Driver Developer Kit

# Mac OS USB DDK API Reference

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# Contents

# Figures and Tables

# About This Note

This document provides an introduction to the features of the Universal Serial Bus (USB). It also describes the Apple Macintosh software components and programming interfaces that support USB device hardware.

This document is intended for experienced hardware and software developers interested in creating USB device drivers for the Macintosh platform. Hardware and software developers reading this document should be familiar with the information related to native drivers in the PCI Driver Development Kit, available on the Developer CD Series, and have a copy of the current *Universal Serial Bus Specification*, which can be found at http://www.usb.org/developers.

If you are not familiar with the terminology used to describe the elements that make up the USB architecture, see Appendix C, "USB Terminology," page 213 before moving on to the rest of the material in this document.

If you are interested in finding out about the features USB provides and want to get a basic description of the elements that make up the USB topology, you should read the introductory material in Chapter 1, "Overview," and Chapter 2, "USB Topology and Communication."

If you already understand the features and topology of the USB architecture and want to get to work developing a Mac OS compatible device driver for your USB device, see the material in Chapter 3, "USB Software Components," Chapter 4, "Writing Mac OS USB Drivers," the reference material in Chapter 5, "USB Services Library Reference," and Chapter 6, "USB Manager Reference." In addition, look at the example code provided in the Mac OS USB Device Driver Kit.

Major differences between versions of the Mac OS USB software are noted in Appendix A, "Changes In Mac OS USB Software," page 203. In particular, this draft includes information related to changes between version 1.0/1.0.1 and version 1.1 of the Mac OS USB software. Versions 1.2 and 1.3 of the Mac OS USB software are also covered by the APIs defined in this document.

**IMPORTANT**

The information in this note is subject to change; no representation or guarantee is made about its accuracy or completeness. ▲

## Contents of This Note

The information is arranged in four chapters and three Appendices:

- Chapter 1, “Overview,” provides an introduction to the USB architecture.
- Chapter 2, “USB Topology and Communication,” provides a high level overview of the topology of the USB and how the host software communicates with devices over the USB.
- Chapter 3, “USB Software Components,” is an overview of the components that make up the Macintosh USB software architecture.
- Chapter 4, “Writing Mac OS USB Drivers,” discusses the composition of Mac OS USB drivers and provides details about how the Mac OS USB software communicates with the driver. It also discusses USB compatibility shims, which developers can create to provide a layer of software that allows applications or other client processes to communicate directly with their vendor specific USB drivers through exported APIs.
- Chapter 5, “USB Services Library Reference,” describes the Mac OS USB system software libraries that developers use to support programming USB class drivers for their USB devices.
- Chapter 6, “USB Manager Reference,” describes the Mac OS USB Manager library that provides service to the Mac OS and extension clients.
- Chapter 7, “HID Library Reference,” defines the HID library API.
- Appendix A, “Changes In Mac OS USB Software,” provides information about the differences between various releases of the Mac OS USB software that developers need to be aware of.
- Appendix B, “Conventions and Abbreviations,” provides a list of standard abbreviations used in Apple technical documentation.
- Appendix C, “USB Terminology,” defines many of the terms that are commonly used in discussion related to the USB hardware and software architecture.

## Supplemental Reference Documents

For technical documentation describing the USB specification, see the Universal Serial Bus Specification, which can be found at

http://www.usb.org/developers

Technical specifications for USB device classes can also be found at the USB web site.

For information about PCI expansion cards, Mac OS Power PC native drivers, the Mac OS Name Registry, the Drivers Services Library, and other invaluable services for the development of modern device drivers for the Mac OS platform, refer to *Designing PCI Cards and Drivers for Power Macintosh Computers.*

To understand the Mac OS APIs and services provided for application programmers, you should also have copies of the relevant books of the *Inside Macintosh* series, available in technical bookstores and on the World Wide Web at

http://developer.apple.com/techpubs/mac/

The information found in *Inside Macintosh: Power PC System Software, Chapter 3, "Code Fragment Manager"* is a handy reference for developers writing USB device and interface drivers, because USB drivers are essentially code fragments. The information there is not specific to USB device drivers, but it does define how code fragments work, and provide descriptions of the APIs that support code fragments in the Mac OS environment.

## Mac OS USB Resources

For late-breaking information, technical notes, and sample code for developing USB device drivers for the Macintosh platform, visit the Mac OS USB web site:

http://developer.apple.com/dev/usb/

For developers getting started with the Macintosh platform, see the Introduction to Macintosh Programming web site at:

http://developer.apple.com/macos/intro.html

For developers creating Macintosh software for gaming devices, see the Macintosh Game Sprockets web site where you will find information about Input Sprockets version 1.3, which supports writing Input Sprockets for USB gaming devices.

http://developer.apple.com/dev/games/

## Apple Developer Connection Web Site

The Apple Developer Connection Web site is the one-stop source for finding the latest technical and marketing information specifically for developing successful Macintosh-compatible software and hardware products. Developer World can be reached at

<http://developer.apple.com/programs/>

CHAPTER 1

# Overview

This chapter provides a high-level introduction to the features of the Universal Serial Bus™ (USB).

# Introduction to USB

This section describes the benefits of incorporating USB into the Macintosh hardware architecture. It also provides information about the selection of devices supported by the USB architecture.

## Why Incorporate USB Into the Macintosh Architecture?

The motivation behind the selection of USB for the Macintosh architecture is simple.

- USB is a low-cost, medium-speed peripheral expansion architecture that provides data transfer rates up to 12 Mbps.
- The USB is a synchronous protocol that supports isochronous and asynchronous data and messaging transfers.
- USB provides considerably faster data throughput for devices than does the Apple Desktop Bus (ADB) and the Macintosh modem and printer ports. This makes USB an excellent replacement solution for not only the existing slower RS-422 serial channels in the Macintosh today, but also the Apple Desktop Bus, and in some cases slower speed SCSI devices.

In addition to the obvious performance advantages, USB devices are hot pluggable and as such provide a true plug and play experience for computer users. USB devices can be plugged into and unplugged from the USB anytime without having to restart the system. The appropriate USB device drivers are dynamically loaded and unloaded as necessary by the Macintosh USB system software to support hot plugging and unplugging.

### Better Device Expansion Model

The USB specification includes support for up to 127 simultaneously available devices on a single computer system. (One device ID is taken by the root hub.) To connect and use USB devices, it isn't necessary to open up the system and add additional expansion cards. Device expansion is accomplished with the

addition of external USB multiport hubs. Hubs can also embedded in USB devices like keyboards and monitors, which provide device expansion in much the same way that the Apple Desktop Bus (ADB) is extended for the addition of a mouse through the keyboard or monitor. However, the USB implementation doesn't have the device expansion or speed limitations that ADB does.

## Compact Connectors and Cables

USB devices utilize a compact 4-pin connector rather than the larger 8- to 25-pin connectors typically found on RS-232 and RS-422 serial devices. This results in smaller cables with less bulk. The compact USB connector provides two pins for power and two for data I/O. Power on the cable relieves hardware manufacturers of low-power USB devices from having to develop both a peripheral device and an external power supply, thereby reducing the cost of USB peripheral devices for manufacturers and consumers.

The cables for high-speed and low-speed devices differ in construction. High-speed USB device cables require shielding and two pairs of twisted-pair wires inside. One twisted pair provides power, nominally +5V (4.3 to 5.3 V at 100ma) for devices connected directly to the host, and ground. A powered hub can provide up to 500ma of +5V per port. (See "USB Hub Devices" (page 1-20) for a description of the services a hub provides on the USB.) The other pair of wires is for data I/O signals. (Low-speed cables are untwisted and do not require shielding.)

High-speed cables are most common, and appear as patch cables to attach hubs to hubs, or attach high-speed devices to a hub. Low-speed cable length can be up to 3 meters, and high-speed cable length up to 5 meters. Both high-speed and low-speed cables can be used on the same system bus.

USB cables are directional, the upstream connector is mechanically different from the downstream connector. The upstream connector has a small nearly square shape with a stacked pinout and the downstream connector has rectangular shape with an in-line pinout. This prevents users from connecting cables in a way that would create a loopback connection at a hub.

## Use of Standard Hardware

Devices that are designed in accordance with the USB standard should not require any modification to run on a Macintosh computer or other hardware platforms. The only changes that developers need be concerned with to support

the Macintosh market are the changes involved in the development of Macintosh USB device drivers and applications.

### Lower Cost Than Comparable Non-USB Peripherals

Low-power USB devices are less expensive than their serial or parallel interface counterparts, because of the elimination of the power supply and because the USB standard is also incorporated into PC systems developed around the PC ’98 hardware architecture. Future versions of the PC ‘98 compliant operating systems will also include built-in driver support for a wide variety of USB devices. Together these factors mean that a larger customer base will form for USB peripheral devices, resulting in lower retail costs of USB devices for all personal computer users.

## Wide Selection of USB Devices

The USB specification supports lower-speed devices, such as a keyboards, mice, joysticks, and gamepads, at 1.5 Megabits per second and higher speed devices, such as removable storage devices, scanners, or digital cameras, at up to 12 Megabits per second (high-speed is referred to as *full speed signalling* in the USB specification).

### Device Classes

USB devices are categorized by class. Table 1-1 lists a few examples of USB device classes.

**Table 1-1** Examples of USB device classes

| USB device class | USB devices in class |
|---|---|
| Audio class | Speakers, microphones |
| Communication class | Modem, speakerphone, internet phone |
| Composite class | A single device that supports multiple functions, mice, keyboards, and others |
| HID class | Keyboards, mice, joysticks, drawing tablets, and other pointing devices |

**Table 1-1** Examples of USB device classes (continued)

| USB device class | USB devices in class |
|---|---|
| Hub class | Hubs provide additional attachment points for extending the USB. A hub may also be embedded in another device, such as a keyboard or display. |
| Mass storage class | Floppy drives, other removable storage devices. |
| Printing class | Printers |
| Vendor specific | A device that doesn't fit into any other predefined class, or one that doesn't use the standard protocols for an existing class |

## Low- and High-Speed Devices

Low-speed devices, which may include keyboards, mice, drawing tablets and others, are typically in a USB class called the Human Interface Device (HID) class. There is generally some cost reduction in low-speed devices because the cabling is less expensive than cabling for high-speed devices.

Low-speed devices support only short messaging and do not support bulk and isochronous transfers.

High-speed devices generally include communications devices, printing devices, bulk storage devices, audio devices, and others.

There is nothing to prevent USB devices from being in either a high-speed or low-speed category. However, some classes of devices, those that require bulk or isochronous transfer services, cannot be part of the low-speed category.

**Note**
High speed in the case of USB is not comparable to high-speed devices on a FireWire bus. USB is a complementary technology to FireWire, not a competing technology. USB enables the use of affordable higher-speed consumer grade peripherals on Macintosh computers.

## USB Hub Devices

Hubs are also USB devices and provide attachment points to the USB for other devices or hubs. Hubs can be embedded into other USB devices (this is known as a compound class device). For example, a hub can reside in a keyboard, monitor, or printer to provide attachment points for other (typically) low-power devices.

Hubs are also in the form of standalone multi-port hubs that provide attachment points to the USB for other USB devices. Multiport-hubs are generally categorized as bus-powered and self-powered. Bus-powered hubs can request a total of 500ma from the USB and provide no more than 100ma of power at each port on the hub. Even though a bus-powered hub may request 500ma, it may not get the power depending on the devices connected upstream on the USB. Self-powered hubs (hubs that include a source of power external to the USB) can supply additional power to the USB, and are required to provide up to 500ma at each port on the hub.

While it is physically possible to connect two bus-powered hubs together in-line without damaging any devices on the USB, it should not be done because there isn't enough power on the USB to support such an attachment. If sufficient power isn't available for the downstream device, the USB software will not be able to properly configure the device's power requirements. The downstream hub most likely will not function. However, a self-powered hub and bus-powered hub can be connected together in-line.

See Chapter 11 of the Universal Serial Bus Specification for additional information about USB hubs.

## The USB Root Hub

There is also a hub referred to as the root hub. The root hub is a software simulation of a hub with hardware controller support. It acts as part of the host hardware environment on the main logic board or on an I/O expansion card. The root hub is similar to the other hubs, in that it provides an attachment point or points to extend the USB from the host, however it is the initial connection point and parent of the bus at which all signals originate. A simple diagram of the USB topology is shown in Figure 2-1 (page 2-27).

# Compatibility Issues

This section describes issues related to compatibility with legacy Macintosh ADB, serial/LocalTalk, and storage devices. In addition, it describes some fundamental differences in how USB works as a serial communications channel in the Macintosh environment.

## USB Software Gestalt Selectors

There are four gestalt selectors defined for determining the version attributes of the USB software. To use the gestalt selectors you must understand how to use the Gestalt Manager, which is defined in *Inside Macintosh: Overview*. The gestalt selectors for USB software are defined in Chapter 3, "USB Software Presence and Version Attributes."

## ADB, Serial/LocalTalk, and USB

You cannot physically connect legacy ADB devices or serial/LocalTalk devices to USB ports.

It is currently not possible to use a USB keyboard to access Open Firmware if the keyboard is connected to a PCI USB controller card in a Macintosh. Essentially, keystrokes are not recognized early enough in the boot sequence to allow boot keyboard access to Open Firmware. Other keyboard key combinations, such as turning off system extensions with the Shift key down, do function as expected.

## Macintosh-To-Macintosh USB Connections

USB is a serial communications channel, but does not replace LocalTalk functionality on Macintosh computers. You cannot connect two Macintosh computers together using the USB like you can in a LocalTalk serial network for a couple of reasons.

- The USB cable connectors are designed in such a way that it should be impossible to attach two upstream devices together. A standard USB cable has one upstream connector and one downstream connector. The root hub in

the Macintosh computer is the first device on the USB, and as such it is always an upstream device in the USB topology.

- The USB uses a master/slave communication model in which the Macintosh host controls all communication and is the master of the bus. There cannot be two masters on the same bus.

The most cost efficient method for networking USB enabled Macintosh computers together is through the built-in Ethernet port.

## USB Storage Devices

Version 1.0 of the Apple USB software does not support booting from any USB storage device.

## Keyboard Requirements

Apple provides a HID class driver for the Apple USB keyboard, which supports the USB boot protocol. Keyboards intended for use on the Macintosh platform must support the HID boot protocol, as defined in the USB Device Class Definition for Human Interface Devices (HIDs).

## USB Data Transfer Types Supported

There are four data transfer types defined by the USB specification. They are

- Bulk transfers which offer guaranteed delivery of data. This may include retrying transmissions at the hardware level. Bulk data transactions are best suited for printers, scanners, modems, and devices that require accurate delivery of data with relaxed timing constraints.
- Interrupt transfers, which allow a device to signal the host. Interrupt data transactions do not use up CPU cycles unless the device has data ready. Interrupt transactions are used for HID class devices like keyboards, mice, joysticks, as well as devices that want to report status changes, such as serial or parallel adaptors and modems.
- Isochronous transfers for one time delivery of data. Isochronous data transactions are best suited for audio or video data streams.
- Control transfers for device configuration and initialization.

Version 1.0 of the Mac OS USB software provides functions that support only control, bulk, and interrupt transfer types. Version 1.1 supports control, bulk, interrupt, and isochronous transfers types.

## USB Controller Support

The Apple Macintosh USB system software supports controllers compatible with the Open Host Controller Interface (OHCI) specification. It does not support Universal Host Controller Interface (UHCI) controllers.

Some early USB devices (most notably keyboards) can't interoperate with an OHCI controller. These devices will not be supported by the Apple USB system software.

## Maintaining Printer Device and Driver Compatibility

This section deals issues related to USB printer dongles, USB printers, and USB printer device driver development. What follows is a list of recommendations that ensure compatibility and provide a quality customer experience when using a USB printer on a Macintosh computer.

1. Put your vendor ID code in a EPROM of your USB printer dongle adaptor or printer. Don't use the default ID that comes with the USB device part. Failure to do so may cause your vendor specific driver to match against a device other than your own. For example, without a vendor ID EPROM, the USB software will see your dongle as a USB to parallel bridge device rather than your printer device, and your printer driver may never be matched with the printer.
2. If you use the Apple USB printer driver it must remain unchanged, do not supply your own copy of the Apple driver with a different name. Use the Apple USB printer driver as is., and do not change or rename it. Apple's USB printer driver is a generic printer driver.
3. If you do use the Apple USB printer driver, you must obtain the appropriate licensing agreement from Apple Computer, Inc.
4. If you do supply your own printer driver, it absolutely must be vendor specific and not generic. It must be named differently from the Apple USB printer driver, and match to your vendor ID.

There are also important issues related to driver loading options in the driver description structure that must be followed. The driver description structure is

defined in "USBDriverDescription Structure" (page 4-56). Essentially, the rule is that you must set your driver loading options so that your driver does not match to generic devices. To set your driver loading options to do not match generic, specify `kUSBDoNotMatchGenericDevice` in the `USBDriverLoadingOptions` field of the `USBDriverDescription` driver description structure.

Additional information about USB drivers and driver loading can be found in Chapter 5, "USB Services Library Reference," and "Installing The Device Callback Request" (page 6-169).

## Device Support For Multiple Vendor Specific Devices

Beginning with version 1.2 of the Mac OS USB software, multiple class drivers can be merged into a single vendor specific USB extension file. Details on how this is done and the benefits that are provided by this feature can be found in "Major Features Introduced In Version 1.2" (page A-207).

## USB PCI Adapter Card Support

Mac OS USB software is available to support USB PCI adapter cards. The USB system extensions in this package allow users of Power Macintosh computers with PCI slots to install a third-party USB PCI adapter card and communicate with USB devices connected to the USB ports on the adapter card. The software can be found at the Apple Software Updates:

http://asu.info.apple.com/swupdates.nsf/artnum/n11487

This software does not install on Macintosh computers with built-in USB ports.

## Transaction Timeouts

Beginning with version 1.3 of the Mac OS USB software, a 5-second timeout is enforced on control transactions. This can be overridden for drivers with devices that do not support the new behavior. A facility has also been added for class drivers to set a no data timeout for devices. See "Transaction and Data Timeouts" (page 5-94) for details about these new features in the Mac OS USB software.

CHAPTER 2

# USB Topology and Communication

This chapter introduces the USB topology and how the USB host software communicates with devices. This is only a high-level introduction. For the complete details of the USB topology and communication model, see the Universal Serial Bus Specification, which can be found at <http://www.usb.org/developers>.

# USB Bus Topology

This section briefly describes the topology and communication model for the USB architecture.

The USB architecture has a well defined physical and logical bus topology, which is fully described in the Universal Serial Bus Specification. The physical topology defines how USB devices are connected together. The logical topology defines how the various components that make up the physical topology are viewed by the host software.

## Host Software

The client software, the USB management software, and the USB host controller together make up the host software in the USB logical topology.

The host plays a special role as the arbiter of all activity on the USB. A USB device can only gain access to the bus through the host by supplying a device descriptor that includes the information necessary to manage the device according to its features and class identifiers. See Chapter 5, “USB Services Library Reference,” for additional information about the contents of the device configuration descriptor structure.

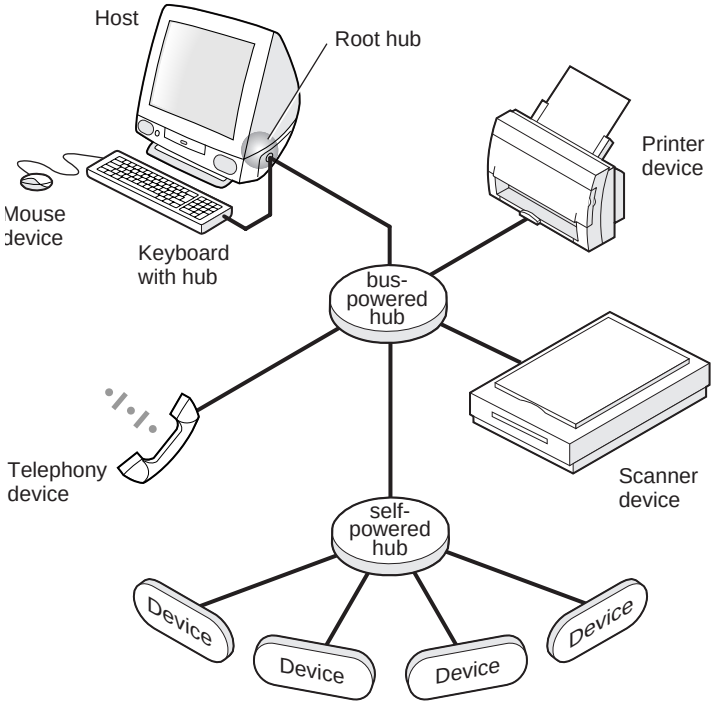
The host interacts with USB devices through the host controller. The host is responsible for:

- Monitoring the attachment and removal of USB devices
- Managing control and data flow between the host and USB devices
- Maintaining device status and activity information
- Providing a limited amount of power to the USB

## Physical Topology

An example of the USB physical topology is shown in Figure 2-1. The system software has to know about the physical topology to perform bandwidth measurements in order to optimize bit time requirements for the USB as it grows with additional hubs and devices. Device drivers do not have to know about the physical topology. The USB specification states that the host can handle up to six levels of hub support.

**Figure 2-1** USB physical topology




## Logical Topology

The logical topology is how the host software views and communicates with devices in the physical topology. From the host software perspective, the USB is

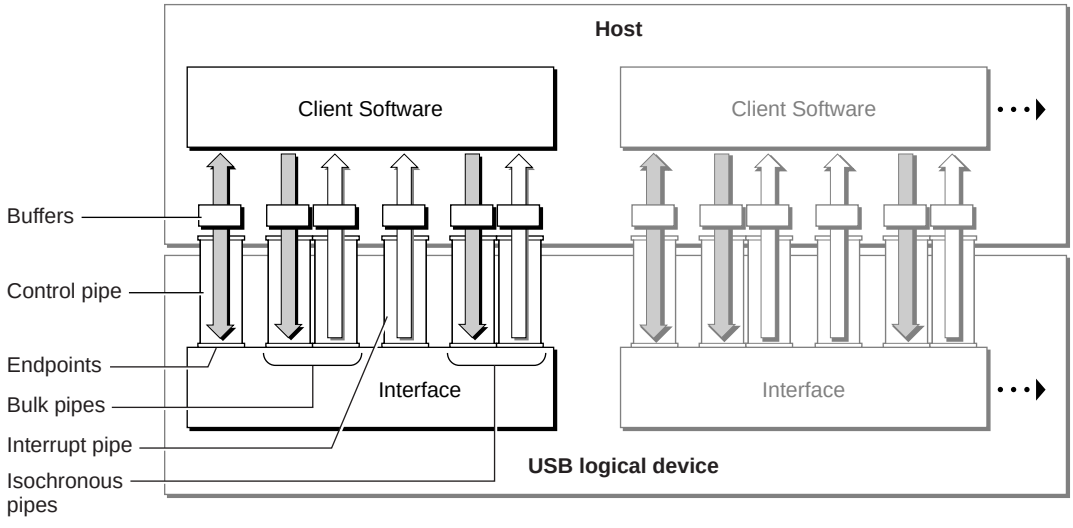
seen as a linear addressing space.The host is aware of the physical topology so that it can accurately support connection and disconnection on hubs with attached devices.

# Communication Over the USB

This section provides an abridged description of the logical communication model on USB. Refer to the Universal Serial Bus Specification for complete technical details. A simplified diagram of the USB communication flow is shown in Figure 2-2.

The USB driver software maintains an abstract view of the logical and physical topology of the bus when it communicates with USB devices. Drivers look for the interface(s) of interest that are available in devices on the USB.

**Figure 2-2** USB communication flow



## USB Interface

Interfaces are a means of determining the functionality a device can provide to the host and the means by which the device is controlled. For example, a device which provides a bulk interface function to the host would be controlled by an driver that understands the interface for the bulk transaction protocol.

Physical devices may contain multiple interfaces, which logically appear as device functions within devices. Each device has one interface for each function is supports.

The logical device is identified through an interface. Drivers use the USB Manager APIs to open interfaces to device functions (capabilities). The device's function(s) are defined by the interface class, subclass, and protocol values in the interface descriptor for the device. The interface descriptor is defined on (page 5-152).

A logical USB device is a collection of endpoints, grouped into endpoint sets, which implement a logical interface. USB software manages the interface using a pipe or pipe bundles. (Pipe bundles are used for bulk and isochronous transfers.) Data is packetized in a USB-defined structure by the host controller and moved across the USB between a software serial interface engine on the host and an endpoint on the device.

## USB Devices

Every USB devices is accessed by a unique USB address, which is assigned by the USB host software after initial device recognition and configuration takes place. Each USB device additionally supports one or more endpoints with which the host may communicate. All USB devices must support a specially designated Endpoint 0 to which the USB device's default control pipe is attached during device initialization.

## Endpoints

Endpoints are the terminus of a communication flow between a USB device and the host. Endpoints are a logical point inside the USB device to which the host may attach a pipe to initiate communication with a USB device. Endpoints represent a specific data connection where interfaces represent a larger functional connection.

### Endpoint 0

Endpoint 0 has a special responsibility. It is used for USB device initialization and configuration. All USB devices must support a default endpoint 0. Endpoint 0 supports control transfers which provide control pipe access to device descriptors and control requests to modify the device's behavior.

### Non-0 Endpoints

Non-0 endpoints are endpoints greater than 0. Low speed functions are limited to two optional endpoints beyond the required endpoint 0. Higher speed devices can have additional endpoints. However, no more than 16 input endpoints and 16 output endpoints. Endpoint 0 is used as both an input and output endpoint, which leaves a total of 15 each for input and output endpoints (0 through 15 = 16).

A non-0 endpoint is not available for use until it is configured by the startup configuration process when the device is attached to the USB.

Non-0 endpoints are not unique across device configurations. Endpoint numbers are defined by the device vendor in a configuration descriptor for the device. The associated interface or function associated with an endpoint number may be different for the same endpoint number in different devices. You should not count on endpoint numbers being identical from device to device for a given interface.

## Pipes

A pipe represents the communication link between a USB device endpoint and the host software. Data moves to and from the USB device through the pipe. Pipes have two communication modes, stream and message, and four transfer types, control, isochronous, interrupt, and bulk.

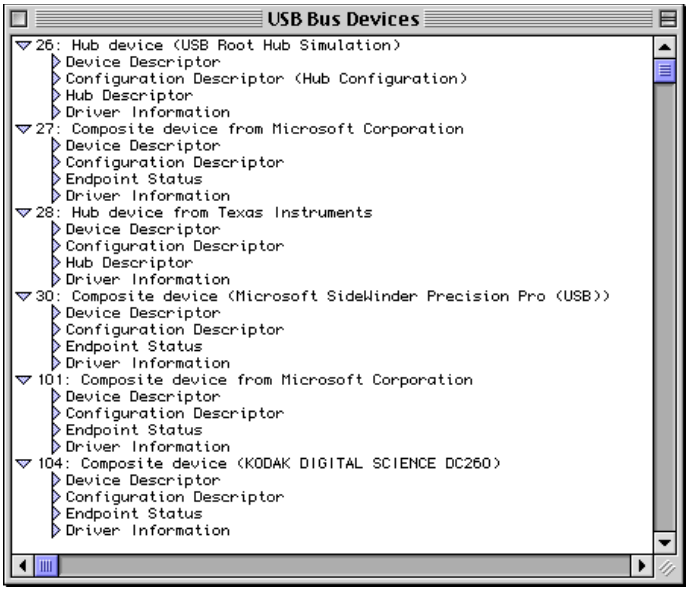
For a detailed descriptions of USB interfaces, endpoints, pipes, communication modes, and transfer types see the Universal Serial Bus Specification, which can be found at <http://www.usb.org>.

# A Look At USB Devices with USB Prober

The USB Prober application, which is included in the Utilities folder of the Mac OS USB Device Driver Kit, is a utility for examining devices on the USB.

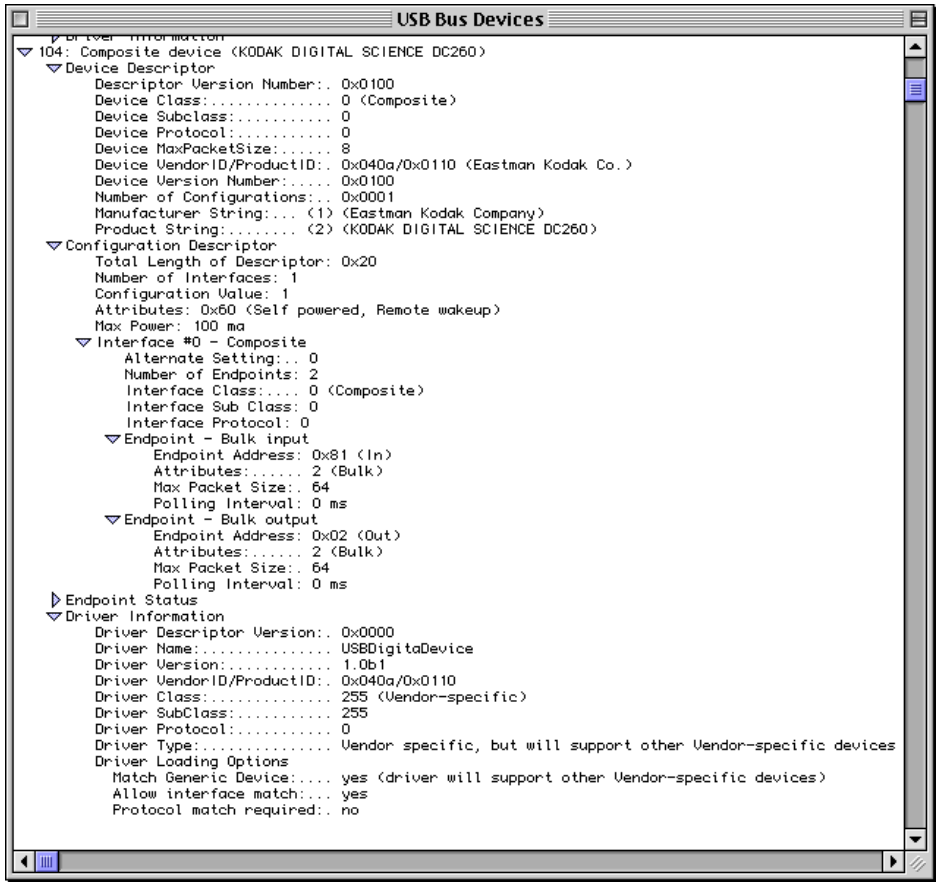
Figure 2-4 shows the USB Bus Probe window. The example shows the root hub simulation at the top, then various USB devices connected to a 2-port USB PCI card. A mouse and a self-powered 4-port hub are connected to the USB PCI card. The 4-port hub has three devices connected to it.

**Figure 2-3** USB Prober utility, USB Bus Devices window




In Figure 2-4 the device descriptor, configuration descriptor, and driver information categories for a digital camera with a USB port are expanded to show how the device and its associated drivers are defined.

**Figure 2-4** USB Prober view of a USB device




The digital camera belongs to the composite class and has a composite interface with a two bulk transfer endpoints; one supporting bulk input and the other supporting bulk output transfers. The camera's device driver is matched to the vendor ID and product ID values found in the device descriptor and driver descriptor.

## USB Prober Features for Developers

The USB Prober application provides several features that are useful to programmers who are debugging USB device drivers, or anyone interested in knowing what devices the Mac OS USB software recognizes on the USB.

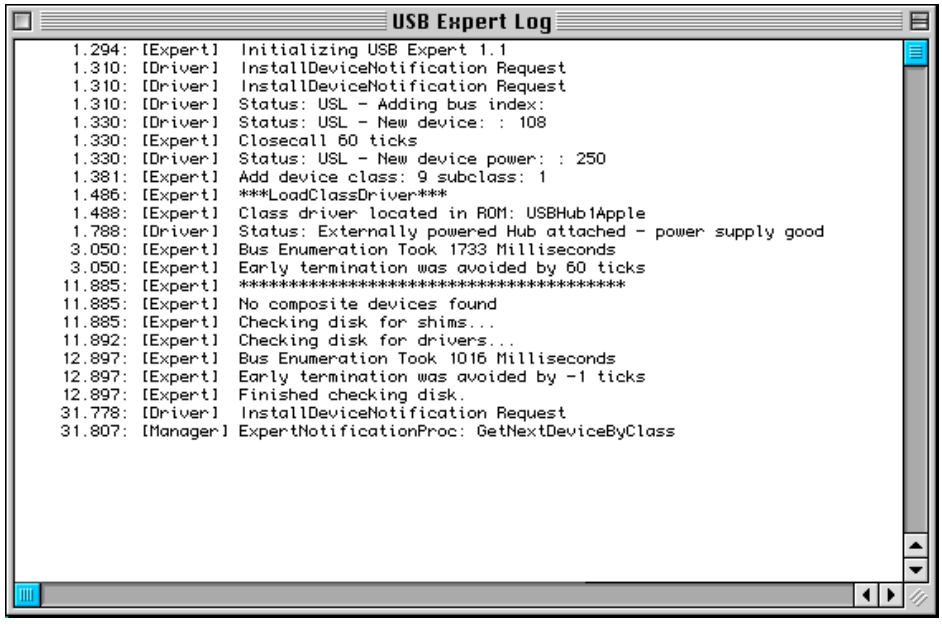
The primary features of the USB Prober are those found in the Windows menu.

### USB Prober Windows

The features of the USB Prober Windows menu include:

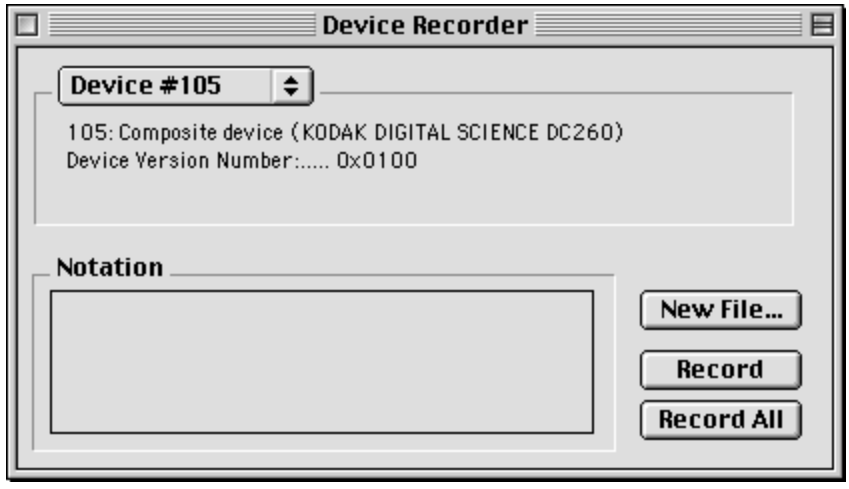
- **USB Bus Probe:** This window option lists all the device and driver information known about USB bus devices connected to the USB, including the root hub. The content typically displayed in the USB Bus Device window is shown in Figure 2-3 and Figure 2-4.
- **Open HCI Registers:** This window option displays the OHCI controller for each USB bus in the current system, and displays a decoded hierarchical list of the contents of the controller registers.
- **USB Expert Log:** This window option, shown in Figure 2-5, provides a running list of status messages posted by various parts of the USB system software. Both the USB Expert and device driver software routinely post status information here, giving a great deal of insight as to what's happening, or not happening on the bus. Information in this log can help you to determine when or if your driver is loading as expected. You can control the level of status that is displayed in the window by selection one of 5 levels found under the Commands menu in the Status Level menu item. The levels are defined as:
  - 1: Fatal errors.
  - 2: General errors that may or may not effect operation.
  - 3: General driver messages.
  - 4: Important messages generated by the USB Expert and USL.
  - 5: General messages from the USB Expert and USL. This is the default level selected when the Prober is first launched.

**Figure 2-5** Expert log window




- **Device Recorder:** This window option records information about a specified device from a list of attached devices is provided in a popup menu. When you press the Record button in the Device Recorder window, shown in Figure 2-6, USB Prober saves the entire list of information in the USB Bus Devices window that corresponds to the selected device into a file on disk. The information it saves to disk includes the raw device, configuration, string, and hub descriptor data.

