USB Host SDK for OS-9®

Version 2.0
Copyright and publication information

This manual reflects version 2.0 of USB Host SDK for OS-9. Reproduction of this document, in part or whole, by any means, electrical, mechanical, magnetic, optical, chemical, manual, or otherwise is prohibited, without written permission from RadiSys Microware Communications Software Division, Inc.

Disclaimer

The information contained herein is believed to be accurate as of the date of publication. However, RadiSys Corporation will not be liable for any damages including indirect or consequential, from use of the OS-9 operating system, Microware-provided software, or reliance on the accuracy of this documentation. The information contained herein is subject to change without notice.

Reproduction notice

The software described in this document is intended to be used on a single computer system. RadiSys Corporation expressly prohibits any reproduction of the software on tape, disk, or any other medium except for backup purposes. Distribution of this software, in part or whole, to any other party or on any other system may constitute copyright infringements and misappropriation of trade secrets and confidential processes which are the property of RadiSys Corporation and/or other parties. Unauthorized distribution of software may cause damages far in excess of the value of the copies involved.
# Table of Contents

## Chapter 1: Getting Started with USB Host for OS-9®

- **8** System Overview
- **9** System Requirements
- **9** Windows Development Platform Hardware Requirements
- **9** Windows Development Platform Software Requirements
- **10** OS-9 Target System/USB Host Hardware Requirements
- **11** Installing the Software
- **11** Installing to the Windows Development Platform
- **13** Installing to the OS-9 Target System/USB Host
- **13** USB Host Module List
- **16** Loading and Starting the USB Host Software
- **21** Example Commands
- **21** Checking for USB Devices
- **21** Getting Device Information
- **22** Checking for Data Transmission
- **24** Mouse Through MAUI®

## Chapter 2: Using USB Host for OS-9

- **28** Overview
- **30** Hardware Controller Driver
- **30** Bus Methods Structure
- **30** Bus Methods Structure Fields
- **31** Pipe Methods Structure
- **31** Bus Methods Structure Fields
- **33** USB Management Driver
- **33** Bus Explore
- **35** Plug and Play
Chapter 3: USB Host API Reference

70 Pipe Functions List
This chapter describes how to install and configure the USB Host SDK for OS-9® software on your Windows development platform and on your OS-9 target system. It includes the following sections:

- System Overview
- System Requirements
- Installing the Software
- Example Commands
System Overview

**Figure 1-1** shows a typical development environment for using USB Host SDK for OS-9. It is recommended that you assemble and configure your development environment before software installation.

**Figure 1-1 USB Host Development Environment**

- **Windows Development Platform**
- **OS-9 Target System/USB Host**
- **USB Device (USB HUB)**
- **Standard USB Cable**
- **series "B" USB receptacle**
- **series "A" USB receptacles**
- **RS-232 null modem serial cable with 9-pin connector**
- **connect to free serial port**
- **connect to Ethernet port (recommended)**

The USB device can be a single device or a USB Hub supporting multiple USB devices.
System Requirements

Windows Development Platform Hardware Requirements

Your Windows development platform must have the following minimum hardware characteristics:

- 250MB of free hard disk space
- the recommended amount of RAM for your particular operating system
- a CD-ROM drive
- a free serial port
- an Ethernet network card (optional but recommended)
- access to an Ethernet network (optional but recommended)

Windows Development Platform Software Requirements

The Windows development platform must have the following software installed:

- Microware OS-9 for Embedded Systems (aka OEM Package)
- USB Host SDK for OS-9 add-on
- Windows ME, 2000, NT 4.0, or XP
- terminal emulation program

Note

The terminal emulation program, Hyperterminal, ships with all Windows operating systems.
OS-9 Target System/USB Host Hardware Requirements

Your OS-9 target system/USB Host reference board requires the following hardware:

- a free serial port
- an RS-232 null modem serial cable with 9-pin connectors
- one or more USB ports
- a standard USB cable
- a free Ethernet port (optional but recommended)
- access to an Ethernet network (optional but recommended)

---

**Note**

Some USB Host Controllers require a non-cached memory shade.

---

**Note**

To use the USB Host system, you will also need standard USB devices such as a mice, keyboards, printers, or mass storage devices and the appropriate cables.
Installing the Software

Installing to the Windows Development Platform

The **USB Host SDK for OS-9** software package is an add-on to OS-9. OS-9 must be installed on your Windows development platform before the USB Host software is installed.

To install OS-9, insert the CD-ROM into your Windows development platform CD-ROM drive and follow the on-screen instructions. After OS-9 is installed, you will be able to choose **USB Host SDK for OS-9** from the Add-Ons menu.

For More Information
For detailed installation instructions, refer to the *Getting Started with Microware Products* manual. This manual is accessible via Acrobat Reader from the Microware OS-9 CD.

NOTE: Portions of the source code for the USB Host SDK have this copyright/license.

Copyright (c) 2001 The NetBSD Foundation, Inc.
All rights reserved.

This code is derived from software contributed to The NetBSD Foundation by Lennart Augustsson (lennart@augustsson.net) at Carlstedt Research & Technology.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:
1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.

2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

3. All advertising materials mentioning features or use of this software must display the following acknowledgement:

   This product includes software developed by the NetBSD Foundation, Inc. and its contributors.

