elements. These structures, indicated by (†), are described in Section A.7.

A.6.1 WDU_Init()

PURPOSE

• Starts listening to devices matching input criteria and registers notification callbacks for these devices.

PROTOTYPE

```
DWORD WDU_Init(WDU_DRIVER_HANDLE *phDriver,
   WDU_MATCH_TABLE *pMatchTables, DWORD dwNumMatchTables,
   WDU_EVENT_TABLE *pEventTable, const char *sLicense, DWORD dwOptions);
```

PARAMETERS

Name	Type	Input/Output
➢ phDriver	WDU_DRIVER_HANDLE *	Output
➢ pMatchTables	WDU_MATCH_TABLE * [A.7.1]	Input (†)
➢ dwNumMatchTables	DWORD	Input
➢ pEventTable	WDU_EVENT_TABLE * [A.7.2]	Input (†)
➢ sLicense	const char *	Input
➢ dwOptions	DWORD	Input

DESCRIPTION

Name	Description
phDriver	Handle to the registration of events & criteria
pMatchTables	Array of match tables defining the devices' criteria
dwNumMatchTables	Number of elements in pMatchTables
pEventTable	Addresses of notification callback functions for changes in the device's status + relevant data for the callbacks
sLicense	WinDriver's license string
dwOptions	Can be zero (0) or: WD_ACKNOWLEDGE - the user can seize control over the device when returning value in `WDU_ATTACH_CALLBACK` [A.5.1]

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.6.2 WDU_SetInterface()

PURPOSE

• Sets the alternate setting for the specified interface.

PROTOTYPE

```
DWORD WDU_SetInterface(WDU_DEVICE_HANDLE hDevice, DWORD dwInterfaceNum,
   DWORD dwAlternateSetting);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ dwInterfaceNum	DWORD	Input
➢ dwAlternateSetting	DWORD	Input

DESCRIPTION

Name	Description
hDevice	A unique identifier for the device/interface
dwInterfaceNum	The interface's number
dwAlternateSetting	The desired alternate setting value

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.6.3 WDU_GetDeviceAddr()

PURPOSE

• Gets USB address that the device uses. The address number is written to the caller supplied pAddress.

PROTOTYPE

```
DWORD WDU_GetDeviceAddr(WDU_DEVICE_HANDLE hDevice,
ULONG *pAddress);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ pAddress	ULONG	Output

DESCRIPTION

Name	Description
hDevice	A unique identifier for a device/interface
pAddress	A pointer to ULONG, in which the result is returned

REMARKS

This function is supported on Windows only.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.6.4 WDU_GetDeviceInfo()

PURPOSE

• Gets configuration information from a device, including all the descriptors in a WDU_DEVICE [A.7.3] structure.
The caller should free *ppDeviceInfo after use by calling WDU_PutDeviceInfo [A.6.5].

PROTOTYPE

```
DWORD WDU_GetDeviceInfo(WDU_DEVICE_HANDLE hDevice,
   WDU_DEVICE **ppDeviceInfo);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ ppDeviceInfo	WDU_DEVICE ** [A.7.3]	Output (†)

DESCRIPTION

Name	Description
hDevice	A unique identifier for a device/interface
ppDeviceInfo	Pointer to pointer to a buffer containing device information

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.6.5 WDU_PutDeviceInfo()

PURPOSE

• Receives a device information pointer, allocated with a previous WDU_GetDeviceInfo() [A.6.4] call, in order to perform the necessary cleanup.

PROTOTYPE

```
DWORD WDU_PutDeviceInfo(WDU_DEVICE *pDeviceInfo);
```

PARAMETERS

Name	Type	Input/Output
➢ pDeviceInfo	WDU_DEVICE * [A.7.3]	Input

DESCRIPTION

Name	Description
pDeviceInfo	Pointer to a buffer containing the device information, as returned by a previous call to WDU_GetDeviceInfo()

RETURN VALUE

None

A.6.6 WDU_Uninit()

PURPOSE

• Stops listening to devices matching a given criteria and unregisters the notification callbacks for these devices.

PROTOTYPE

```
void WDU_Uninit(WDU_DRIVER_HANDLE hDriver);
```

PARAMETERS

Name	Type	Input/Output
➢ hDriver	WDU_DRIVER_HANDLE	Input

DESCRIPTION

Name	Description
hDriver	Handle to the registration received from `WDU_Init` [A.6.1]

A.6.7 WDU_Transfer()

PURPOSE

• Transfers data to or from a device.

PROTOTYPE

```
DWORD WDU_Transfer(WDU_DEVICE_HANDLE hDevice, DWORD dwPipeNum,
   DWORD fRead, DWORD dwOptions, PVOID pBuffer, DWORD dwBufferSize,
   PDWORD pdwBytesTransferred, PBYTE pSetupPacket, DWORD dwTimeout);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ dwPipeNum	DWORD	Input
➢ fRead	DWORD	Input
➢ dwOptions	DWORD	Input
➢ pBuffer	PVOID	Input
➢ dwBufferSize	DWORD	Input
➢ pdwBytesTransferred	PDWORD	Output
➢ pSetupPacket	PBYTE	Input
➢ dwTimeout	DWORD	Input

DESCRIPTION

Name	Description
hDevice	A unique identifier for the device/interface received from `WDU_Init()` [A.6.1]
dwPipeNum	The number of the pipe through which the data is transferred
fRead	TRUE for read, FALSE for write

dwOptions	A bit mask flag: • USB_ISOCH_ASAP - for isochronous data transfers. Set this flag in order to instruct the lower driver (usbd.sys) to use the next available frame to perform the data transfer. If this flag is not set, WinDriver may cause a delay in the isochronous data transfer due to some unused frames. This option affects Windows only (not CE), all other operating systems define it automatically. • USB_ISOCH_RESET - resets the isochronous pipe before the data transfer. It also resets the pipe after minor errors (consequently allowing to continue with the transfer). It is recommended to use USB_ISOCH_ASAP together with this flag. • USB_ISOCH_FULL_PACKETS_ONLY - when set, do not transfer less than packet size on isochronous pipes.
pBuffer	Address of the data buffer.
dwBufferSize	Number of bytes to transfer. The buffer size is not limited to the device's maximum packet size; therefore, you can use larger buffers by setting the buffer size to a multiple of the maximum packet size. Use large buffers to reduce the number of context switches and thereby improve performance.
pdwBytesTransferred	Number of bytes actually transferred.
pSetupPacket	An 8-byte packet to transfer to control pipes.
dwTimeout	Timeout interval of the transfer, in milliseconds. If *dwTimeout* is zero, the function's timeout interval never elapses (infinite wait).

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

The resolution of the timeout (the dwTimeout parameter) is according to the operating system scheduler's timeslot. For example, in Windows the timeout's resolution is 10 milliseconds.

A.6.8 WDU_Wakeup()

PURPOSE

• Enables/Disables the wakeup feature.

PROTOTYPE

```
DWORD WDU_Wakeup(WDU_DEVICE_HANDLE hDevice, DWORD dwOptions);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ dwOptions	DWORD	Input

DESCRIPTION

Name	Description
hDevice	A unique identifier for the device/interface.
dwOptions	Can be either WDU_WAKEUP_ENABLE - enables wakeup, or WDU_WAKEUP_DISABLE - disables wakeup.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.6.9 WDU_TransferDefaultPipe()

PURPOSE

• Transfers data to or from a device through the default pipe.

PROTOTYPE

```
DWORD WDU_TransferDefaultPipe(WDU_DEVICE_HANDLE hDevice,
   DWORD fRead, DWORD dwOptions, PVOID pBuffer, DWORD dwBufferSize,
   PDWORD pdwBytesTransferred, PBYTE pSetupPacket, DWORD dwTimeout);
```

PARAMETERS

Name	Type	Input/Output
See description of `WDU_Transfer` [A.6.7]. Note that dwPipeNum is not a parameter of this function.		

DESCRIPTION

Name	Description
See description of `WDU_Transfer` [A.6.7] . Note that dwPipeNum is not a parameter of this function.	

REMARKS

See description of `WDU_Transfer` [A.6.7] .

A.6.10 WDU_TransferBulk()

PURPOSE

• Performs bulk data transfer to or from a device.

PROTOTYPE

```
DWORD WDU_TransferBulk(WDU_DEVICE_HANDLE hDevice,
   DWORD dwPipeNum, DWORD fRead, DWORD dwOptions, PVOID pBuffer,
   DWORD dwBufferSize, PDWORD pdwBytesTransferred, DWORD dwTimeout);
```

PARAMETERS

Name	Type	Input/Output
See description of `WDU_Transfer` [A.6.7]. Note that pSetupPacket is not a parameter of this function.		

DESCRIPTION

Name	Description
See description of `WDU_Transfer` [A.6.7]. Note that pSetupPacket is not a parameter of this function.	

REMARKS

See description of `WDU_Transfer` [A.6.7].

A.6.11 WDU_TransferIsoch()

PURPOSE

• Performs isochronous data transfer to or from a device.

PROTOTYPE

```
DWORD WDU_TransferIsoch(WDU_DEVICE_HANDLE hDevice, DWORD dwPipeNum,
   DWORD fRead, DWORD dwOptions, PVOID pBuffer, DWORD dwBufferSize,
   PDWORD pdwBytesTransferred, DWORD dwTimeout);
```

PARAMETERS

Name	Type	Input/Output
See description of `WDU_Transfer` [A.6.7]. Note that pSetupPacket is not a parameter of this function.		

DESCRIPTION

Name	Description
See description of `WDU_Transfer` [A.6.7]. Note that pSetupPacket is not a parameter of this function.	

REMARKS

See description of `WDU_Transfer` [A.6.7].

A.6.12 WDU_TransferInterrupt()

PURPOSE

• Performs interrupt data transfer to or from a device.

PROTOTYPE

```
DWORD WDU_TransferInterrupt(WDU_DEVICE_HANDLE hDevice,
   DWORD dwPipeNum, DWORD fRead, DWORD dwOptions, PVOID pBuffer,
   DWORD dwBufferSize, PDWORD pdwBytesTransferred, DWORD dwTimeout);
```

PARAMETERS

Name	Type	Input/Output
See description of `WDU_Transfer` [A.6.7]. Note that pSetupPacket is not a parameter of this function.		

DESCRIPTION

Name	Description
See description of `WDU_Transfer` [A.6.7]. Note that pSetupPacket is not a parameter of this function.	

REMARKS

See description of `WDU_Transfer` [A.6.7].

A.6.13 WDU_HaltTransfer()

PURPOSE

• Halts the transfer on the specified pipe (only one simultaneous transfer per pipe is allowed by WinDriver).

PROTOTYPE

```
DWORD WDU_HaltTransfer(WDU_DEVICE_HANDLE hDevice, DWORD dwPipeNum);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ dwPipeNum	DWORD	Input

DESCRIPTION

Name	Description
hDevice	A unique identifier for the device/interface
dwPipeNum	The number of the pipe

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.6.14 WDU_ResetPipe()

PURPOSE

• Resets a pipe by clearing both the halt condition on the host side of the pipe and the stall condition on the endpoint. This function is applicable for all pipes except pipe00.

PROTOTYPE

```
DWORD WDU_ResetPipe(WDU_DEVICE_HANDLE hDevice, DWORD dwPipeNum);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ dwPipeNum	DWORD	Input

DESCRIPTION

Name	Description
hDevice	A unique identifier for the device/interface
dwPipeNum	The pipe's number

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

This function should be used if a pipe is halted, in order to clear the halt.

A.6.15 WDU_ResetDevice()

PURPOSE

• Resets a device to help recover from an error, when a device is marked as connected but is not enabled.

PROTOTYPE

```
DWORD WDU_ResetDevice(WDU_DEVICE_HANDLE hDevice, DWORD dwOptions);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ dwOptions	DWORD	Input

DESCRIPTION

Name	Description
hDevice	A unique identifier for the device/interface.
dwOptions	Can be either 0 or WD_USB_HARD_RESET - will reset the device even if it is not disabled. After using this option it is advised to set the interface of the device, using `WDU_SetInterface()` [A.6.2].

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

`WDU_ResetDevice` is supported only on Windows.

This function issues a request from the Windows USB driver to reset a hub port, provided the Windows USB driver supports this feature.

A.6.16 WDU_GetDeviceData()

PURPOSE

• Gets configuration information from the device, including all the descriptors in a WDU_DEVICE [A.7.3] struct, and copies it to a user-allocated buffer.