**Figure 2-6** USB Prober Device Recorder window




**Device Record Viewer:** Device specific information saved by the Device Recorder can be displayed in hierarchical view with the Device Record Viewer. The information can be saved as a text file that can be viewed by any application that supports text files. The list of information about the device is fully expanded in the text file that is saved.

Additional details about how to programmatically access the information that defines a USB device can be found in “USB Services Library Reference.”

CHAPTER 3

# USB Software Components

This chapter is in preliminary overview of the components that make up the Macintosh USB software architecture.

# Mac OS Software for USB Devices

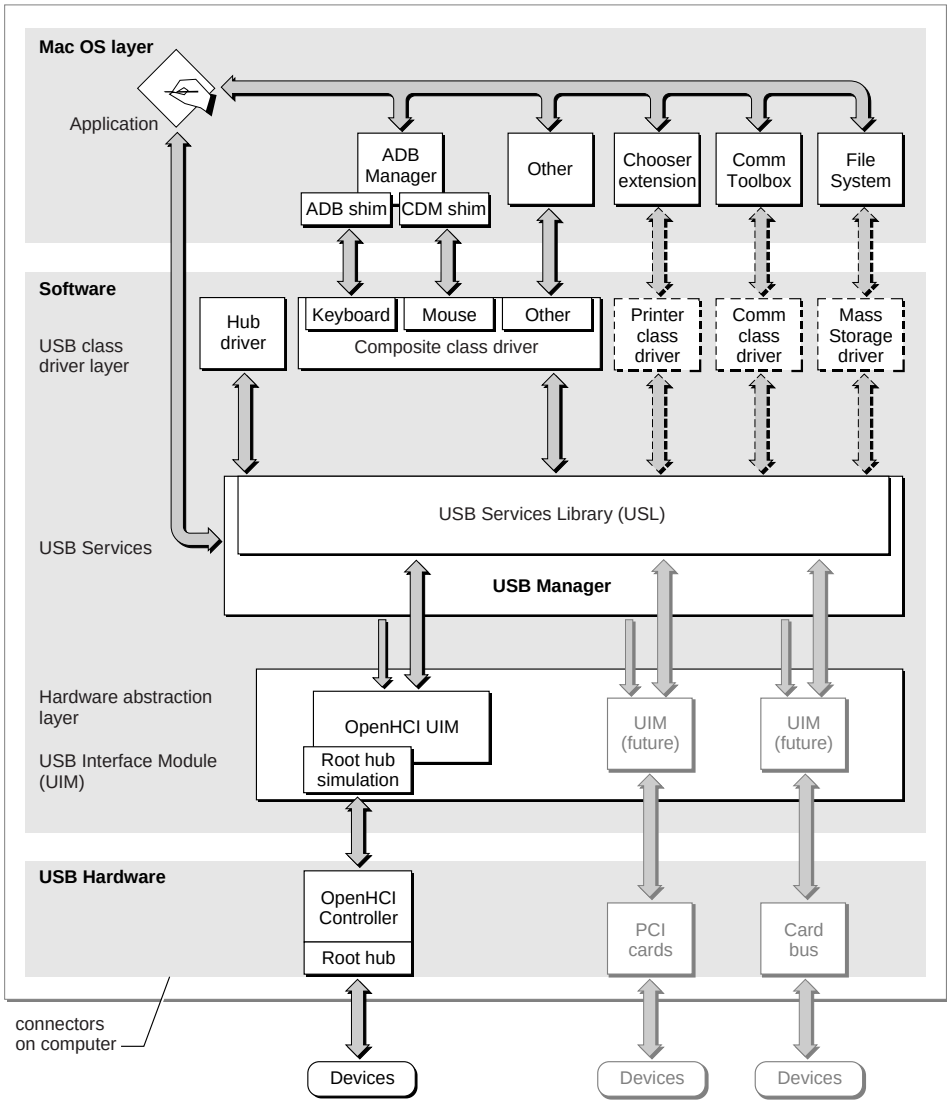
The software that supports USB devices in the Mac OS environment includes a USB Interface Module (UIM), a USB Manager, a USB Services Library (USL), and USB class drivers.

- The UIM, pronounced *whim*, communicates with the USB controller hardware and provides a hardware abstraction layer for the USL and USB Manager.
- The USB Manager is the API provided to the Mac OS, or extensions that need information related to the USB.
- The USL is the API that USB device drivers use to add device functionality to the USB on Macintosh computers. The API is defined in the USB.h file and Chapter 5, “USB Services Library Reference.”
- Device class drivers in version 1. 0 of the Macintosh USB system software include a USB composite device class driver to support USB HIDs, such as keyboards and mice, and a hub class driver to support hubs attached to the USB. Other drivers may be added in future releases.

The Mac OS USB system software components are available as system extensions for Macintosh systems that do not include built-in USB ports. This generally applies to Macintosh computers that have USB ports on PCI cards. Macintosh computers that have USB ports designed into the main logic board, like the iMac computer, have all of the USB software components, excluding the class drivers, in the Macintosh system ROM file, Mac OS ROM.

Figure 3-1 shows the components that make up the USB software architecture on the Macintosh computer. Release version 1.0 of the Macintosh USB software provides only class driver support for a USB keyboard, mouse, and hub. Later releases will provide support for other devices.

**Figure 3-1** USB architecture



## USB Software Presence and Version Attributes

Applications can obtain information about the presence, version, and attributes of USB software on Macintosh computers by using the Gestalt Manager routines and USB gestalt selectors. The Gestalt Manager is defined in *Inside Macintosh: Overview*.

The `gestaltUSBAttr`, `gestaltUSBPresent`, `gestaltUSBHasIsoch`, and `gestaltUSBVersionGestalt` selectors are defined for Macintosh USB software as follows:

```
gestaltUSBAttr      = 'usb '    USB attributes
gestaltUSBPresent   = 0         Bit 0 is set if USB software is present
gestaltUSBHasIsoch  = 1         Bit 1 is set is USB software supports
                                isochronous transfers
gestaltUSBVersion   = 'usbv'    USB version number
```

The `gestaltUSBVersion` selector returns the version of the USB software in a 32-bit format as follows:

```
MMmmRRss
```

| | |
|---|---|
| MM | The most significant byte containing the major version number. The current value for the major version number is 1. This number will increment with each major release. |
| mm | The next byte contains the minor version and revision number. The current value for the minor version number is 2. This number will increment with each minor release. |
| RR | The next byte contains the release stage. The release stage is defined as: 0x20 = development, 0x40 = alpha, 0x60 = beta, and 0x80 = final. If the software was at the beta release stage, this number would be 0x60. |
| ss | The least significant byte is the sequence number of the release, and it changes with every build of the USB software. |

## USB Interface Module (UIM)

The UIM provides the upper layers of the USB software with a hardware abstraction layer to the USB host controller interface hardware. The UIM communicates directly with the USB controller hardware to set up the

appropriate communication links with the USB devices on the bus. The UIM also provides root hub simulation.

The UIM is a native driver 'ndrv' code fragment, as defined in “Designing Macintosh PCI Cards and Drivers for Power Macintosh Computers.” In addition to supporting the data export guidelines for ndrvs, the UIM provides USB specific data exports that define the UIM driver entry points and descriptor structures built for devices on the USB.

Open Firmware builds a Name Registry entry for the host controller and matching UIM during hardware bring up time, prior to booting the operating system. The USB Manager uses the information in the Name Registry to communicate with the UIM. Once the UIM is loaded and begins hub simulation, the USB Manager determines that a hub is present and loads the hub driver. At this point, the hub driver begins monitoring all USB device activity at the USB hub simulation provided by the UIM.

A UIM is required for every USB bus controller implementation installed in the host. For example, multiple UIMs would be required on a host which has both a built-in USB host controller interface and a USB controller interface on a PCI card. Developers designing PCI, Card Bus, or any other controller interface to the USB may need to provide a UIM for their card interface. For information regarding the APIs needed for UIM software development, send email to the Apple USB evangelist at USB@apple.com.

## USB Manager

The USB Manager performs driver matching and loading services and communicates internally with other components of the Macintosh USB host software to identify devices on the USB. The USB Manager also provides services that Mac OS and applications use to determine the status of devices, handle power management tasks, and notify the user or other applications about USB devices being attached to or removed from the USB.

An example of a service that the USB Manager can provide for a client is when a client makes a request to find a keyboard. The USB Manager determines if a keyboard is installed and returns the appropriate response. If a keyboard is installed, the client can ask where the class driver is for that keyboard. The USB Manager then points to the code fragment that contains the class driver for keyboards. The client then communicates with the keyboard through the class driver. The keyboard class driver communicates with the keyboard interface through the USB Services Library. The API for the USB Manager is included in

Chapter 6, “USB Manager Reference.”The API for the USB Services Library is described in Chapter 5, “USB Services Library Reference.”

## Hub Driver

The hub driver provides support for the USB software architecture by monitoring the connection and removal of devices on the USB at a hub. This process is referred to as device enumeration. When the hub driver recognizes that a device has been plugged into the bus at a given port ID on a hub, it notifies the USL. The USL notifies the USB Manager, which in turn builds the Name Registry entry for the device and binds the appropriate class driver with that device. When the hub driver finds a device, it notifies the USB Manager that a device has been found. The USB Manager loads the appropriate class driver based on the class and subclass and other information found in the device configuration or interface configuration descriptor for the device.

Additional information about the process of bus enumeration is described in Chapter 9 of the Universal Serial Bus Specification.

## USB Class Drivers

A USB device must have a USB class driver or drivers for every interface (function) the device supports to operate properly on the Macintosh computer. Macintosh USB class drivers are implemented as Shared Libraries with a file type 'ndrv' and creator 'usbd'. As with other PCI drivers, the code fragment Manager (CFM) code fragment must export driver description structures to characterize the USB functionality the driver provides. The USB Manager uses the description structure to match drivers with a device or interface.

The USB Manager matches drivers to device interfaces by initially examining the product ID and vendor ID fields in the device descriptor for the device. To ensure proper device and driver matching, additional information regarding the device is examined if none or more than one driver matches the product ID and vendor ID values for the device. Detailed information about how USB class driver and device matching is accomplished is in the Universal Serial Bus Common Class Specification which can be found at <http://www.usb.org>.

There are several classes of drivers defined by various USB specifications, and new classes are being proposed all the time. The Macintosh USB software includes HID class drivers for the HID interfaces in the USB keyboard and mouse. The keyboard and mouse drivers are loaded by a composite class driver,

which is loaded by the hub driver when the keyboard and mouse are found on the USB.

Mouse cursor movement and other operations reported to the Mac OS from keyboards and mice are handled by compatibility shims. Shims provide a layer of software translation between the USB driver and upper-level APIs, such as the Cursor Device Manager (CDM) in the case of a mouse or pointing device. An ADB shim provides compatibility services for the ADB Manager to support the USB keyboard. The ADB compatibility shim services allow older applications that are not USB aware to function as expected with a USB keyboard. The CDM shim provides the same level of compatibility with the USB mouse for older applications.

For additional information about how compatibility shims are used in Mac OS USB environment, see “Applications and USB Drivers” (page 3-44), the driver code sample available in the Mac OS USB DDK, and Chapter 4, “Writing Mac OS USB Drivers.”

A USB device includes an interface or interfaces, which are defined in descriptor data structures associated with the device. The interfaces are like sub devices within the device, each having a function specified by numerical class and sub class identifiers. The functions provide device capabilities to the host system. Interfaces also define how a function in a device is accessed by the host system. The functional features of the device are accessed by the USL when given an interface reference.

The Macintosh system software maintains a driver dispatch table for USB class drivers that defines among other things the driver initialization routine, driver gestalt, and the driver callback completion routine. For more information, see the driver descriptor structure defined in the USB.h file.

## USB Services Library (USL)

The USB Services library is the programming interface that USB device drivers use to communicate with the USB on a Macintosh computer. The USL provides the services necessary to find a device with the appropriate interface, open an interface to the device, open the device, instantiate the appropriate pipe connections, determine device status, and perform read and write transactions with the device. For additional information about the USL, see Chapter 5, “USB Services Library Reference.”

# Applications and USB Drivers

The Mac OS USB architecture implements a driver model in which the USB drivers are dynamically loaded libraries, code fragments with exported symbols in the form of a driver description and driver dispatch table. This allows USB driver writers to export whatever public or private APIs they see fit for their devices. The symbols that drivers export are defined in “Core Mac OS USB Driver Data Exports” (page 4-56).

The USB Manager and its sibling, the USB Family Expert, are used to manage the loading and unloading of USB drivers. The USB Family Expert does the matching of drivers to devices, while the USB Manager provides APIs that let applications, compatibility shims, INITs, and so on, discover what USB devices are currently attached to the USB, and request to be notified whenever devices are connected or disconnected.

There are a number of ways that applications can communicate with USB drivers. They range from calling directly into the USB driver, creating a layer between the application and class driver (a compatibility shim), or creating a unit table driver that calls the class driver. You could also have cdevs and INITs call class drivers, as long as you handle the mixed mode environment properly.

The decision to use one method over the other depends on the following factors:

- Does your device driver emulate a legacy I/O device? For example, a serial device.
- Do you need to have something (a shim) manage multiple devices connected simultaneously?
- Are you planning on publishing the APIs to application programmers, or will you be the only application writer?
- Do you care about architectural issues that may affect you in the future?

Ideally application writers should not have to worry about the USB Manager. Applications have a way of living on for 5, 10, or 15 years. And who knows what changes may take place in the USB Manager services over that entire time span. Instead of relying specifically on the USB Manager APIs from the start, it would be better to export a set of abstract functions from your driver that have little to do with USB specifically.

For example, put your exported APIs into a USB compatibility shim, and let your application call the compatibility shim. That way, you can revise your USB compatibility shim to support any revisions to the USB Manager without needing to rewrite an entire application.

And if you're emulating a legacy device that has a driver model already established (for example, .ain, .aout, .sony, and so on), then you'll want to create a unit table driver that applications can talk to. That's what is done with the Apple USB Storage class driver and USB Modem driver, which are available in Mac OS USB software version 1.2. They both have compatibility shims that create standard Device Manager style unit table drivers.

You need to be very careful when having applications call class drivers directly. It's possible that the driver could unexpectedly quit, or the device may be unexpectedly unplugged. You need to pay careful attention to application quitting and device removal situations.

In summary:

If you're planning on creating APIs that 3rd party application writers can use, then abstract your API so that it isn't USB specific.

If you're planning on developing a device that you will emulate a legacy unit table driver, then you'll need to create unit table driver that in turn calls your USB device's class driver.

You can also have your application call directly into your class driver. But you'll need to weigh the long term application compatibility issues and see what makes the greatest amount of sense to you.

CHAPTER 4

# Writing Mac OS USB Drivers

This chapter describes how the USB Manager interacts with class drivers when a USB device is recognized, and defines the core functionality that the driver must implement to operate properly on the Macintosh platform.

This chapter provides information about the composition of a Mac OS USB driver, describes how drivers are matched to devices, defines the driver entry points and core data structures drivers must export, and discusses how a driver gets called by the Mac OS USB software. Sample code is also provided where necessary to support important concepts.

This chapter is divided into the following sections:

- "Mac OS USB Driver Overview" deals with the basic composition of a USB driver, and refers to the symbols, defined later in "Core Mac OS USB Driver Data Exports", that a driver must export to describe its device support features to the Mac OS USB software.
- "USB Device and Driver Matching" describes the criteria used by the Mac OS USB software to match drivers to USB devices. This section also describes how the fields in the driver core data exports are used to facilitate accurate matching of drivers to devices.
- "Core Mac OS USB Driver Data Exports" defines the contents of the driver description structure that the Mac OS USB software uses to match and load USB class drivers, and the driver dispatch table that class drivers use to communicate with the Mac OS USB software and monitor device activity on the USB. The structures defined in this section are the two symbols that a driver must export to the Mac OS USB software to operate properly with USB devices on the Macintosh platform.
- "Handling Hot Unplugging, Dealing With Notifications" further defines how notification messages, listed in "Driver notificationProc Function" (page 4-66), are used by Mac OS software to communicate device activity on the USB to USB drivers.
- "Communicating With Client Processes" describes how to facilitate communication between Mac OS applications and processes and USB class drivers. Design and use of compatibility shims is discussed in this section.
- "Detecting USB Device Presence" provides ideas about how to implement two different means for finding a USB device.
- "Mac OS USB Compatibility With Mac OS Toolbox Calls" discusses issues USB class drivers should be aware of with regard to the services provided by the Mac OS Toolbox.

Apple provides class drivers for USB hub devices, HID devices (mice, keyboards, joysticks, and gamepads), printing, communications, and mass storage devices shipped in specific system configurations. Other drivers are provided as samples in the Mac OS USB DDK. Unless devices are 100 percent compliant with the class specification and are supported by Apple, developers need to write a class driver for their device.

In addition to writing a USB class driver, another important software component to consider creating is a software compatibility shim which makes it possible for existing processes, such as a Comm Tool box module (CTM) or Chooser printer device, to communicate with the USB device.

**Note**
Input Sprockets version 1.7 provides support for HID devices, such as joysticks, gamepads, steering wheels, and rudder pedals. Input Sprockets version 1.7 will be incorporated into future releases of the Mac OS software.

# Mac OS USB Driver Overview

USB class drivers provide the software interface between USB hardware and client processes that communicate with the hardware. As discussed in Chapter 3, “USB Software Components,” a Mac OS USB class driver is implemented as a shared library with a file type 'ndrv' and creator 'usbd'. In a similar fashion to PCI drivers, the driver CFM code fragment must export driver description structures to characterize the USB functionality the driver provides. All USB class drivers are recognized by the contents ot the `USBDriverDescription` structure, which is defined in, “USBDriverDescription Structure” (page 4-56). The use of the `USBDriverDescription` structure for Mac OS USB drivers is modeled after the `DriverDescription` structure discussed in “Designing PCI Cards Drivers for Power Macintosh Computers, Revised Edition.”

The Mac OS USB Manager handles the recognition of all connected USB devices, both at startup and when hot-plugged. As part of device recognition, Mac OS USB Manager assigns the unique USB address, and opens a control pipe to endpoint zero of the device. Mac OS USB Manager queries the device’s endpoint 0 for the device descriptor, which includes information such as vendor id, product id, device class, subclass, and protocol.

Upon receipt of the standard device descriptor information, the Mac OS USB Manager searches for all USB class drivers by looking at files of type 'ndrv' and creator 'usbd'. For each file, the USB Manager searches for all code fragments and for the exported symbol `USBDriverDescription` and subsequently at the first four bytes of the structure to match the `kUSBDriverDescriptionSignature`. This constant identifies the CFM code fragment as a USB class driver. Refer to the section "USBDriverDescription Sample" for more information and an example of the content of the `USBDriverDescription` structure.

**Note**
In version 1.0 through 1.1 of the Mac OS USB software only a single USB code fragment can exist in the driver file. Beginning with version 1.2 multiple driver CFMs within a driver file are supported. For more information about how to support multiple USB devices with similar characteristics, see "Major Features Introduced In Version 1.2" (page A-207).

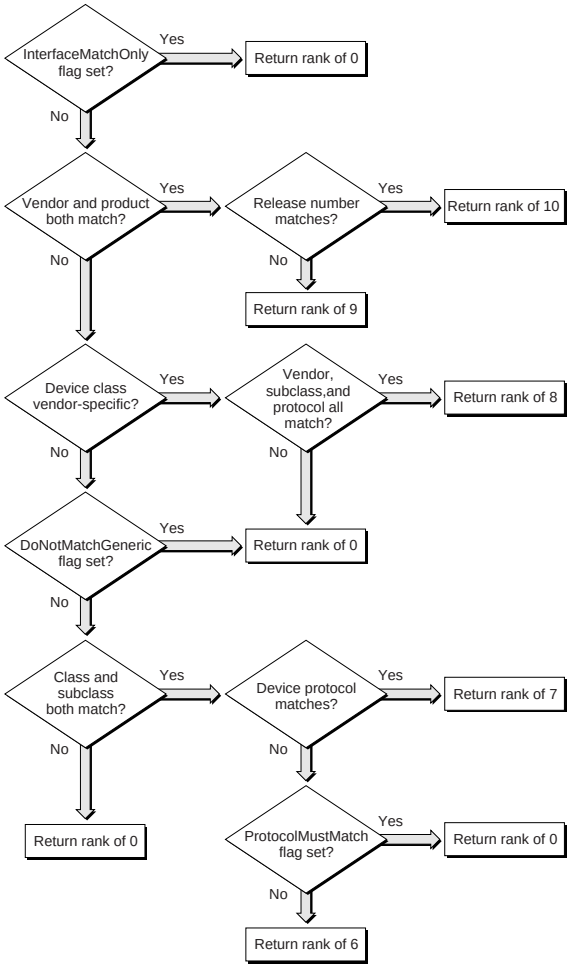
# USB Device and Driver Matching

Mac OS USB defines a match criteria to determine which class driver is selected to support a USB device. A match value is assigned to each USB driver. The following criteria determine the match value under Mac OS USB. The match criteria are listed from highest to lowest.

1. The vendor and product IDs match. A match of the `usbDeviceReleaseNumber` increases the match value.
2. The device class vendor specific, match of vendor ID, device subclass and protocol.
3. `kUSBDoNotMatchGenericDevice` bit clear in the `usbDriverLoadingOptions` field of driver description structure, match of device class, device subclass and device protocol.
4. `kUSBDoNotMatchGenericDevice` bit clear in the `usbDriverLoadingOptions` field of driver description structure, match of device class, device subclass and `kUSBProtocolMustMatch` bit clear in the `usbDriverLoadingOptions` field of driver.

Figure 4-1 provides a flow diagram that illustrates how the USB Manager assigns values to the driver matching criteria.

**Figure 4-1** Device driver matching algorithm




Typically a driver should set the `kUSBDoNotMatchGenericDevice` bit in the `usbDriverLoadingOptions` field of the `USBDriverDescription`, defined in

"USBDriverDescription Structure" (page 4-56), to indicate that it only supports vendor specific devices. This way the driver is not matched as a generic driver for a device that it may not actually support. If the bit is clear, then the driver indicates generic support for devices by device class and subclass. Unless you plan to write a class driver that supports all devices with a specific class and subclass, you should have your device return a device class of 0xFF (vendor specific) and set the `kUSBDoNotMatchGenericDevice` bit in the `usbDriverLoadingOptions` field of the `USBDriverDescription` structure.

Regardless of whether a match, or "best match" is found, the USB Manager registers the device in the Name Registry. Drivers that could potentially support the device are accessed in a high-to-low rank order through the driver's `USBClassDriverPluginDispatchTable`.

The driver's `USBClassDriverPluginDispatchTable` defines five functions that a Mac OS USB driver must support. The contents of the structure and functions are defined in the section "USBClassDriverPlugInDispatchTable Structure" (page 4-61). The functions in the `USBClassDriverPluginDispatchTable` are the driver entry points that the Mac OS USB uses to properly instantiate the appropriate driver for a USB device.

The USB Manager calls the `validateHWProc` to have the class driver verify that the driver supports the hardware. The `validateHWProc` routine can compare the vendor and device ID, or other fields of the device descriptor, to validate that it can support the device. If no error is returned, the `initializeDeviceProc` routine is called so that the class driver can establish communications with the device. Refer to the sections "ValidateHWProc Function" and "InitializeDeviceProc Function" below for more information on implementing these functions.

For USB devices that match to the composite class type (device class 0, subclass 0), the Apple USB composite class driver is loaded, which in turn selects from the available configurations. The composite class driver sets the appropriate configuration based on the power and or bandwidth available, and examines the interface descriptors by calling the `USBExpertInstallInterfaceDriver` function for each interface. The USB Manager uses the interface descriptor, class, subclass, and protocol, and rescans the USB class drivers for a match of the interface descriptor section of the driver descriptor. When a match (or best match) is found, the USB Manager loads the driver code fragment, and finds the `USBClassDriverPluginDispatchTable` for the matched driver. The `initializeInterfaceProc` function is called for the interface driver to initiate communication with the particular function in the device.

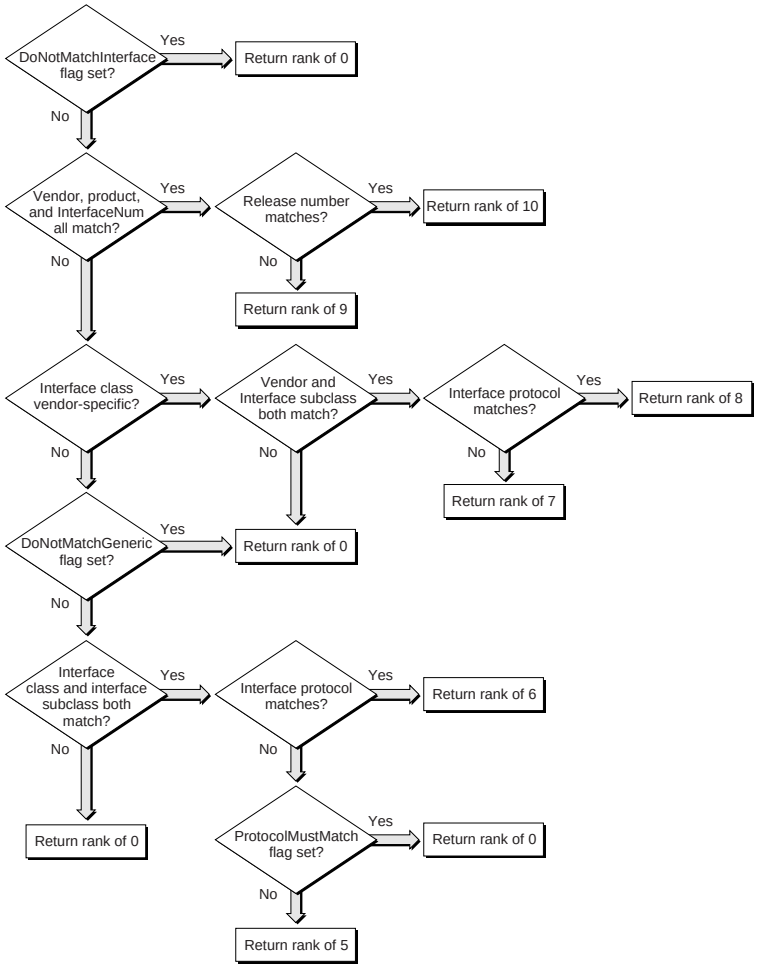
## Matching Interfaces to Interface Drivers

Similar to matching devices with drivers, Mac OS USB defines a match criteria to determine which class driver is selected to support a USB interface. A match value is assigned to each USB driver. The following criteria determine the match value under Mac OS USB v1.0. The criteria is listed in order of match value, 10 being the highest or best match.

1. vendor and product IDs match along with the configuration value and interface number. A match of the `usbDeviceReleaseNumber` increases the match value by 1.
2. interface class vendor specific, match of vendor ID and interface subclass. A match of the protocol increases the match value by 1.
3. `kUSBDoNotMatchGenericDevice` bit clear in the `usbDriverLoadingOptions` field of driver, match of interface class, interface subclass and interface protocol.
4. `kUSBDoNotMatchGenericDevice` bit clear in the `usbDriverLoadingOptions` field of driver, match of interface class, interface subclass,.and `kUSBProtocolMustMatch` bit clear in the `usbDriverLoadingOptions` field of driver.
5. `kUSBDoNotMatchInterface` bit set in the `usbDriverLoadingOptions` field of driver - don't match driver for interface.

Figure 4-2 provides a flow diagram that illustrates how the USB Manager assigns values to the driver matching criteria.

**Figure 4-2** Interface driver matching algorithm




Once the USB Manager has matched a class driver to the interface, the driver's `initializeInterfaceProc` function pointed to from the driver dispatch table is called. The `initializeInterfaceProc` function is used by the class driver to prepare itself to communicate with the interface. When interface class drivers are loaded, the `validateHWProc` is not called. However, a driver can return an error from the `initializeInterfaceProc` and the next best matching driver will

be loaded. As with device matching, you want to specify matching to interfaces by the vendor, product ID, and interface number, or by setting the interface class to 0xFF (vendor specific), and setting the `kUSBDoNotMatchGenericDevice` bit in the `usbDriverLoadingOptions` field to indicate that the driver does not support a class and subclass interface generically.

When a device has been disconnected from the bus, the driver's `notificationProc` function is called, and when it returns `noErr`, the driver's `finalizeProc` function is called by the USB Manager. The `finalizeProc` function is called at task time so that a class driver can clean up memory allocations, and perform other operations associated with the driver or interface no longer being present. The `finalizeProc` must be synchronous. That is, when the driver returns `kUSBNoErr`, the Mac OS USB software assumes that there is no further need to keep the driver code fragment around, and unloads it from memory.

## Matching Class Drivers to Composite Devices

For composite class USB devices, the Mac OS USB software implements class driver matching differently in the following two cases

- when the device is connected at startup, and
- when the device is "hot plugged"

The following explanation of composite class device and driver matching applies to USB v1.0.1 and earlier. At system startup, the Mac OS USB software cannot access file based drivers. To support boot devices, such as the keyboard and mouse, which are USB composite HID class devices, the Mac OS USB software uses the generic composite class driver in the Mac OS ROM file (in iMac and later computers). If a device is identified as a composite device, and it is attached to the USB bus at startup, then the generic composite class driver is matched to that device. This happens even though there may be a file based driver which is a better match for your device. Once the driver is matched, USB v1.0.1 does not check for a better match when the file system becomes available.

If the composite device is hot plugged later, then the USB software can find a better matching disk-based driver, if one exists.

Mac OS USB software v1.1 and later look for a better match disk-based driver when the file system becomes available.

The generic composite class driver sets the configuration for the composite class device to the first configuration it finds. The generic composite class driver only

checks that the configuration's power requirement is within the available power limits of the hub to which the device is connected.

### Device Driver and Interface Driver Matching Differences

The implementation of a Mac OS USB class driver is such that drivers may be loaded as either device drivers or interface drivers. The primary difference between device and interface driver loading is that the device driver code must issue a `SetConfiguration` call (a `USBDeviceRequest` call with the `usbBRequest` field set to `kUSBRqSetConfig`) to define which configuration is active. In contrast, the interface driver can not set a configuration. Both device and interface drivers identify the interfaces present, find one to activate, open the pipes in the desired interface, and handle the I/O on the pipes within the interface.

Typically, the class driver is loaded as an interface driver if the device is detected as a composite class device and the Apple USB composite driver is loaded. The Apple USB composite class driver detects the available configurations and makes the `USBExpertInstallInterfaceDriver` call to the USB Manager, which results in the appropriate class driver being loaded and initialized as specified in the driver's `initializeInterfaceProc`, defined in "USBClassDriverPlugInDispatchTable Structure" (page 4-61).

## Core Mac OS USB Driver Data Exports

This section defines the contents of the `USBDriverDescription` and the `USBClassDriverDispatchTable` structures. The two structures described here are the symbols that a Mac OS USB driver must export to communicate with the Mac OS USB software and in turn the USB device and/or interface the class driver module supports.

### USBDriverDescription Structure

The `USBDriverDescription` is a required exported symbol that the USB Manager uses to first identify USB class drivers, and second, to identify whether a driver supports a specific USB device. The structure of the `USBDriverDescription` structure is as follows:

```
struct USBDriverDescription
{
    OSType                  usbDriverDescSignature;     /* Signature field of */
                                                        /* this structure. */
    USBDriverDescVersion    usbDriverDescVersion;       /* Version of this */
                                                        /* data structure */
    USBDeviceInfo           usbDeviceInfo;              /* Product & Vendor Info */
    USBInterfaceInfo        usbInterfaceInfo;           /* Interface info */
    USBDriverType           usbDriverType;              /* Driver Info */
    USBDriverLoadingOptions usbDriverLoadingOptions;    /* Options for class */
                                                        /* driver loading.  */
};
typedef struct USBDriverDescription USBDriverDescription;
```

#### Field descriptions

`usbDriverDescSignature`

Set to `kTheUSBDriverDescriptionSignature` to indicate that the CFM library is a USB class driver.

`usbDriverDescVersion`

The structure version field. As of the initial release, this field should be set to `kInitialUSBDriverDescriptor`. For future releases of Mac OS USB, you may need to set this field to indicate support for new functionality.

The remaining fields of the driver description record are used to match the class driver to a device or interface. For most of the fields, a value of zero indicates that the field is not to be used to match the class driver to a device. For other fields such as the `usbDeviceClass` and `usbInterfaceClass`, a device and interface specific value must be entered.

`USBDeviceInfo`

The `usbVendorID` and `usbProductID` in the `USBDeviceInfo` structure are used to match a class driver to support both device drivers and interfaces. As indicated above for device and interface matching, the highest match value is generated when the VendorID and ProductID match along with the configuration value.

The `USBDeviceInfo` structure is defined as follows:

```
struct  USBDeviceInfo {
    UInt16  usbVendorID;                /* USB Vendor ID */
    UInt16  usbProductID;               /* USB Product ID */
```

```
    UInt16  usbDeviceReleaseNumber;     /* Release Number of Device */
    UInt16  usbDeviceProtocol;          /* Protocol Info. */
};
```

For the `USBDeviceInfo` fields, `VendorID` and `ProductID`, enter the values that correspond to the device that the class driver will support. For the `DeviceReleaseNumber` field, enter a BCD value for the device version. For the `usbDeviceProtocol` field, enter the protocol value assigned by the USB specification for your device. A value of 0 indicates that no device specific protocol is used and is a valid setting for the device. A value of 0xFF indicates that a vendor specific protocol is used. A match of the `VendorID` and the `ProductID` is the highest possible match.

`USBInterfaceInfo` The information presented in the `USBInterfaceInfo` structure is used to match a class driver to support a device interface. When a device is detected as a composite class device, the composite class driver is loaded and will try to match class a class driver for each interface. For interface matching, the second highest match value is generated when the interface class is vendor specific AND the vendorID and interface subclass match. In case of duplicate matches, matching the interface protocol field for a driver raises its match level.

The `kUSBDoNotMatchInterface` bit must be clear in the `USBDriverLoadingOptions` field in order for the class driver to be checked to see if it can support an interface. For an interface match, the interface number must also match.

A class driver can support an interface class generically by not setting the `kUSBDoNotMatchGenericDevice` bit in the `USBDriverLoadingOptions` field. When this bit is clear, USB checks the class driver's support for the interface class, subclass and protocol against that for the device. When all three values match, the third highest match level is set for the driver. If the class and subclass match and the `kUSBProtocolMustMatch` bit is clear, then the fourth highest match level is set for the driver.

The `USBInterfaceInfo` structure is defined as follows:

```
struct USBInterfaceInfo {
UInt8 usbConfigValue;           /* Configuration Value */
UInt8 usbInterfaceNum;          /* Interface Number */
UInt8 usbInterfaceClass;        /* Interface Class */
UInt8 usbInterfaceSubClass;     /* Interface SubClass */
UInt8 usbInterfaceProtocol;     /* Interface Protocol */
};
```

`USBDriverType` The information provided in the `USBDriverType` structure is used to match a class driver to support a device. For device matching, the second highest match level occurs when the device class is vendor specific, 0xFF, and the `vendorID` in the `USBDeviceInfo` field, the device subclass and protocol fields all match.

A class driver can support a device class generically by not setting the `kUSBDoNotMatchGenericDevice` bit in the `USBDriverLoadingOptions` field. When this bit is clear, USB checks the class driver's support for the device class, subclass and protocol against that for the device. When all three values match, the third highest match level is set for the driver. If the class and subclass match and the `kUSBProtocolMustMatch` bit is clear, then the fourth highest match level is set for the driver.

The `USBDriverType` structure is defined as follows:

```
struct USBDriverType {
    Str31       nameInfoStr;        /* Driver's name when loading */
                                    /* into the Name Registry */
    UInt8       usbDriverClass;     /* USB Class this driver */
                                    /* belongs to */
    UInt8       usbDriverSubClass;  /* Module type */
    NumVersion  usbDriverVersion;   /* Class driver version number */
};
```

The `nameInfoStr` field, is used by the USB Expert to record debugging information. The field is a Pascal string with the string length in byte 0. The `usbDriverClass` and `usbDriverSubClass` fields are used as described above to match a class driver generically to a device. Starting with version 1.2 of the Mac OS USB software, the `usbDriverVersion` field will be used to distinguish class drivers.

`USBDriverLoadingOptions`

The `USBDriverLoadingOptions` field is used to control whether a class driver will support generic devices, interfaces, and other matching options. As of the v1.0 release, the following options are defined.

`kUSBDoNotMatchGenericDevice = 0x00000001`

The `kUSBDoNotMatchGenericDevice` bit indicates whether the class driver supports or does not support all devices or interfaces. When set, the class driver can only support a device with a matching `vendorID` as specified in the `USBDeviceInfo` structure. If this bit setting is clear, then the class driver module can support a device generically as specified in the section "USB Device and Driver Matching" (page 4-50).

`kUSBDoNotMatchInterface = 0x00000002`

The `kUSBDoNotMatchInterface` bit indicates whether the class driver supports USB interfaces. When set, the Mac OS USB software does not consider the driver for support of an interface. If this bit setting is clear, then the class driver module indicates that it can support an interface as defined in the settings of the `USBInterfaceInfo` structure.

`kUSBProtocolMustMatch = 0x00000004`

The `kUSBProtocolMustMatch` bit indicates whether a generic class driver can match when the class and subclass values match, but the protocol does not match. Set this bit in to require that USB match the protocol field, in addition to the class and subclass values during driver matching. Otherwise, leave this bit clear and a match value is generated when the class and subclass match.

The following example of a `USBDriverDescriptor` structure is for a vendor specific device.

```
USBDriverDescription TheUSBDriverDescription = {
    // Signature info
kTheUSBDriverDescriptionSignature,  // specifies USB Class Device Driver
kInitialUSBDriverDescriptor,        // specifies the USB Class Driver version

    // Device Info
kMyVendorID,                        // vendor, 0 = unspecified
```

```
kMyProductID,                       // product, 0 = unspecified
0,                                  // version of product, 0 = unspecified
0,                                  // protocol, 0 = not device specific

    // Interface Info
0,                              // Configuration Value, 0 = unspecified
0,                              // Interface Number, 0 - interface 0
kUSBVendor_Specific,            // Interface Class, 0x03 - HID Interface
0,                              // Interface SubClass
0,                              // Interface Protocol

    // Driver Info
"\pUSBCustomDriver",            // Driver name for Name Registry
kUSBVendor_Specific,            // Device Class, 0x03 HID Interface class
0,                              // Device Subclass
kMyHexMajorVers,
kMyHexMinorVers,
kMyCurrentRelease,
kMyReleaseStage,                // version of driver

    // Driver Loading Info
kUSBDoNotMatchGeneric           // Flags 2 = don't care if protocol matches
                                        will not match a generic device and interface
                                        will match to an interface
```

## USBClassDriverPlugInDispatchTable Structure

The `USBClassDriverPluginDispatchTable` is the second exported symbol that the CFM class driver module must export. The Mac OS USB software looks for this symbol in order to initialize the class driver module. The dispatch table structure contains pointers to functions that your driver must support to operate properly in the Mac OS USB environment.

Typically, class drivers may require additional exports to facilitate communication with a shim of other Mac OS service.

The structure of `USBClassDriverPluginDispatchTable` for class drivers is as follows:

```
struct USBClassDriverPluginDispatchTable {
    UInt32                          pluginVersion;
    USBDValidateHWProcPtr           validateHWProc;         /* Proc for driver to */
```

```
                                                    /* verify proper HW */
    USBDInitializeDeviceProcPtr     initializeDeviceProc;   /* Proc that initializes */
                                                    /* the class driver */
    USBDInitializeInterfaceProcPtr  initializeInterfaceProc;    /* Proc that */
                                                /* initializes particular */
                                                /* interface in the */
                                                /* class driver */
    USBDFinalizeProcPtr             finalizeProc;       /* Proc that finalizes */
                                                /* the class driver */
    USBDDriverNotifyProcPtr         notificationProc;   /* Proc to pass */
                                                /* notifications to */
                                                /* the driver */
};
```

You must initialize the `pluginVersion` field to `kClassDriverPluginVersion` defined in the header file USB.h. The USB Manager uses this field to distinguish between future versions of the dispatch table.

The following fields of the dispatch table are required when the device is initialized

- `validateHWProc`
- `intializeDeviceProc`
- `finalizeProc`

If any of these fields are nil, then the `kUSBBadDispatchTable` error is returned to the USB Family Expert, and the driver load fails. Each of these calls will be made at task time, and each is made synchronously.

You are advised to install a `notificationProc`, so that you can handle a "hot unplug" situation. However, if this field is nil, the device driver load still continues.

If your class driver can be used to communicate with a specific interface portion of a composite device, the following fields of the dispatch table are required.

- `initializeInterfaceProc`
- `finalizeProc`

If either of these fields are nil, then the `kUSBBadDispatchTable` error is returned, and the interface load fails. Each of these calls are made at task time, and each is made synchronously.

As above, you are advised to install a notificationProc, so that you can handle a "hot unplug" situation. However, if this field is nil, the interface driver load still continues.

The contents of the fields in the USBClassDriverPluginDispatchTable are defined in the following sections.

## ValidateHWProc Function

The validateHWProc function is called for a USB class driver to validate that the device is supported by the selected driver. The prototype for the validateHWProc is

```
OSStatus USBDValidateHWProcPtr(
                    USBDeviceRef device,
                    USBDeviceDescriptorPtr pDesc);
```

The USB Manager finds the best matching class driver for a device, then calls the USBValidateHWProcProcPtr to provide the class driver with a chance to check the device descriptor itself to verify that the device is supported. This procedure call is made at system task time, and is issued synchronously. The class driver may want to verify that a certain minimum device hardware version exists, or lock out support for specific incompatible products or versions.

The driver returns a kUSBNoErr OSStatus result, if the class driver supports the hardware, or a value other than kUSBNoErr to indicate that the driver does not support the hardware. The validateHWProc should be used solely to validate the support for a specific hardware device. It should not be used to set up the driver connection. To set up the driver connection use the initializeDeviceProc function, which is discussed next.

## InitializeDeviceProc Function

The Mac OS USB software calls the initializeDeviceProc function to tell the class driver to prepare for communications with the USB device. The prototype for the initializeDeviceProc function is

```
OSStatus USBDInitializeDeviceProcPtr(
                    USBDeviceRef device,
                    USBDeviceDescriptorPtr pDesc,
                    UInt32 busPowerAvailable);
```

The initializeDeviceProc function is called at system task time. The class driver may wish to allocate memory, set up resources (see "Compatibility With Mac OS Toolbox" section below), and initiate the necessary sequence of USB calls to configure the device. This includes identifying the available configurations, specifying the configuration and interface to be used, opening endpoints and pipes, specifying the protocol to be used, installing an interrupt routine, and related actions.

The description that follows applies for cases when the class driver is called through either the initializeDeviceProc or the initializeInterfaceProc function. Both of these functions are called synchronously and at system task time. If either the initializeDeviceProc or initializeInterfaceProc functions return anything other than kUSBNoErr, the driver will not be loaded, and the USB Manager will attempt to load the next-best matching driver. Before returning from the function, the driver must complete any calls that must be made at task time. After doing so, the driver should initiate an asynchronous “state machine process” to complete the connection. This can include memory allocation, assuming that the USBAllocMem call is made. Once the asynchronous state machine process is begun, the driver can return from the initializeDeviceProc function call.

As a reminder, most USB calls are asynchronous. As stated in “Polling Versus Asynchronous Completion (Important)” (page 5-93), a USB driver can NOT poll for completion of these asynchronous USB calls by simply checking the usbStatus field without using a completion routine.

All of the USB example class drivers found in the Mac OS USB DDK implement an asynchronous state machine startup process. In the driver examples, the last thing that the initializeDeviceProc or initializeInterfaceProc code does before returning to the caller, is to make an initiateTransaction call. The initiateTransaction call uses the usbRefCon field in the USB parameter block, defined in “The USBPB Parameter Block” (page 5-83), as a selector into a switch statement. After the first call to initiateTransaction is initiated, control returns to the caller. As the asynchronous call completes, the completion routine checks the call results, modifies the usbRefCon field appropriately and issues a call to the initiateTransaction function. The initiateTransaction function checks the usbRefCon field and issues a new asynchronous call to handle the next step in the state machine. This continues until all of the processing is complete.

## InitializeInterfaceProc Function

The Mac OS USB software calls the `initializeInterfaceProc` function to tell the class driver to prepare for communications with the USB interface. The prototype for the `initializeInterfaceProc` function is

```
OSStatus USBDInitializeInterfaceProcPtr(
                    UInt32 interfaceNum,
                    USBInterfaceDescriptorPtr pInterface,
                    USBDeviceDescriptorPtr pDevice,
                    USBInterfaceRef interfaceRef);
```

A composite USB device generally results in the load of the composite class driver. The composite class driver obtains information about the first configuration, verifies that the bus power required for the device is supported by the hub, then sets the configuration. A new interface reference is created for each interface in the selected configuration, and the USB Manager attempts to find and load a driver for that interface. The interface matching process is described in “USB Device and Driver Matching” (page 4-50).

The `initializeInterfaceProc` function is called synchronously at system task time. If the `initializeInterfaceProc` function returns anything other than `kUSBNoErr`, the driver is not loaded, and the USB Manager attempts to load the next-best matching driver. The class driver may wish to allocate memory, set up resources (see “Mac OS USB Compatibility With Mac OS Toolbox Calls”), and initiate the necessary sequence of USB calls to configure the interface. This will include specifying the interface to be used, opening endpoints and pipes, specifying the protocol to be used, installing an interrupt routine, and related actions.

Before returning from the function, the driver must complete any calls that must be made at task time. After doing so, the driver should initiate an asynchronous “state machine process” to complete the connection. This can include memory allocation, assuming that the `USBAllocMem` call is made. Once the asynchronous state machine process is begun, the driver can return from the `initializeInterfaceProc` function call.

All of the USB example class drivers found in the Mac OS USB DDK implement an asynchronous state machine startup process. In the examples, the last thing that the `initializeInterfaceProc` code does before returning to the caller, is to make an `InitiateTransaction` call. The `initiateTransaction` call uses the `usbRefCon` field as a selector into a switch statement. After the first call to `initiateTransaction` is initiated, control returns to the caller. As the

asynchronous call completes, the completion routine checks the call results, modifies the `usbRefCon` field appropriately and issues a call to the `initiateTransaction` function. The `initiateTransaction` function checks the `usbRefCon` field and issues a new asynchronous call to handle the next step in the state machine. This continues until all of the processing is complete.

## Driver notificationProc Function

The driver `notificatioProc` function receives device notification messages from the Mac OS USB software. The prototype for the `notificatioProc` function is

```
OSStatus USBDDriverNotifyProcPtr(
                    USBDriverNotification notification,
                    void *pointer,
                    UInt32 refcon);
```

The Mac OS USB software calls the driver's `notificationProc` function with a message when something the driver needs to be aware of is happening. There are many messages passed both internally to the USB software and to drivers to communicate what is happening on the USB. The notification messages that are of importance to class drivers are:

```
kNotifySystemSleepRequest = 0x00000001,
kNotifySystemSleepDemand = 0x00000002,
kNotifySystemSleepRevoke = 0x00000003
kNotifyHubEnumQuery = 0x00000006,
kNotifyChildMessage = 0x00000007,
kNotifyExpertTerminating = 0x00000008,
kNotifyDriverBeingRemoved = 0x0000000B
```

The sleep notification messages `kNotifySystemSleepRequest` and `kNotifySystemSleepDemand` are the same on any power-managed system. On PowerBook models, the processor and I/O subsystems are turned off when the machine goes to sleep. Because the USB is part of the I/O subsystem on PowerBooks with built-in USB or USB on a PC Card, the sleep state does effect USB drivers. Desktop Macintosh computers do not see these messages, since the processor and network I/O subsystems on desktop models remain active during system sleep.

When a PowerBook computer with Mac OS USB software version 1.2 or later goes to sleep, the USB Manager sends any active USB drivers the `kNotifySystemSleepDemand` message and then unloads the driver just like a

disconnect (hot unplug). When the PowerBook wakes up, the USB software re-enumerates the USB and appropriate drivers are loaded for any USB devices found on the bus.

### FinalizeProc Function

The Mac OS USB software calls the `finalizeProc` function just before unloading the driver. This function is not called if any of the validate or initialize procs have retuned an error. The prototype for the `finalizeProc` function is

```
OSStatus USBDFinalizeProcPtr(
                    USBDeviceRef device,
                    USBDeviceDescriptorPtr pDesc);
```

A `kNotifyDriverBeingRemoved` notification is sent prior to the `finalizeProc` actually being called. When this notification is received by the driver's `notificationProc` function, it is the last chance a driver has to run any cleanup or user notification code before being unloaded.

The `finalizeProc` function is called at system task time and is called synchronously. When the `finalizeProc` function returns, the class driver may be unloaded from memory. A crash can occur if the `finalizeProc` function is called while the driver has USB calls pending completion. The crash occurs because immediately after returning from the `finalizeProc` function, the class driver is unloaded from memory and any outstanding completion procs may become invalid. To protect against this problem and get additional details about the use of the `notificationProc` function, refer to the section on "Handling Hot Unplugging, Dealing With Notifications"

## Handling Hot Unplugging, Dealing With Notifications

A class driver module must be designed to handle a "hot unplug" situation, in which the client process still has the class driver open. When the Mac OS USB software detects that a device has been unplugged, but before the driver `finalizeProc` is called, the Mac OS USB software calls at system task time, the `notificationProc` that was registered in the driver's `USBClassDriverPluginDispatchTable`. The `notificationProc` is sent the `kNotifyDriverBeingRemoved` message. If the driver still has a client connection to maintain, then it can return the `kUSBDeviceBusy` result. By returning the

kUSBDeviceBusy result, the Mac OS USB software holds off calling the driver's finalizeProc function. The Mac OS USB software then periodically calls the notificationProc with the kNotifyDriverBeingRemoved message until the kUSBNoErr result is returned. Once the kUSBNoErr returns, the driver's finalizeProc is called, after which the driver code fragment is unloaded from memory.

Using the mechanism described above provides a means to protect your driver from being unloaded after the device has been removed by a hot unplug. By continuing to return the kUSBDeviceBusy result, you can hold off execution of the finalizeProc. Note that any calls into the USL to your device, will fail.

This raises the issue as to what happens to pending calls, when the device is unplugged. These calls may complete with error kUSBNotRespondingError, or they may be aborted by the pipe closure process with error kUSBAbortedError. Note that the class driver should never retry an unexpected kUSBAbortedError in the completion routine. The order of these errors or notifications is not guaranteed. They may occur after the notificationProc function is called with the kNotifyDriverBeingRemoved notification message. If this event occurs, then make the USBAbortPipeByReference function call for each pipe with active transactions. The notificationProc must wait until all of the transactions have completed, before returning kUSBNoErr in response to the KNotifyDriverBeingRemoved message. If the kUSBNoErr response is returned with pending transactions incomplete, then the driver's finalizeProc will be called, the class driver will be unloaded, and the system crashes when the completion routine for the transaction finally completes (for example, with a kUSBAbortedError status) at some point later on.

# Communicating With Client Processes

To this point, the discussion in this chapter has been about how a Mac OS USB driver communicates with a USB device. Ultimately, there must be communication that takes place between the USB class driver and the Mac OS applications and processes. While there are specific guidelines for how USB drivers and devices communicate with each other, there is no official API for how client processes communicate with USB drivers. This section discusses different strategies for facilitating these communications.

## The Disappearing Driver

The USB class driver is designed to be loaded and present to support an attached USB device. When the device is detached, the class driver is unloaded from memory. This makes the USB class driver model unsuitable for client processes that are not prepared to deal with a disappearing driver.

## Common Ground and The Compatibility Shim

For most device I/O, a device driver is implemented to present a standard I/O API to client processes. For serial communications and disk storage devices, this may mean that a DRVR/NDRV style resource is loaded into memory with a corresponding unit entry in the device table. Keyboards, mice, and graphics tablets typically register a driver with the Cursor Device Manager. A digital camera implements a video digitizer (also known as a vdig). A printer requires a print chooser device. The key thing to understand is how existing non-USB devices, which are similar to your USB device, currently communicate with Mac OS clients. Once you understand how the non-USB device model works, you then develop a similar type of device driver, one that presents a familiar API to the client process, but also knows how to communicate with the USB class driver. For purposes of this discussion, this modified driver will be called a *compatibility shim*.

## Where To Implement a Compatibility Shim

It's important to understand that the compatibility shim cannot be implemented within the class driver. As mentioned previously, if a device is unplugged suddenly, the class driver is called via it's `finalizeProc` function. Upon completion of the `finalizeProc`, the shared library driver code may be unloaded from memory. If the compatibility shim is included in the class driver, then the shim code also disappears.

In addition, with Mac OS X, it's important to isolate those portions of code that will require change. This is especially true of the compatibility shim, which may require an API under the current OS that may not be supported in the future. For this reason, Apple advises that you not implement the compatibility shim within your class driver code.

## Designing A Compatibility Shim

In considering the design of a compatibility shim, you should be familiar with the method by which application processes communicate with similar non-USB devices. In many cases, the compatibility shim should be thought of as a resident process that client processes can easily find. When the client process opens the compatibility shim, the shim determines whether the USB device is attached and initiates communications with the class driver. The class driver knows about making calls to the USB device. The compatibility shim knows about communicating with the Mac OS services.

**Note**
If you are designing a DRVR style driver, you may find the TradDriverLoadLibrary code invaluable. This code is available on the Developer CD, Tool Chest volume. The Developer CD also includes a RAMDisk sample that demonstrates an implementation of a working DRVR resource.

At some point, the compatibility shim finds the class driver, and implements communications between the class driver, the Mac OS, and finally the user. A discussion of the means by which the compatibility shim code can detect the presence of the class driver is provided in “Detecting USB Device Presence” (page 4-73).

One method for facilitating communication between the Mac OS and the device is for the class driver to export a dispatch table. The `USBClassDriverPluginDispatchTable` is an example of this mechanism. The USB Manager imports the `USBClassDriverPluginDispatchTable` and calls the functions defined in the dispatch table as necessary. Your class driver could define such a dispatch table and export the dispatch table symbol. The compatibility shim, would use the `FindSym` call to obtain the address of the dispatch table, then make calls to the functions that are defined in the dispatch table as appropriate.

For some USB devices, there is no standard mechanism for communications with client processes. It is possible for an application to do exactly what the compatibility shim does. If an application does communicate directly with the USB class driver, an important consideration concerns the hot-unplug situation. The application must be ready to handle this situation, just as the compatibility shim must be designed to do so also. The application should also provide support for multiple devices and dynamically allow them to be used without requiring the user to quit and relaunch the application.

## Helpful Resources For Compatibility Shim Development

This section points you to sample code which you will find helpful in designing compatibility shim code.

For many compatibility shims, a 68K DRVR code resource may prove useful to implement. While this is legacy code and will not be supported under Mac OS X, it is the required mechanism for device Input/Output for many client processes.

For a USB Communications Class devices, the compatibility shim must provide a 68K driver and also register the DRVR with the Communications Toolbox (CRM) Comm Resource Manager. This allows the USB Communications device to be recognized by all CRM aware applications. For more information on the 68K DRVR mechanism, refer to Inside Macintosh: Devices. A description of the standard process by which Mac OS applications find and open serial devices, is presented in Tech Note 1119, Serial Port Apocrypha.

For a sample of implementing a 68K 'DRVR' code resource, there is the RAMDisk v1.45 code sample. This sample is also useful in demonstrating how to set up a Metrowerks CodeWarrior project to create a DRVR code resource. The sample code demonstrates the use of the TradDriverLoaderLib code that facilitates the installation of all DRVR code resources into the Device Manager Device Unit Table.

For Video Input Devices, such as a USB camera, the standard mechanism for processing data from hardware, is the Video Digitizer. You can learn more Video Digitizers in Inside Macintosh: QuickTime Components, available from the QuickTime Developer Documentation Web Page.

For Networking Devices, such as an Ethernet/USB convertor, an Open Transport DLPI Driver must be implemented. As sample Loopback DLPI driver is provided as part of the Open Transport SDK. You can obtain the latest Open Transport SDK from the Apple Developer Open Transport Web Page.

For Print class devices, a compatibility shim would provide a Chooser Printer Driver. An example Chooser Printer Driver is provided with the USB DDK, in the Examples folder.

## TheHIDModuleDispatchTable Structure

This section provides an example of how a cursor device shim and an ADB shim communicate with a class driver.

A HID (Human Interface Device) module, is required to implement and export an additional dispatch table in order to work under the Mac OS. Samples of the use of this structure, are presented in the source code for the Mouse Module and for the Keyboard Module. The source code for these modules is presented in the Examples folder of the USB DDK. The dispatch table is the `TheHIDModuleDispatchTable` and is defined as follows:

```
struct TheHIDModuleDispatchTable {
    UInt32                          hidDispatchVersion;
    USBHIDInstallInterruptProcPtr   pUSBHIDInstallInterrupt;
    USBHIDPollDeviceProcPtr         pUSBHIDPollDevice;
    USBHIDControlDeviceProcPtr      pUSBHIDControlDevice;
    USBHIDGetDeviceInfoProcPtr      pUSBHIDGetDeviceInfo;
    USBHIDEnterPolledModeProcPtr    pUSBHIDEnterPolledMode;
    USBHIDExitPolledModeProcPtr     pUSBHIDExitPolledMode;
};
```

The `USBHIDInstallInterruptProcPtr` is used to install the interrupt routine that is called to process incoming data. The prototype for this function is defined as follows:

```
OSStatus USBHIDInstallInterruptProcPtr(
                    HIDInterruptProcPtr HIDInterruptFunction,
                    UInt32 refcon);
```

When the class driver is called via this dispatch proc pointer, the class driver must save the `HIDInterruptProcPtr` and the refcon. When incoming data has been received, call the registered `HIDInterruptProcPtr` passing the saved refcon value as the first parameter, and the appropriate data structure pointer, as the second parameter. For keyboard devices, this is the `USBKeyboardData` structure. For mouse devices, this is the `USBMouseData` structure. The prototype for the `HIDInterruptProcPtr` function is defined as follows

```
void HIDInterruptProcPtr(UInt32 refcon, void *theData);
```

The `USBHIDPollDeviceProcPtr` is used to ?????

The USBHIDControlDeviceProcPtr is used to have the device perform device specific functions. The prototype for this function is defined as follows:

```
OSStatus USBHIDControlDeviceProcPtr(
                    UInt32 theControlSelector,
                    void *theControlData);
```

The selector values which can be passed depend on the type of device. For mouse type HID devices, the selector values that can be expected are as follows

kHIDRemoveInterruptHandler - clear out the ShimInterruptHandler, as well as the associated refcon and save interrupt handler

kHIDEnableDemoMode - save the current interrupt handler, set up a Cursor Device Manager device, and install a data processing routine similar to the USBMouseIn routine from the file HIDEmulation.c from the Mouse Module example class driver. Refer to the USB DDK for this example.

kHIDDisableDemoMode - this call is made following a control call to kHIDEnableDemoMode. Dispose of the current Cursor Device Manager structure and replace the interrupt handler with the saved interrupt handler.

For keyboard type HID devices, the selector values that can be expected are as follows:

kHIDSetLEDStateByBits - command issued to device to set state of the keyboard LEDs. Refer to the KBDHIDEmulation.c file in the DDK for code that shows how this call should be handled.

kHIDRemoveInterruptHandler - clear out the current interrupt handler along with the refcon and any saved interrupt handler information.

kHIDEnableDemoMode - save the current interrupt routine and replace it with a version like the USBDemoKeyIn code. This routine is

The USBHIDGetDeviceInfoProcPtr is used to (to be completed later)

The USBHIDEnterPolledModeProcPtr is used to (to be completed later)

The USBHIDExitPolledModeProcPtr is used to (to be completed later)

# Detecting USB Device Presence

There are two different means for finding a USB device.

- Use the `USBGetNextDeviceByClass` call to check for the immediate presence of a device and locate its class driver.
- Use the `USBInstallDeviceNotification` mechanism to be alerted when a device or interface is added or removed.

Use the `USBGetNextDeviceByClass` call to determine the presence of a device. This call returns the `CFragConnectionID` associated with the class driver. Use the `CfragConnectionID` with the `FindSym` call to obtain the address of an exported symbol, for example the address to a procptr dispatch table. When making the `USBGetNextDeviceByClass`, you will want to set the input `USBDeviceRef` parameter to `kNoDeviceRef` so that it will find the first instance of a device. Leave the `usbDeviceRef` value set to the last found device to find all devices of this device.

Listing 4-1 is an example of using the `USBGetNextDeviceByClass` function to look for a keyboard device. If the keyboard is found, the sample looks for the `TheHIDModuleDispatchTable` export symbol, which all HID class drivers are required to export. See "TheHIDModuleDispatchTable Structure" for additional information about the contents of the `TheHIDModuleDispatchTable`.

**Listing 4-1** Detecting a keyboard device

```
UInt16  deviceClass = 0x0003;
UInt16  deviceSubClass = 0x0001;
UInt16  keyboardDeviceProtocol = 0x0001;

CFragConnectionID   keyboardConnID = kUSBNoDeviceRef;
CFragSymbolClass    symClass;
THz         currentZone;
currentZone = GetZone ();
SetZone (SystemZone ());    /* Class drivers are always loaded in */
                            /* the System Zone */

while (USBGetNextDeviceByClass(&keyboardConnID, deviceClass,
                        deviceSubClass, keyboardDeviceProtocol))
{
    status = FindSymbol (keyboardConnID, "\pTheHIDModuleDispatchTable",
                        (Ptr *)&pTheKeyboardDispatchTable, &symClass);
}
SetZone (currentZone);
```

The significance of the sample in Listing 4-1, is that it demonstrates a way for the compatibility shim code to find a procedure pointer table defined by the class driver. This mechanism also demonstrates a limitation for writing universal handlers in that all other devices of the same type would need to implement the exact same procedure pointer tables and functionality.

For compatibility shims that need to handle hot plug-in device connections, there is a mechanism for notification of `AddDevice`, `AddInterface`, `RemoveDevice`, and `RemoveInterface` events. Use the `USBInstallDeviceNotification` function to install a notification handler.

The sample code in Listing 4-2 demonstrates the use of the `USBInstallDeviceNotification` call. Note that the sample is designed to have the notification routine called whenever any USB device is plugged in or unplugged from the USB chain.

**Listing 4-2** Using the `USBInstallDeviceNotification` function

```
pb.usbDeviceNotification = -1;          // tell me about everything
pb.usbClass = kUSBHIDInterfaceClass;    // want to know about HID class devices
pb.usbSubClass = kUSBAnySubClass;       // tell me about all sublclass devices
pb.usbProtocol = -1;                    // don't care about the protocol used by device
pb.usbVendor = -1;                      // allow any vendors keyboard notification
pb.usbProduct = -1;                     // allow any product ID notification
pb.result = noErr;
pb.callback = (USBDeviceNotificationCallbackProcPtr)&myNotificationCallback;
pb.refcon = nil;

USBInstallDeviceNotification (&pb);
```

For the notification sample described above, the notification proc might be as shown below.

```
OSStatus ShimOpenDriver(USBDeviceRef theDevRef)
{
    OSStatus            theErr = 0;
    CFragSymbolClass    symClass;
    CFragConnectionID   connID;
    THz                 currentZone;
```

```
    theDevRef = 0;
    currentZone = GetZone();    // save the current zone setting to restore to later
    SetZone (SystemZone ());    // set the current zone to the system zone
                                // look for the desired device
    theErr = USBGetNextDeviceByClass(&theDevRef, &connID,
                                        kUSBInterestingClass, 0, 0);
    SetZone (currentZone);      // restore the zone

    if (theErr == noErr)
    {
        SetZone(SystemZone());          // set the current zone to the system zone
                                        // find the desired exported symbol
        theErr = FindSymbol(connID, "\pTheModuleDispatchTable",
                            (Ptr *)&pTheDispatchTable, &symClass);

        SetZone (currentZone);          // restore the zone
    }
    return theErr;
}

void myNotificationCallback(USBDeviceNotificationParameterBlock *pb)
{
    switch(pb->usbDeviceNotification)   // why were we notified?
    {
        case kNotifyAddInterface:       // because a HID device appeared
            ShimOpenDriver(pb->usbDeviceRef);
            break;

        case kNotifyRemoveInterface:    // because a HID device disappeared
            break;

        default:
            break;
    }
}
```

The format of the exported symbol `TheModuleDispatchTable` referred to in the sample code above would be specific for use between the shim and class driver. Some elements of the dispatch table might include a notification procptr, and other procptrs to handle read, write, control, status, and killio requests from the client.

# Mac OS USB Compatibility With Mac OS Toolbox Calls

The use of Mac OS Toolbox calls is discouraged from within a USB class driver, however, there are cases when the Toolbox calls can be made. Carefully consider whether a Toolbox call is really required within the class driver, as opposed to implementing the functionality within the compatibility shim. There are cases where the use of Toolbox calls make sense to handle concerns that USB Manager may not be able to handle.

It is important to understand that the class driver typically operates at secondary interrupt time, under interrupt conditions. Many of the Toolbox calls cannot be made in an interrupt context. The exception to this guideline is that the `intializeProc` and the `finalizeProc` are called at system task time.

With regard to memory allocation, the use of USL function `USBAllocMem` is preferred over the `NewPtrSys` call. The `USBAllocMem` call is designed to use an appropriate memory allocation method for the system software releases. The `NewPtrSys` call may be supported under the current implementation of USB, but it may not be in the future. Note that one can make the `NewPtrSys` call during the `intializeProc`.

To handle preferences, the preferred solution is to have the compatibility shim access the Resource Manager, then tell the class driver to implement the setting via the ControlProc. The ControlProc would be a proc imported to the compatibility shim as described above.

The 1.2 and earlier releases of Mac OS USB do not provide timeout support for USB calls. Where this is a requirement, the class driver could implement a "watchdog" Time Mananger task, to check if a USB call has completed in a specified period of time. Examples of using the Time Manager can be found in "Inside Macintosh: Processes", Chapter 3, Time Manager.

Driver clients, such as compatibility shims, must also register with the USB Manager to receive notifications. A client registers with the USB Manager by calling the `USBInstallDeviceNotification` function, described in Chapter 6, “Callback Routine for Device Notification.”

The client notification messages are

`kNotifyAddDevice` - USB device driver has been loaded

`kNotifyRemoveDevice` - USB device driver is about to be removed. After this message is processed, the `finalizeProc` for the device is called.

`kNotifyAddInterface` - USB interface driver has been loaded

`kRemoveInterface` - USB device driver that was loaded as an interface driver, is about to be removed. After this message is processed, the `finalizeProc` for the interface is called.

CHAPTER 5

# USB Services Library Reference

This chapter describes the APIs in the Mac OS USB Services Library that support software development of USB class drivers. This chapter does not provide any tutorial material designed to teach programming on the Macintosh platform. For information about how to program the Macintosh computer, see the documentation listed in “Supplemental Reference Documents” (page -13).

The Mac OS USB DDK provides source code for building examples of USB class drivers. The driver sources illustrate how to use the USL for USB class driver development. The USB.h file contains the current application programming interfaces to the USL. Future class driver compatibility requires adhering to the interfaces defined in the USL libraries.

The Mac OS USB DDK ReadMe file in the Mac OS USB DDK folder provides the instructions for setting up your Macintosh development system and target environments.

Mac OS USB Compatibility Notes file contains information about ADB, serial port, and USB gaming device compatibility and software support issues.

The Mac OS USB DDK and other valuable resources for developers can be found at:

http:/ / developer.apple.com / dev / usb / devinfo.htm

**Note**
The hub specific functions have been removed from this draft. Apple strongly recommends that developers of standard USB hub devices utilize the hub driver provided in the Mac OS USB software. The Mac OS hub driver supports hub devices that adhere to the version 1.0 and 1.1 USB specifications for standard hub devices. If you have a hub that you need to write a vendor specific device driver for, contact Apple Developer Technical Support at dts@apple.com and copy usb@apple.com.

# USB Services Library (USL)

The USB Services Library is the programming interface that USB device drivers use to communicate with the USB on a Macintosh computer. The USL provides all of the control and status functions necessary to find a device with the appropriate interface, open an interface to the device, open the device,

instantiate the appropriate pipe connections, determine device status, and perform read and write transactions with the device.

This section includes:

- a definition of the standard error reporting mechanism implemented by the USL
- a discussion of the concept of a USB reference used for the various device types found on the USB
- the USB parameter block used by the majority of USL functions
- guidelines for working in the asynchronous USL environment

Later sections define the functions provided in the USL, list the constants and common data structures, and finally provide a table of the errors returned through the USL.

## Errors And Error Reporting Conventions

The USB software uses a “return errors, set references” convention. In this convention, all APIs return a common `OSStatus` type. `PipeRef`, `DeviceRef`, `InterfaceRef`, and `endpointRef` reference numbers are all in a field of the parameter block passed to the function. No reference variables do double duty. That is, they do not report both error codes and reference numbers (refnums).

Error codes returned by the USL are in the range -6900 to -6999 and are listed in “USL Error Codes” (page 5-154).

The following discussion deals with common causes of errors returned by the USL

### Device Access Errors

Any function that accesses a device may give one of the transfer errors. Transfer errors cause a pipe stall on non-default pipes. The transfer errors are in the range -6901 through -6915 as follows:

| | | |
|---|---|---|
| `kUSBCRCErr` | `-6915` | Bad CRC |
| `kUSBBitstufErr` | `-6914` | Bitstuffing |
| `kUSBDataToggleErr` | `-6913` | Bad data toggle |
| `kUSBEndpointStallErr` | `-6912` | Device didn't understand |
| `kUSBNotRespondingErr` | `-6911` | No device, device hung |
| `kUSBPIDCheckErr` | `-6910` | PID CRC error |
| `kUSBWrongPIDErr` | `-6909` | Bad or wrong PID |

| | | |
|---|---|---|
| kUSBOverRunErr | -6908 | Packet too large or more data than allocated buffer |
| kUSBUnderRunErr | -6907 | Less data than buffer, this error does not stall the pipe on isochronous transactions |
| kUSBBufOvrRunErr | -6904 | Host hardware failure on data in, PCI busy? |
| kUSBBufUnderRunErr | -6903 | Host hardware failure on data out, PCI busy? |
| kUSBNotSent1Err | -6902 | Transaction not sent |
| kUSBNotSent2Err | -6901 | Transaction not sent, this error does not stall the pipe on isochronous transfers |

The kUSBNotRespondingError most often occurs when a device is unplugged. A driver should prepare to be deleted, if it gets this error. This error may occur when a device is hung, or when a bus error occurs.

## Errors on the USB Bus

Errors on the USB bus occur when a device is behaving erratically or there are bad cables or connectors. USB bus errors include:

| | | |
|---|---|---|
| kUSBCRCErr | -6915 | Bad CRC |
| kUSBBitsufErr | -6914 | Bitstuffing |
| kUSBDataToggleErr | -6913 | Bad data toggle |
| kUSBPIDCheckErr | -6910 | PID CRC error |
| kUSBWrongPIDErr | -6909 | Bad or wrong PID |

The USB bus errors are uncommon and should rarely be seen.

## Incorrect Command Errors

When a device receives an incorrect command or a command it cannot comply with, it stalls the pipe and returns a kUSBEndpointStallErr.

## Driver Logic Errors

The kUSBOverRunErr and kUSBUnderRunErr are usually caused by logic errors in the driver. In most cases, the driver and the device are not in agreement as to how much data is to be transferred.

An over run error occurs most often when a buffer is not an exact multiple of the maximum packet size (maxPacketSize), and the controller determines that the last packet will overflow the end of the buffer. This also occurs if a packet is

sent that is larger than the maximum packet size. This is often a protocol error and the sign of a bad device.

In version 1.0 of the USB Services Library software, this error can occur if the transfer buffer is not aligned to the maximum packet size of the endpoint. This problem has been addressed in version 1.1 and later of the Mac OS USB software.