PROTOTYPE

```
DWORD WDU_GetDeviceData(WDU_DEVICE_HANDLE hDevice, PVOID pBuf,
   DWORD *pdwBytes);
```

PARAMETERS

Name	Type	Input/Output
➢ hDevice	WDU_DEVICE_HANDLE	Input
➢ pBuf	PVOID	Input
➢ pdwBytes	DWORD *	Input/Output

DESCRIPTION

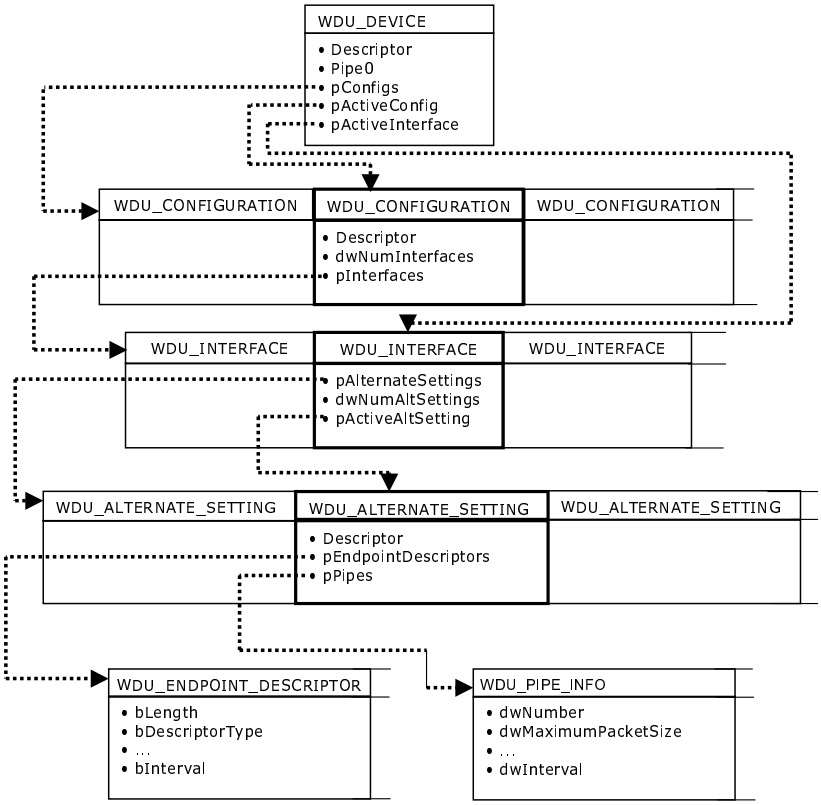
Name	Description
hDevice	A unique identifier for the device/interface
pBuf	Address of the data buffer; Passing 0 will just return in pdwBytes the buffer size required for the data
pdwBytes	If pBuf is 0, returns the data size, otherwise returns pBuf's size

Return Value

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.7 USB - Structures

The following figure depicts the structure hierarchy used by WinDriver's USB API. The arrays situated in each level of the hierarchy may contain more elements than are depicted in the diagram. Arrows are used to represent pointers. In the interest of clarity, only one structure at each level of the hierarchy is depicted in full detail (with all of its elements listed and pointers from it pictured).



A.7.1 WDU_MATCH_TABLE Elements:

NOTE:
(*) For all field members, if value is set to 0 - match all.

Name	Type	Description
wVendorId	WORD	Required USB Vendor ID to detect, as assigned by USB-IF. (*)
wProductId	WORD	Required USB Product ID to detect, as assigned by the product manufacturer. (*)
bDeviceClass	BYTE	The device's class code, as assigned by USB-IF. (*)
bDeviceSubClass	BYTE	The device's sub-class code, as assigned by USB-IF. (*)
bInterfaceClass	BYTE	The interface's class code, as assigned by USB-IF. (*)
bInterfaceSubClass	BYTE	The interface's sub-class code, as assigned by USB-IF. (*)
bInterfaceProtocol	BYTE	The interface's protocol code, as assigned by USB-IF. (*)

A.7.2 WDU_EVENT_TABLE Elements:

Name	Type	Description
pfDeviceAttach	WDU_ATTACH_CALLBACK	Will be called by WinDriver when a device is attached
pfDeviceDetach	WDU_DETACH_CALLBACK	Will be called by WinDriver when a device is detached
pfPowerChange	WDU_POWER_CHANGE_CALLBACK	Will be called by WinDriver when there is a change in a device's power state
pUserData	PVOID	Pointer to user-mode data to be passed to the callbacks

A.7.3 WDU_DEVICE Elements:

Name	Type	Description
Descriptor	WDU_DEVICE_DESCRIPTOR	Contains basic information about a device
Pipe0	WDU_PIPE_INFO	Stores information about the device's default pipe
pConfigs	WDU_CONFIGURATION *	Pointer to buffer containing information about a device's configurations
pActiveConfig	WDU_CONFIGURATION *	Pointer to buffer containing information about the active configuration
pActiveInterface	WDU_INTERFACE *	Pointer to buffer containing information about the active interface

A.7.4 WDU_CONFIGURATION Elements:

Name	Type	Description
Descriptor	WDU_CONFIGURATION_DESCRIPTOR	Contains basic information about a configuration
dwNumInterfaces	DWORD	Number of interfaces supported by this configuration
pInterfaces	WDU_INTERFACE *	Pointer to buffer containing information about this configuration's interfaces

A.7.5 WDU_INTERFACE Elements:

Name	Type	Description
pAlternateSettings	WDU_ALTERNATE_SETTING *	Pointer to buffer containing information about the interface's alternate settings
dwNumAltSettings	DWORD	Number of alternate settings
pActiveAltSetting	WDU_ALTERNATE_SETTING *	Pointer to buffer containing information about the active alternate setting

A.7.6 WDU_ALTERNATE_SETTING Elements:

Name	**Type**	**Description**
Descriptor	WDU_INTERFACE_DESCRIPTOR	Contains basic information about an interface
pEndpointDescriptors	WDU_ENDPOINT_DESCRIPTOR *	Pointer to buffers containing information about a device's endpoints
pPipes	WDU_PIPE_INFO *	Pointer to buffers containing information about a device's pipes

A.7.7 WDU_DEVICE_DESCRIPTOR Elements:

Name	Type	Description
bLength	UCHAR	Size, in bytes, of the descriptor (18 bytes)
bDescriptorType	UCHAR	Device descriptor (0x01)
bcdUSB	USHORT	Number of the USB specification with which the device complies
bDeviceClass	UCHAR	The device's class
bDeviceSubClass	UCHAR	The device's sub-class
bDeviceProtocol	UCHAR	The device's protocol
bMaxPacketSize0	UCHAR	Maximum size of transferred packets
idVendor	USHORT	Vendor ID, as assigned by USB-IF
idProduct	USHORT	Product ID, as assigned by the product manufacturer
bcdDevice	USHORT	Device release number
iManufacturer	UCHAR	Index of manufacturer string descriptor
iProduct	UCHAR	Index of product string descriptor
iSerialNumber	UCHAR	Index of serial number string descriptor
bNumConfigurations	UCHAR	Number of possible configurations

A.7.8 WDU_CONFIGURATION_DESCRIPTOR Elements:

Name	Type	Description
bLength	UCHAR	Size, in bytes, of the descriptor
bDescriptorType	UCHAR	Configuration descriptor (0x02)
wTotalLength	USHORT	Total length, in bytes, of data returned
bNumInterfaces	UCHAR	Number of interfaces
bConfigurationValue	UCHAR	Configuration number
iConfiguration	UCHAR	Index of string descriptor that describes this configuration
bmAttributes	UCHAR	Power settings for this configuration: D6 for self-powered, D5 for remote wakeup (allows device to wake up the host)
MaxPower	UCHAR	Maximum power consumption for this configuration, in 2mA units

A.7.9 WDU_INTERFACE_DESCRIPTOR Elements:

Name	Type	Description
bLength	UCHAR	Size, in bytes, of the descriptor (9 bytes)
bDescriptorType	UCHAR	Interface descriptor (0x04)
bInterfaceNumber	UCHAR	Interface number
bAlternateSetting	UCHAR	Alternate setting number
bNumEndpoints	UCHAR	Number of endpoints used by this interface
bInterfaceClass	UCHAR	The interface's class code, as assigned by USB-IF
bInterfaceSubClass	UCHAR	The interface's sub-class code, as assigned by USB-IF
bInterfaceProtocol	UCHAR	The interface's protocol code, as assigned by USB-IF
iInterface	UCHAR	Index of string descriptor that describes this interface

A.7.10 WDU_ENDPOINT_DESCRIPTOR Elements:

Name	Type	Description
bLength	UCHAR	Size, in bytes, of the descriptor (7 bytes)
bDescriptorType	UCHAR	Endpoint descriptor (0x05)
bEndpointAddress	UCHAR	Endpoint address: Use bits 0-3 for endpoint number, set bits 4-6 to zero (0), and set bit 7 to zero (0) for outbound data and one (1) for inbound data (ignored for control endpoints)
bmAttributes	UCHAR	Specifies the transfer type for this endpoint (control, interrupt, isochronous or bulk). See the USB specification for further information.
wMaxPacketSize	USHORT	Maximum size of packets this endpoint can send or receive
bInterval	UCHAR	Interval, in frame counts, for polling endpoint data transfers. Ignored for bulk and control endpoints. Must equal 1 for isochronous endpoints. May range from 1 to 255 for interrupt endpoints.

A.7.11 WDU_PIPE_INFO Elements:

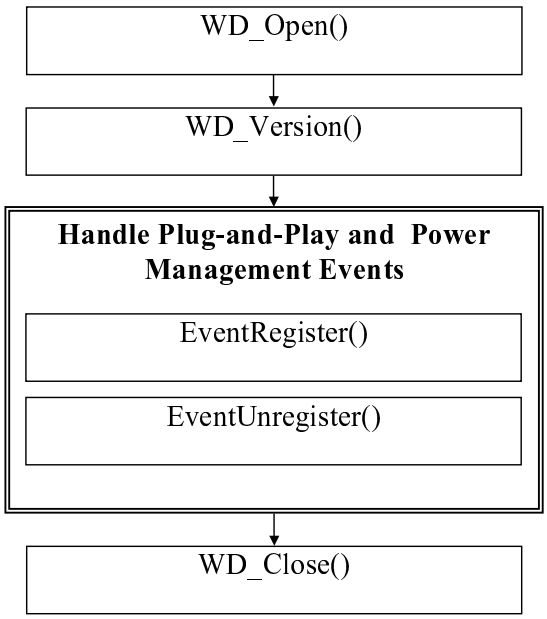
Name	Type	Description
dwNumber	DWORD	Pipe number; 0 for default pipe
dwMaximumPacketSize	DWORD	Maximum size of packets that can be transferred using this pipe
type	DWORD	Transfer type for this pipe
direction	DWORD	Direction of transfer: USB_DIR_IN or USB_DIR_OUT for isochronous, bulk or interrupt pipes, USB_DIR_IN_OUT for control pipes.
dwInterval	DWORD	Interval in milliseconds; Relevant only to interrupt pipes

A.8 Plug and Play and Power Management

A.8.1 Calling Sequence

The following is a typical calling sequence of the WinDriver API, used for handling Plug and Play and power management events.

NOTE:
For USB it is recommended to use `WDU_Init` [A.6.1]/`WDU_Uninit` [A.6.6] (described above) to handle Plug and Play and power management events, instead of directly using the following API.



A.8.2 EventRegister()

PURPOSE

• Register your application to receive Plug and Play and power management event notifications, according to a predefined set of criteria, and call a callback function upon event receipt.

PROTOTYPE

```
DWORD EventRegister(HANDLE *phEvent, HANDLE hWD,
   WD_EVENT *pEvent, EVENT_HANDLER pFunc, void *pData);
```

PARAMETERS

Name	Type	Input/Output
➢ phEvent	HANDLE *	Output
➢ hWD	HANDLE	Input
➢ event	WD_EVENT *	Input
❑ handle	DWORD	Output
❑ dwAction	DWORD	Input
❑ dwStatus	DWORD	N/A
❑ dwEventId	DWORD	N/A
❑ dwCardType	WD_BUS_TYPE	Input
❑ hKernelPlugIn	DWORD	Input
❑ dwOptions	DWORD	Input
❑ u	union	
❖ Pci	struct	
✧ cardId	WD_PCI_ID	
♦ dwVendorId	DWORD	Input
♦ dwDeviceId	DWORD	Input
✧ pciSlot	WD_PCI_SLOT	
♦ dwBus	DWORD	Input
♦ dwSlot	DWORD	Input
♦ dwFunction	DWORD	Input
❖ Usb	struct	
✧ deviceId	WD_USB_ID	

♦ dwVendorId	DWORD	Input
♦ dwProductId	DWORD	Input
✧ dwUniqueID	DWORD	Input
➢ func	EVENT_HANDLER	Input
➢ data	void	Input
➢ dwEventVer	DWORD	Internal use
➢ dwNumMatchTables	DWORD	Input
➢ matchTables[1]	WDU_MATCH_TABLE	Input

DESCRIPTION

Name	Description
phEvent	If successful, phEvent will hold the handle to be used in `EventUnregister` [A.8.3].
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
event	The criteria set for registering to receive event notifications.
handle	Optional handle to be used by `WD_EventUnregister` [A.9.3]. Returns 0 when event registration fails.

dwAction	A bit mask field indicating which events to register to. **Plug and Play events:** • WD_INSERT - Device inserted • WD_REMOVE - Device removed **Device power state:** • WD_POWER_CHANGED_D0 - Full power • WD_POWER_CHANGED_D1 - Low sleep • WD_POWER_CHANGED_D2 - Medium sleep • WD_POWER_CHANGED_D3 - Full sleep • WD_POWER_SYSTEM_WORKING - Fully on **Systems power state:** • WD_POWER_SYSTEM_SLEEPING1 - Fully on but sleeping • WD_POWER_SYSTEM_SLEEPING2 - CPU off, memory on, PCI on • WD_POWER_SYSTEM_SLEEPING3 - CPU off, Memory is in refresh, PCI on aux power • WD_POWER_SYSTEM_HIBERNATE - OS saves context before shutdown • WD_POWER_SYSTEM_SHUTDOWN - No context saved
dwCardType	Can be either WD_BUS_PCI or WD_BUS_USB (from the WD_BUS_TYPE options).
hKernelPlugIn	Handle to Kernel PlugIn returned from `WD_KernelPlugInOpen` [A.11.1] (when using the Kernel PlugIn to handle the events).
dwOptions	Can be either WD_ACKNOWLEDGE or zero. If WD_ACKNOWLEDGE, the user can perform actions on the requested event before acknowledging it. The OS waits on the event until the user calls WD_EventSend(). If the EventRegister() [A.8.2] wrapper is called, WD_EventSend() [A.9.5] will be called automatically after the callback function exits.
dwVendorId	PCI Vendor ID to register to. If zero, register to all PCI vendor ID's.
dwDeviceId	PCI Device ID to register to. If zero, register to all PCI Device ID's.
dwVendorId	Vendor ID of detected device.

dwBus	PCI bus number to register to. If zero, register to all PCI busses.
dwSlot	PCI slot to register to. If zero, register to all slots.
dwFunction	PCI function (on the device) to register to. If zero, registers to all functions.
dwVendorId	USB Vendor ID to register to. If zero, register to all USB vendor ID's.
dwProductId	USB Product ID to register to. If zero, register to all USB Product ID's.
dwUniqueID	Unique ID of the USB device to register to. If zero, register to all unique ID's.
func	The callback function to call upon receipt of event notification.
data	The data to pass to the callback function.
dwEventVer	For internal use only.
dwNumMatchTables	For USB only. (*) **NOTE:** For USB it is recommended to use WDU_Init()/WDU_Uninit() (see USB function reference, Section A.4), instead of directly using EventRegister()/EventUnregister().
matchTables[1]	For USB only; See NOTE above (*).