Under run errors occur when a packet shorter that the maximum packet size is received. It is the pipe policy to treat this situation as an error. Underrun errors are usually not generated. Currently, short packets always cause a normal completion.

### PCI Bus Busy Errors

Errors may be generated if the PCI bus is busy for extended periods of time. These errors include `kUSBBufOverRunErr` and `kUSBBufUnderRunErr`.

## USB References

All references to the USB are made on the basis of a USB reference. The USB references are of type `USBReference`. `USBDeviceRef`, `USBInterfaceRef`, `USBPipeRef`, and `USBEndPointRef` are USB references that you pass into or obtain from the USL functions. The USB reference is an opaque reference maintained by the USB Services Library.

A device reference is obtained when the class or interface driver is initialized, since it is passed as a parameter to the initialization procedure. The USB reference for a particular USB device can be found in the device entry in the Name Registry and vice-versa by calling the USB Manager. See “Topology Database Access Functions” (page 6-159) for a description of the functions available for obtaining information about USB devices.

## The USBPB Parameter Block

The majority of calls to the USL are made with a parameter block of type USBPB. The USBPB parameter block contains all the necessary parameters to facilitate host communication with the device interface or device interface communication with the USB. The parameter block also includes a pointer to a callback completion routine for support of asynchronous calls.

There are currently two versions of the USBPB parameter block, the version 1.0 parameter block (kUSBCurrentPBVersion), and the version 1.1 parameter block (kUSBIsocPBVersion) that supports isochronous transfers. Version 1.1 and later of the Mac OS USB software accepts function calls made with both parameter blocks. For information about converting code that was dependent on the version 1.0 parameter block to use the 1.1 USBPB, see "Code Changes Required To Support The Version 1.1 USBPB" (page A-206).

Parameters for the USBPB parameter block that are not specified as required in the USL function descriptions are ignored by the USL. Parameters that are not specified as output values are not altered, except for the Reserved, usbWValue, and usbWIndex fields.

The types associated with the version USBPB parameter block structure are defined as follows:

```
typedef SInt32          USBReference;
typedef USBReference    USBDeviceRef;
typedef USBReference    USBInterfaceRef;
typedef USBReference    USBPipeRef;
typedef USBReference    USBBusRef;
typedef UInt32          USBPipeState;
typedef UInt32          USBCount;
typedef UInt32          USBFlags;
typedef UInt8           USBRequest;
typedef UInt8           USBDirection;
typedef UInt8           USBRecipient;
typedef UInt8           USBRqType;
typedef UInt16          USBRqIndex;
typedef UInt16          USBRqValue;

typedef void (*USBCompletion)(USBPB *pb);
```

The isochronous version 1.1 USBPB structure is defined as:

```
struct USBIsocFrame {
    OSStatus frStatus;      /* Frame status information */
    UInt16 frReqCount;      /* Bytes to transfer */
    UInt16 frActCount;      /* Actual bytes transferred */
};

struct usbIsocBits {
```

```
    USBIsocFrame *FrameList;
    UInt32 NumFrames;
};

struct usbHubBits {
    UInt32 Request;
    UInt32 Spare;
};

struct usbControlBits {
    UInt8 BMRequestType;            /* For control transactions */
    UInt8 BRequest;                 /* Specific control request */
    USBRqValue WValue;              /* For control transactions, the */
                                    /* value field of the setup packet */
    USBRqIndex WIndex;              /* For control transactions, the */
                                    /* value field of the setup packet */
    UInt16 reserved4;               /* Reserved */
};

struct USBPB{

    void* qlink;
    UInt16 qType;
    UInt16 pbLength;                /* Length of parameter block */
    UInt16 pbVersion;               /* Parameter block version number */
                                    /* kUSBIsocPBVersion = iscohronous */
                                    /* version 1.1 USBPB */
    UInt16 reserved1;               /* Reserved */
    UInt32 reserved2;               /* Reserved */

    OSStatus usbStatus;             /* Completion status of the call */
    USBCompletion usbCompletion;    /* Completion routine */
    UInt32 usbRefcon;               /* For use by completion routine */
    USBReference usbReference;      /* Device, pipe, interface, or */
                                    /* endpoint reference */

    void* usbBuffer;                /* Pointer to the data to be sent */
                                    /* to or received from the device */
    USBCount usbReqCount;           /* Length of usbBuffer */
    USBCount usbActCount;           /* Number of bytes sent */
                                    /* or received */
```

```
    USBFlags usbFlags;              /* Miscellaneous flags */

    UInt32 usbFrame;                /* Start frame of transfer */

union{
    usbControlBits cntl;            /* usbControlBits struct */
                                    /* used for control transactions */
    usbIsocBits isoc;               /* usbIsocBits frames structure */
    usbHubBits hub;                 /* usbHubBits struct */
}usb;

    UInt8 usbClassType;             /* Class for interfaces, */
                                    /* transfer type for endpoints */
    UInt8 usbSubclass;              /* Subclass for interfaces */
    UInt8 usbProtocol;              /* Protocol for interfaces */
    UInt8 usbOther;                 /* General purpose value */
    UInt32 reserved6;               /* Reserved */
    UInt16 reserved7;               /* Reserved */
    UInt16 reserved8;               /* Reserved */

    }USBPB;
```

The older version 1.0 USBPB parameter block is defined as:

```
struct USBPB{

    void*   qlink;
    UInt16 qType;
    UInt16 pbLength;                /* Length of parameter block */
    UInt16 pbVersion;               /* Parameter block version number */
    UInt16 reserved1;               /* Reserved */
    UInt32 reserved2;               /* Reserved */

    OSStatus usbStatus;             /* Completion status of the call */
    USBCompletion usbCompletion;    /* Completion routine */
    UInt32 usbRefcon;               /* For use by the completion */
                                    /* routine */
    USBReference usbReference;      /* Device, pipe, interface, */
                                    /* endpoint reference */
                                    /* as appropriate */
```

```
    void* usbBuffer;                /* Pointer to the data to be sent */
                                    /* to or received from the device */
    USBCount usbReqCount;           /* Length of usbBuffer */
    USBCount usbActCount;           /* Number of bytes sent */
                                    /* or received */
    USBFlags usbFlags;              /* Miscellaneous flags */

    UInt8 usbBMRequestType;         /* For control transactions, */
                                    /* the bmRequestType field */
    UInt8 usbBRequest;              /* Specific control request */
    USBRqValue usbWValue;           /* For control transactions, the */
                                    /* Value field of the setup packet */
    USBRqIndex usbWIndex;           /* For control transactions, the */
                                    /* Index field of the setup packet */
    UInt16 reserved4;               /* Reserved */
    UInt32 usbFrame;                /* Reserved for future use */

    UInt8 usbClassType;             /* Class for interfaces, */
                                    /* transfer type for endpoints */
    UInt8 usbSubclass;              /* Subclass for interfaces */
    UInt8 usbProtocol;              /* Protocol for interfaces */
    UInt8 usbOther;                 /* General-purpose value */
    UInt32 reserved6;               /* Reserved */
    UInt16 reserved7;               /* Reserved */
    UInt16 reserved8;               /* Reserved */

    }USBPB;
```

During asynchronous calls, before the callback, no fields in the parameter block are valid other than the `usbRefcon` field. The `usbRefcon` field is never altered and is free for use by class drivers.

The `USBPB` parameter block has to be at least the minimum size. The size can be extended; the `pbLength` field should contain the extended size.

The current version of the parameter block is represented as a binary-coded decimal number. For version 1.0 it is of the form 0x0100. It is subject to change at any time. Use the constant `kUSBCurrentPBVersion` to make sure you have the version of the parameter block described by the latest revision of this document. The isochronous variant of the parameter block is version 1.1 or later (`kUSBIsocPBVersion`).

The values passed in the `usbBMRequestType` field require a specific format, which can be derived by using the `USBMakeBMRequestType` function (page 5-110).

## Required USB Parameter Block Fields

All calls to the USL that require a `USBPB` parameter block must supply the these fields:

| | |
|---|---|
| `pbLength` | Length of the `USBPB` parameter block, including any client additions |
| `pbVersion` | Version number of `USBPB` in binary-coded decimal, currently 1.1, initialize to `kUSBCurrentPBVersion` or `kUSBIsocPBVersion` for isochronous call support. See "Changes In Mac OS USB Software" (page A-203) for additional information about how it use the isochronous variant of the USB parameter block. |
| `usbCompletion` | Completion routine |
| `usbRefcon` | For client use |
| `usbFlags` | Unless otherwise specified in the function description, should be set to 0 |

The listed fields may not explicitly be referenced in all the call descriptions in this document, but they are required.

## Standard Parameter Block Errors

All of the functions that use the parameter block return errors when a bad value was passed in the parameter block. The standard parameter block errors are listed in Table 5-1.

**Table 5-1** Standard parameter block errors

| Error constant | Error code | Definition |
|---|---|---|
| `kUSBPBVersionError` | -6986 | The `pbVersion` field of the parameter block contains an incorrect version number. |
| `kUSBPBLengthError` | -6985 | The `pbLength` field of the parameter block contains a value that is smaller than the sizeof(USBPB) |
| `kUSBCompletionError` | -6984 | The `usbCompletion` pointer is nil or is set to `kUSBNoCallBack` and the function does not support this behavior |
| `kUSBFlagsError` | -6983 | An unspecified flag has been set |

## Using the USBPB For Isochronous Transactions

This section defines how to use the fields that support isochronous transactions in the version 1.1 `USBPB`.

When making isochronous calls, you set the `pbVersion` field in the `USBPB` parameter block to `kUSBIsocPBVersion`, and use the isochronous variant of the `USBPB` parameter block.

Isochronous transfers occur on a per frame basis. Mac OS USB version 1.1 does not implement the per sample method suggested in Chapter 10 of the USB Specification 1.0. This may be added in a future release.

The isochronous transfer implementation requires managing data flow in specific frames. An isochronous pipe has a maximum number of bytes that it can transfer every frame. The pipe can transfer fewer bytes, but it can not transfer more. Each frame can generate its own error code.

To support frames for isochronous transfers, the following new structure is introduced:

```
typedef struct{
    OSStatus    frStatus;
    UInt16      frReqCount
    UInt16      frActCount;
}USBIsocFrame;
```

This structure encapsulates the transfer for one frame. On entry, the value of the `frReqCount` field is set to indicate how many bytes are to be transferred (in or out) for this particular frame. (Note 16 bits is more than enough, the `maxpacketsize` is 1023 bytes, 10 bits).

On completion, the `frActCount` field indicates how many bytes were actually transferred and the `frStatus` field specifies the result of the attempt.

For input transfers the `frStatus` field may return errors, such as:

| | | |
|---|---|---|
| `kUSBUnderRunErr` | `-6907` | Packet received was shorter than expected |
| `kUSBOverRunErr` | `-6908` | Packet too large or more data than buffer |
| `kUSBCRCErr` | `-6915` | Pipe stall, bad CRC; packet was received corrupt |

In all of the above cases, there is data in the `usbBuffer` (it may not be very good data) which the class driver can use as it pleases.

For output, the error code is less interesting, you only know that the packet was launched onto the bus (or not as the case may be). There is not any indication that the data packet was received correctly, or that anyone was listening to it at all.

The `usbStatus` field returns an overall status for the isochronous transaction. If `usbStatus` returns with no error, then the status for all of the packets is also no error. If `usbStatus` is returned with another status value, then all of the individual packets should be examined for error codes. The `usbStatus` field contains a representative error if there are multiple packet errors.

The `usbBuffer` field points to the data, all of the packets to be sent or received are laid end to end.

The `usbReqCount` and `usbActCount` fields specify the overall total of data for all the packets sent or received.

The `usbReference` field is a pipe reference to an isochronous pipe.

The `FrameList` field (`usb.isoc.FrameList`) in the `usbIsocBits` structure is a pointer to an array of `USBIsocFrame` structures that specify the individual packets. The start of any individual packet is found by adding the values in the

frReqCount fields for all the preceding packets and adding that to usbBuffer. For example, if the frReqCount values are (61, 62, 63, 64, and so on) and you want the address for the packet to be sent in the third frame, start with the address of usbBuffer and add 61 + 62.

The NumFrames field (usb.isoc.NumFrames) is the number of frames pointed to by the FrameList field, and also defines over how many frames the call will be active.

The usbFrame field specifies the frame number on which the transfers are to start. A frame is specified to be the nearest frame to the current frame with the specified low 32 bits when the transfer is called. This method eliminates the need for a 64-bit frame counter as long as the class driver has a latency of less than 23 days.

Isochronous pipes are opened when a USBConfigureInterface function (page 5-103) is called. During a call to USBConfigureInterface function, the available bandwidth is checked. If bandwidth is insufficient, the call to open the isochronous pipes could fail.

## Asynchronous Call Support

As a general rule, function calls to the USL complete asynchronously, with the exception of the functions listed here:

```
USBGetPipeStatusByReference
USBAbortPipeByReference
USBResetPipeByReference
USBClearPipeStallByReference
USBSetPipeIdleByReference
USBSetPipeActiveByReference
USBGetFrameNumberImmediate
USBFindNextEndpointDescriptorImmediate
USBFindNextInterfaceDescriptorImmediate
```

Since most USL functions complete asynchronously, it's important to allocate a parameter block in memory that will be available until the call completes, either with a call back or with an immediately returned error. Unless there is an immediate error, the parameter block cannot be reused until the completion routine is called. You can force the completion routine to be called for pipe transactions by calling the USBAbortPipeByReference function.

Asynchronous calls to the USL are supported by a completion routine mechanism. You pass a pointer to a completion routine in the `USBPB` parameter block. The completion routine is invoked when the USL function call completes, informing the driver of the calls completion.

The USB completion routine is of this form:

```
typedef void (*USBCompletion)(USBPB *pb);
```

The fields required in the `USBPB` parameter block for all USL functions that return asynchronously are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |

During the call to the completion routine, these fields are valid:

| | |
|---|---|
| `--> usbStatus` | Status information |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `-->` | Any other call-specific fields marked as output from the call |
| `-->` | Any other call-specific fields used as input to and not output from the call |

When the completion routine is called, the processing of the parameter block is complete and the parameter block is again available for use. The completion routine may use the same parameter block to make a new call to the USL. Polling the `usbStatus` field is not supported, since it may be used internally during function execution.

The execution level that the completion routine may be called back at is not guaranteed, unless otherwise specified in the individual routine specification. Completion usually occurs at secondary interrupt level, or at system task level. If the execution context is important to the operation of the code, the driver services call `CurrentExecutionLevel` can be used to discover the current execution level.

The driver services library function `CallSecondaryInterruptHandler2` can be used to continue execution at secondary interrupt level. The `USBDelay*` function can be used to effect a transition to task level. Note system task level is not the

same as application task level, it may not be safe to make some Mac OS calls, particularly file system calls at system task level. Unless otherwise specified, all of the USL functions are safe to be called from either secondary interrupt level or from system task level.

*This functionality is missing in the `USBDelay` function in USB software versions 1.0 and 1.0.1, it does work as described with USB version 1.1 and higher. For USB versions earlier that 1.1, the execution level can be checked with the `CurrentExecutionLevel` function, and the delay retried if the call back happens at a time other than task level. The `CurrentExecutionLevel` function is defined in the Driver Services Library chapter of Designing PCI Cards and Drivers for Power Macintosh Computers. The function returns a constant that defines the current execution level:

```
kHardwareInterruptLevel
kSecondaryInterruptLevel
kTaskLevel
```

An execution level of `kHardwareInterruptLevel` should not be seen for USL functions. If the current execution level is hardware interrupt level it indicates that something is not operating correctly.

## Polling Versus Asynchronous Completion (Important)

The Mac OS USB Service Library (USL) allows class drivers to poll for the completion of USL function calls by polling the `usbRefcon` field of the parameter block. In general, it is strongly advised to use asynchronous completion via the call back mechanism defined in “Asynchronous Call Support,” instead of polling. Polling the `usbRefcon` field is discouraged and should only be implemented under exceptional circumstances.

The primary concern with polling lies with code that is designed to use the asynchronous USL call mechanism, and then enters a tight code loop where little happens except to check the `usbRefcon` field, and only exits the loop when the `usbRefcon` field changes. This form of polling robs time from the system, because nothing useful can happen while the code runs in the tight loop.

USB time scales are on the order of milliseconds. A tight polling loop represents and eternity of time wasted, when the system could be doing useful work. Some devices have very slow completion times. Completion times on the order of 100ms are not uncommon. If a driver polled for this length of time, the user would notice the pause, and system performance could suffer. In fact, there are

circumstances in which polling the parameter block can cause the system to hang. These circumstances and some guidelines for avoiding them are further defined below:

Never poll from secondary interrupt time. Secondary interrupts are queued, and most I/O including the USL completes at secondary interrupt time. If you poll within secondary interrupt time, USL calls will never get a chance to complete, and the poll will never complete.

If you poll from task level time (task level is described in *Designing PCI Cards and Drivers for the Power Macintosh Computer*) the system may still hang. In order to guard against this you should either:

1). Applications can give time back to the system by calling waitnext event. Shims should use SystemTask to give time back to the system.

2). Only poll for a limited time.

Option 1 is usually only practical from an application. Applications should not be making USL calls. Only class drivers should make USL calls. The use of USL calls by an application, is not supported.

Option 2 can be used by class drivers. The USB standard calls for a 5 second timeout on all transactions. The polling software should make frequent calls to `USBGetFrameNumberImmediate` to determine the elapsed time. If the elapsed time becomes too great, the attempt should be abandoned with the `USBAbortPipeByReference` call.

In general, it is best to use asynchronous completion routines wherever possible.

## Transaction and Data Timeouts

There are two types of timeout conditions on the USB, which can generally be referred to as “transaction” timeouts and “no data” timeouts.

- Transaction timeouts occur when too much time passes since a transaction became active.
- No data timeouts occur when too much time passes since the last data packet was transferred.

The clock for a transaction timeout starts when a transaction reaches the head of the endpoint queue. The transaction times out when the total amount of time

the transaction is active is greater than the specified number of frames. Transaction timeouts apply to the following functions:

```
USBDeviceRequest
USBControlRequest
USBBulkRead
USBBulkWrite
USBIntRead
USBIntWrite
```

Class drivers may request a transaction timeout by setting the `usbFlags` field to `kUSBTimeout` and specifying the time for the timeout in frames in the `usbFrame` field.

No data timeouts occur when there is no data flow on the pipe for the specified time. At the device level this means that the device has NAKed the request for the specified period of time. If any data transfer takes place (even a single ACKed transaction), the timeout clock is reset to the start. No data timeouts currently only apply to control transactions where the standard timeout is 5 seconds.

Class drivers may request a no data timeout by setting the `usbFlags` field to `kUSBNoDataTimeout` and specifying the time for the timeout in frames in the `usbFrame` field.

When a transaction has timed out, the pipe is aborted along with all pending transactions, and the `kUSBTimedout` error status is returned.

Starting with version 1.3 of the Mac OS USB software control transactions are subject to a 5 second no data timeout. This new default behavior can be overridden by a class driver by setting the `usbFlags` field in the USB parameter block to `kUSBNo5SecTimeout`. The use of `kUSBNo5SecTimeout` is not recommended. It should only be used in cases where the device is not compliant with the standard.

Driver specified timeouts are not meant to be totally accurate. Like other USB timing issues, the time value specified should be treated in a “no less than” manner. It may be longer than the specified value because of other system activity. No data timeouts are checked every 500ms, and specifying a value less than 500ms is of no use.

Setting both `kUSBTimeout` and `kUSBNoDataTimeout` is allowed, however the no data timeout cannot expire before the transaction timeout and therefore setting both is redundant. For control transactions, setting `usbFlags` to `kUSBNoDataTimeout` and specifying a timeout value in `usbFrame` overrides the 5 second no data timeout without the need to set `kUSBNo5SecTimout`.

**Note**
Isochronous transactions are time sensitive by nature and are not subject to the timeout mechanism described in this section. The timeout flags are not supported in isochronous transactions.

# USL Functions

This section describes the functions in the USB Services Library.

## Determining The Version of USB Software Present

Beginning with version 1.3 of the Mac OS USB software, the `USBGetVersion` function provides a way for drivers to determine the version number of Mac OS USB software present.

### USBGetVersion

The `USBGetVersion` function allows device drivers to determine the version of Mac OS USB software that is running on the current Macintosh computer.

```
UInt32 USBGetVersion
                    (void);
```

The `USBGetVersion` function returns the version of the USB software in a 32-bit format as follows:

```
MMmmRRss
```

| | |
|---|---|
| MM | The most significant byte containing the major version number. The current value for the major version number is 1. This number will increment with each major release. |

| | |
|---|---|
| mm | The next byte contains the minor version and revision number. The current value for the minor version number is 2. This number will increment with each minor release. |
| RR | The next byte contains the release stage. The release stage is defined as: 0x20 = development, 0x40 = alpha, 0x60 = beta, and 0x80 = final. If the software was at the beta release stage, this number would be 0x60. |
| ss | The least significant byte is the sequence number of the release, and it changes with every build of the USB software. |

The following example demonstrates how this function may be used.

```
#include <USB.h> /* be sure that you are using the 1.3 USB.h file */

UInt32 MyUSBGetVersion (void)
{
    UInt32 version;
    if ((Ptr) USBGetVersion != (Ptr) kUnresolvedCFragSymbolAddress)
        version = USBGetVersion();
    else
        version = 0;        /* version of the USB less than 1.3 */
    return version;
}
```

## USB Configuration Functions

To make a connection to a USB device, the class driver must find an interface function that meets its requirements, and then configure the USB device for subsequent operations. The functions described in this section provide Mac OS USB configuration services.

The first thing a class driver needs to do when configuring a device is find the *function* in a device configuration on which the driver is to operate and set the configuration. The *function* the driver is interested in is represented in the USB device hierarchy by an interface inside of a configuration. The programmatic view of the USB hierarchy is devices-> configurations-> interfaces-> endpoints.

## USBFindNextInterface

The `USBFindNextInterface` function is used to find an interface and its parent configuration. The `USBFindNextInterface` function searches through all configurations for interfaces matching the USB class, subclass, and protocol input parameters and returns both the number of the configuration it found the interface in, and the number of the matching interface. The interface numbers are returned in the order in which they appear in the configuration descriptor. You can iterate through the list of both configurations and interfaces until you find the interface you are looking for. The returned configuration information is used in the `USBSetConfiguration` function call to set the device configuration containing the interface. (The `USBSetConfiguration` function was called `USBOpenDevice` prior to version 1.1 of the Mac OS USB software)

```
OSStatus USBFindNextInterface(USBPB *pb);
```

Required fields in the `USBPB` parameter block for the `USBFindNextInterface` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | Device reference |
| `-- usbBuffer` | Should be set to 0 (0 returned); reserved in this call |
| `-- usbActCount` | Should be set to 0 (0 returned); reserved in this call |
| `--> usbReqCount` | Maximum power requirement of the configuration, or 0 if not concerned about the power requirement. If the configuration requires more power than specified, the `kUSBDevicePowerProblem` error is returned. In versions of the Mac OS USB software prior to version 1.1, this field is not used and should be set to 0. |
| `--> usbFlags` | Should be set to 0 (0 returned); reserved in this call |
| `<--> usbClassType` | --> Class, 0 matches any class<br><-- Class value for interface found |
| `<--> usbSubclass` | --> Subclass, 0 matches any subclass<br><-- Subclass value for interface found |

<--> usbProtocol --> Protocol, 0 matches any protocol
<-- Protocol value for interface found

<--> usb.cntl.WValue
Configuration number; start with 0

<--> usb.cntl.WIndex
--> Interface number; start with 0
<-- Interface number

<--> usbOther Alternate interface, set to 0xff to find first alternate only

For alternate interface settings, the usbOther field provides a method for getting details about a specific alternate interface or all of the alternate interfaces as a set. For example, the composite class driver would find all the interfaces in a device and load drivers for those interfaces. It would, however, treat the set of alternates as one interface and load only one driver for the alternate. That alternate driver would then have to determine what alternate settings were appropriate and choose the appropriate driver for those settings.

To support finer granularity search criteria when looking for a specific interface in a device, and to avoid matching an interface that requires too much power, the usbReqCount field supports passing a value for the maximum power supported by the configuration. A driver can look for an interface with a specific class, subclass, and protocol in a configuration that supports less than a specified amount of power. It the appropriate amount of power is not available for the device, an error of kUSBDevicePowerProblem is retuned. The driver can choose to notify the user or continue looking for an interface that satisfies all the parameters.

If a driver chooses not to pass the power requirement in the usbReqCount field when looking for an interface, the USL matches interfaces with the other parameters even though they require more power than is available. When the configuration for a device that requires more power than is available is passed in with the USBSetConfiguration function, the USL generates a power alert to the USB Manager.

The value of 0 for usbClass, usbSubclass, or usbProtocol is a wildcard value that indicates the caller is interested in whatever information can be found for those parameters in the search. The actual values for any interface found are returned in those fields. If a driver wants to make a subsequent call using wildcards for the class, subclass, and protocol values, a 0 value must be explicitly passed in for the usbClass, usbSubclass, and usbProtocol fields, since the actual values for the interface found during the last call are returned in those fields of the parameter block.

The usb.cntl.WValue and usb.cntl.WIndex fields should be set to 0 upon first entry of the USBFindNextInterface function to indicate the search should start at the beginning of the configuration descriptors. For subsequent calls to the USBFindNextInterface function, the values returned in the usb.cntl.WValue and usb.cntl.WIndex fields should be passed back in without modification. The next interface matching the specified values will be found.

Errors returned by the USBFindNextInterface function include

| | | |
|---|---|---|
| paramErr | | usbBuffer pointer, usbReqCount, or usbActCount fields are not set to 0 |
| kUSBDevicePowerProblem | -6976 | an interface was found that matches the class, subclass, and protocol, but failed the power requirements. This error is also returned because no matching interfaces were found that meet the power requirement |
| kUSBUnknownDeviceErr | -6998 | usbReference does not refer to a current device |
| kUSBInternalErr, paramErr | -6999 | internal configuration descriptor cache corrupted |
| kUSBNotFound | -6987 | interface or configuration specified is not in configuration descriptors |

## USBSetConfiguration, USBOpenDevice

Once a suitable interface is found, the device is opened with the configuration specified in the USBSetConfiguration function.

For version 1.1 and greater of the Mac OS USB software USBSetConfiguration replaces the USBOpenDevice function name. The USBSetConfiguration and the USBOpenDevice functions have the same behavior, but USBSetConfiguration is the preferred function name, and should be used in versions of the Mac OS USB software 1.1 and greater.

The input and return values in the parameter block for the USBSetConfiguration are identical to those for the old USBOpenDevice function.

```
OSStatus USBOpenDevice(USBPB *pb); /* obsolete, do not use */

OSStatus USBSetConfiguration(USBPB *pb); /* for version 1.1 and later */
```

Required fields in the `USBPB` parameter block for the `USBSetConfiguration` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | Device reference |
| `-- usbBuffer` | Should be set to 0 (0 returned); reserved in this call |
| `-- usbActCount` | Should be set to 0 (0 returned); reserved in this call |
| `-- usbReqCount` | Should be set to 0 (0 returned); reserved in this call |
| `--> usb,cntl.WValue` | Configuration number |
| `--> usbFlags` | Should be set to 0 |
| `<-- usbOther` | Number of interfaces in configuration |

The configuration number is an arbitrary number assigned by the device to label the configurations. The number is usually sequential 1,2,3 and so on, but not guaranteed to be so.

An interface reference cannot be used in the `usbReference` field to change the configuration. A device reference is required to implement a configuration change. However, an interface reference will not cause an error if used to specify the currently set configuration. This provides a level of backward compatibility.

Errors returned by the `USBOpenDevice` and `USBSetConfiguration` function include

| | | |
|---|---|---|
| `paramErr` | | `usbBuffer` pointer, `usbReqCount`, or `usbActCount` fields are not set to 0 |
| `kUSBUnknownDeviceErr` | `-6998` | `usbReference` does not refer to a current device |
| `kUSBDevicePowerProblem` | `-6976` | the device requires more power than is currently available. A power alert message will be displayed to the user. If the current driver does its own power error handling, it should not call `USBSetConfiguration` when the power is not available. |

| | | |
|---|---|---|
| kUSBDeviceBusy | -6977 | the device is already being configured |
| kUSBInternalErr, paramErr | -6999 | internal configuration descriptor cache corrupted |
| kUSBNotFound | -6987 | interface or configuration specified is not in configuration descriptors |

## Opening An Interface

The USBNewInterfaceRef function performs the first step in opening an interface. The USBConfigureInterface function (page 5-103) completes the process by setting up the interface for further communication.

## USBNewInterfaceRef

The USBNewInterfaceRef function generates a new reference number that allows the interface in the specified device to be referred to. An interface reference can be used in most circumstances where a device reference can be used. Individual function descriptions indicate where an interface or device reference cannot be used interchangeably.

```
OSStatus USBNewInterfaceRef(USBPB *pb);
```

Required fields in the USBPB parameter block for the USBNewInterfaceRef function are

| | |
|---|---|
| --> pbLength | Length of parameter block |
| --> pbVersion | Parameter block version number |
| --> usbCompletion | The completion routine |
| --> usbRefcon | General-purpose value passed back to the completion routine |
| <--> usbReference | --> Device reference of device being configured<br><-- Interface reference returned |
| -- usbBuffer | Should be set to 0 (0 returned); reserved in this call |
| -- usbActCount | Should be set to 0 (0 returned); reserved in this call |
| -- usbReqCount | Should be set to 0 (0 returned); reserved in this call |
| --> usb.cntl.WIndex | Interface number |

`--> usbFlags` Should be set to 0

If you create an interface reference, the interface reference must be disposed of in the driver finalize routine. In version 1.1 and later of the Mac OS USB software, the interface references are disposed of when a device is unplugged. However, you should still call the driver finalize routine and ignore any `kUSBUnknownDeviceErr` to ensure compatibility with all versions of the Mac OS USB software.

Errors returned by the `USBNewInterfaceRef` function include

| | | |
|---|---|---|
| `paramErr` | | `usbBuffer` pointer, `usbReqCount`, or `usbActCount` fields are not set to 0 |
| `kUSBUnknownDeviceErr` | -6998 | `usbReference` does not refer to a current device |
| `kUSBDeviceBusy` | -6977 | the device is already being configured |
| `kUSBNotFound` | -6987 | interface or configuration specified is not in configuration descriptor |
| `kUSBOutOfMemoryErr` | -6988 | ran our of internal structures |

## Configuring The Device Interface(s)

Configuring the interface or interfaces of a device is done with the `USBConfigureInterface` function.

### USBConfigureInterface

The `USBConfigureInterface` function sets the interface on the device, and opens each pipe in the interface. The number of pipes opened is returned. It can also be used to set an alternate interface on the device.

This function does not currently operate as defined above. It does not set the device interface, it will in the future. At this time, the class driver must call the `USBDeviceRequest` function and make a `set_interface` device request to set the device interface. The driver can then call `USBConfigureInterface` to open the pipes in the interface and get the number of pipes. If required, an alternate interface can be specified upon entry in the `usbOther` field.

```
OSStatus USBConfigureInterface(USBPB *pb);
```

Required fields in the `USBPB` parameter block for the `USBConfigureInterface` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | Interface reference obtained from `USBNewInterfaceRef` |
| `-- usbBuffer` | Should be set to 0 (0 returned); reserved in this call |
| `-- usbActCount` | Should be set to 0 (0 returned); reserved in this call |
| `-- usbReqCount` | Should be set to 0 (0 returned); reserved in this call |
| `--> usbFlags` | Should be set to 0 |
| `<--> usbOther` | --> Alternate interface; <-- Number of pipes in interface |

If information about an individual pipe or other element is needed, a device request has to be made.

Configuring an already opened interface is not an error. This sets the alternate and flags settings for the interface. It also invalidates any pipe references you are using.

Errors returned by the `USBConfigureInterface` function include

| | | |
|---|---|---|
| `kUSBUnknownInterfaceErr` | `-6978` | `usbReference` does not refer to a current interface |
| `kUSBUnknownDeviceErr` | `-6998` | `usbReference` does not refer to a current device |
| `paramErr` | | `usbBuffer` pointer, `usbReqCount`, or `usbActCount` fields are not set to 0 |
| `kUSBInternalErr`, `paramErr` | `-6999` | internal configuration descriptor cache corrupted |
| `kUSBNotFound` | `-6987` | interface or configuration specified is not in configuration descriptor |
| `kUSBIncorrectTypeErr` | `-6995` | interface has control endpoints |
| `kUSBTooManyPipesErr` | `-6996` | ran out of internal structures |

## Finding A Pipe

After the functions used to open the interface have completed, you need to work out which already open pipe in the interface is the one you want to communicate through.

## USBFindNextPipe

The USBFindNextPipe function can be used to either find a specific pipe, as specified by the direction in the usbFlags field and type in the usbClassType field, or to search through the available pipes.

```
OSStatus USBFindNextPipe(USBPB *pb);
```

Required fields required the USBPB parameter block for the USBFindNextPipe function are

| | |
|---|---|
| --> pbLength | Length of parameter block |
| --> pbVersion | Parameter block version number |
| --> usbCompletion | The completion routine |
| --> usbRefcon | General-purpose value passed back to the completion routine |
| <--> usbReference | --> Interface or pipe reference<br><-- Pipe reference |
| -- usbBuffer | Should be set to 0 (0 returned); reserved in this call |
| -- usbActCount | Should be set to 0 (0 returned); reserved in this call |
| -- usbReqCount | Should be set to 0 (0 returned); reserved in this call |
| <--> usbFlags | --> Specific direction of pipe (kUSBIn or kUSBOut) or kUSBAnyDirn as a wildcard<br><-- Direction of input or output pipe |
| <--> usbClassType | --> Specific endpoint type (kUSBControl, kUSBInterrupt, or kUSBBulk) or kUSBAnyType as a wildcard<br><-- Endpoint type |
| <-- usb.cntl.WValue | Maximum packet size of endpoint |

This function takes either an interface or pipe reference in the usbReference field. To find the first pipe of a particular type, make a call to the function with an interface reference. To find the next pipe of the same type, enter the pipe reference returned by the previous call.

Some additional explanation is in order with regard to the use of the phrase “the same type.” You may want to find a pipe with exactly the same type as that given in the previous call, either specific or wildcard, or find a pipe of exactly the same type as that returned by the last call, which is always a specific pipe type.

For example, you can search for any type and get a bulk-in pipe. After that, you could search for the next pipe of any type by using the returned pipe reference and the same wildcard values again, or you could search for the next bulk-in pipe by using the pipe reference returned from the last call.

The `usbFlags` field takes either a specified endpoint direction or a wildcard of `kUSBAnyDirn`. The `usbClassType` field takes either a specified endpoint type or a wildcard of `kUSBAnyType`. For example, if you specify values for an input interrupt pipe, the function returns only the input interrupt pipes found. If a wildcard is used, all pipes of any type and direction found are returned. Multiple iterations using a wildcard value require that the wildcard be set up for each subsequent call.

Errors returned by the `USBFindNextPipe` function include

| | | |
|---|---|---|
| `paramErr` | | `usbBuffer` pointer, `usbReqCount`, or `usbActCount` fields are not set to 0 |
| `kUSBUnknownDeviceErr` | `-6998` | `usbReference` does not refer to a current device |
| `kUSBUnknownPipeErr` | `-6997` | pipe reference specified is unknown |
| `kUSBNotFound` | `-6987` | interface or configuration specified is not in configuration descriptor |

## Getting Information About an Open Interface or Pipe

Information about an opened interface or pipe is contained within the interface and pipe descriptors, and other descriptors associated with them.