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

Remarks

This function wraps `WD_EventRegister` [A.9.2], `WD_EventPull` [A.9.4], `WD_EventSend` [A.9.5] and `InterruptEnable` [A.2.14].

Example

```
HANDLE *event_handle;
WD_EVENT event;
DWORD dwStatus;
BZERO(event);
event.dwAction = WD_INSERT | WD_REMOVE;
event.dwCardType = WD_BUS_PCI;
dwStatus = EventRegister(&event_handle, hWD, &event,
   event_handler_func, NULL);
if (dwStatus!=WD_STATUS_SUCCESS)
{
   printf("Failed register\n");
   return;
}
```

A.8.3 EventUnregister()

PURPOSE

• Un-registers from receiving Plug and Play and power management event notifications.

PROTOTYPE

```
DWORD EventUnregister(HANDLE hEvent);
```

PARAMETERS

Name	Type	Input/Output
➢ hEvent	HANDLE *	Input

DESCRIPTION

Name	Description
hEvent	Handle received from `EventRegister` [A.8.2].

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

This function wraps `WD_EventUnregister` [A.9.3] and `InterruptDisable` [A.2.15].

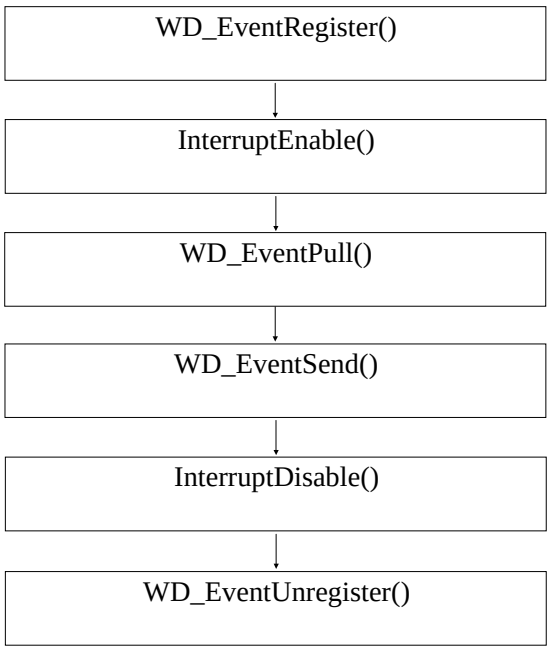
EXAMPLE

```
EventUnregister(event_handle);
```

A.9 Plug and Play and Power Management - Low Level Functions

A.9.1 Calling Sequence

The following is a typical calling sequence of the WinDriver API, used for handling Plug and Play and power management events. We recommend that you use `EventRegister` [A.8.2] and `EventUnregister` [A.8.3], or `WDU_Init` [A.6.1] and `WDU_Uninit` [A.6.6] (for USB), instead of these low level functions, in order to handle Plug and Play and power management events in a more convenient manner.



A.9.2 WD_EventRegister()

PURPOSE

• Register your application to receive Plug and Play and power management event notifications, according to a predefined set of criteria.

PROTOTYPE

```
DWORD WD_EventRegister(HANDLE hWD, WD_EVENT *pEvent);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pEvent	WD_EVENT *	
❑ handle	DWORD	Output
❑ dwAction	DWORD	Input
❑ dwStatus	DWORD	N/A
❑ dwEventId	DWORD	N/A
❑ dwCardType	WD_BUS_TYPE	Input
❑ hKernelPlugIn	DWORD	Input
❑ dwOptions	DWORD	Input
❑ u	union	
❖ Pci	struct	
✧ cardId	WD_PCI_ID	
♦ dwVendorId	DWORD	Input
♦ dwDeviceId	DWORD	Input
✧ pciSlot	WD_PCI_SLOT	
♦ dwBus	DWORD	Input
♦ dwSlot	DWORD	Input
♦ dwFunction	DWORD	Input
❖ Usb	struct	
✧ deviceId	WD_USB_ID	
♦ dwVendorId	DWORD	Input
♦ dwProductId	DWORD	Input
✧ dwUniqueID	DWORD	Input

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pEvent	WD_EVENT elements:
handle	Handle to be used by `WD_EventUnregister` [A.9.3]. Returns 0 when event registration fails.
dwAction	A bit mask field indicating which events to register to. **Plug and Play events:** • WD_INSERT - Device inserted • WD_REMOVE - Device removed **Device power state:** • WD_POWER_CHANGED_D0 - Full power • WD_POWER_CHANGED_D1 - Low sleep • WD_POWER_CHANGED_D2 - Medium sleep • WD_POWER_CHANGED_D3 - Full sleep • WD_POWER_SYSTEM_WORKING - Fully on **Systems power state:** • WD_POWER_SYSTEM_SLEEPING1 - Fully on but sleeping • WD_POWER_SYSTEM_SLEEPING2 - CPU off, memory on, PCI on • WD_POWER_SYSTEM_SLEEPING3 - CPU off, Memory is in refresh, PCI on aux power • WD_POWER_SYSTEM_HIBERNATE - OS saves context before shutdown • WD_POWER_SYSTEM_SHUTDOWN - No context saved
dwCardType	Can be either WD_BUS_PCI or WD_BUS_USB (from the WD_BUS_TYPE options).
hKernelPlugIn	Optional handle to Kernel PlugIn returned from `WD_KernelPlugInOpen` [A.11.1].
dwOptions	Can be either WD_ACKNOWLEDGE or zero.
dwVendorId	PCI Vendor ID to register to. If zero, register to all PCI vendor ID's.
dwDeviceId	PCI Device ID to register to. If zero, register to all PCI Device ID's.
dwVendorId	Vendor ID of detected device.

dwBus	PCI bus number to register to. If zero, register to all PCI busses.
dwSlot	PCI slot to register to. If zero, register to all slots.
dwFunction	PCI function (on the device) to register to. If zero, registers to all functions.
dwVendorId	USB Vendor ID to register to. If zero, register to all USB vendor ID's.
dwProductId	USB Product ID to register to. If zero, register to all USB Product ID's.
dwUniqueID	Unique ID of the USB device to register to. If zero, register to all unique ID's.

Return Value

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

Remarks

In order to receive the desired notifications you must also call `InterruptEnable` [A.2.14]. When the callback function sent to `InterruptEnable` is called it means that a new event has occurred.

NOTE:
If WD_ACKNOWLEDGE is set in the dwOptions field, you must call `WD_EventPull` [A.9.4] and `WD_EventSend` [A.9.5] to acknowledge the event in order to allow the system to handle the event normally. If you do not call `WD_EventPull` and `WD_EventSend`, the system might hang while waiting for your application to acknowledge the event.

Example

```
WD_EVENT Event;
BZERO(Event);
Event.dwAction = WD_INSERT | WD_REMOVE;
Event.dwCardType = WD_BUS_PCI;
WD_EventRegister(hWD, &Event);
if (Event.handle)
   printf("successfully registered to receive Plug and Play events\n");
else
   printf("WD_EventRegister failed\n");
```

A.9.3 WD_EventUnregister()

PURPOSE

• Un-registers from receiving Plug and Play and power management events notifications.

PROTOTYPE

```
DWORD WD_EventUnregister(HANDLE hWD, WD_EVENT *pEvent);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pEvent	WD_EVENT *	
❑ handle	DWORD	Input
❑ dwAction	DWORD	N/A
❑ dwStatus	DWORD	N/A
❑ dwEventId	DWORD	N/A
❑ dwCardType	WD_BUS_TYPE	N/A
❑ hKernelPlugIn	DWORD	N/A
❑ dwOptions	DWORD	N/A
❑ u	union	
❖ Pci	struct	
✧ cardId	WD_PCI_ID	
♦ dwVendorId	DWORD	N/A
♦ dwDeviceId	DWORD	N/A
✧ pciSlot	WD_PCI_SLOT	
♦ dwBus	DWORD	N/A
♦ dwSlot	DWORD	N/A
♦ dwFunction	DWORD	N/A
❖ Usb	struct	
✧ deviceId	WD_USB_ID	
♦ dwVendorId	DWORD	N/A
♦ dwProductId	DWORD	N/A
✧ dwUniqueID	DWORD	N/A

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pEvent	WD_EVENT elements:
handle	Handle received by `WD_EventRegister` [A.9.2].

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_EVENT Event;
BZERO(Event);
Event.handle = handle;
WD_EventUnregister(hWD, &Event);
```

A.9.4 WD_EventPull()

PURPOSE

• Retrieves information regarding a Plug and Play or power management event that occurred.

PROTOTYPE

```
DWORD WD_EventPull(HANDLE hWD, WD_EVENT *pEvent);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pEvent	WD_EVENT *	
❑ handle	DWORD	Input
❑ dwAction	DWORD	Output
❑ dwStatus	DWORD	N/A
❑ dwEventId	DWORD	Output
❑ dwCardType	WD_BUS_TYPE	Output
❑ hKernelPlugIn	DWORD	N/A
❑ dwOptions	DWORD	Output
❑ u	union	
❖ Pci	struct	
✧ cardId	WD_PCI_ID	
♦ dwVendorId	DWORD	Output
♦ dwDeviceId	DWORD	Output
✧ pciSlot	WD_PCI_SLOT	
♦ dwBus	DWORD	Output
♦ dwSlot	DWORD	Output
♦ dwFunction	DWORD	Output
❖ Usb	struct	
✧ deviceId	WD_USB_ID	
♦ dwVendorId	DWORD	Output
♦ dwProductId	DWORD	Output
✧ dwUniqueID	DWORD	Output

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pEvent	WD_EVENT elements:
handle	Handle received from `WD_EventRegister` [A.9.2].
dwAction	A bit mask field indicating which events to register to. **Plug and Play events:** • WD_INSERT - Device inserted • WD_REMOVE - Device removed **Device power state:** • WD_POWER_CHANGED_D0 - Full power • WD_POWER_CHANGED_D1 - Low sleep • WD_POWER_CHANGED_D2 - Medium sleep • WD_POWER_CHANGED_D3 - Full sleep • WD_POWER_SYSTEM_WORKING - Fully on **Systems power state:** • WD_POWER_SYSTEM_SLEEPING1 - Fully on but sleeping • WD_POWER_SYSTEM_SLEEPING2 - CPU off, memory on, PCI on • WD_POWER_SYSTEM_SLEEPING3 - CPU off, Memory is in refresh, PCI on aux power • WD_POWER_SYSTEM_HIBERNATE - OS saves context before shutdown • WD_POWER_SYSTEM_SHUTDOWN - No context saved
dwEventId	An ID to identify the event in the complementary `WD_EventSend` [A.9.5] function.
dwCardType	Can be either WD_BUS_PCI or WD_BUS_USB (from the WD_BUS_TYPE options).
dwOptions	Return WD_ACKNOWLEDGE if it was used in `WD_EventRegister` [A.9.2].
dwVendorId	PCI Vendor ID.
dwDeviceId	PCI Device ID.
dwBus	PCI bus number.
dwSlot	PCI slot.
dwFunction	PCI function (on the device).

dwVendorId	USB Vendor ID.
dwProductId	USB Product ID.
dwUniqueID	Unique ID of the USB device.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

Your application should call `WD_EventPull` [A.9.4], after receiving an event notification, in order to retrieve additional information identifying the event. (For example: your application can register to receive a notification about every Plug and Play or power management event that occurs, and after receiving a notification, it can retrieve the exact details of the event i.e., insertion/removal, vendor ID, device ID, etc.).

EXAMPLE

```
WD_EVENT Event;
BZERO(Event);
Event.handle = handle;
WD_EventPull(hWD, &Event);
if (Event.dwCardType==WD_BUS_PCI)
{
   printf("got PCI event %d.%d.%d vid %04x/%04x action 0x%x\n",
      Event.u.Pci.pciSlot.dwBus, Event.u.Pci.pciSlot.dwSlot,
      Event.u.Pci.pciSlot.dwFunction, Event.u.Pci.cardId.dwVendorId,
      Event.u.Pci.cardId.dwDeviceId, Event.dwAction);
}
else
{
   printf("got USB event unique %x vid %04x/%04x action 0x%x\n",
      Event.u.Usb.dwUniqueID, Event.u.Usb.deviceId.dwVendorId,
      Event.u.Usb.deviceId.dwProductId, Event.dwAction);
}
```

A.9.5 WD_EventSend()

PURPOSE

• Acknowledges a Plug and Play or power management event.

PROTOTYPE

```
DWORD WD_EventSend(HANDLE hWD, WD_EVENT *pEvent);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pEvent	WD_EVENT *	
❑ handle	DWORD	Input
❑ dwAction	DWORD	Input
❑ dwStatus	DWORD	N/A
❑ dwEventId	DWORD	Input
❑ dwCardType	WD_BUS_TYPE	N/A
❑ hKernelPlugIn	DWORD	N/A
❑ dwOptions	DWORD	Input
❑ u	union	
❖ Pci	struct	
✧ cardId	WD_PCI_ID	
♦ dwVendorId	DWORD	N/A
♦ dwDeviceId	DWORD	N/A
✧ pciSlot	WD_PCI_SLOT	
♦ dwBus	DWORD	N/A
♦ dwSlot	DWORD	N/A
♦ dwFunction	DWORD	N/A
❖ Usb	struct	
✧ deviceId	WD_USB_ID	
♦ dwVendorId	DWORD	N/A
♦ dwProductId	DWORD	N/A
✧ dwUniqueID	DWORD	N/A

DESCRIPTION

Name	Description
hWD	The handle to WinDriver's kernel-mode driver received from `WD_Open` [A.1.2].
pEvent	WD_EVENT elements:
handle	Handle to be used by `WD_EventUnregister` [A.9.3]. Returns zero when event registration fails.
dwEventId	Event ID received from `WD_EventPull` [A.9.4].
dwOptions	Should be WD_ACKNOWLEDGE.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

You must use `WD_EventSend` [A.9.5] to acknowledge Plug and Play or power management events, if you registered to receive notifications of such events with the WD_ACKNOWLEDGE flag set in `WD_EventRegister` [A.9.2].

EXAMPLE

```
WD_EVENT Event;
BZERO(Event);
Event.handle = handle;
WD_EventPull(hWD, &Event);
if (Event.dwOptions & WD_ACKNOWLEDGE)
   WD_EventSend(hWD, &Event);
```

A.10 Extension for custom USB HID

A.10.1 Calling Sequence

The following is a typical calling sequence for the WinDriver extension for custom USB HID:

- Call `WDL_Version` [A.10.2] to check the version is correct
- Call `WDL_Init` [A.10.3] to attach to a specific device, and get handle for further commands
- Call `WDL_SetNotificationCallback` [A.10.11] to set callbacks for connect/disconnect
- Call `WDL_Read` [A.10.5]/`WDL_Write` [A.10.6] to read/write data
- Call `WDL_Close` [A.10.4] to close the device

A.10.2 WDL_Version()

PURPOSE

• Get WinDriver version information of the library.

PROTOTYPE

```
WDL_STATUS WDL_Version(u32 *version_number, const char **version_string);
```

PARAMETERS

Name	Type	Input/Output
➢ version_number	u32 *	Output
➢ version_string	const char **	Output

DESCRIPTION

Name	Description
version_number	Returns an integer containing the version number
version_string	Returns a pointer to string containing the version text

RETURN VALUE

Returns WDL_SUCCESS (0) on success, or an appropriate WDL_STATUS error code otherwise.

EXAMPLE

```
u32 ver;
char *vers;
WDL_Version(&ver, &vers);
```

A.10.3 WDL_Init()

PURPOSE

• Register to work with a specific USB HID device.

PROTOTYPE

```
WDL_STATUS WDL_Init(WDL_HANDLE *handle, u16 vid, u16 pid,
   void *context, char *license);
```

PARAMETERS

Name	Type	Input/Output
➢ handle	WDL_HANDLE *	Output
➢ vid	u16	Input
➢ pid	u16	Input
➢ context	void *	Input
➢ license	char *	Input

DESCRIPTION

Name	Description
handle	Returns handle to the device opened
vid	VendorID of the device to open
pid	ProductID of the device to open
context	Parameter to be passed to callback functions
license	License string of WinDriver

RETURN VALUE

Returns WDL_SUCCESS (0) on success, or an appropriate WDL_STATUS error code otherwise.

EXAMPLE

```
WDL_HANDLE myhandle;
WDL_Init(&myhandle, 0x5310, 0x4432, NULL, "my license string");
```

A.10.4 WDL_Close()

PURPOSE

• Close the device opened via WinDriver.

PROTOTYPE

```
WDL_STATUS WDL_Close(WDL_HANDLE handle);
```

PARAMETERS

Name	Type	Input/Output
➢ handle	WDL_HANDLE	Input

DESCRIPTION

Name	Description
handle	Handle to the device to be closed

RETURN VALUE

Returns WDL_SUCCESS (0) on success, or an appropriate WDL_STATUS error code otherwise.

EXAMPLE

```
WDL_Close(myhandle);
```

A.10.5 WDL_Read()

PURPOSE

• Read a report from a device.

PROTOTYPE

```
WDL_STATUS WDL_Read(WDL_HANDLE handle, int reportid, u8 *buffer,
   size_t max_buffer_size, size_t *buffer_read_size, WDL_TIMEOUT timeout);
```

PARAMETERS

Name	Type	Input/Output
➢ handle	WDL_HANDLE	Input
➢ reportid	int	Input
➢ buffer	u8 *	Output
➢ max_buffer_size	size_t	Input
➢ buffer_read_size	size_t *	Output
➢ timeout	WDL_TIMEOUT	Input

DESCRIPTION

Name	Description
handle	Handle to the device to be read from
reportid	ID of the report to read (unused)
buffer	Buffer for the report read
max_buffer_size	Maximum size of buffer
buffer_read_size	Size of read buffer
timeout	Timeout for operation in milliseconds

Return Value

Returns WDL_SUCCESS (0) on success, or an appropriate WDL_STATUS error code otherwise.

Remarks

Read operation is done synchronously. The calling application should take care of setting any read threads for asynchronous operation. The timeout may be INFINITE.

Example

```
struct MyReport0 {
  unsigned char reportid;
  unsigned char X;
  unsigned char Y;
  unsigned char button1: 1;
  unsigned char button2: 1;
  unsigned char button3: 1;
  unsigned char button4: 1;
  unsigned char button5: 1;
  unsigned char button6: 1;
} ;

MyReport0 report;
size_t num_read;
WDL_Read(myhandle, 0, (u8 *)report, sizeof(report), &num_read, 200);
```

A.10.6 WDL_Write()

PURPOSE

• Write a report to a device.

PROTOTYPE

```
WDL_STATUS WDL_Write(WDL_HANDLE handle, int reportid, u8 *buffer,
   size_t buffer_size, WDL_TIMEOUT timeout);
```

PARAMETERS

Name	Type	Input/Output
➢ handle	WDL_HANDLE	Input
➢ reportid	int	Input
➢ buffer	u8 *	Input
➢ buffer_size	size_t	Input
➢ timeout	WDL_TIMEOUT	Input

DESCRIPTION

Name	Description
handle	Handle to the device to write to
reportid	ID of the report to write (unused)
buffer	Buffer for the report data
buffer_size	Size of buffer
timeout	Timeout for operation in milliseconds

Return Value

Returns WDL_SUCCESS (0) on success, or an appropriate WDL_STATUS error code otherwise.

Remarks

Write operation is done synchronously. The calling application should take care of setting any write threads for asynchronous operation. timeout may be INFINITE.

Example

```
struct MyReport0 {
 unsigned char reportid;
 unsigned char X;
 unsigned char Y;
 unsigned char button1: 1;
 unsigned char button2: 1;
 unsigned char button3: 1;
 unsigned char button4: 1;
 unsigned char button5: 1;
 unsigned char button6: 1;
} ;

MyReport0 report;
report.reportid=0;
report.X=5;
report.Y=34;
size_t num_read;
WDL_Write(myhandle, 0, (u8 *)report, sizeof(report), 200);
```

A.10.7 WDL_GetFeature()

PURPOSE

• Read a feature report from a device.

PROTOTYPE

```
WDL_STATUS WDL_GetFeature(WDL_HANDLE handle, int reportid,
   u8 *buffer, size_t max_buffer_size);
```

PARAMETERS

Name	Type	Input/Output
➢ handle	WDL_HANDLE	Input
➢ reportid	int	Input
➢ buffer	u8 *	Output
➢ max_buffer_size	size_t	Input

DESCRIPTION

Name	Description
handle	Handle to the device to be read from
reportid	ID of the report to read (unused)
buffer	Buffer for the report read
max_buffer_size	Maximum size of buffer

RETURN VALUE

Returns WDL_SUCCESS (0) on success, or an appropriate WDL_STATUS error code otherwise.

REMARKS

Get feature operation is done synchronously. The calling application should take care of setting any read threads for asynchronous operation.

EXAMPLE

```
struct MyReport0 {
  unsigned char reportid;
  unsigned char X;
  unsigned char Y;
  unsigned char button1: 1;
  unsigned char button2: 1;
  unsigned char button3: 1;
  unsigned char button4: 1;
  unsigned char button5: 1;
  unsigned char button6: 1;
} ;

MyReport0 report;
size_t num_read;
WDL_GetFeature(myhandle, 0, (u8 *)report, sizeof(report));
```

A.10.8 WDL_SetFeature()

PURPOSE

• Write a feature report to a device.

PROTOTYPE

```
WDL_STATUS WDL_SetFeature(WDL_HANDLE handle, int reportid,
   u8 *buffer, size_t max_buffer_size);
```

PARAMETERS

Name	Type	Input/Output
➢ handle	WDL_HANDLE	Input
➢ reportid	int	Input
➢ buffer	u8 *	Input
➢ max_buffer_size	size_t	Input

DESCRIPTION

Name	Description
handle	Handle to the device to write to
reportid	ID of the report to write (unused)
buffer	Buffer for the report to write
max_buffer_size	Maximum size of buffer

RETURN VALUE

Returns WDL_SUCCESS (0) on success, or an appropriate WDL_STATUS error code otherwise.

REMARKS

Set feature operation is done synchronously. The calling application should take care of setting any write threads for asynchronous operation.

EXAMPLE

```
struct MyReport0 {
 unsigned char reportid;
 unsigned char X;
 unsigned char Y;
 unsigned char button1: 1;
 unsigned char button2: 1;
 unsigned char button3: 1;
 unsigned char button4: 1;
 unsigned char button5: 1;
 unsigned char button6: 1;
} ;

MyReport0 report;
repot.reportid=0;
report.X=65;
report.Y=12;
WDL_SetFeature(myhandle, 0, (u8 *)report, sizeof(report));
```

A.10.9 WDL_IsAttached()

PURPOSE

• Check if the USB HID device is attached.

PROTOTYPE

```
WDL_STATUS WDL_IsAttached(WDL_HANDLE handle);
```

PARAMETERS

Name	Type	Input/Output
➢ handle	WDL_HANDLE	Input

DESCRIPTION

Name	Description
handle	Handle to the device

RETURN VALUE

Returns WDL_SUCCESS (0) on success, or an appropriate WDL_STATUS error code otherwise.

REMARKS

WDL_IsAttached returns WDL_SUCCESS if the device is attached.

EXAMPLE

```
WDL_STATUS res=WDL_IsAttached(myhandle);
```

A.10.10 WDL_CheckHandle()

PURPOSE

• Check if the handle is valid and exists.

PROTOTYPE

```
WDL_STATUS WDL_CheckHandle(WDL_HANDLE handle);
```

PARAMETERS

Name	Type	Input/Output
➢ handle	WDL_HANDLE	Input

DESCRIPTION

Name	Description
handle	Handle to the device

RETURN VALUE

Returns WDL_SUCCESS (0) on success, or an appropriate WDL_STATUS error code otherwise.

REMARKS

WDL_CheckHandle returns WDL_SUCCESS if the handle is valid.

EXAMPLE

```
WDL_STATUS res=WDL_CheckHandle(myhandle);
```

A.10.11 WDL_SetNotificationCallback()

PURPOSE

• Set callback notifications for the device.

PROTOTYPE

```
WDL_STATUS WDL_SetNotificationCallback(WDL_HANDLE handle,
   WDL_CALLBACK_OPS *ops);
```

PARAMETERS

Name	Type	Input/Output
➢ handle	WDL_HANDLE	Input
➢ ops	WDL_CALLBACK_OP *	Input
❑ cbConnect	WDL_CALLBACK	
❑ cbDisconnect	WDL_CALLBACK	
❑ cbPower	WDL_CALLBACK	
❑ cbDataAvailable	WDL_CALLBACK	
❑ cbDataSent	WDL_CALLBACK	

DESCRIPTION

Name	Description
handle	Handle to the device
ops	Pointer to callback functions structure
cbConnect	Connect callback
cbDisconnect	Disconnect callback
cbPower	Power change callback (N/A)
cbDataAvailable	Read completed callback (N/A)
cbDataSent	Write completed callback (N/A)

Return Value

Returns WDL_SUCCESS (0) on success, or an appropriate WDL_STATUS error code otherwise.

Remarks

Callbacks are defined as follows:

```
typedef void (__cdecl *WDL_CALLBACK)(WDL_HANDLE handle, void *context);
```

Where **handle** is the handle to the HID object performing the callback, and **context** is a pointer to parameter as received from `WDL_Init()` [A.10.3].

Example

```
WDL_CALLBACK_OPS ops;
ZeroMemory(&ops,sizeof(ops));
ops.cbConnect=OnConnect;
ops.cbDisconnect=OnDisconnect;
WDL_SetNotificationCallback(myhandle,&ops);
```

A.10.12 WDL_Stat2Str()

PURPOSE

• Retrieves the status string that corresponds to a status code.

PROTOTYPE

```
const char *WDL_Stat2Str(WDL_STATUS status);
```

PARAMETERS

Name	Type	Input/Output
➢ status	WDL_STATUS	Input

DESCRIPTION

Name	Description
status	A numeric status code.

RETURN VALUE

Returns the verbal status description (string) that corresponds to the specified numeric status code.

REMARKS

See Section A.14 for a complete list of status codes and strings.

A.11 Kernel PlugIn - User-Mode Functions

The following functions are the user-mode functions which initiate the Kernel PlugIn operations, and activate its callbacks.

A.11.1 WD_KernelPlugInOpen()

PURPOSE

• Obtain a valid handle for the Kernel PlugIn.

PROTOTYPE

```
DWORD WD_KernelPlugInOpen(HANDLE hWD, WD_KERNEL_PLUGIN
   *pKernelPlugIn);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Output
➢ pKernelPlugIn	WD_KERNEL_PLUGIN *	
❑ hKernelPlugIn	DWORD	Output
❑ pcDriverName	PCHAR	Input
❑ pcDriverPath	PCHAR	Input
❑ pOpenData	PVOID	Input

DESCRIPTION

Name	Description
hWD	Handle to WinDriver
pKernelPlugIn	Pointer to WD_KERNEL_PLUGIN information
hKernelPlugIn	Returns the handle to the Kernel PlugIn
pcDriverName	Name of Kernel PlugIn to load, up to 12 chars
pcDriverPath	File name of Kernel PlugIn to load. If NULL, the driver will be searched for in the Windows **system** directory using the name in pcDriverName

pOpenData	Pointer to data that will be passed to the `KP_Open` [A.12.2] callback in the Kernel PlugIn

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_KERNEL_PLUGIN kernelPlugIn;
BZERO(kernelPlugIn);

// Tells WinDriver which driver to open
kernelPlugIn.pcDriverName = "KPTEST";

HANDLE hWD = WD_Open(); // validate handle here

dwStatus = WD_KernelPlugInOpen(hWD, &kernelPlugIn);
if (dwStatus)
   printf ("Failed opening a handle to the Kernel
      PlugIn. Error: 0x%x (%s)\n", dwStatus,
      Stat2Str(dwStatus));
else
  printf("Opened a handle to the Kernel PlugIn
     (0x%x)\n", kernelPlugIn.hKernelPlugIn);
```

A.11.2 WD_KernelPlugInClose()

PURPOSE

• Closes the WinDriver Kernel PlugIn handle obtained from `WD_KernelPlugInOpen` [A.11.1].

PROTOTYPE

```
DWORD WD_KernelPlugInClose(HANDLE hWD,WD_KERNEL_PLUGIN
   *pKernelPlugIn);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pKernelPlugIn	WD_KERNEL_PLUGIN *	Input

DESCRIPTION

Name	Description
hWD	Handle to WinDriver
pKernelPlugIn	Pointer to WD_KERNEL_PLUGIN information

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

EXAMPLE

```
WD_KernelPlugInClose(hWD, &kernelPlugIn);
```

A.11.3 WD_KernelPlugInCall()

PURPOSE

• Calls a routine in the Kernel PlugIn to be executed.

PROTOTYPE

```
DWORD WD_KernelPlugInCall( HANDLE hWD, WD_KERNEL_PLUGIN_CALL
   *pKernelPlugInCall);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pKernelPlugInCall	WD_KERNEL_PLUGIN_CALL *	Input
❑ hKernelPlugIn	DWORD	Input
❑ dwMessage	DWORD	Input
❑ pData	PVOID	Input
❑ dwResult	DWORD	Output

DESCRIPTION

Name	Description
hWD	Handle to WinDriver
pKernelPlugInCall	Pointer to WD_KERNEL_PLUGIN_CALL information
hKernelPlugIn	Handle to the Kernel PlugIn
dwMessage	Message ID to pass to the `KP_Call` [A.12.4] callback
pData	Pointer to data to pass to the `KP_Call` callback
dwResult	Value set by `KP_Call` callback

Return Value

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

Remarks

Calling the `WD_KernelPlugInCall` [A.11.3] function in the user mode will call your `KP_Call` [A.12.4] callback function in the kernel. The `KP_Call` function in the Kernel PlugIn will determine what routine to execute according to the message passed to it in the WD_KERNEL_PLUGIN_CALL structure.

Example

```
WD_KERNEL_PLUGIN_CALL kpCall;

BZERO (kpCall);
// Prepare the kpCall structure from WD_KernelPlugInOpen()
kpCall.hKernelPlugIn = hKernelPlugIn;
// The message to pass to KP_Call(). This will determine
// the action performed in the kernel:
kpCall.dwMessage = MY_DRV_MSG;

kpCall.pData = &mydrv; // The data to pass to the call.
dwStatus = WD_KernelPlugInCall(hWD, &kpCall);
if (dwStatus)
   printf("Result = 0x%x\n", kpCall.dwResult);
else
   printf("WD_KernelPlugInCall() failed. Error: 0x%x
      (%s)\n", dwStatus, Stat2Str(dwStatus));
```

A.11.4 WD_IntEnable()

PURPOSE

• Enables interrupts for Kernel Plugin

PROTOTYPE

```
DWORD WD_IntEnable(HANDLE hWD,WD_INTERRUPT *pInterrupt);
```

PARAMETERS

Name	Type	Input/Output
➢ hWD	HANDLE	Input
➢ pInterrupt	WD_INTERRUPT *	
❑ kpCall	WD_KERNEL_PLUGIN_CALL	
❖ hKernelPlugIn	HANDLE	Input
❖ dwMessage	DWORD	N/A
❖ pData	PVOID	Input
❖ dwResult	DWORD	N/A

DESCRIPTION

Name	Description
hWD	Handle to WinDriver
pInterrupt	Pointer to WD_INTERRUPT information
hKernelPlugIn	Handle to the Kernel PlugIn. If zero, no Kernel PlugIn interrupt handler is installed
dwMessage	N/A
pData	Pointer to data to pass to the `KP_IntEnable` callback
dwResult	N/A

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

REMARKS

If a valid handle to a Kernel PlugIn is passed to this function, the interrupts will be handled in the Kernel PlugIn.

In such a case, the `KP_IntEnable` callback will execute as a result of the call to `WD_IntEnable` and upon receiving the interrupt, your kernel-mode `KP_IntAtIrql` function [A.12.8] will execute. If this function returns a value greater than 0, your deferred procedure call, `KP_IntAtDpc` [A.12.9] , will be called. For information about all other parameters of `WD_IntEnable`, refer to the documentation of `WD_IntEnable`, in Chapter A, in Section A.3.2.

EXAMPLE

```
WD_INTERRUPT Intrp;
BZERO(Intrp);
Intrp.hInterrupt = hInterrupt; // from WD_CardRegister()
// from WD_KernelPlugInOpen():
Intrp.kpCall.hKernelPlugIn = hKernelPlugIn;

WD_IntEnable(hWD, &Intrp);

if (!Intrp.fEnableOk)
 printf ("failed enabling interrupt\n");
```

A.12 Kernel PlugIn - Kernel-Mode Functions

The following functions are callback functions which are implemented in your Kernel PlugIn driver, and which will be called when their calling event occurs. For example: `KP_Init` [A.12.1] is the callback function that is called when the driver is loaded. Any code that you want to execute upon loading should be in this function.

`KP_Init` sets the the name of the driver and the `KP_Open` function.

`KP_Open` sets the rest of the driver's callback functions.

For example:

```
kpOpenCall->funcClose = KP_Close;
kpOpenCall->funcCall = KP_Call;
kpOpenCall->funcIntEnable = KP_IntEnable;
kpOpenCall->funcIntDisable = KP_IntDisable;
kpOpenCall->funcIntAtIrql = KP_IntAtIrql;
kpOpenCall->funcIntAtDpc = KP_IntAtDpc;
kpOpenCall->funcEvent = KP_Event;
```

NOTE:
It is the convention of this reference guide to mark the Kernel PlugIn callback functions as `KP_XXX` - i.e. `KP_Open`, `KP_Call`, etc. However, you are free to select any name that you wish for your Kernel PlugIn callback functions, apart from `KP_Init`, provided you implement relevant callback functions in your Kernel PlugIn. The generated DriverWizard Kernel PlugIn code, for example, uses the selected driver name in the callback function names (e.g. for a <MyKP> driver: `KP_MyKP_Open`, `KP_MyKP_Call`, etc.).

A.12.1 KP_Init()

PURPOSE

• Called when the Kernel PlugIn driver is loaded.
Sets the name of the Kernel PlugIn driver and the `KP_Open` [A.12.2] callback function.

PROTOTYPE

```
BOOL __cdecl KP_Init(KP_INIT *kpInit);
```

PARAMETERS

Name	Type	Input/Output
➢ kpInit	KP_INIT *	
❑ dwVerWD	DWORD	Output
❑ cDriverName[12]	CHAR	Output
❑ funcOpen	KP_FUNC_OPEN	Output

DESCRIPTION

Name	Description
kpInit	KP_INIT elements:
dwVerWD	The version of the WinDriver Kernel PlugIn library
cDriverName	The device driver name (up to 12 characters)
funcOpen	The `KP_Open` callback function, which will be executed when `WD_KernelPlugInOpen` is called

RETURN VALUE

TRUE if successful. Otherwise FALSE.

REMARKS

You must define the `KP_Init` function in your code in order to link the Kernel PlugIn driver to WinDriver. `KP_Init` is called when the driver is loaded. Any code that you want to execute upon loading should be in this function.

EXAMPLE

```
BOOL __cdecl KP_Init(KP_INIT *kpInit)
{
  // Check if the version of the WinDriver Kernel
  // PlugIn library is the same version
  // as windrvr.h and wd_kp.h
  if (kpInit->dwVerWD != WD_VER)
  {
     // You need to re-compile your Kernel PlugIn
     // with the compatible version of the WinDriver
     // Kernel PlugIn library, windrvr.h and wd_kp.h
    return FALSE;
  }

  kpInit->funcOpen = KP_Open;
  strcpy (kpInit->cDriverName, "KPTEST"); // up to 12 chars

  return TRUE;
}
```

A.12.2 KP_Open()

PURPOSE

• Called when `WD_KernelPlugInOpen` [A.11.1] is called from user mode.
Sets the rest of the Kernel PlugIn callback functions (`KP_Call`, `KP_IntEnable`, etc.) and performs any other desired initialization (such as allocating memory for the driver context and filling it with data passed from the user mode, etc.).
The returned driver context (pDrvContext) will be passed to rest of the Kernel PlugIn callback functions.

PROTOTYPE

```
BOOL __cdecl KP_Open(KP_OPEN_CALL *kpOpenCall, HANDLE hWD,
   PVOID pOpenData, PVOID *ppDrvContext);
```

PARAMETERS

Name	Type	Input/Output
➢ kpOpenCall	KP_OPEN_CALL	Input
➢ hWD	HANDLE	Input
➢ pOpenData	PVOID	Input
➢ ppDrvContext	PVOID *	Output

DESCRIPTION

Name	Description
kpOpenCall	Structure to fill in the addresses of the `KP_xxx` callback functions
hWD	The WinDriver handle that `WD_KernelPlugInOpen` [A.11.1] was called with
pOpenData	Pointer to data passed from user mode
ppDrvContext	Pointer to driver context data with which the `KP_Close` [A.12.3], `KP_Call` [A.12.4], `KP_IntEnable` [A.12.6] and `KP_Event` [A.12.5] functions will be called. Use this to keep driver specific information, which will be shared among these callbacks

RETURN VALUE

TRUE if successful. If FALSE, the call to `WD_KernelPlugInOpen` from the user mode will fail.

EXAMPLE

```
BOOL __cdecl KP_Open(KP_OPEN_CALL *kpOpenCall, HANDLE hWD,
         PVOID pOpenData, PVOID *ppDrvContext)
{
   kpOpenCall->funcClose = KP_Close;
   kpOpenCall->funcCall = KP_Call;
   kpOpenCall->funcIntEnable = KP_IntEnable;
   kpOpenCall->funcIntDisable = KP_IntDisable;
   kpOpenCall->funcIntAtIrql = KP_IntAtIrql;
   kpOpenCall->funcIntAtDpc = KP_IntAtDpc;
   kpOpenCall->funcEvent = KP_Event;