### USBFindNextAssociatedDescriptor

You use the `USBFindNextAssociatedDescriptor` function to find a specific interface or pipe descriptor, or any descriptor associated with the interface or endpoint. For example, a HID interface driver could use this function to find HID descriptors.

```
OSStatus USBFindNextAssociatedDescriptor(USBPB *pb);
```

Required fields required the `USBPB` parameter block for the `USBFindNextAssociatedDescriptor` function are

`--> pbLength` Length of parameter block

| | |
|---|---|
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | Interface or pipe reference |
| `<--> usb.cntl.WIndex` | Descriptor index start at zero |
| `--> usbBuffer` | Descriptor buffer |
| `--> usbReqCount` | Size of buffer |
| `<-- usbActCount` | Size of the descriptor returned |
| `<--> usbOther` | Descriptor type (a value of 0 matches any) |

The `USBFindNextAssociatedDescriptor` function steps through the descriptors following the relevant interface or endpoint descriptor, and returns the descriptors matching the given parameters. If `usbReference` is an interface reference, all the descriptors are returned until the next interface descriptor is found, or until the end of the configuration descriptor is reached. If `usbReference` is a pipe reference, all of the descriptors are returned until the next endpoint or interface descriptor is found, or until the end of the configuration descriptor is reached.

The `usb.cntl.WIndex` field provides an index into all the available descriptors. A value of 1 describes the interface or endpoint descriptor itself, so passing 0 allows the interface or endpoint descriptor to be returned. If `usb.cntl.WIndex` is passed back in the next call untouched, the function returns the next available matching descriptor.

The `usbOther` field contains a descriptor type to match. If searching for any type (`usbOther` set to 0) all descriptors are matched. To use this method of search again for all descriptors, the `usbOther` field has to be set to 0 each time the function is called.

The errors returned by the `USBFindNextAssociatedDescriptor` function include:

| | | |
|---|---|---|
| `kUSBUnknownInterfaceErr` | `-6978` | `usbReference` does not refer to a current interface or pipe |
| `kUSBInternalErr`, `paramErr` | `-6999` | internal configuration descriptor cache corrupted |
| `kUSBNotFound` | `-6987` | interface or configuration specified does not follow the starting index. A matching descriptor may already have been passed. |

## USBGetConfigurationDescriptor

The `USBGetConfigurationDescriptor` function gives class drivers access to the USB configuration descriptor.

The `USBGetConfigurationDescriptor` function returns configuration descriptors that define the contents of the configuration data for the device. The configuration descriptor is 9 bytes, and is followed by all the interface descriptors complete with their associated endpoint descriptors as well as any class or vendor specific descriptors. The `USBGetConfigurationDescriptor` function returns as much of this data for one configuration as requested.

```
OSStatus USBGetConfigurationDescriptor(USBPB *pb);
```

Required fields in the `USBPB` parameter block for the `USBGetConfigurationDescriptor` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | Device reference |
| `--> usbWValue` | Configuration number |
| `--> usbReqCount` | Amount of configuration data requested |
| `--> usbBuffer` | `-->` Pointer to the address to store the data in |
| `<-- usbActCount` | Actual amount of data returned |
| `--> usbFlags` | Should be set to 0 |

The `USBGetConfigurationDescriptor` function differs from the `USBGetFullConfigurationDescriptor` function in that it allows the calling driver to specify how much configuration data the function should return. `USBGetConfigurationDescriptor` allows the caller to get either the 9-byte configuration descriptor (`USBConfigurationDescriptor`), a descriptor specified in `usbWValue`, or as much of the configuration data as requested.

The `USBGetConfigurationDescriptor` function requires the caller to allocate the memory for the returned data and pass a pointer to the address of the allocated memory block in `usbBuffer`. The caller must also specify how many bytes of the configuration data to return to the buffer in the `usbReqCount` field.

The usbReqCount field specifies the largest amount of data that you want returned. If the descriptor has less data, less data is returned. If the descriptor has more data, only the requested amount of data is returned. This is not an error condition.

## USBDisposeInterfaceRef

The USBDisposeInterfaceRef function closes the specified interface currently opened. The interface reference obtained with the USBNewInterfaceRef function for this interface is no longer valid after the call USBDisposeInterfaceRef call completes.

```
OSStatus USBDisposeInterfaceRef(USBPS *pb);
```

Required fields in the USBPB parameter block for the USBDisposeInterfaceRef function are

| | |
|---|---|
| --> pbLength | Length of parameter block |
| --> pbVersion | Parameter block version number |
| --> usbCompletion | The completion routine |
| --> usbRefcon | General-purpose value passed back to the completion routine |
| --> usbReference | Interface reference for the interface to close. |
| --> usbFlags | Should be set to 0 |

If the usbCompletion field is set to kUSBNoCallBack, the call back mechanism is not invoked. This is useful for finalization routines which need to clean up immediately and can't wait for a callback routine to complete.

If the no call back option (kUSBNoCallBack) is used, the parameter block is free as soon as the USBDisposeInterfaceRef call returns.

Errors returned by the USBDisposeInterfaceRef function include

| | | |
|---|---|---|
| kUSBUnknownInterfaceErr | -6978 | usbReference does not refer to a current interface |

## Generalized USB Device Request Function

The USB standard specifies one of the fields of a control request as a `BMRequestType`. This field is a bit-mapped byte that tells the USB function about the request. Information about the request includes direction of data flow, how the function is defined (standard, class, or vendor specific) and what logically is the recipient of the request.

### USBMakeBMRequestType

The `USBMakeBMRequestType` function formats device and control request type parameters into the `bmRequestType` format, which are passed to the USL in the `usbBMRequestType` field of the `USBDeviceRequest` function.

**Note**
The use of this function is optional if the requestType values are already provided in the standard documentation describing the device. The known requestType values can be transcribed directly into the `usbBMRequestType` field of the `USBDeviceRequest` function.

The `USBMakeBMRequestType` function returns a UInt8 or 0xff if one or more of the parameters is incorrect. A value of 0xff is not a legal value and is not accepted by the subsequent control call.

```
UInt8 USBMakeBMRequestType(UInt8 direction, UInt8 type,
                    UInt8 recipient);
```

| | |
|---|---|
| `direction` | Direction of data flow, `kUSBOut`, `kUSBIn`, or `kUSBNone` |
| `type` | Definition of the request, `kUSBStandard`, `kUSBClass`, or `kUSBVendor` |
| `recipient` | Part of the device receiving the request, `kUSBDevice`, `kUSBInterface`, `kUSBEndpoint`, or `kUSBOther` |

All USB devices respond to requests from the host on the device's default pipe. These requests are made using control transfers. The request and the request's parameters are sent to the device in the setup packet.

## USBDeviceRequest

The `USBDeviceRequest` function performs control transactions to default pipe 0 (zero) of a device.

```
OSStatus USBDeviceRequest(USBPB *pb);
```

Required fields in the `USBPB` parameter block for the `USBDeviceRequest` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | The device reference passed to the driver when it is loaded |
| `--> usbBMRequestType` | The `usbBMRequestType` field is made up of the `direction`, `type`, and `recipient` values |
| `direction` | One of the following: |
| `kUSBIn` | Data will be transferred to the host. |
| `kUSBOut` | Data will be transferred to the device. |
| `kUSBNone` | No data will be transferred. The length and buffer parameters are ignored. |
| `type` | One of the following: |
| `kUSBStandard` | A request defined in the USB standard. |
| `kUSBClass` | A request defined in a class standard. |
| `kUSBVendor` | A vendor unique request type. |
| `recipient` | One of the following: |
| `kUSBDevice` | The request is to the whole device. |
| `kUSBInterface` | The request is to a specific interface in the device. |
| `kUSBEndpoint` | The request is to a specific pipe endpoint in a device. |
| `kUSBOther` | The request is going somewhere else. |

| | |
|---|---|
| --> usbBRequest | Defined by the USB standard, defined by a class driver standard, or vender unique. See "usbBRequest Constants" (page 5-148) |
| --> usbWValue | General parameter unique to the transaction request. This value is in host endian format, and will be swapped if necessary when it is sent to the device. |
| --> usbWIndex | General parameter unique to the transaction request. This value is in host endian format, and will be swapped if necessary when it is sent to the device. |
| --> usbReqCount | Specifies the size of the data to transfer. If this is set to 0, no transfer occurs |
| --> usbBuffer | Points to the data to be transferred (kUSBOut request) or where data will end up (kUSBIn request). The buffer should be at least as big as the size specified in the usbReqCount field. If usbBuffer is set to nil, no data is transferred in the data phase regardless of the value of length, setup and status still occurs |
| <-- usbActCount | Specifies the actual amount of data transferred on completion |
| --> usbFlags | Should be set to 0, or kUSBAddressRequest for control transactions addressed to an interface or endpoint. You may also use kUSBTimeout to indicate that you are setting the transaction timeout value according to the amount of frames in the usbFrame field. See "Transaction and Data Timeouts" for additional information about transaction timeouts. |

The request is sent to the default pipe 0 and the relevant data is transferred.

The flag kUSBAddressRequest supports USB control transactions addressed to an interface or endpoint of a device. The kUSBAddressRequest flag allows the control call to be made without the driver explicitly knowing the number of the endpoint or interface before the call is made. The USL fills in the interface or endpoint number in the setup packet based on the pipe or interface reference that is passed in with the call.

To use the addressed device request feature, specify the kUSBAddessRequest flag in the usbFlags field. If the recipient field of the BMRequestType is an endpoint or interface, the relevant endpoint or interface number is derived from the pipe or interface reference that is passed in the usbReference field. The interface or endpoint number is put into the WIndex field of the setup packet before the control transaction call takes place.

Drivers should not issue device requests for

```
Set_Address (bRequest = 5, type = standard, recipient = device)
Set_Config (bRequest = 9, type = standard, recipient = device)
```

These are reserved for system use. Issuing a `set_address` device request could disrupt communication on the USB. The `USBSetConfiguration` function should be used to set a configuration instead of a `set_config` device request through the `USBDeviceRequest` function. An attempt to issue a `set_config` with the `USBDeviceRequest` function will cause the `USBSetConfiguration` function to be called.

For additional information about the parameters specified for control transactions, see section 9 of the USB Specification.

If the request is a `set_config` request, the `USBDeviceRequest` function returns the same errors as those for the `USBSetConfiguration` function. Other errors returned by the `USBDeviceRequest` function include

| | | |
|---|---|---|
| `kUSBUnknownDeviceErr` | -6998 | `usbReference` does not refer to a current device |
| `kUSBRqErr` | -6994 | the value in the `usbBMRequestType` field is not valid |
| `kUSBUnknownRequestErr` | -6993 | request code for a standard USB call is not recognized |
| `kUSBInvalidBuffer` | | bad buffer specified |

## USB Transaction Functions

There are four transaction types supported by the USL, control, interrupt, bulk, or isochronous. When making isochronous calls, you set the `pbVersion` field in the `USBPB` parameter block to `kUSBIsocPBVersion`, and use the isochronous variant of the `USBPB` parameter block, described in “The USBPB Parameter Block”.

When making function calls that are not a direct result of a call to the Device Manager, such as the USB transaction functions, class drivers should arrange to hold the memory for the data buffer used in the `usbBuffer` field. The driver can do this with either the `PrepareMemoryForIO` function described in *“Designing PCI Cards & Drivers for Power Macintosh Computers,”* or the older `HoldMemory` function described in the Virtual Memory Manager section of *“Inside Macintosh:Memory.”* It should be noted that memory returned by the USL `USBAllocMem` function is held as it is with `PoolAllocateResident`, and is therefore safe.

The PrepareMemoryForIO and HoldMemory functions are only safe to call at task level (any non-secondary interrupt time). One way to safely prepare the memory is to create and hold a single buffer at driver initialization time, which occurs at task level. You then use this buffer to make all transaction requests. The USB Manager holds the driver code and globals automatically when the driver is loaded. Therefore, declaring a buffer in the driver's global space guarantees the memory will be held before requesting a transaction.

## USBControlRequest

A general device control request can be issued on a non-default control pipe (a control pipe other than pipe 0) using the USBControlRequest function. The specified request is sent to the specified pipe's endpoint and the relevant data is transferred. This function call can only be used after a device has been configured. See the USBSetConfiguration function description on (page 5-100), for additional information about configuring a device.

```
OSStatus USBControlRequest(USBPB *pb);
```

The fields required in the USBPB parameter block for the USBControlRequest function are:

--> pbLength — Length of parameter block

--> pbVersion — Parameter block version number

--> usbCompletion — The completion routine

--> usbRefcon — General purpose value passed back to the completion routine

--> usbReference — The pipe reference returned by the USBFindNextPipe call for the device you want to send the control request to. The device must have already been configured before a USBControlRequest is made.

--> usbBMRequestType — The usbBMRequestType field is made up of the direction, type, and recipient values (see also, the USBMakeBMRequestType function (page 5-110))

direction — One of the following:

kUSBIn — Data will be transferred to the host.

kUSBOut Data will be transferred to the device.

kUSBNone No data will be transferred. The length and buffer parameters are ignored.

type One of the following:

kUSBStandard A request defined in the USB standard.

kUSBClass A request defined in a Class standard.

kUSBVendor A vendor unique request type.

recipient One of the following:

kUSBDevice The request is to the whole device.

kUSBInterface The request is to a specific interface in the device.

kUSBEndpoint The request is to a specific pipe endpoint in a device.

kUSBOther The request is going somewhere else.

--> usb.cntl.BRequest

Defined by the USB standard, or vender unique

--> usb.cntl.WValue

General parameter unique to the transaction request

--> usb.cntl.WIndex

General parameter unique to the transaction request

--> usbReqCount Specifies the size of the data to transfer. If this is set to zero, no data transfer will occur in the data phase.

--> usbBuffer Points to the data to be transferred (kUSBOut request) or where data will end up (kUSBIn request). The buffer should be at least as big as the size specified in the usbReqCount field. If buffer is set to nil, no data is transferred in the data phase regardless of the value of length, setup and status still occur

<-- usbActCount Specifies the actual amount of data transferred on completion

--> usbFlags Should be set to 0, or kUSBNo5SecTimeout to disable the default 5-second timeout for control transactions. See “Transaction and Data Timeouts” for additional information about transaction timeouts.

In order to avoid the loss of data when transferring data from a device, `usbBuffer` and `usbReqCount` should be at least the MaxPacket size.

For additional information about the parameters specified for control transactions, see section 9 of the USB Specification.

The errors returned by the `USBControlRequest` function are

| | | |
|---|---|---|
| `kUSBUnknownDeviceErr` | `-6998` | `usbReference` does not refer to a current device |
| `kUSBRqErr` | `-6994` | the value in the `usbBMRequestType` field is not valid |
| `kUSBUnknownRequestErr` | `-6993` | request code for a standard USB call is not recognized |
| `kUSBInvalidBuffer` | | bad buffer specified |

## USBIntRead

The `USBIntRead` function queues an interrupt in transaction on the specified pipe. The device is periodically polled and the transaction completes when the device returns some data.

```
OSStatus USBIntRead(USBPB *pb);
```

Required fields in the `USBPB` parameter block for the `USBIntRead` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | The pipe reference returned by the `USBFindNextPipe` function |
| `--> usbReqCount` | Specifies the size of the data to transfer. If this is set to 0, anything but a zero length packet causes an error. A zero length buffer causes a zero length packet to be sent to the device. |
| `--> usbBuffer` | Points to a buffer to which the incoming data is transferred |
| `<-- usbActCount` | Specifies the actual amount of data transferred on completion |

| | |
|---|---|
| --> usbFlags | Should be set to 0 |

In order to avoid the loss of data when transferring data from a device, usbBuffer and usbReqCount should be a multiple of the value of the MaxPacketSize field, in the device's endpoint descriptor.

Errors returned by the USBIntRead function include

| | | |
|---|---|---|
| kUSBUnknownPipeErr | -6997 | pipe reference specified is unknown |
| kUSBIncorrectTypeErr | -6995 | pipe is not an interrupt pipes |
| kUSBPipeIdleErr | -6980 | specified pipe is in the idle state |
| kUSBPipeStalledErr | -6979 | specified pipe is stalled |

## USBIntWrite

The USBIntWrite function queues an interrupt transaction on the specified pipe. The device is periodically polled and the transaction completes when the device has accepted the data in usbActCount. Interrupt out transactions were introduced in version 1.1 of the USB Specification. This function is only available in version 1.2 and later of the Mac OS USB software.

```
OSStatus USBIntWrite(USBPB *pb);
```

Required fields in the USBPB parameter block for the USBIntRead function are

| | |
|---|---|
| --> pbLength | Length of parameter block |
| --> pbVersion | Parameter block version number |
| --> usbCompletion | The completion routine |
| --> usbRefcon | General-purpose value passed back to the completion routine |
| --> usbReference | The pipe reference returned by the USBFindNextPipe function, |
| --> usbReqCount | Specifies the size of the data to transfer, should be no longer than the MaxPacketSize of the endpoint |
| --> usbBuffer | Points to a buffer containing the outgoing data |
| <-- usbActCount | Specifies the actual amount of data transferred on completion |
| --> usbFlags | Should be set to 0 |

Errors returned by the `USBIntWrite` function include

| | | |
|---|---|---|
| `kUSBUnknownPipeErr` | `-6997` | pipe reference specified is unknown |
| `kUSBIncorrectTypeErr` | `-6995` | pipe is not an interrupt pipes |
| `kUSBPipeIdleErr` | `-6980` | specified pipe is in the idle state |
| `kUSBPipeStalledErr` | `-6979` | specified pipe is stalled |

## USBBulkRead

The `USBBulkRead` function can be used to request multiple bulk transactions on an inbound bulk pipe to fulfill the size of request specified, or for the entire transfer.

```
OSStatus USBBulkRead(USBPB *pb);
```

Required fields in the `USBPB` parameter block for the `USBBulkRead` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | The pipe reference returned by the USBFindNextPipe function |
| `--> usbReqCount` | Specifies the size of the data to transfer. Must be a multiple of the packet size. If it is not a multiple of the packet size, the last packet my overrun. If set to 0, any non-zero size transfer causes an error |
| `--> usbBuffer` | Points to a buffer to which the incoming data is transferred |
| `<-- usbActCount` | Specifies the actual amount of data transferred on completion |
| `--> usbFlags` | Should be set to 0 |

In order to avoid the loss of data when transferring data from a device, `usbBuffer` and `usbReqCount` should be a multiple of the endpoint `MaxPacketSize` in the device's endpoint descriptor. See also "Bulk Data Transfer Performance Issues" (page A-208).

If you want less data than `MaxPacketSize`, it is still advisable to make a `MaxPacketSize` request, because the device is not aware of the actual amount of

data requested, it just sees a request for more data. If `MaxPacketSize` is requested, any data transfer terminates the request. A short packet automatically terminates the request. If a request is made for `MaxPacketSize` and a `MaxPacketSize` size packet is returned, the transfer is also terminated, since the total amount of data requested is satisfied.

You should check the `usbActCount` field upon completion for the actual amount of data returned. If the value of `usbActCount` indicates that more or less data were returned than you expected, there may be a problem with your device. Requesting less than `MaxPacketSize` may cause a `kUSBOverRunErr` error to be returned if the device returns more data than was needed, in which case no data in the buffer is valid.

Errors returned by the `USBBulkRead` function include

| | | |
|---|---|---|
| `kUSBUnknownPipeErr` | `-6997` | pipe reference specified is unknown |
| `kUSBIncorrectTypeErr` | `-6995` | pipe reference is not a bulk-in pipe |
| `kUSBPipeIdleErr` | `-6980` | specified pipe is in the idle state |
| `kUSBPipeStalledErr` | `-6979` | specified pipe is stalled |
| `kUSBOverRunErr` | `-6908` | packet too large or more data than buffer |

## USBBulkWrite

The `USBBulkWrite` function requests multiple bulk out transactions on an outbound bulk pipe to fulfill the size of request specified.

```
OSStatus USBBulkWrite(USBPB *pb);
```

Required fields in the `USBPB` parameter block for the `USBBulkWrite` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | The pipe reference returned by the `USBFindNextPipe` or `USBSetConfiguration` functions |

| | |
|---|---|
| --> usbReqCount | Specifies the size of the data to transfer. If this is set to 0, no data transfer occurs, but the device senses a 0 length bulk transaction |
| --> usbBuffer | Points to the data to be transferred. The buffer should be at least as big as the size specified in the usbReqCount field. If the buffer is set to nil, no data is transferred regardless of the value of usbReqCount |
| <-- usbActCount | Specifies the actual amount of data transferred on completion |
| --> usbFlags | Should be set to 0 |

Errors returned by the USBBulkWrite function include

| | | |
|---|---|---|
| kUSBUnknownPipeErr | -6997 | pipe reference specified is unknown |
| kUSBIncorrectTypeErr | -6995 | pipe reference is not a bulk-out pipe |
| kUSBPipeIdleErr | -6980 | specified pipe is in the idle state |
| kUSBPipeStalledErr | -6979 | specified pipe is stalled |

## USBIsocRead

Isochronous data transfers are supported in version 1.2 and higher of the Mac OS USB software.

The USBIsocRead function supports isochronous read data transfers, and is defined as follows:

```
OSStatus USBIsocRead(USBIsocPB *pb);
```

Required fields in the isochronous version of the USBPB parameter block for the USBIsocRead function are

| | |
|---|---|
| --> pbLength | Length of parameter block |
| --> pbVersion | Parameter block version, must be kUSBIsocPBVersion for isochronous function calls |
| <--usbStatus | Aggregate status, see discussion in “Using the USBPB For Isochronous Transactions” |
| --> usbCompletion | The completion routine |
| --> usbRefcon | General-purpose value passed back to the completion routine |

| | |
|---|---|
| `--> usbReference` | The isochronous pipe reference returned by the `USBFindNextPipe` function |
| `--> usbReqCount` | Specifies the size of the data to transfer. May be any size, but no less than the sum of the individual packets sizes. If set to 0, any non-zero size transfer causes an error. |
| `--> usbBuffer` | Points to a buffer to which the incoming data is transferred |
| `<-- usbActCount` | Specifies the actual amount of data transferred on completion |
| `--> usbFlags` | Should be set to 0 |
| `--> usb.isoc.FrameList` | Pointer to the list of frame structures |
| `--> frReqCount` | Number of bytes requested for each packet |
| `<-- frStatus` | Status returned by packet |
| `<-- frActCount` | Actual bytes transferred by packet |
| `--> usb.isoc.NumFrames` | Number of frames (specified in the FrameList) to attempt transfers in |
| `--> usbFrame` | Frame number of the first frame to transfer data |

A complete discussion of how isochronous support is implemented and additional details about using the fields in the isochronous version of the USBPB parameter block can be found in “Using the USBPB For Isochronous Transactions” (page 5-89).

## USBIsocWrite

The `USBIsocWrite` function supports isochronous write transactions, and is defined as follows:

```
USBIsocWrite(USBIsocPB *pb);
```

Required fields in the isochronous version of the `USBPB` parameter block for the `USBIsocWrite` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version, must be `kUSBIsocPBVersion` for isochronous function calls |

| | |
|---|---|
| `<--usbStatus` | Aggregate status, see discussion in "Using the USBPB For Isochronous Transactions" |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | The isochronous pipe reference returned by the `USBFindNextPipe` or `USBSetConfiguration` functions |
| `--> usbReqCount` | Specifies the size of the data to transfer. If this is set to 0 in the `frReqCount` field in the frame structure, the call sends a packet size of 0. |
| `--> usbBuffer` | Points to the data to be transferred. The buffer should be at least as big as the size specified in the `usbReqCount` field. If the buffer is set to `nil`, no data is transferred regardless of the value of `usbReqCount` |
| `<-- usbActCount` | Specifies the actual amount of data transferred on completion |
| `--> usbFlags` | Should be set to 0 |
| `--> usb.isoc.FrameList` | Pointer to the list of frame structures |
| `--> frReqCount` | Number of bytes requested for each packet |
| `<-- frStatus` | Status returned by packet |
| `<-- frActCount` | Actual bytes transferred by packet |
| `--> usb.isoc.NumFrames` | Number of frames to attempt transfers in |
| `--> usbFrame` | Frame number of the first frame to transfer data |

A complete discussion of how isochronous support is implemented and additional details about using the fields in the isochronous version of the USBPB parameter block can be found in "Using the USBPB For Isochronous Transactions".

## Pipe State Control Functions

A pipe's state is governed by two factors:

- the state of the device's endpoint
- the USL's state

The USL state can be one of the following:

- Active: The pipe is open and can transmit data.
- Stalled: An error occurred on the pipe, no new transactions are accepted until the stall is cleared.
- Idle: The pipe will not accept any transactions.

A transaction error (errors -6915 to -6901) causes the pipe to enter the stalled state. The class driver can change the state of the pipe using the functions in this section.

Note that the pipe and interface control functions differ from most other USL calls in these two ways:

- They do not take a parameter block as a parameter.
- They complete synchronously. There is no facility for asynchronous completion.

Also note that pipe 0 to a device cannot be stalled. If a communication error happens on pipe 0, the stall is automatically cleared before the call completes. Thus some of these functions can affect a device's default pipe 0 and some can't. Those functions that operate on both the default pipe 0 and pipes other than pipe 0, take a device reference for the default pipe or a pipe reference for a specific pipe. Those functions that can't affect the default pipe, take only a pipe reference.

These calls can be used on a device's default pipe 0:

```
USBGetPipeStatusByReference
USBAbortPipeByReference
USBResetPipeByReference
```

These calls cannot be used on a device's default pipe 0:

```
USBClearPipeStallByReference
USBSetPipeIdleByReference
```

Except for entering the stalled state on an error, the USL does not keep track of the state of the device's endpoint. The class driver must keep track of the state of the endpoint.

## Data Toggle Synchronization

When a pipe is reset, aborted, or had a stall cleared, the expected data toggle on that pipe's endpoint is reset to data0. This means that the next packet read on that pipe may be discarded unless the device is told to synchronize its endpoint data toggle.

The method of synchronizing the endpoint for the device is device specific. In general, it should be possible to perform endpoint data toggle synchronization with a call to the `USBDeviceRequest` function addressed to the endpoint in question. A USB device request command of `CLEAR_FEATURE` and a feature selector of `ENDPOINT_STALL` should complete the required data toggle synchronization.

## USBGetPipeStatusByReference

The `USBGetPipeStatusByReference` function returns status on a specified pipe or the device's default pipe 0.

```
OSStatus USBGetPipeStatusByReference (
                    USBReference ref,
                    USBPipeState *state);
```

`--> ref` Pipe reference.

`<-- state` Returns the pipe state, it can be one of these constants:

| | |
|---|---|
| `kUSBActive` | Pipe can accept new transactions |
| `kUSBIdle` | Pipe cannot accept new transactions |
| `kUSBStalled` | An error occurred on the pipe |

If the status is not active (`kUSBActive`), a non-zero status code (`kUSBPipeIdleErr` or `kUSBPipeStalledErr`) is also returned. If any other error is returned, the `state` variable is not changed.

Returning a non-zero status when the call succeeds, can make using this function a little tricky. This can be simplified if the pipe `state` variable is preloaded with a value not returned by the function, for example -1. The pipe `state` variable can then be examined to see if there was an error or to determine what state the pipe is in.

Errors returned by the `USBGetPipeStateByReference` function include:

| | | |
|---|---|---|
| `noErr` | `0` | specified pipe is active |
| `kUSBUnknownPipeErr` | `-6997` | pipe reference specified is unknown |
| `kUSBPipeIdleErr` | `-6980` | specified pipe is in the idle state |
| `kUSBPipeStalledErr` | `-6979` | specified pipe is stalled |

In version 1.0 of the Mac OS USB software the `USBGetPipeStatusByReference` function does not operate as defined above. If the pipe is not active, it returns an error and the state is not set. The `USBGetPipeStatusByReference` function does work as defined in version 1.0.1 and later of the Mac OS USB software. If `noErr` is returned, the state is returned correctly. If 1.0 compatibility is desired, it can be worked around by examining the status returned. If this call returns an error, the error should be examined to see what state the pipe is in.

## USBAbortPipeByReference

The `USBAbortPipeByReference` function aborts operations on a specified pipe or the device's default pipe 0.

```
OSStatus USBAbortPipeByReference(USBReference ref);
```

`--> ref` Pipe reference, or device reference for implicit default pipe 0.

All outstanding transactions on the pipe are returned with a `kUSBAborted` status. The state of the pipe is not affected.

After this function is called, the device's endpoint needs to be synchronized with the host's endpoint. See "Data Toggle Synchronization" (page 5-124) for information about how to accomplish endpoint data toggle synchronization.

Errors returned by the `USBAbortPipeByReference` function include:

| | | |
|---|---|---|
| `kUSBUnknownPipeErr` | `-6997` | pipe reference specified is unknown |

## USBResetPipeByReference

The `USBResetPipeByReference` function resets the specified pipe or the device's default pipe 0.

```
OSStatus USBResetPipeByReference(USBReference ref);
```

`--> ref` Pipe reference, or device reference for implicit default pipe 0.

In version 1.2 and later of the Mac OS USB software, all outstanding transactions on the pipe are returned with a `kUSBAborted` status. The pipe status is set to active. The stalled and idle state are cleared.

After this function is called, the device's endpoint needs to be synchronized with the host's endpoint. See "Data Toggle Synchronization" (page 5-124) for information about how to accomplish endpoint data toggle synchronization.

**IMPORTANT**

For USB parameter block version 1.0, the implementation of `USBResetPipeByReference` does nothing if passed a real pipe reference. However, if the function is passed a non-existent pipe reference, it will corrupt low memory. Version 1.0.1 and later of the USB Services software corrects this problem.

Errors returned by the `USBRestPipeByReference` function include:

| | | |
|---|---|---|
| `kUSBUnknownPipeErr` | `-6997` | pipe reference specified is unknown |

In version 1.0 of the USB Services software, the pipe may or may not have been made active, depending on whether the pipe was previously stalled or not, and the `kUSBPipeIdleErr` is returned. If an idle pipe was not stalled, it is not affected. If an idle pipe was stalled, it is made active. In version 1.0.1 and later of the USB Services software this behavior is corrected.

In version 1.0 of the USB Services software, the `kUSBPipeStalledErr` is returned if the pipe was previously idle and the call succeeded despite the error. This behavior is not an error and `noErr` is returned in versions 1.0.1 and later of the USB Services software.

| | | |
|---|---|---|
| `kUSBPipeStalledErr` | `-6979` | pipe stalled, pipe is reset despite the error |

## USBClearPipeStallByReference

The `USBClearPipeStallByReference` function clears a stall on the specified pipe. This call can only be used on a pipe, not on a device's default pipe 0.

```
OSStatus USBClearPipeStallByReference(USBPipeRef ref);
```

`--> ref` Pipe reference.

All outstanding transactions on the pipe are returned with a `kUSBAborted` status. The pipe status is set to active; if the pipe was previously idle it is set back to idle. The stalled state is cleared, idle is not.

A call to this function does not clear a device's endpoint stall. The class driver has to take care of that by using USB standard device commands, such as `CLEAR_ENDPOINT_STALL`. The class driver may need to take other remedial actions.

After this function is called, the device's endpoint needs to be synchronized with the host's endpoint. See "Data Toggle Synchronization" for information about how to accomplish endpoint data toggle synchronization.

Errors returned by the `USBClearPipeStallByReference` function include:

| | | |
|---|---|---|
| `kUSBUnknownPipeErr` | `-6997` | pipe reference specified is unknown |
| `kUSBPipeIdleErr` | `-6980` | specified pipe is in the idle state |

## USBSetPipeIdleByReference

The `USBSetPipeIdleByReference` function sets a specified pipe to the idle state. This call can be used only on a specified pipe, not on a device's default pipe 0.

```
OSStatus USBSetPipeIdleByReference(USBPipeRef ref);
```

`--> ref` Pipe reference.

The state of the pipe is set to idle. No outstanding transactions are affected.

Errors returned by the `USBSetPipeIdleByReference` function include:

| | | |
|---|---|---|
| `kUSBUnknownPipeErr` | `-6997` | pipe reference specified is unknown |

In version 1.0 of the USB Services software, the following errors are returned if the pipe is not currently active. In these instances, the call has succeeded despite

the returned error. This behavior is not an error and `noErr` is returned in versions 1.0.1 and later of the USB Services software.

| | | |
|---|---|---|
| `kUSBPipeIdleStalled` | `-6979` | pipe was stalled, pipe is still active despite error |
| `kUSBPipeIdleErr` | `-6980` | specified pipe is in the idle state |

## USBSetPipeActiveByReference

The `USBSetPipeActiveByReference` function sets the state of a specified pipe to active.

```
OSStatus USBSetPipeActiveByReference(USBPipeRef ref);
```

`--> ref` Pipe reference.

The pipe status is set to active if the pipe is not stalled. The idle state is cleared, stalled is not.

Errors returned by the `USBSetPipeActiveByReference` function include:

| | | |
|---|---|---|
| `kUSBUnknownPipeErr` | `-6997` | pipe reference specified is unknown |
| `kUSBPipeIdleStalled` | `-6979` | pipe was stalled, pipe is set idle |

In version 1.0 of the USB Services software, the following error is returned if the pipe was previously idle. In this instance the call has succeeded despite the returned error. This behavior is not an error and `noErr` is returned in versions 1.0.1 and later of the USB Services software.

| | | |
|---|---|---|
| `kUSBPipeIdleErr` | `-6980` | pipe was previously idle, pipe is still made active |

## USBResetDevice

The `USBResetDevice` function resets a specified device. The port the device is attached to sends the reset signal for 10ms, as specified in the USB Specification. Following the reset signal, the device's USB address is set so that the USB device reference, `usbReference`, remains valid when the complettion routine is called. The reset does not affect any other devices on the bus, unless the device reset is a hub. However, only hub drivers should be concerned with hubs.

This function should be considered a last resort to bring a misbehaving device back on line. If a device is reset, the driver will have to reinstate the device configuration again, starting with getting a new interface reference. See “USBFindNextInterface” (page 5-98) for details.

```
OSStatus USBResetDevice(USBPB *pb);
```

Required fields in `USBPB` parameter block for the `USBResetDevice` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | Device reference |
| `--> usbFlags` | Set to 0 |

## USB Management Services Functions

The USL provides an interface to services provided by the USB Manager. These services make it so class drivers need only link against the USB Services library or Driver Services library.

The errors returned by the USB Management functions include:

| | | |
|---|---|---|
| `kUSBBadDispatchTable` | `-6950` | improper driver dispatch table |
| `kUSBUnknownNotification` | `-6949` | notification type not defined |
| `kUSBQueueFull` | `-6948` | internal queue full |

## USBExpertInstallDeviceDriver

The `USBExpertInstallDeviceDriver` function notifies the USB Manager that there is a device that needs a driver matched and loaded. Typically only hub drivers need the service provided by this function.

```
OSStatus USBExpertInstallDeviceDriver (
                    USBDeviceRef ref,
                    USBDeviceDescriptorPtr *descUSBReference hubRef,
                    UInt32 port,
                    UInt32 busPowerAvailable);
```

The `ref` parameter can be a device reference or an interface reference. Similarly the `desc` parameter can be a device or interface descriptor.

`--> ref` Device reference of the new device.

`--> desc` Device descriptor of the device to find a driver for. See also, "Device Descriptor Structure" (page 5-151)

`--> hubRef` The device reference of the parent hub of this device.

`--> port` The parent port of this device.

`busPowerAvailable`
How much current is available from the bus for the device, in 2 milliamperes (mA) units. This should have one of two values, 100mA (`kUSB100mAAvailable`) for a bus-powered hub parent and 500mA (`kUSB500mAAvailable`) for a self-powered parent. See "USB Power and Bus Attribute Constants" (page 5-150).

## USBExpertRemoveDeviceDriver

The `USBExpertRemoveDeviceDriver` function notifies the USB Manager that a device has been removed from the bus and that the class driver for that device needs to be terminated. Typically only hub drivers need the service provided by this function.

```
OSStatus USBExpertRemoveDeviceDriver(USBDeviceRef ref);
```

The `ref` parameter can be a device reference or an interface reference.

--> ref Device reference of the device removed from the bus.

## USBExpertInstallInterfaceDriver

The USBExpertInstallInterfaceDriver function notifies the USB Manager that a class driver needs to be loaded for the given interface of the given device. This function is used by class drivers that select configurations and interfaces. The drivers that use this functionality are typically composite class drivers.

```
OSStatus USBExpertInstallInterfaceDriver (
                    USBDeviceRef ref,
                    USBDeviceDescriptor *desc,
                    USBInterfaceDescriptor *interface,
                    USBReference hubRef,
                    UInt32 busPowerAvailable);
```

--> ref Device reference of device containing the interface.