   // You can allocate driver context memory here:
   *ppDrvContext = malloc(sizeof(MYDRV_STRUCT));
   return *ppDrvContext!=NULL;
}
```

A.12.3 KP_Close()

PURPOSE

• Called when `WD_KernelPlugInClose` [A.11.2] is called from the user mode. Can be used to perform any required clean-up for the Kernel PlugIn (such as freeing memory previously allocated for the driver context, etc.).

PROTOTYPE

```
void __cdecl KP_Close(PVOID pDrvContext);
```

PARAMETERS

Name	Type	Input/Output
➢ pDrvContext	PVOID	Input

DESCRIPTION

Name	Description
pDrvContext	Driver context data that was set by `KP_Open` [A.12.2]

RETURN VALUE

None

EXAMPLE

```
void __cdecl KP_Close(PVOID pDrvContext)
{
  if (pDrvContext)
      free(pDrvContext); // Free allocated driver context memory
}
```

A.12.4 KP_Call()

PURPOSE

• Called when the user-mode application calls the `WD_KernelPlugInCall` [A.11.3] function.
This function is a message handler for your utility functions.

PROTOTYPE

```
void __cdecl KP_Call(PVOID pDrvContext, WD_KERNEL_PLUGIN_CALL
   *kpCall, BOOL fIsKernelMode);
```

PARAMETERS

Name	Type	Input/Output
➢ pDrvContext	PVOID	Input/Output
➢ kpCall	WD_KERNEL_PLUGIN_CALL	
❑ dwMessage	DWORD	Input
❑ pData	PVOID	Input/Output
❑ dwResult	DWORD	Output
➢ fIsKernelMode	BOOL	Input

DESCRIPTION

Name	Description
pDrvContext	Driver context data that was set by `KP_Open` [A.12.2] and will also be passed to `KP_Close` [A.12.3], `KP_IntEnable` [A.12.6] and `KP_Event` [A.12.5]
kpCall	Structure with user-mode information from `WD_KernelPlugInCall` [A.11.3] and/or with information to return back to the user mode
dwMessage	Message ID passed from `WD_KernelPlugInCall`
pData	Pointer to data passed from `WD_KernelPlugInCall` and/or to data to return to the user mode
dwResult	Value to return to the user mode
fIsKernelMode	This parameter is passed by the WinDriver kernel (see remarks)

Return Value

None

Remarks

- Calling the `WD_KernelPlugInCall` [A.11.3] function in the user mode will call your `KP_Call` [A.12.4] callback function in the kernel mode. The `KP_Call` function in the Kernel PlugIn will determine which routine to execute according to the message passed to it in the WD_KERNEL_PLUGIN_CALL structure.
- The fIsKernelMode parameter is passed by the WinDriver kernel to the `KP_Call` routine. The user is not required to do anything about this parameter. However, notice how this parameter is passed in the sample code to the macro `COPY_TO_USER_OR_KERNEL` – This is required for the macro to function correctly. Please refer to section A.12.10 for more details regarding the `COPY_TO_USER_OR_KERNEL` and `COPY_FROM_USER_OR_KERNEL` macros.

Example

```
void __cdecl KP_Call(PVOID pDrvContext,
  WD_KERNEL_PLUGIN_CALL *kpCall, BOOL fIsKernelMode)
{
   kpCall->dwResult = MY_DRV_OK;
   switch (kpCall->dwMessage)
   {
      // in this sample we implement a GetVersion message
      case MY_DRV_MSG_VERSION:
         {
          DWORD dwVer = 100;
          MY_DRV_VERSION *ver = (MY_DRV_VERSION *)kpCall->pData;
          COPY_TO_USER_OR_KERNEL(&ver->dwVer, &dwVer,
             sizeof(DWORD), fIsKernelMode);
          COPY_TO_USER_OR_KERNEL(ver->cVer, "My Driver V1.00",
             sizeof("My Driver V1.00")+1, fIsKernelMode);

          kpCall->dwResult = MY_DRV_OK;
         }
         break;
      // you can implement other messages here
      default:
```

```
        kpCall->dwResult = MY_DRV_NO_IMPL_MESSAGE;
    }
}
```

A.12.5 KP_Event()

PURPOSE

• Called when a Plug-and-Play or power management event for the device is received, provided the user-mode application first called `EventRegister` [A.8.2] with a handle to the Kernel PlugIn (see Remarks).

PROTOTYPE

```
BOOL __cdecl KP_Event(PVOID pDrvContext, WD_EVENT *wd_event);
```

PARAMETERS

Name	Type	Input/Output
➢ pDrvContext	PVOID	Input/Output
➢ wd_event	WD_EVENT *	Input

DESCRIPTION

Name	Description
pDrvContext	Driver context data that was set by `KP_Open` [A.12.2] and will also be passed to `KP_Close` [A.12.3], `KP_IntEnable` [A.12.6] and `KP_Call` [A.12.4]
wd_event	Pointer to the PnP/power management event information received from the user mode

RETURN VALUE

TRUE in order to notify the user about the event.

REMARKS

`KP_Event` will be called if the application called `EventRegister()` [A.8.2] with a handle to the Kernel PlugIn.

EXAMPLE

```
BOOL __cdecl KP_Event(PVOID pDrvContext, WD_EVENT *wd_event)
{
   // handle the event here
   return TRUE; // Return TRUE to notify the user about the event.
}
```

A.12.6 KP_IntEnable()

PURPOSE

• Called when `WD_IntEnable` [A.3.2] is called from the user mode with a Kernel PlugIn handle.
The interrupt context (pIntContext) will be passed to the rest of the Kernel PlugIn interrupt functions.

PROTOTYPE

```
BOOL __cdecl KP_IntEnable (PVOID pDrvContext,
   WD_KERNEL_PLUGIN_CALL *kpCall, PVOID *ppIntContext);
```

PARAMETERS

Name	Type	Input/Output
➢ pDrvContext	PVOID	Input/Output
➢ kpCall	WD_KERNEL_PLUGIN_CALL	Input
❑ dwMessage	DWORD	Input
❑ pData	PVOID	Input/Output
❑ dwResult	DWORD	Output
➢ ppIntContext	PVOID *	Input/Output

DESCRIPTION

Name	Description
pDrvContext	Driver context data that was set by `KP_Open` [A.12.2] and will also be passed to `KP_Close` [A.12.3], `KP_Call` [A.12.4] and `KP_Event` [A.12.5]
kpCall	Structure with information from `WD_IntEnable` [A.3.2]
dwMessage	Message ID passed from `WD_IntEnable`
pData	Pointer to data passed from `WD_IntEnable` or to data to return to the user mode
dwResult	Value to return to the user mode

ppIntContext	Pointer to interrupt context data that will be passed to the `KP_IntDisable` [A.12.7], `KP_IntAtIrql` [A.12.8] and `KP_IntAtDpc` [A.12.9] functions. Use this to keep interrupt specific information

RETURN VALUE

Returns TRUE if enable is successful.

REMARKS

This function should contain any initialization needed for your Kernel PlugIn interrupt handling.

EXAMPLE

```
BOOL __cdecl KP_IntEnable(PVOID pDrvContext,
    WD_KERNEL_PLUGIN_CALL *kpCall, PVOID *ppIntContext)
{
   DWORD *pIntCount;

   // You can allocate specific memory for each interrupt
   // in *ppIntContext
   *ppIntContext = malloc(sizeof (DWORD));
   if (!*ppIntContext)
      return FALSE;
   // In this sample the information is a DWORD used to
   // count the incoming interrupts
   pIntCount = (DWORD *) *ppIntContext;
   *pIntCount = 0; // reset the count to zero

   return TRUE;
}
```

A.12.7 KP_IntDisable()

PURPOSE

• Called when the user-mode application calls the `WD_IntDisable` [A.3.5] function.
This function should free any memory that was allocated in `KP_IntEnable` [A.12.6].

PROTOTYPE

```
void __cdecl KP_IntDisable(PVOID pIntContext);
```

PARAMETERS

Name	Type	Input/Output
➢ pIntContext	PVOID	Input

DESCRIPTION

Name	Description
pIntContext	Interrupt context data that was set by `KP_IntEnable` [A.12.6]

RETURN VALUE

None

EXAMPLE

```
void __cdecl KP_IntDisable(PVOID pIntContext)
{
  // You can free the interrupt specific memory
  // allocated to pIntContext here
  free(pIntContext);
}
```

A.12.8 KP_IntAtIrql()

PURPOSE

• This function will run at HIGH IRQL if the Kernel PlugIn handle is passed when enabling interrupts.

PROTOTYPE

```
BOOL __cdecl KP_IntAtIrql(PVOID pIntContext,
   BOOL *pfIsMyInterrupt);
```

PARAMETERS

Name	Type	Input/Output
➢ pIntContext	PVOID	Input/Output
➢ pfIsMyInterrupt	BOOL *	Input

DESCRIPTION

Name	Description
pIntContext	Interrupt context data that was set by `KP_IntEnable` [A.12.6] and will also be passed to `KP_IntAtDpc` [A.12.9] (if executed) and `KP_IntDisable` [A.12.7]
pfIsMyInterrupt	Set this to TRUE if the interrupt belongs to this driver, or FALSE if not. If you are not sure, it is safest to return FALSE

RETURN VALUE

TRUE if deferred interrupt processing (DPC) is required; otherwise FALSE.

REMARKS

Code running at IRQL will only be interrupted by higher priority interrupts.

Code running at IRQL is limited by the following restrictions:

- You may only access non-pageable memory.
- You may only call the following functions: `WD_Transfer` [A.2.10], `WD_MultiTransfer` [A.2.11], `WD_DebugAdd` [A.1.6] and specific OS kernel functions (such as Windows DDK functions) that are allowed to be called from an IRQL. Note that using OS-specific kernel functions may damage the code's portability to other operating systems.
  You may not call `malloc`, `free`, or any `WD_xxx` API other than the aforementioned functions.

The code performed at HIGH IRQL should be minimal (e.g., only the code that acknowledges level-sensitive interrupts), since it is operating at a high priority. The rest of your code should be written at `KP_IntAtDpc` [A.12.9], which runs at the deferred DISPATCH level and is not subject to the above restrictions.

EXAMPLE

```
BOOL __cdecl KP_IntAtIrql(PVOID pIntContext,
   BOOL *pfIsMyInterrupt)
{
   DWORD *pdwIntCount = (DWORD *) pIntContext;

   // You should check your hardware here to see
   // if the interrupt belongs to you.
   // If in doubt, return FALSE (this is the safest)
   *pfIsMyInterrupt = FALSE;

   // In this example we will schedule a DPC
   // once in every 5 interrupts
   (*pdwIntCount) ++;
   if (*pdwIntCount==5)
   {
      *pdwIntCount = 0;
      return TRUE;
   }

   return FALSE;
}
```

A.12.9 KP_IntAtDpc()

PURPOSE

• This is the Deferred Procedure Call which is executed only if the `KP_IntAtIrql` [A.12.8] function returned TRUE.

PROTOTYPE

```
DWORD __cdecl KP_IntAtDpc(PVOID pIntContext, DWORD dwCount);
```

PARAMETERS

Name	Type	Input/Output
➢ pIntContext	PVOID	Input/Output
➢ dwCount	DWORD	Input

DESCRIPTION

Name	Description
pIntContext	Interrupt context data that was set by `KP_IntEnable` [A.12.6], passed to `KP_IntAtIrql` [A.12.8] and will be passed to `KP_IntDisable` [A.12.7]
dwCount	The number of times `KP_IntAtIrql` [A.12.8] returned TRUE since the last DPC call. If dwCount is 1, `KP_IntAtIrql` requested a DPC only once since the last DPC call. If the value is greater than 1, `KP_IntAtIrql` has already requested a DPC a few times, but the interval was too short, therefore `KP_IntAtDpc` was not called for each DPC request.

Return Value

Returns the number of times to notify user mode (i.e., return from `WD_IntWait` [A.3.3]).

Remarks

Most of the interrupt handling should be written at DPC.
If `KP_IntAtDpc` returns with a value of 1 or more, `WD_IntWait` returns and the user-mode interrupt handler will execute in the number of times set in the return value. If you do not want the user-mode interrupt handler to execute, `KP_IntAtDpc` should return 0.

Example