--> desc Device descriptor of the interface to find a driver for. See also, “Device Descriptor Structure” (page 5-151)

--> interface Interface descriptor of interface to find a driver for. See also, “Interface Descriptor Structure” (page 5-152).

--> hubRef The device reference for the device containing this interface. Usually a device reference of a hub.

--> busPowerAvailable
How much current is available from the bus for the device, in 2 milliamperes (mA) units. This should have one of two values, 100mA for a bus-powered hub parent and 500mA for a self-powered parent.

### USBExpertRemoveInterfaceDriver

The `USBExpertRemoveInterfaceDriver` function notifies the USB Manager that a device has been removed from the bus and that the class driver needs to be disposed.

```
OSStatus USBExpertRemoveInterfaceDriver(USBInterfaceRef ref);
```

`--> ref` Interface reference from the removed device

## USB Time Utility Functions

This section describes the functions for managing time within the context of USB frames. A USB frame is approximately a 1 ms unit of time. Approximately, because it may vary a few bit times.

### USBDelay

The `USBDelay` function calls back through the normal completion mechanism when the specified number of frames have passed. There is up to an extra one frame delay to accommodate synchronizing with USB frames. For example, 0 frames delay means after the current frame, which could be up to 1 ms plus any other system delays.

```
OSStatus USBDelay(USBPB *pb);
```

Required fields in the `USBPB` parameter block for the `USBDelay` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | A device, interface, or pipe reference which associates the call with a device |
| `--> usbReqCount` | Number of frames to delay |

| | |
|---|---|
| <-- usbActCount | Frame number at completion of delay |
| --> usbFlags | Callback flag |

Setting the usbFlags parameter to kUSBTaskTimeFlag requests that a call back be made at task level, and thus the callback only occurs at task level, and never at secondary interrupt time. This potentially means that the delay could be extended. Using the task time mechanism requires that the rest of the system software cooperates and gives the USB software time.

The usbReqCount field specifies the number of frames to delay. A requested delay of kUSBNoDelay causes the call back to occur as soon as possible. When used in conjunction with the kUSBTaskTimeFlag flag, you can effect the quickest transition to task time.

It should be noted that the delay time requested is a minimum time. The actual delay time will never be less than the requested time, however it may be a longer delay depending upon other system activity. As noted in the previous discussion, using the kUSBTaskTimeFlag can cause the longest delays. Even if the kUSBTaskTimeFlag flag is not specified, the callback may be delayed if the USB Manager is not given time by the system.

The USBDelay function should not be used as a system-wide timing mechanism, since the time values are only relevant within the context of USB frames. The Mac OS USB software guarantees that only the specified number of frames will pass over the USB before the completion routine executes. It will never be less than the specified length of delay. Other activity affecting the system may determine how long it actually takes for a specified number of frames to pass. The functions in the Driver Services library provide accurate timing services for native drivers.

There must be a valid USBReference passed in the usbReference field of the parameter block. If a nil value or a reference that does not match an existing device, interface, or pipe is passed in, the call returns immediately with an unknown device error.

If the device associated with a call to the USBDelay function is unplugged and its driver removed while the function call is pending, the delay is cancelled and the function will not complete. In version 1.3 and later of the USB software, the delay will complete with a kUSBAbortedError if the kUSBReturnOnException flag is specified. Your finalize routine can assume that the delay is finished and safely dispose of the parameter block.

The `USBDelay` function returns the following errors:

| | | |
|---|---|---|
| `kUSBUnknownDeviceErr` | `-6998` | `usbReference` does not refer to a current device |
| `kUSBAbortedError` | `-6982` | Pipe aborted. This error is returned when a delay call is pending and the associated device is unplugged |

## USBGetFrameNumberImmediate

The `USBGetFrameNumberImmediate` function returns the current frame number for the specified device. The function completes synchronously and is the recommended function to use for making time calculations for a class driver. It can be called at any execution level. This function also supports multiple USB bus implementations.

```
OSStatus USBGetFrameNumberImmediate(USBPB *pb);
```

Required fields in the `USBPB` parameter block for the `USBGetFrameNumberImmediate` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | Device, interface, or endpoint reference |
| `--> usbReqCount` | Size of buffer (0 or size of UInt64) |
| `--> usbBuffer` | `Nil` or pointer to a UInt64 structure for full 64 bits of frame data. |
| `<-- usbActCount` | Size of data returned |
| `<-- usbFrame` | Low 32 bits of the current frame number |

In multiple USB bus configurations, each bus has an independent frame count. The `USBGetFrameNumberImmediate` function takes any device, interface, or endpoint reference as input and returns the current frame number for the bus on which that device, interface, or endpoint is connected.

The frame count for each bus is maintained internally by the USB software as a 64 bit value. The `USBGetNextFrameNumberImmediate` function allows a driver to get either the low 32 bits of this value in the parameter block, or the full 64 bit value in a UInt64 structure. To get the low 32 bits, specify a value of nil in `usbBuffer` and a value of 0 in `usbReqCount`. To get the full 64 bits, specify the size of the UInt64 structure in the `usbReqCount` field and pointer to an address of the structure in `usbBuffer`.

This function does not call the completion routine. However, a value is required in the `usbCompletion` field. `kUSBNoCallBack` can be specified as the completion routine.

The `USBGetNextFrameNumberImmediate` function returns the following error:

| | | |
|---|---|---|
| `kUSBUnknownDeviceErr` | `-6998` | `usbReference` does not refer to a current device |

## USB Memory Functions

The memory functions allow USB class drivers to allocate and deallocate memory. Since memory allocation must typically occur at task time, the memory functions will queue the request until task time is available, then allocate the memory and return asynchronously. These functions are the preferred way of specifying memory requirements, because they relieve the class driver from monitoring execution levels when performing memory management functions.

### USBAllocMem

The `USBAllocMem` function allocates a specified amount of memory.

```
OSStatus USBAllocMem(USBPB *pb);
```

Required fields in the `USBPB` parameter block for the `USBAllocMem` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |

| | |
|---|---|
| --> usbRefcon | General-purpose value passed back to the completion routine |
| --> usbReference | A device, interface, or pipe reference which associates the call with a device |
| --> usbReqCount | Amount of memory required to be allocated |
| <-- usbActCount | Amount of memory actually allocated |
| <-- usbBuffer | Memory allocated |
| --> usbFlags | Should be set to 0 |

There must be a valid USBReference passed in the usbReference field of the parameter block. If a nil value or a reference that does not match an existing device, interface, or pipe is passed in, the call returns immediately with an unknown device error.

If the device associated with this call is unplugged and its driver removed while this function call is pending, the function will not complete. In version 1.3 and later of the USB software, if the kUSBReturnOnException flag is specified, the delay completes with a kUSBAbortedError. Your finalize routine can assume that the delay is finished and safely dispose of the parameter block for this call.

The USBAllocMem function returns the following error:

| | | |
|---|---|---|
| kUSBUnknownDeviceErr | -6998 | usbReference does not refer to a current device |
| kUSBAbortedError | -6982 | Pipe aborted. This error is returned when the call is pending and the associated device is unplugged |

## USBDeallocMem

The USBDeallocMem function deallocates the memory allocated with the USBAllocMem function.

```
OSStatus USBDeallocMem(USBPB *pb);
```

Required fields in the USBPB parameter block for the USBDeallocMem function are:

| | |
|---|---|
| --> pbLength | Length of parameter block |
| --> pbVersion | Parameter block version number |
| --> usbCompletion | The completion routine |

| | |
|---|---|
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbReference` | A device, interface, or pipe reference which associates the call with a device |
| `<--> usbBuffer` | --> previously allocated memory to be deallocated<br><-- pointer set to nil |
| `--> usbFlags` | Should be set to 0 |

You can pass `kUSBNoCallBack` as the `usbCompletion` field parameter to notify the USL that you want the operation to complete immediately if at task time. It is an error to specify no call back, if the current execution level is not task time.

If the `usbCompletion` field is set to `kUSBNoCallBack`, the call back mechanism is not invoked, and the specified `usbReference` is not checked or used. This is useful for finalization routines which need to clean up immediately and can't wait for a callback routine to complete.

There must be a valid `USBReference` passed in the `usbReference` field of the parameter block. If a reference that does not match an existing device, interface, or pipe is passed in, the call returns immediately with an unknown device error.

If the device associated with this call is unplugged and its driver removed while this function call is pending, the function will not complete. In version 1.3 and later of the USB software, if the `kUSBReturnOnException` flag is specified, the delay completes with a `kUSBAbortedError`. Your finalize routine can assume that the delay is finished and safely dispose of the parameter block for this call.

The `USBDeAllocMem` function returns the following error:

| | | |
|---|---|---|
| `kUSBUnknownDeviceErr` | `-6998` | `usbReference` does not refer to a current device |
| `kUSBCompletionError` | `-6984` | `kUSBNoCallBack` was specified and current execution level is not task time |
| `kUSBAbortedError` | `-6982` | Pipe aborted. This error is returned when the call is pending and the associated device is unplugged |

## Byte Ordering (Endianism) Functions

There are several functions to deal with the differences in byte ordering between the Intel platform and Mac OS platform. The USB uses Intel byte

ordering (called little endian) on all multibyte fields, which is reversed from the Mac OS byte ordering (called big endian, because the most significant byte appears at the lowest memory address). These functions are of endian neutral form. Using these functions correctly allows the code to be recompiled on an Intel endian platform and still work as expected.

All parameters and parameter block elements are automatically swapped by the USB Services Library. These functions need be used only for data that the USL has no knowledge of. This includes all descriptors returned from the descriptor functions.

If you need to embed a 16-bit USB constant in your code, you can use this macro:

```
USB_CONSTANT16(x)
```

`x` The USB constant

This macro is only useful for the C or C++ programming languages.

## HostToUSBWord

The `HostToUSBWord` function changes the byte order of a value from big endian to little endian.

```
UInt16 HostToUSBWord(UInt16 value)
```

## HostToUSBLong

The `HostToUSBLong` function changes the byte order of a value from big endian to little endian.

```
UInt16 HostToUSBLong(UInt32 value)
```

### USBToHostWord

The `USBToHostWord` function changes the byte order of a value from little endian to big endian.

```
UInt16 USBToHostWord(UInt16 value)
```

If you need to embed a 16-bit USB constant in your code, you can use this macro:

```
USB_CONSTANT16(x)
```

`x` The USB constant

This macro is only useful for the C or C++ programming languages.

### USBToHostLong

The `USBToHostLong` function changes the byte order of a value from little endian to big endian.

```
UInt16 USBToHostLong(UInt32 value)
```

## USL Logging Services Functions

The USB Manager provides services to log status messages from drivers to aid in debugging and software development. The USL provides an interface to this service. When one of these messages is sent, it currently ends up in a buffer that the USB Prober utility knows how to read. Choose the USB Expert Log menu item in the USB Prober Window menu to look at the message.

## USBExpertStatus

The `USBExpertStatus` function sends a general message out to the user. No weight is attached to this message by the operating system.

```
OSStatus USBExpertStatus (
                    USBDeviceRef ref,
                    void *pointer,
                    UInt32 value);
```

`--> ref` Device reference for the device driver giving notification. The reference is for the purpose of displaying information only. Currently this reference is not validated.

`--> pointer` A pointer to a string to display. This value is a P-string.

`--> value` An arbitrary number to display.

## USBExpertStatusLevel

The `USBExpertStatus` function sets the value for the level of status messages sent to the USB Manager. These messages can be seen by the USB Prober application in the USB Expert Log window. For more information about the USB Expert Log window, see “USB Prober Features for Developers” (page 2-33).

```
OSStatus USBExpertStatusLevel (
                    UInt32 level,
                    USBDeviceRef ref,
                    char *status,
                    UInt32 value);
```

`level` The level to assign to the status message. Integers 1 through 5

| | |
|---|---|
| `kUSBStatusLevelFatal = 1` | Fatal errors. |
| `kUSBStatusLevelError = 2` | General errors that may or may not effect operation. |
| `kUSBStatusLevelClient = 3` | General driver messages. |
| `kUSBStatusLevelGeneral = 4` | Important messages generated by |

| | |
|---|---|
| | the USB Expert and USL. |
| `kUSBStatusLevelVerbose = 5` | General messages from the USB Expert and USL. |
| `ref` | Device reference for the device driver giving notification. The reference is for the purpose of displaying information only. Currently this reference is not validated. |
| `status` | A pointer to a string status message to display. This value is a P-string. |
| `value` | An arbitrary number to display. |

**Note**
The `USBExpertStatusLevel` function was added to the USL in Mac OS USB software version 1.2. Unless you weak link to this symbol, using this function prevents your driver from loading on systems running Mac OS USB software prior to version 1.2. ◆

## USBExpertFatalError

The `USBExpertFatalError` function is intended to inform the system of nonrecoverable errors in a class driver. Currently no action is taken when this message is received other than to add the message to the expert log. In the future it may cause a driver to be unloaded.

```
OSStatus USBExpertFatalError (
                    USBDeviceRef ref,
                    OSStatus status,
                    void *pointer,
                    UInt32 value);
```

| | |
|---|---|
| `--> ref` | Device reference for the device driver giving notification. |
| `--> status` | The error status that explains the failure. |
| `--> pointer` | A pointer to a error status string to display. This value is a P-string. |
| `--> value` | An arbitrary number to display. |

## USB Descriptor Functions

All of the USB configuration services were not fully implemented in earlier versions of the USL. USB configuration had to be performed manually by the class driver. To make this process less cumbersome, configuration descriptor parsing functions were provided. These functions are still available, and some sample drivers may use them, but it is recommended that you use the configuration services described in "USL Functions" (page 5-96).

The immediate functions (those that end with `Immediate` in the function name) may be used repeatedly with the same parameter block to search for interface and endpoint descriptors.

### USBGetFullConfigurationDescriptor

The `USBGetFullConfigurationDescriptor` function returns the entire block of configuration data from the specified device and any associated descriptors, which includes interface and endpoint descriptors, and all of the information that pertains to them. The configuration data returned by the `USBGetFullConfigurationDescriptor` function is suitable for use with the `USBFindNextInterfaceDescriptorImmediate` and the `USBFindNextEndpointDescriptorImmediate` functions.

```
OSStatus USBGetFullConfigurationDescriptor(USBPB *pb)
```

Required fields in the `USBPB` parameter block for the `USBGetFullConfigurationDescriptor` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `--> usbFlags` | Should be set to 0 |
| `--> usbReference` | Device reference |
| `--> usb.cntl.WValue` | Configuration index |
| `<-- usbBuffer` | Points to a configuration descriptor structure |

`<-- usbActCount` Size of descriptor returned

The `USBGetFullConfigurationDescriptor` function determines the size of a full configuration descriptor, including all interface and endpoint descriptors for a given configuration, allocates memory for the configuration descriptor, and reads all the descriptors in.

You don't pass the `USBGetFullConfigurationDescriptor` function a buffer pointer, the function allocates one and passes a pointer back in the `usbBuffer` field of the parameter block. The memory for the configuration descriptor must be deallocated when the information is no longer needed. The `USBDeallocMem` function should be used in the class driver's finalize routine for deallocating memory and disposing of the descriptor.

The `USBGetFullConfigurationDescriptor` function is unusual in that it takes a configuration index in the `usb.cntl.WValue` field rather than a configuration value. The configuration value is found in the configuration descriptor, and is not available until the descriptor has been read. The configuration index refers to the 1st, 2nd, 3rd, or greater configuration descriptor in a device by specifying 0, 1, 2, or greater respectively. The configuration index is independent of the configuration value found in the configuration descriptor. The configuration value is used as an input parameter to set the configuration for a device.

Currently there are no other functions in the USB configuration services that provide the same functionality as the `USBGetFullConfigurationDescriptor` function. Configuration descriptors can be retrieved using the `USBGetConfigurationDescriptor` function, but the driver has to find the length of the configuration descriptor and allocate the memory for the descriptor when calling the function. Specific types of descriptors can be found with the `USBFindNextAssociatedDescriptor` function.

Once you have obtained the configuration descriptor, you need to find the interface you're interested in within the configuration descriptor by using the `USBFindNextInterfaceDescriptorImmediate` function.

## USBFindNextInterfaceDescriptorImmediate

The `USBFindNextInterfaceDescriptorImmediate` function returns the address to the next interface descriptor in a specified configuration descriptor.

```
OSStatus USBFindNextInterfaceDescriptorImmediate(USBPB *pb)
```

Required fields in the `USBPB` parameter block for the `USBFindNextInterfaceDescriptorImmediate` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |
| `--> usbRefcon` | General-purpose value passed back to the completion routine |
| `<--> usbBuffer` | --> Configuration descriptor<br><-- Interface descriptor |
| `--> usbFlags` | Should be set to 0 |
| `<-- usbActcount` | Length of interface descriptor found |
| `<--> usbReqCount` | --> 0, This should be set to 0 the first time the call is made. Otherwise, the value from the last call should be left alone.<br><-- Offset of this descriptor from the start of the configuration descriptor |
| `<--> usbClassType` | --> Class; 0 matches any class<br><-- Class value for interface found |
| `<--> usbSubclass` | --> Subclass; 0 matches any subclass<br><-- Subclass value for interface found |
| `<--> usbProtocol` | --> Protocol; 0 matches any protocol<br><-- Protocol value for interface found |
| `<--> usb.cntl.WValue` | --> 0<br>Configuration number: If more than one interface is described in the configuration descriptor, this field specifies the absolute number of the interface in the list. |
| `<-- usb.cntl.WIndex` | Interface number |
| `<-- usbOther` | Alternate interface |

The `usbReqCount` field should be set to 0 for the first iteration of this call. For each subsequent call to the `USBFindNextInterfaceDescriptorImmediate` function, `usbReqCount` contains the offset of the current interface descriptor from the beginning of the configuration descriptor.

The `usbBuffer` field should be assigned the address of the start of the configuration descriptor obtained from a call to the `USBGetFullConfigurationDescriptor` function. This must be the full

configuration descriptor returned by `USBGetFullConfigurationDescriptor`. The `usbBuffer` is assigned a pointer to the next interface descriptor within the specified configuration for each subsequent call to the `USBFindNextInterfaceDescriptorImmediate` function.

The `usbClass`, `usbSubclass`, and `usbProtocol` fields should contain either specific class, subclass, and protocol numbers, or contain 0 to use for a wildcard search if the caller wants to find an interface regardless of these fields. Upon return, these fields contain the class, subclass, and protocol values for the next interface found. If the caller wants to perform a wildcard search again, the wildcard values must be reset, because these fields are filled in with the returned values from the last call.

Once you've found an interface in the device, you need to find the endpoints that make up that interface.

If no interface is found that matches the requested interface, `kUSBNotFound` is returned.

The errors returned by the `USBFindNextInterfaceDescriptorImmediate` function include:

| | |
|---|---|
| `kUSBNotFound` | interface specified is not in configuration |
| `kUSBInternalErr`, `paramErr` | not a valid configuration descriptor |

## USBFindNextEndpointDescriptorImmediate

The `USBFindNextEndpointDescriptorImmediate` function returns the address to the next endpoint descriptor in a configuration descriptor that follows a specified interface descriptor. This is a synchronous call.

```
OSStatus USBFindNextEndpointDescriptorImmediate(USBPB *pb)
```

Required fields in the `USBPB` parameter block for the `USBFindNextEndpointDescriptorImmediate` function are

| | |
|---|---|
| `--> pbLength` | Length of parameter block |
| `--> pbVersion` | Parameter block version number |
| `--> usbCompletion` | The completion routine |

| | |
|---|---|
| --> usbRefcon | General-purpose value passed back to the completion routine |
| <--> usbFlags | --> Direction of endpoint (kUSBIn, kUSBOut, or kUSBAnyDirn)<br><-- Direction is returned here if kUSBAnyDirn is used in the usbClassType field. Note that if kUSBAnyDirn is specified, this field is altered on the calls return. If you want to make another call to find an endpoint of any direction, kUSBAnyDirn must be specified again. Direction is also returned if kUSBIn or kUSBOut are specified. It will however, be the same value as that passed in. |
| <--> usbBuffer | --> Interface descriptor on the first call, points to an endpoint descriptor on subsequent calls<br><-- Endpoint descriptor |
| <--> usbReqCount | Offset of interface or endpoint descriptor in configuration descriptor |
| <-- usbActcount | Length of endpoint descriptor found |
| <--> usbClassType | --> Specific endpoint type, or kUSBAnyType as wildcard<br><-- Endpoint type |
| <--> usbOther | --> Endpoint number, always pass 0 unless you want to match a specific endpoint number.<br><-- Next matching endpoint is returned |
| <-- usb.cntl.WValue | Maximum packet size of endpoint |

The usbBuffer should be assigned the address of the start of the interface descriptor obtained from a call to the USBFindNextInterfaceDescriptorImmediate function. For each subsequent call to USBFindNextEndpointDescriptorImmediate, usbBuffer is assigned a pointer to the next endpoint descriptor within the specified interface.

The errors returned by the USBFindNextEndpointDescriptorImmediate function include:

| | | |
|---|---|---|
| kUSBNotFound | -6987 | endpoint specified is not in configuration |
| kUSBInternalErr, paramErr | -6999 | not a valid configuration descriptor |

# Deprecated Pipe Functions

The `USBOpenPipe` and `USBClosePipeByReference` functions have been deprecated from the current Mac OS USB API. Use of these functions is not supported for future compatibility. Some of the old code samples in the Mac OS USB DDK used the `USBOpenPipe` and `USBClosePipeByReference` functions.

If you want your code to be compatible with future versions of the Mac OS USB software, use the functions defined in "USB Configuration Functions" (page 5-97) to configure a device interface and discover a pipe.

# Constants and Data Structures

This section lists the constants and data structures used by the USL. Always check the USB.h header file for the current version of the constants and structures that support Mac OS USB driver development.

## USB Constants

The constants recognized by the USL are listed in this section.

### Parameter Block Constants

```
kUSBCurrentPBVersion    = 0x0100            /* version 1.00*/
kUSBIsocPBVersion       = 0x0109            /* version 1.10*/
kUSBCurrentHubPB        = kUSBIsocPBVersion
```

## Endpoint Type Constants

```
kUSBControl     = 0
kUSBIsoc        = 1
kUSBBulk        = 2
kUSBInterrupt   = 3
kUSBAnyType     = 0xff
```

## usbBMRequest Direction Constants

```
kUSBOut         = 0     /* Data is transfered to the device */
kUSBIn          = 1     /* Data is transfered to the host */
kUSBNone        = 2     /* No data is transfered */
kUSBAnyDirn     = 3     /* Any direction */
```

## usbBMRequestType Type Constants

```
kUSBStandard    = 0
kUSBClass       = 1
kUSBVendor      = 2
```

## usbBMRequest Recipient Constants

```
kUSBDevice      = 0
kUSBInterface   = 1
kUSBEndpoint    = 2
kUSBOther       = 3
```

## usbBRequest Constants

```
kUSBRqGetStatus     = 0
kUSBRqClearFeature  = 1
kUSBRqReserved1     = 2
kUSBRqSetFeature    = 3
kUSBRqReserved2     = 4
kUSBRqSetAddress    = 5
kUSBRqGetDescriptor = 6
```

```
    kUSBRqSetDescriptor = 7
    kUSBRqGetConfig     = 8
    kUSBRqSetConfig     = 9
    kUSBRqGetInterface  = 10
    kUSBRqSetInterface  = 11
    kUSBRqSyncFrame     = 12
```

## Interface Constants

```
    kUSBHIDInterfaceClass       = 0x03
    kUSBNoInterfaceSubClass     = 0x00
    kUSBBootInterfaceSubClass   = 0x01
```

## Interface Protocol Constants

```
    kUSBNoInterfaceProtocol         = 0x00
    kUSBKeyboardInterfaceProtocol   = 0x01
    kUSBMouseInterfaceProtocol      = 0x02
```

## Driver Class Constants

```
    kUSBCompositeClass      = 0,
    kUSBAudioClass          = 1
    kUSBCOMMClass           = 2,
    kUSBHIDClass            = 3,
    kUSBDisplayClass        = 4,
    kUSBPrintingClass       = 7
    kUSBMassStorageClass    = 8
    kUSBHubClass            = 9,
    kUSBDataClass           = 10
    kUSBVenderSpecificClass = 0xFF
};
```

## Descriptor Type Constants

```
kUSBDeviceDesc      = 1
kUSBConfDesc        = 2
kUSBStringDesc      = 3
kUSBInterfaceDesc   = 4
kUSBEndpointDesc    = 5
kUSBHIDDesc         = 0x21
kUSBReportDesc      = 0x22
kUSBPhysicalDesc    = 0x23
kUSBHUBDesc         = 0x29
```

## Pipe State Constants

```
kUSBActive      = 0,    /* Pipe can accept new transactions*/
kUSBIdle        = 1,    /* Pipe cannot accept new transactions*/
kUSBStalled     = 2     /* An error occured on the pipe*/
```

## USB Power and Bus Attribute Constants

```
kUSB100mAAvailable  = 50
kUSB500mAAvailable  = 250
kUSB100mA           = 50
kUSBAtrBusPowered   = 0x80
kUSBAtrSelfPowered  = 0x40
kUSBAtrRemoteWakeup = 0x20
```

## Driver File and Resource Types

```
kServiceCategoryUSB                 = FOUR_CHAR_CODE('usb ')
kUSBTypeIsHub                       = FOUR_CHAR_CODE('hubd')
kUSBTypeIsHID                       = FOUR_CHAR_CODE('HIDd')
kUSBTypeIsDisplay                   = FOUR_CHAR_CODE('disp')
kUSBTypeIsModem                     = FOUR_CHAR_CODE('modm')
kUSBDriverFileType                  = FOUR_CHAR_CODE('ndrv')
kUSBDriverRsrcType                  = FOUR_CHAR_CODE('usbd')
kUSBShimRsrcType                    = FOUR_CHAR_CODE('usbs')
kTheUSBDriverDescriptionSignature   = FOUR_CHAR_CODE('usbd')
```

### Driver Loading Option Constants

```
kUSBDoNotMatchGenericDevice = 0x00000001,   /* Driver's VendorID */
                                            /* must match Device's */
                                            /* VendorID*/
kUSBDoNotMatchInterface = 0x00000002,       /* Do not load this driver */
                                            /* as an interface driver.*/
kUSBProtocolMustMatch = 0x00000004,         /* Do not load this driver */
                                            /* if protocol field */
                                            /* doesn't match.*/
kUSBInterfaceMatchOnly = 0x00000008         /* Only load this driver */
                                            /* as an interface driver.*/
```

### Error Status Level Constant

```
kUSBStatusLevelFatal    = 1,
kUSBStatusLevelError    = 2,
kUSBStatusLevelClient   = 3,
kUSBStatusLevelGeneral  = 4,
kUSBStatusLevelVerbose  = 5
```

## USB Data Structures

These are the data structures defined by the USL for USB device and driver descriptors. The current definitions can also be found in the USB.h file.

### Device Descriptor Structure

The USB device descriptor is of this form:

```
struct USBDeviceDescriptor {
    UInt8       length;             /* Length of this descriptor */
    UInt8       descType;
    UInt16      usbRel;
    UInt8       deviceClass;
    UInt8       deviceSubClass;
    UInt8       protocol;
    UInt8       maxPacketSize;
    UInt16      vendor;
```

```
    UInt16      product;
    UInt16      devRel;
    UInt8       manuIdx;
    UInt8       prodIdx;
    UInt8       serialIdx;
    UInt8       numConf;
    UInt16      descEnd;
};
```

Additional information about valid values for the fields in `USBDeviceDescriptor` structure can be found in the USB specifications.

## Configuration Descriptor Structure

The USB device configuration descriptor is of this form:

```
struct USBConfigurationDescriptor {
    UInt8       length;
    UInt8       descriptorType;
    UInt16      totalLength;
    UInt8       numInterfaces;
    UInt8       configValue;
    UInt8       configStrIndex;
    UInt8       attributes;
    UInt8       maxPower;
};
```

## Interface Descriptor Structure

The USB device interface descriptor is of this form:

```
struct USBInterfaceDescriptor {
    UInt8       length;
    UInt8       descriptorType;
    UInt8       interfaceNumber;
    UInt8       alternateSetting;
    UInt8       numEndpoints;
    UInt8       interfaceClass;
    UInt8       interfaceSubClass;
```

```
    UInt8       interfaceProtocol;
    UInt8       interfaceStrIndex;
};
```

## Endpoint Descriptor Structure

The USB device endpoint descriptor is of this form:

```
struct USBEndPointDescriptor {
    UInt8       length;
    UInt8       descriptorType;
    UInt8       endpointAddress;
    UInt8       attributes;
    UInt16      maxPacketSize;
    UInt8       interval;
};
```

## HID Descriptor Structure

The USB HID descriptor is of this form:

```
struct USBHIDDescriptor {
    UInt8       descLen;
    UInt8       descType;
    UInt16      descVersNum;
    UInt8       hidCountryCode;
    UInt8       hidNumDescriptors;
    UInt8       hidDescriptorType;
    UInt8       hidDescriptorLengthLo;
    UInt8       hidDescriptorLengthHi;
};
```

## HID Report Descriptor Structure

The USB HID report descriptor is of this form:

```
struct USBHIDReportDesc {
    UInt8       hidDescriptorType;
    UInt8       hidDescriptorLengthLo;
    UInt8       hidDescriptorLengthHi;
};
```

# USL Error Codes

Error codes returned by the USL are in the range -6900 to -6999 as listed in Table 5-2.

**Table 5-2** Error definitions

| Error constant | Number | Definition |
|---|---|---|
| kUSBNoErr | 0 | No error occurred |
| kUSBInternalErr | -6999 | Internal error |
| kUSBUnknownDeviceErr | -6998 | Device reference not recognized |
| kUSBUnknownPipeErr | -6997 | Pipe reference not recognized |
| kUSBTooManyPipesErr | -6996 | Too many pipes |
| kUSBIncorrectTypeErr | -6995 | Incorrect type specified |
| kUSBRqErr | -6994 | Request error |
| kUSBUnknownRequestErr | -6993 | Unknown request |
| kUSBTooManyTransactionsErr | -6992 | Too many transactions |
| kUSBAlreadyOpenErr | -6991 | Device already open |
| kUSBNoDeviceErr | -6990 | No device |
| kUSBDeviceErr | -6989 | Device error |
| kUSBOutOfMemoryErr | -6988 | Out of memory |
| kUSBNotFound | -6987 | USB not found |
| kUSBPBVersionError | -6986 | Wrong parameter block version |
| kUSBPBLengthError | -6985 | pbLength too small |
| kUSBCompletionError | -6984 | No completion routine specified |
| kUSBFlagsError | -6983 | Flags not initialized to 0 |
| kUSBAbortedError | -6982 | Pipe aborted |
| kUSBNoBandwidthError | -6981 | Not enough bandwidth available |

**Table 5-2** Error definitions

| Error constant | Number | Definition |
|---|---|---|
| kUSBPipeIdleError | -6980 | Pipe is idle; it cannot accept transactions |
| kUSBPipeStalledError | -6979 | Pipe has stalled; it cannot be used until the error is cleared with a USBClearPipeStallByReference call |
| kUSBUnknownInterfaceErr | -6978 | Interface reference not recognized |
| kUSBDeviceBusy | -6977 | Device is already being configured |
| kUSBDevicePowerProblem | -6976 | Device has a power problem |
| kUSBInvalidBuffer | -6975 | Bad buffer, usually nil |
| kUSBDeviceSuspended | -6974 | Device is suspended |
| kUSBDeviceNotSuspended | -6973 | Device is not suspended for resume |
| kUSBDeviceDisconnected | -6972 | Disconnected during suspend or reset |
| kUSBTimedOut | -6971 | Transaction timed out. See “Transaction and Data Timeouts,” for additional details |
| kUSBBadDispatchTable | -6950 | Improper driver dispatch table |
| kUSBUnknownNotification | -6949 | Notification type not defined |
| kUSBQueueFull | -6948 | Internal queue full |
| kUSBLinkErr | -6916 | Link error |
| kUSBCRCErr | -6915 | Pipe stall: bad CRC |
| kUSBBitstufErr | -6914 | Pipe stall: bitstuffing |
| kUSBDataToggleErr | -6913 | Pipe stall: bad data toggle |
| kUSBEndpointStallErr | -6912 | Device didn’t understand |
| kUSBNotRespondingErr | -6911 | Pipe stall, no device, or device hung |

**Table 5-2** Error definitions

| Error constant | Number | Definition |
|---|---|---|
| kUSBPIDCheckErr | -6910 | Pipe stall: PID CRC error |
| kUSBWrongPIDErr | -6909 | Pipe stall: Bad or wrong PID |
| kUSBOverRunErr | -6908 | Packet too large or more data than buffer |
| kUSBUnderRunErr | -6907 | Less data than buffer |
| kUSBBufOvrRunErr | -6904 | Host hardware failure on data in |
| kUSBBufUnderRunErr | -6903 | Host hardware failure on data out |
| kUSBNotSent1Err | -6902 | Transaction not sent |
| kUSBNotSent2Err | -6901 | Transaction not sent |

CHAPTER 6

# USB Manager Reference

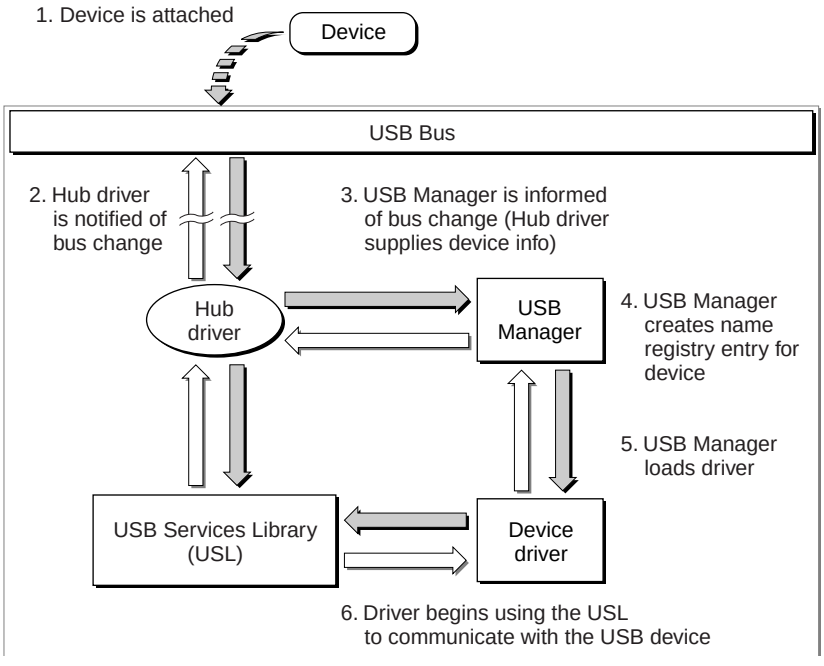
The USB Manager API is described in this chapter.

# Overview

The USB Manager maintains a database of all the currently connected devices that communicate using the USB protocol. Whenever a device is added to the USB, it is the responsibility of the USB Manager to register the device with the Name Registry and load the device's driver software. In the event of a device being removed, the USB Manager must ensure that the driver is removed cleanly from the system and all references to the device in the Name Registry are removed.

Figure 6-1 depicts the sequence of events that the USB Manager participates in when a device is added to the USB.

**Figure 6-1** Device addition event sequence on the USB



The USB Manager consists of native code fragments wrapped in a file of type 'expt'. A complete description of code fragments and the mechanisms for dealing with them in applications can be found in *Inside Macintosh: Power PC System Software, Chapter 3, "Code Fragment Manager."*

During the Macintosh boot sequence, the USB Manager is loaded immediately following all native drivers ('ndrv') and before generic INIT files. The USB Manager resides in the Mac OS ROM file, or in the case of machines without built-in USB ports, the USB Support extension in the Extensions folder.

The USB Manager is responsible for the following services which support the USB architecture.

- Maintain USB topology in database: keep updated information about the USB in the Name Registry and dynamically update the information as devices are added or removed from the bus.
- Provide access functions for database information: Device information needed by either the USL or a device driver should be accessible via the USB Manager.
- Generate unique opaque bus reference, a USBBusRef defined is a USBReference (SInt32), when a root hub is detected / loaded. For possible future use, a unique bus reference is generated by the USB Manager for each instantiated root hub. Every device record stores the bus reference of the bus.

# USB Manager API

This section describes the data structures and functions supported by the USB Manager API. In this chapter functions refers to the function declarations for the APIs rather than functions within USB devices.

Prototypes for all functions and definitions of other related data types are in the USB.h header file. The file is typically found in the includes folder.

## Topology Database Access Functions

The functions for getting information about the USB topology are defined in this section.

## Getting Device Descriptors

The `USBGetDeviceDescriptor` function returns a pointer to the device descriptor of the specified device reference.

```
OSStatus USBGetDeviceDescriptor (
                    USBDeviceRef *deviceRef,
                    USBDeviceDescriptor *deviceDescriptor,
                    UInt32 size);
```

`--> deviceRef` A pointer to the allocated device reference for which you want the device descriptor.

`<-- deviceDescriptor`
A pointer to the device descriptor.

`--> size` Size of the descriptor. If the descriptor that is returned is larger than the requested size, a `kUSBOverRunErr` is returned and only the first size bytes of the descriptor are filled in.

## Getting Interface Descriptors

The `USBGetInterfaceDescriptor` function returns a pointer to the interface descriptor of supplied interface reference.

```
OSStatus USBGetInterfaceDescriptor (
                    USBInterfaceRef *interfaceRef,
                    USBInterfaceDescriptor *InterfaceDescriptor,
                    UInt32 size);
```

`--> interfaceRef`
A pointer to the allocated interface reference for which you want the interface descriptor.

`<-- interfaceDescriptor`
A pointer to the device interface descriptor.

`--> size` Size of the descriptor. If the descriptor that is returned is larger than the requested size, a `kUSBOverRunErr` is returned and only the first size bytes of the descriptor are filled in.

## Finding The Driver For A Device By Class

The `USBGetNextDeviceByClass` function returns a class driver reference for the class driver matching the specified device class and optionally the device subclass for that device. This function also works with interface references.

```
OSStatus USBGetNextDeviceByClass (
                    USBDeviceRef *deviceRef,
                    CFragConnectionID *connID,
                    UInt16 theClass,
                    UInt16 theSubClass,
                    UInt16 theProtocol);
```

`<--> deviceRef`
: A pointer to the device or interface driver reference for the device or interface class specified.

`<-- connID`
: A pointer to the device connection ID.

`--> theClass`
: A number representing the device or interface class for which you want a compatible class driver. You can pass in `kUSBAnyClass` as a wildcard value. See the USB Specification for the device and interface class descriptions and identifiers.

`--> theSubClass`
: A number representing the device or interface sub class for which you want a compatible class driver. You can pass in `kUSBAnySubClass` as a wildcard value. See the USB Specification for the device and interface subclass descriptions and identifiers.

`--> theProtocol`
: A number representing the device or interface protocol for which you want a compatible class driver. You can pass in `kUSBAnyProtocol` as a wildcard value. See the USB Specification for the device and interface protocol descriptions and identifiers.

The `USBGetNextDeviceByClass` function returns a pointer to the next `usbDeviceRef` for a class driver matching the specified `deviceClass` and (optionally) `deviceSubClass` and `deviceProtocol` parameters. Pass `kNoDeviceRef` for the `deviceRef` parameter to begin, then pass the returned device reference for subsequent searches.

An OSStatus error of -43 is returned if a device cannot be found with the specified parameters. The device reference, `deviceRef`, returns unchanged if no subsequent match is made. The typical way to find all similar devices is to keep

calling the USBGetNextDeviceByClass function until the status value changes from noErr. At that point, the deviceRef is officially undefined.

The driver descriptor structure must have the same class and subclass codes as the codes for the device that is specified in the function call. This is particularly important for vendor specific devices, since the correct driver for the device would not typically load if the class and subclass codes don't match those for the device.

If you are developing a device and the USBGetNextDeviceByClass function isn't finding the requested device, be sure that the driver descriptor structure for your device driver has the same class and subclass codes as the device.

Constants are defined for the device class, subclass, protocol, vendor, and product identifiers which you can pass as wildcard values in the functions USBGetNextDeviceByClass and USBInstallDeviceNotification (page 6-169).

| Constant | Value | Description |
|---|---|---|
| kUSBAnyClass | 0xffff | Pass in as a wildcard in the deviceClass parameter or usbClass field in the device notification parameter block. |
| kUSBAnySubClass | 0xffff | Pass in as a wildcard in the deviceSubClass parameter or usbSubClass field in the device notification parameter block |
| kUSBAnyProtocol | 0xffff | Pass in as a wildcard in the deviceProtocol parameter or usbProtocol field in the device notification parameter block |
| kUSBAnyVendor | 0xffff | Pass in as a wildcard in the usbVendor field in the device notification parameter block. |
| kUSBAnyClass | 0xffff | Pass in as a wildcard in the usbProduct field in the device notification parameter block |

**Note**
In USB version 1.0.1 (the iMac update 1.0) a bug prevented correct searches if usbClass, usbSubclass, and usbProtocol were equal 0 and kNoDeviceRef is used for the deviceRef. This behavior is not present in version 1.1 and greater of the Mac OS USB software.

## Getting The Connection ID For Class Driver

The `USBGetDriverConnectionID` function returns a pointer to the connection ID, `CFragConnectionID`, of the driver referenced by the device or interface reference.

```
OSStatus USBGetDriverConnectionID (
                    USBDeviceRef *deviceRef,
                    CFragConnectionID *connID);
```

`--> deviceRef` A pointer to the device or interface reference for which you want a connection ID.

`<-- connID` A pointer to the connection ID.

This function can be used to get the code fragment connection ID of a device driver or interface driver. An example of its use in a application would be to locate and display information about a device driver. You could use the `USBGetDriverConnectionID` function to get the connection ID, and then pass the connection ID to the `FindSymbol` function, defined in *Inside Macintosh: Power PC System Software, Chapter 3, "Code Fragment Manager,"* to locate the address of the `pTheUSBDriverDescription` structure, which contains the USB driver description information.

Here's a code snippet showing the basic idea. This snippet does not include any error or system zone checking code, which the driver would have to supply.

```
USBGetDriverConnectionID(&theDeviceRef, &connID);
FindSymbol (connID, "\pTheUSBDriverDescription",
            (Ptr *)&pTheUSBDriverDescription, &symClass);
sprinf((char *)buf, "Driver Description Version:. 0x%04x",
            pTheUSBDriverDescription->usbDriverDescVersion);
```

## Getting The Bus Reference For a Device

The `USBDeviceRefToBusRef` function returns a pointer to the bus reference for the device specified with a device reference.

```
OSStatus USBDeviceRefToBusRef (
                    USBDeviceRef *deviceRef,
                    USBBusRef *busRef);
```

`--> deviceRef` A pointer to an already established device reference for which you want the bus reference.

`<-- busRef` A pointer to the bus reference.

## Passing Messages To Another Driver

The `USBDriverNotify` function supports message passing between drivers.

```
OSStatus USBDriverNotify (
                    USBReference reference,
                    USBDriverMessage mesg,
                    UInt32 refcon,
                    USBDriverNotificationCallbackPtr callback);
```

`--> reference` A `USBReference` for the recipient driver.

`--> mesg` The message to pass to the recipient driver

`--> refcon` General reference value passed the completion routine for use by the driver.

`--> callback` A pointer to a callback function.

Drivers call the `USBDriverNotify` function with the USB reference of the recipient driver, a message, a refcon, and an optional pointer to a callback function. The USB Manager locates the recipient driver based on the supplied reference and passes the message on by calling the `USBDeviceNotificationCallbackProc` for recipient driver, if it has a notification proc. Possible message constants are:

```
kNotifySystemSleepRequest = 0x00000001,
kNotifySystemSleepDemand = 0x00000002,
kNotifySystemSleepRevoke = 0x00000003
kNotifyHubEnumQuery = 0x00000006,
kNotifyChildMessage = 0x00000007,
kNotifyExpertTerminating = 0x00000008,
kNotifyDriverBeingRemoved = 0x0000000B
```

The sleep notification messages `kNotifySystemSleepRequest` and `kNotifySystemSleepDemand` are the same on any power-managed system. On PowerBook models, the processor and I/O subsystems are turned off when the machine goes to sleep. Because the USB is part of the I/O subsystem on PowerBooks with built-in USB or USB on a PC Card, the sleep state does effect USB drivers. Desktop Macintosh computers do not see these messages, since the processor and network I/O subsystems on desktop models remain active during system sleep.

When a PowerBook computer with Mac OS USB software version 1.2 or later goes to sleep, the USB Manager sends any active USB drivers the `kNotifySystemSleepDemand` message and then unloads the driver just like a disconnect (hot unplug). When the PowerBook wakes up, the USB software re-enumerates the USB and appropriate drivers are loaded for any USB devices found on the bus.

## Receiving A Message From A Child Driver

The `USBExpertNotifyParent` function allows a child driver to send a message to its parent driver.

```
USBExpertNotifyParent (
                    USBReference reference,
                    void * pointer);
```

`--> reference` The USB reference for the calling child driver.

`--> pointer` A pointer to a privately defined message for the parent driver.

If a parent driver has its `USBDeviceNotificationCallbackProc` called with a `kNotifyChildMessage`, then the parent driver should interpret the `pointer` argument as a privately defined message type from the child driver and the `refcon` argument as the `USBReference` of that child.

See the “Device Notification Parameter Block” (page 6-167) for details about information passed in the device notification callback.

## Registering Shims After Boot Time

The `USBAddShimFromDisk` function allows extensions or installers to register a shim with the USB family expert after the system has booted. This function is available in version 1.3 and later of the Mac OS USB software.

```
USBAddShimFromDisk (
                    FSSpec *shimFilePtr);
```

`shimFilePtr` The `FSSpec` file system specification record for the file containing the shim or shims. The Macintosh file system specification `FSSpec` record is defined in Chapter 2 of *Inside Macintosh: Files*.

The `USBAddShimFromDisk` function loads all code fragments that export the symbol `"USBShim"` from the file described by the FSSpec, and then calls the

USBShim function. If the function returns a non-zero value, the code fragment is unloaded, otherwise it remains loaded while USB is active, typically until shutdown. However USB could be replaced, which would also cause shims to be unloaded. Code fragments and shims are discussed in Chapter 4, "Writing Mac OS USB Drivers."

The USBAddShimFromDisk function is intended to be called by installers, or extensions that want to register a shim with the USB expert, but can't do it at boot time because they require services that are not yet available. For example, they link to libraries such as QuickTime or OpenTransport.

This function provides a method for installers or extensions to load a shim in order to use a device immediately without the need to reboot. An example use for this function would be in a USB software updater/installer application. Such an installer could be designed to work when software is downloaded over the internet by installing driver software, and using USBAddShimFromDisk function to activate any shims that were installed in the Extensions folder. The device could then begin to function immediately without rebooting the computer as is typically required for driver software with shims.

**Note**
This function is exported from the USBFamilyExpertLib and not from the USBManagerLib.

## Adding a Driver For a Device After Boot Time

The USBAddDriverForFSSpec function adds a driver for a given device based on the device reference specified. Example uses for this function would be to load a specific driver for a device that doesn't have a current driver loaded in the extensions folder, or to ensure that a vendor-specific driver is loaded for a vendor-specific device. This function is available in version 1.3 and later of the Mac OS USB software.

```
USBAddDriverForFSSpec (
                    USBReference reference
                    FSSpec *fileSpec);
```

| | |
|---|---|
| reference | The USBReference for the device. Interface references are not permitted. |
| fileSpec | Pointer to the FSSpec file system specification record for the driver file . The Macintosh file system specification FSSpec record is defined in Chapter 2 of *Inside Macintosh: Files*. |

## Callback Routine for Device Notification

The callback routine, callback routine parameter block, and callback notification request functions used for device notification are listed in this section.

The device notification mechanism is used to inform clients when devices are added and removed from the USB. Clients register for notification services using the `USBInstallDeviceNotification` function and can request all notifications or a specific notification type. Whenever a device or interface is added or removed from the bus, all registered clients are called back with the information about the device or interface.

**Note**
Device notifications are only sent by the USB Manager when there are drivers currently loaded for the device or specific interface the notification request is registered for.

Clients that register for notifications must be sure to un-register with the `USBRemoveDeviceNotification` function before their code fragment is unloaded.

The callback routine is always called at task time, and may allocate memory, make Macintosh Toolbox calls, or perform other system maintenance operations.

### Device Notification Callback Routine

The device notification callback routine declaration is defined as:

```
typedef void (USBDeviceNotificationCallbackProc)
                    (USBDeviceNotificationParameterBlockPtr pb);

typedef USBDeviceNotificationCallbackProc
*USBDeviceNotificationCallbackProcPtr;
```

### Device Notification Parameter Block

The parameter block for the device notification callback routine is defined as:

```
/* Device Notification Parameter Block */
struct USBDeviceNotificationParameterBlock
{
UInt16                                  pbLength;
UInt16                                  pbVersion;
```

```
USBNotificationType                     usbDeviceNotification;
UInt8                                   reserved1;
USBDeviceRef                            usbDeviceRef;
UInt16                                  usbClass;
UInt16                                  usbSubClass;
UInt16                                  usbProtocol;
UInt16                                  usbVendor;
UInt16                                  usbProduct;
OSStatus                                result;
UInt32                                  token;
USBDeviceNotificationCallbackProcPtr    callback;
UInt32                                  refcon;
};
```

### Field descriptions

`--> pbLength` Length of parameter block

`--> pbVersion` Version number of this parameter block

`<--> usbDeviceNotification`
The type of notification
The following notifications are defined:
`kNotifyAnyEvent`
`kNotifyAddDevice`
`kNotifyAddInterface`
`kNotifyRemoveDevice`
`kNotifyRemoveInterface`

`--> reserved1[1]` Reserved, needed because of 2-byte 68k alignment

`<-- usbDeviceRef` The device reference for the target device

`<--> usbClass` The class of the target device, use `kUSBAnyClass` for any class

`<--> usbSubClass` The subclass of the target device, use `kUSBAnySubClass` for any subclass

`<--> usbProtocol` The protocol of the target device, use `kUSBAnyProtocol` for any protocol

`<--> usbVendor` The vendor ID of the target device, use `kUSBAnyVendor` for any vendor

`<--> usbProduct` The product ID of the target device, use `kUSBAnyProduct` for any product

`<-- result` The status of the call

| | |
|---|---|
| <-- token | The value returned to uniquely identify this particular device notification. You pass this value to the USBRemoveDeviceNotification function. |
| --> callback | A pointer to the callback routine to be called when the notification criteria is satisfied |

## Installing The Device Callback Request

The USBInstallDeviceNotification function installs the device notification routine for the device specified in the USBDeviceNotificationParameterBlock. Pass in 0xffff or the wildcard constants as a wildcard for class, subclass, protocol, vendor, and / or product. Pass in kNotifyAnyEvent (0xff) in the usbDeviceNotification field to be notified for any change that occurs.

```
void USBInstallDeviceNotification (USBDeviceNotificationParameterBlock
                    *pb);
```

| | |
|---|---|
| pb | A pointer to the USBDeviceNotificationParameterBlock defined on (page 6-167). |

If a code fragment installs a device notification routine, the device notification routine must be removed with the USBRemoveDeviceNotification function before the code fragment is unloaded.

When registering with the USB Manager to be notified when device connections occur, you will also be notified when interfaces are connected to the USB stack. There is a differences between the notification implementation for devices connections and device driver loading and interface connections and interface driver loading. The difference is how the USB stack is informed about the connection.

With composite devices that are handled by the Apple composite driver, the USB stack is told about the interface by virtue of the load interface driver request. This occurs because the Apple composite driver discovers the interface and asks the USB stack to handle it. For vendor specific drivers, the interfaces are not discovered by the Apple composite driver, and the USB stack is not informed or asked to handle the interface.

This means that if a shim or application installs a notification request into the USB Manager for an interface, and the device is handled by a vendor specific driver, then the shim or application won't be notified that the interface was discovered.

Unless a device is managed by the Apple composite driver, the shim or application will not be notified when a device with a particular interface is connected. Even if you have registered for notifications for that interface class and subclass, or is you are watching for a specific interface's class or subclass.

### Removing The Device Callback Request

The `USBRemoveDeviceNotification` function removes a previously installed device notification routine.

```
OSStatus USBRemoveDeviceNotification (UInt32 token);
```

`token` Notification identifier from the previously installed device notification routine.

## Errors Returned By The USB Manager

Table 6-1 lists errors returned by the USB Manager.

**Table 6-1** USB Manager error codes

| | | |
|---|---|---|
| `kUSBBadDispatchTable` | `-6950` | Improper driver dispatch table |
| `kUSBUnknownNotification` | `-6949` | Notification type not defined |
| `kUSBQueueFull` | `-6948` | Internal queue full |

CHAPTER 7

# HID Library Reference

The Human Interface Device (HID) library APIs for the Mac OS are described in this chapter. To help understand the information presented in this chapter, you should be familiar with the material in the other chapters of this document, as well as the *Device Class Definitions for Human Interface Devices (HID)*, *HID Usage Table*, and *Usage Tables for HID Power Devices* class specifications, which are available at the USB organization web site. The USB class specifications can be downloaded at:

http://www.usb.org/developers/index.html

# Overview

The Mac OS USB software includes a HID library for the purpose determining the features of a HID device by parsing HID report descriptors. Examples of the types of HID devices the HID library can provide support for are:

- USB audio devices, such as external speakers with push button controls
- USB gaming devices, such as joysticks and gamepads
- Display monitors with USB ports and push button controls
- Uninterruptable power supplies with a USB host interface

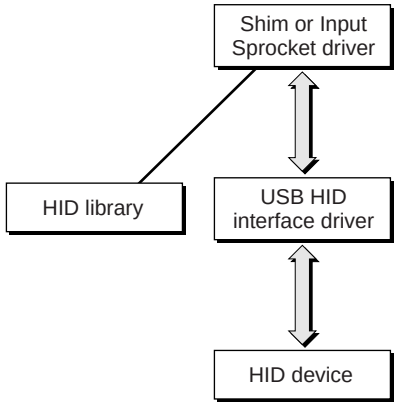
The HID library is a shared library that is compatible with all Power Macintosh computers running Mac OS 8.1 or later. It does require that the Macintosh computer include a USB interface and have the Mac OS USB software version 1.2 or later installed. The USB hardware interface can be either built-in, like it is in the iMac computer, or in the form of a PCI card installed in the system.

The HID library is primarily used by higher-level drivers or shims, such as an InputSprocket driver or the USB Mouse shim, to parse HID report descriptors and decode HID reports.

The block diagram in Figure 7-1 shows how HID library fits into the Mac OS USB software architecture. The diagram shows a HID device, the USB HID interface driver, the HID library, and a block which can be a high-level InputSprocket driver or USB shim. There are several additional Mac OS USB software components involved in making communication with the HID device possible. This diagram only shows those the higher-level driver generally deals with when using the HID library.

In this software model, the vendor specific USB HID interface driver exports a HID dispatch table, as defined in “TheHIDModuleDispatchTable Structure”for the device or devices it supports and is matched against. The higher level software, such as a shim or InputSprocket driver, uses the API entry points for the device’s HID interface driver, which are defined in the dispatch table, to communicate with the device. The higher-level driver or shim software uses the HID library functions to obtain additional information about the features of the device. For example, an InputSprocket driver for a joystick will want to know what button features are available on the device and present that information to the user in a game environment. In order to find out what features are available, the InputSprocket driver will have to use the HID library functions to parse the HID report descriptor and decode the HID report for the joystick.

**Figure 7-1** HID library in USB software architecture




# HID Library API Reference

This section describes the functions supported by the HID Library.

## HIDOpenReportDescriptor

```
extern OSStatus HIDOpenReportDescriptor (
                    void * hidReportDescriptor,
                    ByteCount descriptorLength,
                    HIDPreparsedDataRef * preparsedDataRef,
                    UInt32 flags);
```

The `HIDOpenReportDescriptor` function allocates the memory the parser needs to handle the given report descriptor, and then parses the report descriptor. A data reference to the parsed report information is returned.

`hidReportDescriptor`
Contains a pointer to the actual HID report descriptor from the USB device's firmware.

`descriptorLength`
The length of the HID report descriptor

`preparsedDataRef`
Preparsed data reference to be used for subsequent function calls

`flags` Flags for this function are `kHIDFlag_StrictErrorChecking = 0x00000001`

When the parsed information is no longer needed, clients should call the `HIDCloseReportDescriptor` function.

## HIDCloseReportDescriptor

```
extern OSStatus HIDCloseReportDescriptor (
                    HIDPreparsedDataRef preparsedDataRef);
```

Disposes of the memory the parser allocated for the `HIDOpenReportDescriptor` function.

`preparsedDataRef`
: Preparsed data reference for the report that is returned by the `HIDOpenReportDescriptor` function. After making a call to the `HIDCloseReportDescriptor` function, the `preparsedDataRef` is invalid and should not be used.

## HIDGetButtonCaps

```
extern OSStatus HIDGetButtonCaps (
                    HIDReportType reportType,
                    HIDButtonCapsPtr buttonCaps,
                    UInt32 * buttonCapsSize,
                    HIDPreparsedDataRef preparsedDataRef);
```

Returns the button capabilities structures for a HID device based on the given preparsed data.

`reportType`
: Specifies the type or report for which to retrieve the scaled value. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`

`buttonCaps`
: Points to a caller-allocated buffer that will contain, on return, an array of `HIDButtonCaps` structures. The structures contain information for all buttons that meet the search criteria.

`buttonCapsSize`

`preparsedDataRef`
: Preparsed data reference for the report that is returned by the `HIDOpenReportDescriptor` function. After making a call to the `HIDCloseReportDescriptor` function, the `preparsedDataRef` is invalid and should not be used.

## HIDGetCaps

```
extern OSStatus HIDGetCaps (
                    HIDPreparsedDataRef preparsedDataRef,
                    HIDCapsPtr capabilities);
```

Returns the capabilities of a HID device based on the given preparsed data.

`preparsedDataRef`
: Preparsed data reference returned by calling the `HIDOpenReportDescriptor` function

`capabilities`
: Points to a caller allocated buffer, that upon return contains the parsed capability information for this HID device.

## HIDGetCollectionNodes

```
extern OSStatus HIDGetCollectionNodes (
                    HIDCollectionNodePtr collectionNodes,
                    UInt32 * collectionNodesLength,
                    HIDPreparsedDataRef preparsedDataRef);
```

Returns an array of `HIDCollectionNode` structures that describe the relationships and layout of the link collections within this top level collection.

`collectionNodes`
: Points to a caller-allocated array of `HIDCollectionNode` structures in which this routine returns an entry for each collection withing the top level collection. A collection is a group of corresponding HID descriptors containing input, output, and feature items that have some common relationship to one another. For example, a pointer collection contains items for x and y position data, and button data.

`<--> collectionNodesLength`
: On input, specifies the length in array elements, of the buffer provided at `collectionNodes`. On output, this parameter is set to the number of entries in the `collectionNodes` array that were initialized.

preparsedDataRef
The preparsed data reference from HIDOpenReportDescriptor

The length of the buffer required, in array elements, for an entire collection node array is found in the HIDCaps structure member numberCollectionNodes. You obtain the HIDCaps information by calling the HIDGetCaps function.

For information on the relationships of link collections described by the data returned from this routine, see the description of the HIDCollectionNode structure.

## HIDGetScaledUsageValue

```
extern OSStatus HIDGetScaledUsageValue (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage usage,
                    SInt32 * usageValue,
                    HIDPreparsedDataRef preparsedDataRef,
                    void * report,
                    ByteCount reportLength);
```

The HIDGetScaledUsageValue function returns the capabilities for all buttons for a given top level collection.

| | |
|---|---|
| reportType | Specifies the type or report for which to retrieve the scaled value. This parameter must be one of the following: kHIDInputReport, kHIDOutputReport, or kHIDFeatureReport |
| usagePage | Specifies the usage page of the value to be retrieved. |
| collection | Optionally specifies the link collection identifier of the value to be retrieved. |
| usage | Specifies the usage of the scaled value to be retrieve. |
| usageValue | Points to a variable, that on return from this routine holds the scaled value retrieved from the device report. |

preparsedDataRef
Preparsed data reference from HIDOpenReportDescriptor

| | |
|---|---|
| report | Points to the caller-allocated buffer that contains the device report data |
| reportLength | Specifies the length, in bytes, of the report data provided at report. |

Clients who wish to obtain all capabilities for a usage that contains multiple data items for a single usage that corresponds to a HID byte array, must call the HIDGetUsageValueArray function.

## HIDGetSpecificButtonCaps

```
extern OSStatus HIDGetSpecificButtonCaps (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage usage,
                    HIDButtonCapsPtr buttonCaps,
                    UInt32 * buttonCapsLength,
                    HIDPreparsedDataRef preparsedDataRef);
```

Retrieves the capabilities for all buttons in a specific type of report that meet the search criteria.

| | |
|---|---|
| reportType | Specifies the type or report for which to retrieve the button capabilities. This parameter must be one of the following: kHIDInputReport, kHIDOutputReport, or kHIDFeatureReport |
| usagePage | Specifies a usage page identifier to use as a search criteria. If this parameter is non-zero, then only buttons that specify this usage page will be retrieved. |
| collection | Specifies a link collection identifier to use as a search criteria. If this parameter is non-zero, then only buttons that are part of the specified link collection are retrieved. |
| usage | Specifies a usage identifier to use as a search criteria. If this parameter is non-zero, then only buttons that match the value specified are retrieved. |

`buttonCaps` Points to a caller-allocated buffer that will contain, on return, an array of `HIDButtonCaps` structures. The structures contain information for all buttons that meet the search criteria.

`buttonCapsLength`
On output, specifies the length, in array elements, of the buffer provided in the `buttonCaps` parameter. On output, this parameter is set to the actual number of elements that were returned by the function call, in the buffer provided in the `buttonCaps` parameter, if the routine completed without error.

The correct length necessary to retrieve the button capabilities can be found in the capability data returned for the device by the `HIDGetCaps` function.

`preparsedDataRef`
Preparsed data reference returned by the `HIDOpenReportDescriptor` function

The `HIDGetSpecificButtonCaps` function retrieves capability data for buttons that meet a given search criteria, as opposed to the `HIDGetButtonCaps` function which returns the capability data for all buttons on the device. Calling this routine specifying zero for `usagePage`, `usage`, and `collection` is equivalent to calling the `HIDGetButtonCaps` function.

## HIDGetSpecificValueCaps

```
extern OSStatus HIDGetSpecificValueCaps (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage usage,
                    HIDValueCapsPtr valueCaps,
                    UInt32 * valueCapsLength,
                    HIDPreparsedDataRef preparsedDataRef);
```

Retrieves the capabilities for all values in a specific type of report that meet the search criteria.

`reportType` Specifies the type or report for which to retrieve the value capabilities. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`

`usagePage` Specifies a usage page identifier to use as a search criteria. If this parameter is non-zero, then only values that specify this usage page will be retrieved.

`collection` Specifies a link collection identifier to use as a search criteria. If this parameter is non-zero, then only values that are part of this link collection will be retrieved.

`usage` Specifies a usage identifier to use as a search criteria. If this parameter is non-zero, then only values that specify this usage will be retrieved.

`valueCaps` Points to a caller-allocated buffer that will contain, on return, an array of `HIDValueCaps` structures that contain information for all values that meet the search criteria

`valueCapsLength`
Specifies the length on input, in array elements, of the buffer provided in the `valueCaps` parameter. On output, this parameter is set to the actual number of elements that were returned by this function call, in the buffer provided in `valueCaps` parameter, if the routine completed without error.

The correct length necessary to retrieve the value capabilities can be found in the capability data returned for the device from the `HIDGetCaps` function.

`preparsedDataRef`
Preparsed data reference returned from the `HIDOpenReportDescriptor` function

The `HIDGetSpecificValueCaps` function retrieves capability data for values that meet given search criteria, as opposed to the `HIDGetValueCaps` function, which returns the capability data for all values on the device. Calling this routine with a value of zero for `usagePage`, `usage`, and `collection` parameters is equivalent to calling the `HIDGetValueCaps` function.

## HIDGetButtonsOnPage

```
HIDGetButtonsOnPage(
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage * usageList,
                    UInt32 * usageListSize,
                    HIDPreparsedDataRef preparsedDataRef,
                    void * report,
                    ByteCount reportLength);
```

Retrieves the button state information for buttons on a specified usage page.

`reportType` Specifies the type of report, provided in the `report` parameter, from which to retrieve the buttons. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`

`usagePage` Specifies the usage page of the buttons for which to retrieve the current state.

`collection` Optionally specifies the link collection identifier used to retrieve only specific button states. If this value is non-zero, only the buttons that are part of the given collection are returned.

`usageList` On return, points to a caller-allocated buffer that contains the usages of all the buttons that are pressed and belong to the usage page specified in the `usagePage` parameter.

`usageListSize`

Is the size, in array elements, of the buffer provided in the `usageList` parameter. On return, this parameter contains the number of button states that were set by this routine. If the error `kHIDBufferTooSmallErr` was returned, this parameter contains the number of array elements required to hold all button data requested.

The maximum number of buttons that can ever be returned for a given type of report can be obtained by calling the `HIDMaxUsageListLength` function.

`preparsedDataRef`
: Preparsed data reference returned from the `HIDOpenReportDescriptor` function

`report`
: Points to the caller-allocated buffer that contains the device report data

`reportLength`
: Specifies the size, in bytes, of the report data provided in the `report` parameter.

## HIDGetButtons

```
extern OSStatus HIDGetButtons (
                    HIDReportType reportType,
                    UInt32 collection,
                    HIDUsageAndPagePtr * usageList,
                    UInt32 * usageListSize,
                    HIDPreparsedDataRef preparsedDataRef,
                    void * report,
                    ByteCount reportLength);
```

The `HIDGetButtons` function takes a report from a HID device an sets the current state of the buttons in that report.

`reportType`
: Specifies the type of report, provided in the `report` parameter, from which to retrieve the buttons. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`

`collection`
: Optionally specifies the link collection identifier used to retrieve only specific button states. If this value is non-zero, only the buttons that are part of the given collection are returned.

`usageList`
: On return, points to a caller-allocated buffer that contains the usages of all the buttons that are pressed.

`usageListSize`
: Is the size, in array elements, of the buffer provided in the `usageList` parameter. On return, this parameter contains the number of button states that were set by this routine. If the error `kHIDBufferTooSmallErr` was returned, this parameter contains the number of array elements required to hold all button data

requested.

The maximum number of buttons that can ever be returned for a given type of report can be obtained by calling the `HIDMaxUsageListLength` function.

`preparsedDataRef`
Preparsed data reference returned from the `HIDOpenReportDescriptor` function

`report` Points to the caller-allocated buffer that contains the device report data

`reportLength` Specifies the length, in bytes, of the report data provided in the `report` parameter.

## HIDGetUsageValue

```
extern OSStatus HIDGetUsageValue (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage usage,
                    SInt32 * usageValue,
                    HIDPreparsedDataRef preparsedDataRef,
                    void * report,
                    ByteCount reportLength);
```

The `HIDGetUsageValue` function returns a value from a device data report given a selected search criteria.

`reportType` Specifies the type of report, provided at report, from which to retrieve the value. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`

`usagePage` Specifies the usage page of the value to retrieve.

`collection` Optionally specifies the link collection identifier of the value to be retrieved.

`usage` Specifies the usage of the value to be retrieve.

`usageValue` Points to a variable, that on return from this routine holds the value retrieved from the device report.

`preparsedDataRef` The preparsed data reference obtained by calling the `HIDOpenReportDescriptor` function.

`report` Points to the caller-allocated buffer that contains the device report data.

`reportLength` Specifies the size, in bytes, of the report data provided in the `report` parameter.

The `HIDGetUsageValue` function does not sign the value. To have the sign bit automatically applied, use the `HIDGetScaledUsageValue` function instead. For manually assigning the sign bit, the position of the sign bit can be found in the `HIDValueCaps` structure for this value.

Clients who wish to obtain all data for a usage that contains multiple data items for a single usage, corresponding to a HID byte array, must call the `HIDGetUsageValueArray` function instead.

## HIDGetUsageValueArray

```
extern OSStatus HIDGetUsageValueArray (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage usage,
                    Byte * usageValueBuffer,
                    ByteCount usageValueBufferSize,
                    HIDPreparsedDataRef preparsedDataRef,
                    void * report,
                    ByteCount reportLength);
```

The `HIDGetUsageValueArray` function returns a value from a device data report given a selected search criteria.

`reportType` Specifies the type of report, provided at report, from which to retrieve the values. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`.

`usagePage` Specifies the usage page of the data to be retrieved.

`collection` Optionally specifies the link collection identifier of the data to be retrieved.

`usage` Specifies the usage identifier of the value to be retrieve.

`usageValueBuffer`
Points to a caller-allocated buffer that contains, on output, the data from the device. The correct length for this buffer can be found by multiplying the `reportCount` and `bitSize` fields of the `HIDValueCaps` structure for this value and rounding the resulting value up to the nearest byte.

`usageValueBufferSize`
Specifies the size, in bytes, of the buffer in the `usageValueBuffer` parameter.

`preparsedDataRef`
The preparsed data reference returned from the `HIDOpenReportDescriptor` function.

`report` Points to the caller-allocated buffer that contains the device report data.

`reportLength` Specifies the size, in bytes, of the report data provided at report.

When the `HIDGetUsageValueArray` function retrieves the data, it fills in the buffer in little-endian order beginning with the least significant bit of the data for this usage. The data is filled in without regard to byte alignment and is shifted such that the least significant bit is placed as the 1st bit of the given buffer.

## HIDGetValueCaps

```
extern OSStatus HIDGetValueCaps (
                    HIDReportType reportType,
                    HIDValueCapsPtr valueCaps,
                    UInt32 * valueCapsSize,
                    HIDPreparsedDataRef preparsedDataRef);
```

The `HIDGetValueCaps` function retrieves the capabilities for all values for a specified top level collection.

`reportType` Specifies the type or report for which to retrieve the value capabilities. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`.

`valueCaps` On return, points to a caller-allocated buffer that contains an array of `HIDValueCaps` structures containing information for all values in the top level collection.

`valueCapsSize`
On input, specifies the size in array elements of the buffer provided in the `valueCaps` parameter. On output, this parameter is set to the actual number of elements that were returned in the buffer provided in the `valueCaps` parameter, if the function completed without error.

The correct length necessary to retrieve the value capabilities can be found in the capability data returned for the device by the `HIDGetCaps` function.

`preparsedDataRef`
The preparsed data reference returned from the `HIDOpenReportDescriptor` function.

The `HIDGetValueCaps` function retrieves the capability data for all values in a top level collection without regard for the usage, usage page, or collection of the value. To retrieve value capabilities for a specific usage, usage page, or collection, use the `HIDGetSpecificValueCaps` function.

## HIDMaxUsageListLength

```
extern UInt32 HIDMaxUsageListLength (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    HIDPreparsedDataRef preparsedDataRef);
```

The `HIDMaxUsageListLength` function returns the maximum number of buttons that can be returned from a given report type for the top level collection.

`reportType` Specifies the type of report for which to get a maximum usage count. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`

`usagePage` Optionally specifies the usage page identifier to use as a search criteria. If this parameter is zero, the function returns the number of buttons for the entire top-level collection regardless of the actual value of the usage page.

`preparsedDataRef` The preparsed data reference for the report descriptor returned from the `HIDOpenReportDescriptor` function.

## HIDSetScaledUsageValue

```
extern OSStatus HIDSetScaledUsageValue (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage usage,
                    SInt32 usageValue,
                    HIDPreparsedDataRef preparsedDataRef,
                    void * report,
                    ByteCount reportLength);
```

The `HIDSetScaledUsageValue` function takes a signed physical (scaled) number and converts it to the logical, or device representation and inserts it in a given report.

`reportType` Specifies the type of report, provided at report. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`

`usagePage` Specifies the usage page identifier of the value to be set in the report.

`collection` Optionally specifies the link collection identifier to distinguish between values that have the same usage page and usage identifiers. If this parameter is zero, it will be ignored.