```
DWORD __cdecl KP_IntAtDpc(PVOID pIntContext, DWORD dwCount)
{
  // Return WD_IntWait as many times as KP_IntAtIrql
  // scheduled KP_IntAtDpc()
  return dwCount;
}
```

A.12.10 COPY_TO_USER_OR_KERNEL, COPY_FROM_USER_OR_KERNEL()

PURPOSE

• Macros for copying data from the user mode to the Kernel PlugIn and vice versa.

REMARKS

The `COPY_TO_USER_OR_KERNEL` and `COPY_FROM_USER_OR_KERNEL` are macros used for copying data (when necessary) to/from user-mode memory addresses (respectively), when accessing such addresses from within the Kernel PlugIn. Copying the data ensures that the user-mode address can be used correctly, even if the context of the user-mode process changes in the midst of the I/O operation. This is particularly relevant for long operations, during which the context of the user-mode process may change. The use of macros to perform the copy provides a generic solution for all supported operating systems.

Please note that if you wish to access the user-mode data from within the `KP_IntAtIrql()` [A.12.8] or `KP_IntAtDpc()` [A.12.9] functions, you should first copy the data into some variable in the Kernel PlugIn before the execution of these routines.

The `COPY_TO_USER_OR_KERNEL` and `COPY_FROM_USER_OR_KERNEL` macros are defined in the **WinDriver\include\kpstdlib.h** header file.

For an example of using the `COPY_TO_USER_OR_KERNEL` macro, see the `KP_Call()` [A.12.4] implementation in the sample **kptest.c** file (found under the **WinDriver\kerplug\kptest\kermode** directory).

To share a data buffer between the user-mode and Kernel PlugIn routines (e.g., `KP_IntAtIrql()` [A.12.8] and `KP_IntAtDpc()` [A.12.9]) safely, consider using the technique outlined in the technical document titled "How do I share a memory buffer between Kernel PlugIn and user-mode projects for DMA or other purposes?" found under the "Kernel PlugIn" technical documents section of the "Support" section.

A.13 Kernel PlugIn - Structure Reference

This section contains detailed information about the different Kernel PlugIn related structures.
WD_xxx structures are used in user-mode functions and KP_xxx structures are used in kernel-mode functions.

A.13.1 WD_KERNEL_PLUGIN

Defines a Kernel PlugIn open command.

Used by `WD_KernelPlugInOpen` [A.11.1] and `WD_KernelPlugInClose` [A.11.2].

Members:

Type	Name	Description
DWORD	hKernelPlugIn	Handle to a Kernel PlugIn
PCHAR	pcDriverName	Name of Kernel PlugIn driver. Should be no longer than 12 characters. Should not include the VXD or SYS extension.
PCHAR	pcDriverPath	This field should be set to NULL. WinDriver will search for the driver in the operating system's drivers/modules directory.
PVOID	pOpenData	Data to pass to the `KP_Open` [A.12.2] callback in the Kernel PlugIn.

A.13.2 WD_INTERRUPT

Used to describe an interrupt.

Used by the following functions: `InterruptEnable` [A.2.14], `InterruptDisable` [A.2.15], `WD_IntEnable` [A.3.2], `WD_IntDisable` [A.3.5], `WD_IntWait()` [A.3.3], `WD_IntCount()` [A.3.4].

Members:

Type	Name	Description
WD_KERNEL_ PLUGIN_CALL [A.13.3]	kpCall	The kpCall structure contains the handle to the Kernel PlugIn and to other information that should be passed to the kernel-mode interrupt handler when installing it. If the handle is zero, the interrupt is installed without a Kernel PlugIn interrupt handler. If a valid Kernel PlugIn handle is set, this structure will passed as a parameter to the `KP_IntEnable` [A.12.6] Kernel PlugIn callback function.

For information about the other members of `WD_INTERRUPT`, see Section A.2.14.

A.13.3 WD_KERNEL_PLUGIN_CALL

Contains information that will be passed to the Kernel PlugIn. This structure is used when passing messages to the Kernel PlugIn or when installing a Kernel PlugIn interrupt.
Used by `WD_KernelPlugInCall` [A.11.3], `InterruptEnable` [A.2.14] and `WD_IntEnable` [A.3.2].
Passed as a parameter to the Kernel PlugIn `KP_Call` [A.12.4] and `KP_IntEnable` [A.12.6] callback functions.

Members:

Type	Name	Description
DWORD	hKernelPlugIn	Handle to a Kernel PlugIn.
DWORD	dwMessage	Message ID to pass to a Kernel PlugIn callback.
PVOID	pData	Pointer to data to pass to Kernel PlugIn callback.
DWORD	dwResult	Value set by a Kernel PlugIn callback, to return back to user mode.

A.13.4 KP_INIT

The `KP_INIT` structure is used by the `KP_Init` [A.12.1] function in the Kernel PlugIn. Its primary use is for notifying WinDriver of the given driver's name and of which kernel-mode function to call when `WD_KernelPlugInOpen` [A.11.1] is called from the user mode.

MEMBERS:

Type	Name	Description
DWORD	dwVerWD	The version of the WinDriver Kernel PlugIn library.
CHAR	cDriverName[12]	The device driver name, up to 12 characters.
KP_FUNC_OPEN	funcOpen	The `KP_Open` [A.12.2] kernel-mode function that WinDriver should call when `WD_KernelPlugInOpen` [A.11.1] is called from the user mode.

A.13.5 KP_OPEN_CALL

This is the structure through which the Kernel PlugIn defines the names of the callbacks which it implements. It is used in the `KP_Open` [A.12.2] Kernel PlugIn function.

A Kernel PlugIn may implement 7 different callback functions:

funcClose - Called when the application is done with this instance of the driver.

funcCall - Called when the application calls `WD_KernelPlugInCall` [A.11.3]. This function is a general purpose function. In it, implement any functions that should run in kernel mode (except the interrupt handler which is a special case). The `funcCall` will determine which function to execute according to the message passed to it.

funcIntEnable - Called when the application calls `WD_IntEnable` [A.3.2] / `InterruptEnable` [A.2.14] with a Kernel PlugIn handle. This callback function should perform any initalization required when enabling an interrupt.

funcIntDisable - The cleanup function, which is called when the application calls `WD_IntDisable` [A.3.5] / `InterruptDisable` [A.2.15].

funcIntAtIrql - This is the kernel mode interrupt handler. This callback function is called at HIGH IRQL when WinDriver processes the interrupt that is assigned to this Kernel PlugIn. If this function returns a value greater than 0, `funcIntAtDpc` is called as a Deferred procedure call.

funcIntAtDpc - Most of your interrupt handler code should be written in this callback. It is called as a deferred procedure call, if `funcIntAtIrql` returns a value greater than 0.

funcEvent - Called when a Plug-and-Play or power management event occurs, if the application first called `EventRegister` [A.8.2] with a Kernel PlugIn handle. This callback function should implement the desired kernel handling for Plug-and-Play and power management events.

Type	Name	Description
KP_FUNC_CLOSE	funcClose	Name of your `KP_Close` [A.12.3] function in the kernel.
KP_FUNC_CALL	funcCall	Name of your `KP_Call` [A.12.4] function in the kernel.
KP_FUNC_INT_ENABLE	funcIntEnable	Name of your `KP_IntEnable` [A.12.6] function in the kernel.
KP_FUNC_INT_DISABLE	funcIntDisable	Name of your `KP_IntDisable` [A.12.7] function in the kernel.
KP_FUNC_INT_AT_IRQL	funcIntAtIrql	Name of your `KP_IntAtIrql` [A.12.8] function in the kernel.
KP_FUNC_INT_AT_DPC	funcIntAtDpc	Name of your `KP_IntAtDpc` [A.12.9] function in the kernel.
KP_FUNC_EVENT	funcEvent	Name of your `KP_Event` [A.12.5] function in the kernel.

A.14 WinDriver Status/Error Codes

A.14.1 Introduction

Most of the WinDriver API functions return a status code, where 0 (WD_STATUS_SUCCESS) means success and a non-zero value means failure. The `Stat2Str` [A.15.1] and `WDL_Stat2Str` [A.10.12] can be used to retrieve the status description string for a given status code. The status codes and their descriptive strings are listed below.

A.14.2 Status Codes Returned by WinDriver

Code	Descriptive String
WD_STATUS_SUCCESS	Success
WD_STATUS_INVALID_WD_HANDLE	Invalid WinDriver handle
WD_WINDRIVER_STATUS_ERROR	Error
WD_INVALID_HANDLE	Invalid handle
WD_INVALID_PIPE_NUMBER	Invalid pipe number
WD_READ_WRITE_CONFLICT	Conflict between read and write operations
WD_ZERO_PACKET_SIZE	Packet size is zero
WD_INSUFFICIENT_RESOURCES	Insufficient resources
WD_UNKNOWN_PIPE_TYPE	Unknown pipe type
WD_SYSTEM_INTERNAL_ERROR	Internal system error
WD_DATA_MISMATCH	Data mismatch
WD_NO_LICENSE	No valid license
WD_NOT_IMPLEMENTED	Function not implemented
WD_KERPLUG_FAILURE	Kernel PlugIn failure
WD_FAILED_ENABLING_INTERRUPT	Failed enabling interrupt
WD_INTERRUPT_NOT_ENABLED	Interrupt not enabled
WD_RESOURCE_OVERLAP	Resource overlap
WD_DEVICE_NOT_FOUND	Device not found
WD_WRONG_UNIQUE_ID	Wrong unique ID
WD_OPERATION_ALREADY_DONE	Operation already done
WD_USB_DESCRIPTOR_ERROR	Usb descriptor error
WD_SET_CONFIGURATION_FAILED	Set configuration operation failed

WD_CANT_OBTAIN_PDO	Cannot obtain PDO
WD_TIME_OUT_EXPIRED	Timeout expired
WD_IRP_CANCELED	IRP operation cancelled
WD_FAILED_USER_MAPPING	Failed to map in user space
WD_FAILED_KERNEL_MAPPING	Failed to map in kernel space
WD_NO_RESOURCES_ON_DEVICE	No resources on the device
WD_NO_EVENTS	No events
WD_INVALID_PARAMETER	Invalid parameter
WD_INCORRECT_VERSION	Incorrect WinDriver version installed
WD_TRY_AGAIN	Try again
WD_INVALID_IOCTL	Received an invalid IOCTL

A.14.3 Status Codes Returned by USBD

The following WinDriver status codes comply with USBD_XXX status codes returned by the USB stack drivers.

Code	**Descriptive String**
USBD Status Types	
WD_USBD_STATUS_SUCCESS	USBD: Success
WD_USBD_STATUS_PENDING	USBD: Operation pending
WD_USBD_STATUS_ERROR	USBD: Error
WD_USBD_STATUS_HALTED	USBD: Halted
USBD Status Codes (NOTE: These are comprised of one of the status types above and an error code, i.e., 0xXYYYYYYYL, where X=status type and YYYYYYY=error code. The same error codes may also appear with one of the other status types as well.)	
HC (Host Controller) Status Codes (NOTE: These use the WD_USBD_STATUS_HALTED status type.)	
WD_USBD_STATUS_CRC	HC status: CRC
WD_USBD_STATUS_BTSTUFF	HC status: Bit stuffing
WD_USBD_STATUS_DATA_TOGGLE_MISMATCH	HC status: Data toggle mismatch
WD_USBD_STATUS_STALL_PID	HC status: PID stall
WD_USBD_STATUS_DEV_NOT_RESPONDING	HC status: Device not responding
WD_USBD_STATUS_PID_CHECK_FAILURE	HC status: PID check failed

WD_USBD_STATUS_UNEXPECTED_PID	HC status: Unexpected PID
WD_USBD_STATUS_DATA_OVERRUN	HC status: Data overrun
WD_USBD_STATUS_DATA_UNDERRUN	HC status: Data underrun
WD_USBD_STATUS_RESERVED1	HC status: Reserved1
WD_USBD_STATUS_RESERVED2	HC status: Reserved2
WD_USBD_STATUS_BUFFER_OVERRUN	HC status: Buffer overrun
WD_USBD_STATUS_BUFFER_UNDERRUN	HC status: Buffer Underrun
WD_USBD_STATUS_NOT_ACCESSED	HC status: Not accessed
WD_USBD_STATUS_FIFO	HC status: Fifo
For Windows only:	
WD_USBD_STATUS_XACT_ERROR	HC status: The host controller has set the Transaction Error (XactErr) bit in the transfer descriptor's status field
WD_USBD_STATUS_BABBLE_DETECTED	HC status: Babble detected
WD_USBD_STATUS_DATA_BUFFER_ERROR	HC status: Data buffer error
For Windows CE only:	
WD_USBD_STATUS_NOT_COMPLETE	USBD: Transfer not completed
WD_USBD_STATUS_CLIENT_BUFFER	USBD: Cannot write to buffer
For all platforms:	
WD_USBD_STATUS_CANCELED	USBD: Transfer cancelled
Returned by HCD (Host Controller Driver) if a transfer is submitted to an endpoint that is stalled:	
WD_USBD_STATUS_ENDPOINT_HALTED	HCD: Transfer submitted to stalled endpoint
Software Status Codes (NOTE: Only the error bit is set):	
WD_USBD_STATUS_NO_MEMORY	USBD: Out of memory
WD_USBD_STATUS_INVALID_URB_FUNCTION	USBD: Invalid URB function
WD_USBD_STATUS_INVALID_PARAMETER	USBD: Invalid parameter
Returned if client driver attempts to close an endpoint/interface or configuration with outstanding transfers:	
WD_USBD_STATUS_ERROR_BUSY	USBD: Attempted to close endpoint/interface/configuration with outstanding transfer
Returned by USBD if it cannot complete a URB request. Typically this will be returned in the URB status field (when the Irp is completed) with a more specific NT error code. The Irp status codes are indicated in WinDriver's Debug Monitor tool (wddebug_gui):	

WD_USBD_STATUS_REQUEST_FAILED	USBD: URB request failed
WD_USBD_STATUS_INVALID_PIPE_HANDLE	USBD: Invalid pipe handle
Returned when there is not enough bandwidth available to open a requested endpoint:	
WD_USBD_STATUS_NO_BANDWIDTH	USBD: Not enough bandwidth for endpoint
Generic HC (Host Controller) error:	
WD_USBD_STATUS_INTERNAL_HC_ERROR	USBD: Host controller error
Returned when a short packet terminates the transfer, i.e., USBD_SHORT_TRANSFER_OK bit not set:	
WD_USBD_STATUS_ERROR_SHORT_TRANSFER	USBD: Transfer terminated with short packet
Returned if the requested start frame is not within USBD_ISO_START_FRAME_RANGE of the current USB frame (NOTE: The stall bit is set):	
WD_USBD_STATUS_BAD_START_FRAME	USBD: Start frame outside range
Returned by HCD (Host Controller Driver) if all packets in an isochronous transfer complete with an error:	
WD_USBD_STATUS_ISOCH_REQUEST_FAILED	HCD: Isochronous transfer completed with error
Returned by USBD if the frame length control for a given HC (Host Controller) is already taken by another driver:	
WD_USBD_STATUS_FRAME_CONTROL_OWNED	USBD: Frame length control already taken
Returned by USBD if the caller does not own frame length control and attempts to release or modify the HC frame length:	
WD_USBD_STATUS_FRAME_CONTROL_NOT_OWNED	USBD: Attempted operation on frame length control not owned by caller
Additional software error codes added for USB 2.0 (for Windows only):	
WD_USBD_STATUS_NOT_SUPPORTED	USBD: API not supported/implemented
WD_USBD_STATUS_INAVLID_CONFIGURATION_DESCRIPTOR	USBD: Invalid configuration descriptor
WD_USBD_STATUS_INSUFFICIENT_RESOURCES	USBD: Insufficient resources
WD_USBD_STATUS_SET_CONFIG_FAILED	USBD: Set configuration failed
WD_USBD_STATUS_BUFFER_TOO_SMALL	USBD: Buffer too small

WD_USBD_STATUS_INTERFACE_NOT_FOUND	USBD: Interface not found
WD_USBD_STATUS_INAVLID_PIPE_FLAGS	USBD: Invalid pipe flags
WD_USBD_STATUS_TIMEOUT	USBD: Timeout
WD_USBD_STATUS_DEVICE_GONE	USBD: Device gone
WD_USBD_STATUS_STATUS_NOT_MAPPED	USBD: Status not mapped
Extended isochronous error codes returned by USBD. *These errors appear in the packet status field of an isochronous transfer:*	
WD_USBD_STATUS_ISO_NOT_ACCESSED_BY_HW	USBD: The controller did not access the TD associated with this packet
WD_USBD_STATUS_ISO_TD_ERROR	USBD: Controller reported an error in the TD
WD_USBD_STATUS_ISO_NA_LATE_USBPORT	USBD: The packet was submitted in time by the client but failed to reach the miniport in time
WD_USBD_STATUS_ISO_NOT_ACCESSED_LATE	USBD: The packet was not sent because the client submitted it too late to transmit

A.14.4 Error Codes Returned by WDL_Stat2Str (HID Support)

Code	**Descriptive String**
WDL_SUCCESS	Success
WDL_FAIL	Error
WDL_TIMEOUT_EXPIRED	TimeOut expired
WDL_FAILED_TO_REGISTER_NOTIFICATIONS	Failed to register notifications
WDL_INVALID_HANDLE	Invalid handle
WDL_BUFFER_TOO_SMALL	Buffer too small
WDL_DEVICE_NOT_CONNECTED	Device not connected
WDL_NO_LICENSE	No valid license

A.15 User-Mode Utility Functions

This section describes a number of user-mode utility functions you will find useful for implementing various tasks. These utility functions are multi-platform, implemented on all operating systems supported by WinDriver.

A.15.1 Stat2Str()

PURPOSE

• Retrieves the status string that corresponds to a status code.

PROTOTYPE