`usage` Specifies the usage identifier of the value to be set in the report.

`usageValue` Specifies the physical, or scaled, value to be set in the value for the given report.

`preparsedDataRef`
: The preparsed data reference for the report descriptor returned from the `HIDOpenReportDescriptor` function.

`report`
: Points to the caller-allocated buffer that contains the device report data.

`reportLength`
: Specifies the length, in bytes, of the report data specified in the `report` parameter.

The `HIDSetScaledUsageValue` function automatically handles the setting of the signed bit in the data to be sent to the device.

## HIDSetButtons

```
extern OSStatus HIDSetButtons (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage * usageList,
                    UInt32 * usageListSize,
                    HIDPreparsedDataRef preparsedDataRef,
                    void * report,
                    ByteCount reportLength);
```

The `HIDSetButtons` function takes a report from a HID device an returns the current state of the buttons in that report.

`reportType`
: Specifies the type of report, provided at report. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`.

`usagePage`
: Specifies the usage page identifier of the value to be set in the report.

`collection`
: Optionally specifies the link collection identifier to distinguish between buttons. If this parameter is zero, it is ignored.

`usageList`
: Points to a caller-allocated buffer that contains an array of button data to be set in the report in the `report` parameter.

`usageListSize`
: Specifies the size, in array elements, of the buffer provided in the `usageList` parameter. If an error is returned by a call to this function, the `usageListLength` parameter contains the location in the array provided in the `usageList` parameter where the error was encountered. All array entries encountered prior to the error location were successfully set in the report provided in the `report` parameter.

`preparsedDataRef`
: The preparsed data reference for the report descriptor returned by the `HIDOpenReportDescriptor` function.

`report`
: Points to the caller-allocated buffer that contains the device report data.

`reportLength`
: Specifies the size, in bytes, of the report data provided in the `report` parameter.

## HIDSetUsageValue

```
extern OSStatus HIDSetUsageValue (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage usage,
                    SInt32 usageValue,
                    HIDPreparsedDataRef preparsedDataRef,
                    void * report,
                    ByteCount reportLength);
```

The `HIDSetUsageValue` function sets a value in a given report.

`reportType`
: Specifies the type of report, provided at report. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`.

`usagePage`
: Specifies the usage page identifier of the value to be set in the report.

| | |
|---|---|
| collection | Optionally specifies the link collection identifier to distinguish between values that have the same usage page and usage identifiers. If this parameter is zero, it is ignored. |
| usage | Specifies the usage identifier of the value to be set in the report. |
| usageValue | Specifies the data this is to be set in the value for the given report. |
| preparsedDataRef | The preparsed data reference for the report descriptor returned from the HIDOpenReportDescriptor function. |
| report | Points to the caller-allocated buffer that contains the device report data. |
| reportLength | Specifies the size, in bytes, of the report data provided in the report parameter. |

The HIDSetUsageValue function does not automatically handle the sign bit. Clients must either manually set the sign bit, at the position provided in the HIDValueCaps structure for this value, or call the HIDSetScaledUsageValue function.

## HIDSetUsageValueArray

```
extern OSStatus HIDSetUsageValueArray (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage usage,
                    Byte * usageValueBuffer,
                    ByteCount usageValueBufferLength,
                    HIDPreparsedDataRef preparsedDataRef,
                    void * report,
                    ByteCount reportLength);
```

The HIDSetUsageValue function sets an array of values in a given report.

| | |
|---|---|
| reportType | Specifies the type of report, provided at report. This parameter must be one of the following: kHIDInputReport, kHIDOutputReport, or kHIDFeatureReport. |

| | |
|---|---|
| `usagePage` | Specifies the usage page identifier of the value to be set in the report. |
| `collection` | Optionally specifies the link collection identifier to distinguish between values that have the same usage page and usage identifiers. If this parameter is zero, it is ignored. |
| `usage` | Specifies the usage identifier of the value to be set in the report. |
| `usageValueBuffer` | Points to a caller-allocated buffer that contains, on output, the data from the device. The correct length for this buffer can be found by multiplying the `reportCount` and `bitSize` fields of the `HIDValueCaps` structure for this value and rounding the resulting value up to the nearest byte. |
| `usageValueBufferLength` | Specifies the size, in bytes, of the buffer in the `usageValueBuffer` parameter. |
| `preparsedDataRef` | The preparsed data reference for the report descriptor returned from the `HIDOpenReportDescriptor` function. |
| `report` | Points to the caller-allocated buffer that contains the device report data. |
| `reportLength` | Specifies the size, in bytes, of the report data provided in the `report` parameter. |

The `HIDSetUsageValue` function does not automatically handle the sign bit. Clients must either manually set the sign bit, at the position provided in the `HIDValueCaps` structure for this value, or call the `HIDSetScaledUsageValue` function.

## HIDUsageListDifference

```
extern OSStatus HIDUsageListDifference (
                    HIDUsage * previousUsageList,
                    HIDUsage * currentUsageList,
                    HIDUsage * breakUsageList,
                    HIDUsage * makeUsageList,
                    HIDUsage usageListsLength);
```

The `HIDUsageListDifference` function compares and provides the differences between two lists of buttons.

`previousUsageList`
Points to the older button list to be used for comparison.

`currentUsageList`
Points to the newer button list to be used for comparison.

`breakUsageList`
On return, points to a caller allocated buffer that contains the buttons set in the older list, specified in the `previousUsageList` parameter, but not set in the new list, specified in the `currentUsageList` parameter.

`makeUsageList`
On return, points to a caller allocated buffer that contains the buttons set in the new list, specified in the `currentUsageList` parameter, but not set in the old list, specified in the `previousUsageList` parameter.

`usageListsLength`
Specifies the length, in array elements, of the buffers provided in the `currentUsageList` and `previousUsageList` parameters.

## HIDSetButton

```
extern OSStatus HIDSetButton (
                    HIDReportType reportType,
                    HIDUsage usagePage,
                    UInt32 collection,
                    HIDUsage usage,
                    HIDPreparsedDataRef preparsedDataRef,
                    void * report,
                    ByteCount reportLength);
```

The `HIDSetButton` function takes a report from a HID device an sets the current state of the specified button in that report.

`reportType` Specifies the type of report, provided at report. This parameter must be one of the following: `kHIDInputReport`, `kHIDOutputReport`, or `kHIDFeatureReport`.

| | |
|---|---|
| `usagePage` | Specifies the usage page identifier of the value to be set in the report. |
| `collection` | Optionally specifies the link collection identifier to distinguish between buttons. If this parameter is zero, it is ignored. |
| `usage` | Points to a caller-allocated buffer that contains the button data to be set in the report in the `report` parameter. |
| `preparsedDataRef` | The preparsed data reference for the report descriptor returned by the `HIDOpenReportDescriptor` function. |
| `report` | Points to the caller-allocated buffer that contains the device report data. |
| `reportLength` | Specifies the size, in bytes, of the report data provided in the `report` parameter. |

# HID Library Constants

This section lists the constants associated in the HID library APIs.

## HID Report Constants

```
kHIDInputReport     = 1,
kHIDOutputReport    = 2,
kHIDFeatureReport   = 3,
kHIDUnknownReport   = 255
```

## HIDOpenReportDescriptor Flags

```
kHIDFlag_StrictErrorChecking = 0x00000001
```

## HIDGetDeviceInfo Constants

The constants listed below are passed to the `HIDGetDeviceInfo` function, which is implemented in the TheHIDModuleDispatchTable.

```
kHIDGetInfo_VendorID               = 1,
kHIDGetInfo_ProductID              = 2,
kHIDGetInfo_VersionNumber          = 3,
kHIDGetInfo_MaxReportSize          = 0x10,
kHIDGetInfo_GetManufacturerString  = 0x0100,
kHIDGetInfo_GetProductString       = 0x0101,
kHIDGetInfo_GetSerialNumberString  = 0x0102,
kHIDGetInfo_GetIndexedString       = 0x0103,
kHIDGetInfo_VendorSpecificStart    = 0x00010000
```

## HIDOpenDevice Constants

These permission constants are passed to the `HIDControlDevice` function.

```
kHIDPerm_ReadOnly          = 0x0001,
kHIDPerm_ReadWriteShared   = 0x0003,
kHIDPerm_ReadWriteExclusive = 0x0013
```

## HIDInstallReportHandler Constant

```
kHIDFlag_CallbackIsResident = 0x0001
```

## HIDControlDevice Constant

```
kHIDVendorSpecificControlStart = 0x00010000
```

## Usage Table Constants

Usage table constants can be found in the *HID Usage Table* class specification and in the HID.h file.

# HID Library Data Structures

This section lists the data structures that are associated with the HID Library.

## HIDUsageAndPage

```
struct HIDUsageAndPage
{
    HIDUsage        usage;
    HIDUsage        usagePage;
};

typedef HIDUsageAndPage * HIDUsageAndPagePtr;
```

The `HIDUsageAndPage` data structure is used by HID clients when obtaining status of buttons to hold the usage page and usage of a button that is down.

### Field descriptions

`usage` Specifies the usage identifier within the usage page specified by usagePage of a button that is down.

`usagePage` Specifies the usage page identifier of a button that is down.

Clients use the `HIDUsageAndPage` structure with the `HIDGetButtonsEx` function to obtain both the usage page and usage identifiers of each button that is down.

## HIDCaps

```
struct HIDCaps
{
    HIDUsage    usage;
    HIDUsage    usagePage;
    UInt32      inputReportByteLength;
    UInt32      outputReportByteLength;
    UInt32      featureReportByteLength;
```

```
    UInt32      numberCollectionNodes;
    UInt32      numberInputButtonCaps;
    UInt32      numberInputValueCaps;
    UInt32      numberOutputButtonCaps;
    UInt32      numberOutputValueCaps;
    UInt32      numberFeatureButtonCaps;
    UInt32      numberFeatureValueCaps;
};

typedef HIDCaps * HIDCapsPtr;
```

The `HIDCaps` data structure is used by HID clients to hold the capabilities of a HID device.

### Field descriptions

`usage` Specifies the specific class of functionality that this device provides. This value is dependent and specific to the value provided in the `usagePage` field. For example, a keyboard could have a `usagePage` of `kHIDUsagePage_Generic` and a `usage` of `kHIDUsage_Generic_Keyboard`.

`usagePage` Specifies the usage page identifier for this top level collection.

`inputReportByteLength` Specifies the maximum length, in bytes, of an input report for this device, including the report ID which is unilaterally prepended to the device data.

`outputReportByteLength` Specifies the maximum length, in bytes, of an output report for this device, including the report ID which is unilaterally prepended to the device data.

`featureReportByteLength` Specifies the maximum length, in bytes, of a feature report for this device, including the report ID which is unilaterally prepended to the device data.

`numberCollectionNodes` Specifies the number of `HIDCollectionNode` structures that are returned for this top level collection by the `HIDGetConnectionNodes` function.

`numberInputButtonCaps` Specifies the number of input buttons.

`numberInputValueCaps`
: Specifies the number of input values.

`numberOutputButtonCaps`
: Specifies the number of output buttons.

`numberOutputValueCaps`
: Specifies the number of output values.

`numberFeatureButtonCaps`
: Specifies the number of feature buttons.

`numberFeatureValueCaps`
: Specifies the number of feature values.

This structure holds the parsed capabilities and data maximums returned for a device by the `HIDGetCaps` function.

## HIDCollectionNode

```
struct HIDCollectionNode
{
    HIDUsage    collectionUsage;
    HIDUsage    collectionUsagePage;
    UInt32      parent;
    UInt32      numberOfChildren;
    UInt32      nextSibling;
    UInt32      firstChild;
};
typedef HIDCollectionNode * HIDCollectionNodePtr;
```

## HIDButtonCaps

```
struct HIDButtonCaps
{
    HIDUsage    usagePage;
    UInt32      reportID;
    UInt32      bitField;
    UInt32      collection;
    HIDUsage    collectionUsage;
```

```
    HIDUsage    collectionUsagePage;
    Boolean     isRange;
    Boolean     isStringRange;
    Boolean     isDesignatorRange;
    Boolean     isAbsolute;
    {
    struct
        {
        HIDUsage    usageMin;
        HIDUsage    usageMax;
        UInt32      stringMin;
        UInt32      stringMax;
        UInt32      designatorMin;
        UInt32      designatorMax;
        } range;
    struct
        {
        HIDUsage    usage;
        HIDUsage    reserved1;
        UInt32      stringIndex;
        UInt32      reserved2;
        UInt32      designatorIndex;
        UInt32      reserved3;
        } notRange;
    } u;
};
typedef HIDButtonCaps * HIDButtonCapsPtr;
```

The `HIDButtonCaps` structure is used by HID clients to hold the capabilities data for a button on a HID device.

## HIDValueCaps

```
struct HIDValueCaps
{
    HIDUsage    usagePage;
    UInt32      reportID;
    UInt32      bitField;
    UInt32      collection;
```

```
    HIDUsage    collectionUsage;
    HIDUsage    collectionUsagePage;

    Boolean     isRange;
    Boolean     isStringRange;
    Boolean     isDesignatorRange;
    Boolean     isAbsolute;

    UInt32      bitSize;
    UInt32      reportCount;

    SInt32      logicalMin;
    SInt32      logicalMax;
    SInt32      physicalMin;
    SInt32      physicalMax;

    union
        {
        struct
        {
            HIDUsage    usageMin;
            HIDUsage    usageMax;
            UInt32      stringMin;
            UInt32      stringMax;
            UInt32      designatorMin;
            UInt32      designatorMax;
        } range;
        struct
        {
            HIDUsage    usage;
            HIDUsage    reserved1;
            UInt32      stringIndex;
            UInt32      reserved2;
            UInt32      designatorIndex;
            UInt32      reserved3;
        } notRange;
    } u;
};
typedef HIDValueCaps * HIDValueCapsPtr;
```

The `HIDValueCaps` structure is used by HID clients to hold the capabilities data for a value from a HID device.

## HIS Library Error Codes

Table contains a list of error codes returned by the HID library. The HID library returns errors in the range -13949 to -13900.

**Table 7-1** HID library error codes

| Error code | Error name | Description |
|---|---|---|
| 0 | kHIDSuccess | |
| -13950 | kHIDBaseError | |
| -13949 | kHIDNullStateErr | |
| -13948 | kHIDBufferTooSmallErr | |
| -13947 | kHIDValueOutOfRangeErr | |
| -13946 | kHIDUsageNotFoundErr | |
| -13945 | kHIDNotValueArrayErr | |
| -13944 | kHIDInvalidPreparsedDataErr | |
| -13943 | kHIDIncompatibleReportErr | |
| -13942 | kHIDBadLogPhysValuesErr | |
| -13941 | kHIDInvalidReportTypeErr | |
| -13940 | kHIDInvalidReportLengthErr | |
| -13939 | kHIDNullPointerErr | |
| -13938 | kHIDBadParameterErr | |
| -13937 | kHIDNotEnoughMemoryErr | |
| -13936 | kHIDEndOfDescriptorErr | |
| -13935 | kHIDUsagePageZeroErr | |
| -13934 | kHIDBadLogicalMinimumErr | |

**Table 7-1** HID library error codes

| Error code | Error name | Description |
|---|---|---|
| -13933 | kHIDBadLogicalMaximumErr | |
| -13932 | kHIDInvertedLogicalRangeErr | |
| -13931 | kHIDInvertedPhysicalRangeErr | |
| -13930 | kHIDUnmatchedUsageRangeErr | |
| -13929 | kHIDInvertedUsageRangeErr | |
| -13928 | kHIDUnmatchedStringRangeErr | |
| -13927 | kHIDUnmatchedDesignatorRangeErr | |
| -13926 | kHIDReportSizeZeroErr | |
| -13925 | kHIDReportCountZeroErr | |
| -13924 | kHIDReportIDZeroErr | |
| -13923 | kHIDInvalidRangePageErr | |
| -13910 | kHIDDeviceNotReady | |
| -13909 | kHIDVersionIncompatibleErr | |

APPENDIX A

# Changes In Mac OS USB Software

This appendix includes a general discussion of the features in version 1.1 of the Mac OS USB software. In addition, it defines the use of the version 1.1 USPB parameter block that supports isochronous transfers, and it includes some discussion of the feature enhancements in version 1.2 of the Mac OS USB software.

There are significant differences in the features supported in version 1.1 and later of the Mac OS USB software. To take advantage of the new features some modification of existing code that supported version 1.0 Mac OS USB software is required. For information about the required code changes to support version 1.1, see "Code Changes Required To Support The Version 1.1 USBPB" (page 206).

## Major Feature Updates In Version 1.1

The major feature enhancements included in version 1.1 of the Mac OS USB software are:

- Isochronous support, new parameter block defined in "The USBPB Parameter Block" (page 83)
- Multiple bus support
- Improved bus enumeration
- Driver notification messages that support Mac OS sleep and wake
- Improved functionality for USB control requests

**IMPORTANT**

It should be noted that although the features listed here are supported by the version 1.1 `USBPB` parameter block, all Macintosh computers that support USB may not include the necessary ROM code to implement the features. Always check the USB gestalt selectors, defined in "Isochronous Transfer Support" (page 205) and "USB Software Presence and Version Attributes" (page 40), rather than the version number to ensure that the features you are interested in are supported on the Macintosh your software is running on.

## Improved Bus Enumeration

Version 1.1 provides improved bus enumeration at startup to support proper USB driver loading before other system extensions are initialized. This is accomplished by providing task time for the USB expert loader to process all hub communications. When all hubs have reported that they have discovered their devices, and the USB system software has completed the search for USB class drivers, then the remainder of the booting process, loading extensions and launching the finder, continues.

## Multiple USB Bus Support

The Mac OS USB version 1.1 software supports multiple USB buses on a system. If you are looking through the name registry, you need to check every USB controller node for attached hubs and devices.

## Driver Notification Messages

Additional messages have been defined for handling Mac OS power management features. Version 1.1 of the Mac OS USB software notifies class drivers through the `USBDriverNotificationProcPtr` with the following messages:

**Message constant name**

`kNotifyUSBSystemSleepRequest`

**Message constant name**

`kNotifyUSBSystemSleepDemand`

`kNotifyUSBSystemSleepWakeUp`

`kNotifyUSBSystemSleepRevoke`

These messages correspond to the `Sleep` procedure selector codes defined in the Chapter 6, “Power Manager,” in Inside Macintosh, “Devices.” Your driver should return an appropriate response to these messages as defined in “Writing a Sleep Procedure” Chapter 6, “Power Manager,” Inside Macintosh: Devices.

## Isochronous Transfer Support

Version 1.1 contains support for isochronous transfers. You can test for the presence of isochronous support by checking the gestalt selector `gestaltUSBAttr` (‘`usb `‘). If `gestaltUSBHasIsoch` (bit 1 = 0x02) is set, then isochronous support is available in the form of two new calls:

```
OSStatus USBIsocWrite(USBPB *pb);
OSStatus USBIsocRead(USBPB *pb);
```

## Improved Functionality For USB Control Requests

A new flag was added to the `USBDeviceRequest` function (page 111) to allow for USB control transactions addressed to an interface or endpoint of a device. The new feature allows the call to be made without the driver explicitly knowing the number of the endpoint or interface before the call is made. The USL now fills in the interface or endpoint number when an interface or pipe reference is passed in with the call.

To use the new feature, you specify the flag `kUSBAddessRequest` in the `usbFlags` field of the `USBDeviceRequest` function. If the `recipient` field in `BMRequestType` is an endpoint or interface, the relevant endpoint or interface number is derived from the pipe or interface reference passed in the `usbReference` field. The appropriate interface or endpoint number is put into the `usbWIndex` field before the control transaction call takes place.

## Code Changes Required To Support The Version 1.1 USBPB

This section describes the changes you should be aware of if you are working with code that supported the version 1.0 parameter block in USB.h and you want to take advantage of the features in version 1.1 of the Mac OS USB software.

The `USBPB` parameter block structure has been converted to include unions that provide support for isochronous transfers. The change is binary compatible (you can keep the same `kUSBCurrentVersion` value), but it is necessary to make changes to existing source code in order to use the version 1.1 USB.h file.

At the simplest level, the necessary changes can be made by doing a search and replace of the following strings in your code:

| Old string | New replacement string |
|---|---|
| `usbBMRequestType` | `usb.cntl.BMRequestType` |
| `usbBRequest` | `usb.cntl.BRequest` |
| `usbWValue` | `usb.cntl.WValue` |
| `usbWIndex` | `usb.cntl.WIndex` |

To aid with the conversion process, macros with the substitutions are available in the version 1.1 USB.h file. To use the macros, add a define for `OLDUSBNAMES` before including USB.h. It is recommended that you make the actual string changes in the source, because the macro facility is not guaranteed to be available in later versions of the USB.h file.

The `USBClassDriverPlugInDispatchTable` has changed in version 1.1. If the version of `USBClassDriverPluginDispatchTable` is set to `kUSBClassDriverPluginVersion` it indicates that `USBDriverNotifyProcPtr` has the following prototype:

```
OSStatus USBDriverNotifyProc (
                    USBDriverNotification notification,
                    void *pointer,
                    Uint32 refcon);
```

Drivers that were compiled with earlier versions of the USB.h header file will have a different `kUSBClassDriverPluginVersion` value and the USB Manager will call the `USBDriverNotifyProc` without the `refcon` parameter.

Check that the current version of USB software has isochronous support before making the `USBIsocRead` or `USBIsocWrite` calls. You must also weak link your class driver with the USBServicesLib USB.h file. If your driver makes `USBIsocRead` and `USBIsocWrite` calls and hard links to the USBServicesLib file, the system will check for support of these calls. If it finds that they are not available, the driver will not load.

# Major Features Introduced In Version 1.2

Beginning with version 1.2 of the Mac OS USB software, multiple class drivers can be merged into a single Mac OS extension file. This feature is beneficial in situations where you have several vendor specific devices in a product family, each device requiring slightly different driver functionality. Rather than creating a standalone native driver for each device, you can write driver code for each device and merge all the driver code into a single file. The single file will be loaded based on vendor and product specific ID information in favor of the Apple generic drivers, which guarantees proper support your family of devices.

The steps below define how to merge USB class drivers into a single file using CodeWarrior IDE 2.0 or greater. This discussion assumes familiarity with the Macintosh and CodeWarrior programming environments.

1. Create each class driver into a Shared Library file of type `'shlb'`, not `'ndrv'` as you presently would for a standalone USB class driver.
2. Set the CodeWarrior Target Setting with the linker popup to Mac OS Merge. Note that this target could be within the same project that creates the separate driver files to be merged.
3. In the Mac OS Merge Panel under the Linker grouping, set the Project type popup menu to Shared Library, set the file name and set the file creator to `'usbd'`, and file type to `'ndrv'`. Ensure that the Copy Code Fragments option is checked. If there are resources associated with either of the drivers, then make sure that the Copy Resources option is checked.
4. For this target, set the source files to be the shared library files which contain the drivers to be merged.

# Release Notes And Compatibility Issues

This section provides release notes and describes various Mac OS USB software implementation issues that developers should be aware of.

## Bulk Data Transfer Performance Issues

As of Mac OS USB v1.2, an issue has been identified with how USB resources are used for USB bulk read and write calls for large data transfers. If a buffer is passed to a USB bulk call that is not aligned to a `MaxPacketSize` boundary, then USB may require up to twice as many Transfer Descriptor resources in order to process the data coming in or going out. More importantly, for large transfer, passing a misaligned buffer means that the transport descriptor will be limited to a 4K transfer, while an aligned buffer extends the limit to 8K. For small transfers (less than 8K), this issue may not make a noticeable difference. For larger transfers, the use of a misaligned buffer can affect performance.

Note that the `MaxPacketSize` is the value read from the configuration descriptor. For bulk devices, the `MaxPacketSize` values are 1, 2, 4, 8, 16, 32 and 64.

Assuming that you want to pass in a buffer that is 4 times `MaxPacketSize`, the following algorithm demonstrates how one goes about setting up the `usbBuffer` that begins on a `MaxPacketSize` aligned address. Note that you are working with logical, not physical addresses.

```
#define kBufferMultiplier 4             // allocate a buffer that is 4x MaxPacketSize
UInt16      maxpacksize = 64;           // set for MaxPacketSize of
                                        // a bulk or control transaction

UInt8       *buffer;
UInt8       *alignedBuffer;
                                // first allocate a buffer that is the desired
                                // size + maxpacksize

buffer = NewPtrSys((kBufferMultiplier + 1) * maxpacksize);

                                // figure out where the buffer falls on the
                                // maxpacksize aligned address
```

```
alignedbuffer = (buffer + maxpacksize) & ~(maxpacksize - 1);
```

Following this example, you would set

```
usbReqCount = kBufferMultiplier * maxpacksize;
usbBuffer = alignedBuffer;
```

There is no limit as to the size of the buffer, however, the buffer size must be a multiple of `MaxPacketSize` for maximum performance.

## Understanding Generic Drivers

Any driver that does not have the `kUSBDoNotMatchGeneric` flag set in the `usbDriverLoadingOptions` field in the `USBDriverDescription` structure is technically considered a generic driver. Such a driver may be loaded for any device or interface that matches the class, subclass, and protocol specified in the `USBDriverDescriptor` structure.

Note however, that a driver is not really generic if it uses the `validateHWproc` funtion as defined in “USBClassDriverPlugInDispatchTable Structure” (page 61) to prevent it from being used for anything other than a specific set of vendor IDs and/or product IDs. Using the `validateHWProc` function is the best way for device developers to supply a generic style vendor-specific driver without utilizing multiple fragments in a single driver file. The intended purpose of the `ValidateHW` function was essentially to provide an alternative method for implementing generic-style driver functionality.

For developers that want to keep the list of valid vendor and product IDs in resources (or text files), loading those resource in your `ValidateHW` function, which is called at file-safe task time, would be the best way to do it.

**IMPORTANT**

Don’t abuse the load generic ability. Always check for your device(s) in a `validateHW` function. The problems associated with not doing so are drivers that are matched to devices they know nothing about. For example, a printer driver that is loaded for the mouse because it matched device class 0/0 - composite, or a storage device driver that is loaded for a scanner (it could match interface class 0/0). Don’t let this happen to you - use a `validateHW` function.

APPENDIX A

# Changes In Mac OS USB Software

# Conventions and Abbreviations

This developer note uses the following typographical conventions and abbreviations.

## Conventions

Computer-language text—any text that is literally the same as it appears in computer input or output—appears in `Letter Gothic` font.

Hexadecimal numbers are preceded by a zero x (0x). For example, the hexadecimal equivalent of decimal 16 is written as 0x10.

**Note**
A note like this contains information that is of interest but is not essential for an understanding of the text. ◆

**IMPORTANT**
A note like this contains important information that you should read before proceeding. ▲

## Abbreviations

When unusual abbreviations appear in this developer note, the corresponding terms are also spelled out. Standard units of measure and other widely used abbreviations are not spelled out.

Here are the standard units of measure used in developer notes:

| | | | |
|---|---|---|---|
| A | amperes | mA | milliamperes |
| dB | decibels | µA | microamperes |
| GB | gigabytes | MB | megabytes |
| Hz | hertz | MHz | megahertz |
| in. | inches | mm | millimeters |
| k | 1000 | ms | milliseconds |

| | | | |
|---|---|---|---|
| K | 1024 | µs | microseconds |
| KB | kilobytes | ns | nanoseconds |
| kg | kilograms | Ω | ohms |
| kHz | kilohertz | sec. | seconds |
| kΩ | kilohms | V | volts |
| lb. | pounds | W | watts |

Other abbreviations that may be used in this note include:

| | |
|---|---|
| $*n* | hexadecimal value *n* |
| ADB | Apple Desktop Bus |
| ATA | advanced technology attachment |
| ATAPI | advanced technology attachment packet interface |
| AV | audiovisual |
| CD-ROM | compact disc read-only memory |
| DIN | Deutsche Industries Norm |
| EMI | electromagnetic interference |
| GCR | group code recording |
| IC | integrated circuit |
| IDE | integrated device electronics |
| I/O | input/output |
| IR | infrared |
| JEDEC | Joint Electronics Devices Engineering Council |
| PCI | Peripheral Component Interconnect |
| PIO | parallel input output |
| SCSI | Small Computer System Interface |
| SCC | serial communications controller |
| USB | Universal Serial Bus |

# USB Terminology

The USB terminology used in this document is defined here:

| | |
|---|---|
| asynchronous data | Data transferred at irregular intervals with no specific latency requirements. |
| bandwidth | The amount of data capable of being transmitted per unit of time, typically bits per second (bps) or bytes per second (Bps). |
| big endian | A method of storing data that places the most significant byte of multiple byte values at a lower storage address. For example, a word stored in big endian format places the least significant byte at the higher address and the most significant byte at the lower address. See also, little endian. |
| bps | Transmission rate expressed in bits per second. |
| buffer | Storage used to compensate for a difference in data rates or time of occurrence of events, when transmitting data from one device to another. The area in memory where data is either stored or retrieved programmatically. |
| bulk transfer | Nonperiodic, large bursts of communication typically used for a data transfer that can use any available bandwidth and also be delayed until bandwidth is available. |
| bus enumeration | Detecting and identifying Universal Serial Bus devices. |
| class | A group of devices or interfaces that have a set of attributes or functions in common. |
| client | Software resident on the host that interacts with host software to arrange data transfer between a function in a device and the host. The client is often the data provider and consumer for transferred data. |
| configuration | One of possibly several settings a device can be programmed into. Configurations may be constrained by available power or bandwidth, or may be differentiated by function. See also, function. |

| | |
|---|---|
| configuring software | The host software responsible for configuring a Universal Serial Bus device. This may be a system configurator or software specific to the device. |
| control pipe | Same as a message pipe. |
| control transfer | One of four Universal Serial Bus Transfer Types. Control transfers support configuration / command / status type communications between client and function. |
| default address | An address defined by the Universal Serial Bus Specification and used by a Universal Serial Bus device when it is first powered or reset. The default address is 0x0. |
| default pipe | The message pipe created by Universal Serial Bus system software to pass control and status information between the host and a Universal Serial Bus device's Endpoint 0. See also, pipe. |
| device | A logical or physical entity that performs a function. The actual entity described depends on the context of the reference. At the lowest level, device may refer to a single physical hardware component, as in a memory device. At a higher level, it may refer to a collection of hardware components that perform a particular function, such as a Universal Serial Bus interface device. At an even higher level, device may refer to the function performed by an entity attached to the Universal Serial Bus; for example, a data / FAX modem device. Devices may be physical, electrical, addressable, and logical.<br><br>When used as a non-specific reference, a Universal Serial Bus device is either a hub or a function. |
| device address | The address of a device on the Universal Serial Bus. The device address is the default address when the Universal Serial Bus device is first powered or reset. Hubs and functions are assigned a unique device address by Universal Serial Bus software. See also, hub. |
| device driver | A program responsible for interfacing to a hardware device. |

| | |
|---|---|
| device endpoint | A uniquely identifiable portion of a Universal Serial Bus device that is the source or sink of information in a communication flow between the host and device. See also, isochronous sink endpoint, and isochronous source endpoint. |
| downstream | The direction of data flow from the host or away from the host. A downstream port is the port on a hub electrically farthest from the host that generates downstream data traffic from the hub. Downstream ports receive upstream data traffic. |
| endpoint | See device endpoint. |
| endpoint address | The combination of a Device Address and an Endpoint Number on a Universal Serial Bus device. |
| endpoint number | A number that identifies a unique pipe endpoint on a Universal Serial Bus device. |
| frame | The time from the start of one start of frame (SOF) token to the start of the subsequent SOF token. A frame is the master clock of the USB, and is typically 1ms long. See also, SOF. |
| function | A capability provided to the host by a Universal Serial Bus device. For example, an ISDN connection, a digital microphone, or speakers. A device may provide one or more functions. |
| host | The computer system in which the Universal Serial Bus host controller is installed. This includes the host hardware platform (CPU, bus, etc.) and the operating system in use. |
| host controller | The host's Universal Serial Bus interface. |
| host controller driver | The Universal Serial Bus software layer that abstracts the host controller hardware. Host Controller Driver provides an SPI for interaction with a host controller. Host Controller Driver hides the specifics of the host controller hardware implementation. On the Macintosh this is the Universal Serial Bus interface module (UIM), which is pronounced *whim*. |
| hub | A Universal Serial Bus device that provides additional attachment points to the Universal Serial Bus. |

| | |
|---|---|
| interface | A collection of pipes which form a logical interface to part or all of a device. USB devices all have an interface or interfaces. Interfaces provide the definitions of the functions available within a device. The device's function or functions are defined by the interfaces it supports. See also, pipe. |
| isochronous data | A stream of data whose timing is implied by its delivery rate. |
| isochronous device | An entity with isochronous endpoints, as defined in the USB specification, that sources or sinks sampled analog streams or synchronous data streams. |
| isochronous sink endpoint | An endpoint that is capable of consuming an isochronous data stream. |
| isochronous source endpoint | An endpoint that is capable of producing an isochronous data stream. |
| Isochronous transfer | One of four Universal Serial Bus transfer types. Isochronous transfers are used when working with isochronous data. Isochronous transfers provide periodic, continuous communication between host and device. |
| little endian | Method of storing data that places the least significant byte of multiple byte values at lower storage addresses. For example, a word stored in little endian format places the least significant byte at the lower address and the most significant byte at the higher address. The USB standard uses little-endian format for multi-byte fields. See also big endian. |
| message pipe | A pipe that transfers data using a request / data / status paradigm. The data has an imposed structure which allows requests to be reliably identified and communicated. See also, pipe. |
| packet | Data organized in a group for transmission. Packets typically contain three elements: control information (source, destination, and length), the data to be transferred, and error detection and correction bits. |
| packet buffer | The logical buffer used by a Universal Serial Bus device for sending or receiving a single packet. This determines the maximum packet size the device can send or receive. |

| | |
|---|---|
| packet ID (PID) | A field in a Universal Serial Bus packet that indicates the type of packet, and by inference the format of the packet and the type of error detection applied to the packet. |
| physical device | A device that has a physical implementation; for example, speakers, microphones, and CD players. |
| pipe | A logical abstraction representing the association between an endpoint on a device and software on the host. A pipe has several attributes; for example, a pipe may transfer data as streams (stream pipe) or messages (message pipe). |
| port | Point of access to or from a system or circuit. For Universal Serial Bus, the point where a Universal Serial Bus device is attached. |
| root hub | A Universal Serial Bus hub attached directly to the host controller. The root hub is the origin (tier 0) of the USB, and is a software simulation of a standard USB hub device. |
| root port | The upstream port on a hub. |
| SOF | An acronym for Start of Frame. The SOF is the first transaction token in each frame. SOF allows endpoints to identify the start of frame and synchronize internal endpoint clocks to the host. |
| stream pipe | A pipe that transfers data as a stream of samples with no defined Universal Serial Bus structure. |
| synchronization type | A classification that characterizes an isochronous endpoint's capability to connect to other isochronous endpoints. |
| transaction | The delivery of service to an endpoint; a complete logical transfer with a beginning and end, consists of a token packet, optional data packet, and optional handshake packet. Specific packets are allowed / required based on the transaction type. |
| transfer | One or more bus transactions to move information between a software client and its function. |
| transfer type | Determines the characteristics of the data flow between a software client and its function. Four transfer types are defined: control, interrupt, bulk, and isochronous. |

| | |
|---|---|
| UIM | The Universal Serial Bus Interface Module (UIM); the low-level (controller specific) software that provides the upper layers of the USB management software with a hardware abstraction layer to the USB host controller interface hardware. |
| Universal Serial Bus (USB) | A collection of Universal Serial Bus devices and the software and hardware that allow them to connect the capabilities provided by functions to the host. |
| USB software | The host-based software responsible for managing the interactions between the host and the attached Universal Serial Bus devices. The USB drivers, USB Manager, and UIM provide these software services on the Macintosh computer. |
| USB driver | The host-resident software entity responsible for providing common services to clients that are manipulating one or more functions on one or more host controllers, hubs or devices. |
| upstream | The direction of data flow towards the host. An upstream port is the port on a device electrically closest to the host that generates upstream data traffic from the hub. Upstream ports receive downstream data traffic. |

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