```
const char * Stat2Str(DWORD dwStatus);
```

PARAMETERS

Name	Type	Input/Output
➢ dwStatus	DWORD	Input

DESCRIPTION

Name	Description
dwStatus	A numeric status code

RETURN VALUE

Returns the verbal status description (string) that corresponds to the specified numeric status code.

REMARKS

See Section A.14 for a complete list of status codes and strings.

A.15.2 get_os_type()

PURPOSE

• Retrieves the type of the operating system.

PROTOTYPE

```
OS_TYPE get_os_type();
```

PARAMETERS

None

RETURN VALUE

Returns the type of the operating system.
If the operating system type is not detected, returns OS_CAN_NOT_DETECT.

A.15.3 ThreadStart()

PURPOSE

• Creates a thread.

PROTOTYPE

```
DWORD ThreadStart(HANDLE *phThread, HANDLER_FUNC pFunc, void *pData);
```

PARAMETERS

Name	Type	Input/Output
➢ phThread	HANDLE *	Output
➢ pFunc	HANDLER_FUNC	Input
➢ pData	VOID *	Input

DESCRIPTION

Name	Description
phThread	Returns the handle to the created thread
pFunc	Starting address of the code that the new thread is to execute
pData	Pointer to the data to be passed to the new thread

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.15.4 ThreadWait()

PURPOSE

• Waits for a thread to exit.

PROTOTYPE

```
void ThreadWait(HANDLE hThread);
```

PARAMETERS

Name	Type	Input/Output
➢ hThread	HANDLE	Input

DESCRIPTION

Name	Description
hThread	The handle to the thread whose completion is awaited

RETURN VALUE

None

A.15.5 OsEventCreate()

PURPOSE

• Creates an event object.

PROTOTYPE

```
DWORD OsEventCreate(HANDLE *phOsEvent);
```

PARAMETERS

Name	Type	Input/Output
➢ phOsEvent	HANDLE *	Output

DESCRIPTION

Name	Description
phOsEvent	The pointer to a variable that receives a handle to the newly created event object

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.15.6 OsEventClose()

PURPOSE

• Closes a handle to an event object.

PROTOTYPE

```
void OsEventClose(HANDLE hOsEvent)
```

PARAMETERS

Name	Type	Input/Output
➢ hOsEvent	HANDLE	Input

DESCRIPTION

Name	Description
hOsEvent	The handle to the event object to be closed

RETURN VALUE

None

A.15.7 OsEventWait()

PURPOSE

• Waits until a specified event object is in the signaled state or the time-out interval elapses.

PROTOTYPE

```
DWORD OsEventWait(HANDLE hOsEvent, DWORD dwSecTimeout)
```

PARAMETERS

Name	Type	Input/Output
➢ hOsEvent	HANDLE	Input
➢ dwSecTimeout	DWORD	Input

DESCRIPTION

Name	Description
hOsEvent	The handle to the event object
dwSecTimeout	Time-out interval of the event, in seconds. If dwSecTimeout is INFINITE, the function's time-out interval never elapses.

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.15.8 OsEventSignal()

PURPOSE

• Sets the specified event object to the signaled state.

PROTOTYPE

```
DWORD OsEventSignal(HANDLE hOsEvent);
```

PARAMETERS

Name	Type	Input/Output
➢ hOsEvent	HANDLE	Input

DESCRIPTION

Name	Description
hOsEvent	The handle to the event object

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.15.9 OsEventReset()

PURPOSE

• Resets the specified event object to the non-signaled state.

PROTOTYPE

```
DWORD OsEventReset(HANDLE hOsEvent);
```

PARAMETERS

Name	Type	Input/Output
➢ hOsEvent	HANDLE	Input

DESCRIPTION

Name	Description
hOsEvent	The handle to the event object

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.15.10 OsMutexCreate()

PURPOSE

• Creates a mutex object.

PROTOTYPE

```
DWORD OsMutexCreate(HANDLE *phOsMutex);
```

PARAMETERS

Name	Type	Input/Output
➢ phOsMutex	HANDLE *	Output

DESCRIPTION

Name	Description
phOsMutex	The pointer to a variable that receives a handle to the newly created mutex object

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.15.11 OsMutexClose()

PURPOSE

• Closes a handle to a mutex object.

PROTOTYPE

```
void OsMutexClose(HANDLE hOsMutex);
```

PARAMETERS

Name	Type	Input/Output
➢ hOsMutex	HANDLE	Input

DESCRIPTION

Name	Description
hOsMutex	The handle to the mutex object to be closed

RETURN VALUE

None

A.15.12 OsMutexLock()

PURPOSE

• Locks the specified mutex object.

PROTOTYPE

```
DWORD OsMutexLock(HANDLE hOsMutex)
```

PARAMETERS

Name	Type	Input/Output
➢ hOsMutex	HANDLE	Input

DESCRIPTION

Name	Description
hOsMutex	The handle to the mutex object to be locked

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.15.13 OsMutexUnlock()

PURPOSE

• Releases (unlocks) a locked mutex object.

PROTOTYPE

```
DWORD OsMutexUnlock(HANDLE hOsMutex);
```

PARAMETERS

Name	Type	Input/Output
➢ hOsMutex	HANDLE	Input

DESCRIPTION

Name	Description
hOsMutex	The handle to the mutex object to be unlocked

RETURN VALUE

Returns WD_STATUS_SUCCESS (0) on success, or an appropriate error code otherwise.

A.15.14 PrintDbgMessage()

PURPOSE

• Sends debug messages to the debug monitor.

PROTOTYPE

```
void PrintDbgMessage(DWORD dwLevel, DWORD dwSection,
   const char *format[, argument]...);
```

PARAMETERS

Name	Type	Input/Output
➢ dwLevel	DWORD	Input
➢ dwSection	DWORD	Input
➢ format	const char *	Input
➢ argument		Input

DESCRIPTION

Name	Description
dwLevel	Assigns the level in the Debug Monitor, in which the data will be declared. If dwLevel is 0, then D_ERROR will be declared. For more details please refer to DEBUG_LEVEL in **windrvr.h**.
dwSection	Assigns the section in the Debug Monitor, in which the data will be declared. If dwSection is 0, then S_MISC section will be declared. For more details please refer to DEBUG_SECTION in **windrvr.h**.
format	Format-control string
argument	Optional arguments, limited to 256 bytes

RETURN VALUE

None

Appendix B

Troubleshooting and Support

Please refer to `http://www.jungo.com/support` for addition resources for developers, including:

- Technical documents
- FAQs
- Samples
- Quick start guides

Appendix C

Limitations of the Different Evaluation Versions

Windows 98/Me and NT/2000/XP/Server 2003

- Each time WinDriver is activated, an **Unregistered** message appears.
- When using the DriverWizard, a dialog box with a message stating that an evaluation version is being run appears on every interaction with the hardware.
- WinDriver will function for only 30 days after the original installation.

Windows CE

- Each time WinDriver is activated, an **Unregistered** message appears.
- The WinDriver CE Kernel (**windrvr6.dll**) will operate for no more than 60 minutes at a time.
- WinDriver CE emulation on Windows NT will stop working after 30 days.

Linux

- Each time WinDriver is activated, an **Unregistered** message appears.

- When using the DriverWizard, a dialog box with a message stating that an evaluation version is being run appears on every interaction with the hardware.
- The Linux Kernel will work for no more then 60 minutes at a time.
  In order to continue working, WinDriver Kernel module must be reloaded (remove and insert the module) using the following commands:
  To remove:
  `/sbin# rmmod`
  To insert:
  `/sbin# insmod`
  The parameter for the above commands is: windrvr6 (after successful installation).

Solaris

- Each time WinDriver is activated, an **Unregistered** message appears.
- When using the DriverWizard, a dialog box with a message stating that an evaluation version is being run appears on every interaction with the hardware.
- The Solaris kernel will work for no more then 60 minutes at a time. In order to continue working, WinDriver Kernel module must be reloaded (remove and insert the module) using the following commands:
  To remove:
  `/usr/sbin$ rem_drv`
  To insert:
  `/usr/sbin$ add_drv`
  The parameter for the above commands is: windrvr6 (after successful installation).

VxWorks

- The VxWorks Kernel will work for no more then 60 minutes at a time.
  In order to continue working, the system must be rebooted.

DriverWizard GUI

- Each time WinDriver is activated, an **Unregistered** message appears.
- When using the DriverWizard, a dialog box with a message stating that an evaluation version is being run appears on every interaction with the hardware.

Appendix D

Purchasing WinDriver

Fill in the order form found in **Start | WinDriver | Order Form** on your Windows start menu, and send it to Jungo via email, fax or mail (see details below).

Your WinDriver package will be sent to you via Fedex or standard postal mail. The WinDriver license string will be emailed to you immediately.

E M A I L

Support: support@jungo.com

Sales: sales@jungo.com

P H O N E / F A X

Phone:

USA (Toll-Free): 1-877-514-0537

Worldwide: +972-9-8859365

Fax:

USA (Toll-Free): 1-877-514-0538

Worldwide: +972-9-8859366

W E B:

`http://www.jungo.com`

P O S T A L A D D R E S S

Jungo Ltd.
P.O.Box 8493
Netanya 42504
ISRAEL

Appendix E

Distributing Your Driver – Legal Issues

WinDriver is licensed per-seat. The WinDriver license allows one developer on a single computer to develop an unlimited number of device drivers, and to freely distribute the created drivers without royalties, as outlined in the license agreement in the ***windriver/docs/license.txt*** *file.*

Appendix F

Additional Documentation

Updated Manual

The most updated WinDriver User's manual can be found on Jungo's site at:
http://www.jungo.com/support/manuals.html#manuals

Version History

If you wish to view WinDriver version history, please refer to
http://www.jungo.com/wdver.html. Here you will be able to view a list of all new features, enhancements and fixes which have been added in each WinDriver version.

Technical Documents

For additional information, you may refer to the Technical Documents database on our site at:
http://www.jungo.com/support/tech_docs_indexes/main_index.html.
The Technical Documents database includes detailed descriptions of WinDriver's features, utilities and APIs and their correct usage, troubleshooting of common problems, useful tips and answers to frequently asked questions.