4. Neither the name of The NetBSD Foundation nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE NETBSD FOUNDATION, INC. AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE FOUNDATION OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
Getting Started with USB Host for OS-9®

Installing to the OS-9 Target System/USB Host

Before installing the USB Host software onto your OS-9 target system/USB Host, you must complete the following steps:

---

**Step 1.** Assemble and configure your USB Host development environment hardware.

**Step 2.** Install OS-9 and the **USB Host SDK for OS-9** software onto your Windows development platform.

**Step 3.** Create an OS-9 ROM Image and load it onto your OS-9 target system/USB Host.

**Step 4.** Boot your OS-9 Target System/USB Host to an OS-9 prompt. The OS-9 prompt must be accessible via your terminal emulation program.

---

For More Information

Creating an OS-9 ROM Image, loading the image onto the target system, and booting to an OS-9 prompt is described in your target system’s board guide. The board guides are accessible via Acrobat Reader from the Microware OS-9 CD.

---

USB Host Module List

After installing the **USB Host SDK for OS-9** add-on package onto your Windows development platform, the following USB Host modules will be present on your system:

- **USB Controller Drivers**

  C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\usbhcd
  C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\usbhcde
- **USB Controller Driver Descriptors**
  C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\NULLFM\usbhc
  C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\NULLFM\usbhc2
  C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\NULLFM\usbhc3
  C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\NULLFM\usbhc4

- **USB Keyboard MAUI Protocol Module**
  C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\MAUI\mp_usbkbd

- **USB Mouse and Keyboard MAUI CDB Module**
  C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\MAUI\cdb_usb*

- **USB Host Manager Driver**
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\usbman

- **USB Host Manager Driver Descriptor**
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\usb

- **USB Mouse Driver**
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\ums

- **USB Mouse descriptors**
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\um0
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\um1

- **USB Keyboard Driver**
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\ukbd

- **USB Keyboard Descriptor**
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\ukbd0

- **USB Generic Driver**
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\spugen

- **USB Generic Driver descriptors**
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\ugen0
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\ugen1

- **USB Printer Driver**
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\ulpt

- **USB Printer Descriptor**
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USBH\ulp0
Getting Started with USB Host for OS-9®

- **USB Mass Storage Device Driver**
  
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJ\USBH\udiskd

- **USB Mass Storage Device Descriptors**
  
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJ\USBH\DESC\muh*
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJ\USBH\DESC\uh*

- **NullFM file manager**
  
  C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJ\nullfm

---

**Note**

The drive letter, <processor> directory, and <board_port> directory will vary depending on your particular installation.
Loading and Starting the USB Host Software

The objective of this procedure is to move the USB Host modules, which are drivers and descriptors, from the Windows development platform onto the OS-9 target system/USB Host. Some port directories include support in the Wizard for USB Host. If your port directly supports USB host, there will be a USB Host check-box on the bootfile options tab.

Click this checkbox to enable USB Host support. You will also want to select MAUI, keyboard, and mouse from the master builder window to include the appropriate software.

**Note**

The USB Host software works best when the system tick rate (ticks per second) is 1000 or higher. This allows the USB Host software to accurately implement delays and time-outs. This value can be set on the “Init Options” tab of the Disk Options dialog.
If your port does not directly support USB host, you will need to manually load the software onto your target. There are several ways this can be accomplished and the following procedure describes only one method of accomplishing this task.

Step 1. On the Windows development platform, open a text editor, such as Notepad, and create a text file list that includes the USB Host modules. Be sure there is only one module per line and that you include the full path.

Your final text file should look something like the following:

```
C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\NULLFM\usbhcd
C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\NULLFM\usbc
C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\NULLFM\usbhcd2
C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\NULLFM\usbhc
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\usbman
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\usb
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\ums
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\um0
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\um1
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\ukbd
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\ukbd0
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\apugen
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\ugen0
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\ugen1
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\ulpt
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\ulp0
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\udiskd
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\DESC\muh01
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\DESC\muh11
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\DESC\muh21
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\USB\DESC\muh31
C:\MWOS\OS9000\<PROCESSOR>\CMDS\BOOTOBJS\nullfm
C:\MWOS\OS9000\<PROCESSOR>\CMDS\usbd
C:\MWOS\OS9000\<PROCESSOR>\CMDS\usbdevs
C:\MWOS\OS9000\<PROCESSOR>\CMDS\ugenstat
```

**Note**
The drive letter, <processor> directory, and <board_port> directory will vary depending on your particular installation.
Step 2. Save this file as `usb_mods.ml` on your Windows system in a location of your choice.
Step 3. On the Windows development platform, open a DOS shell. Using DOS commands, navigate to the directory where usb_mods.ml is located, and type the following DOS command:

```
% os9merge -z=usb_mods.ml>usb_mods
```

This creates a merged file called usb_mods. usb_mods will be located in the same directory that usb_mods.ml is located.

Step 4. Load the usb_mods file onto the OS-9 target system/USB Host system's RAM.

From the Windows desktop, start Hawk™ by selecting Start -> RadiSys -> Microware OS-9 for <product> -> Microware Hawk IDE.

From the Target Menu, select Load. Enter the IP address of your OS-9 target. In the Module dialog, push the navigation button and navigate to the location of the usb_mods file and select usb_mods. Press the Load button.

---

**Note**

This procedure requires that the Hawk debugger daemons be loaded and running on the OS-9 target system. You can make this selection while building the OS-9 ROM Image.

---

Step 5. Start the USB Host software by typing the following command from the terminal emulation window on the Windows development platform:

```
$ usbd &
```

The USB Host modules are now loaded and running on your OS-9 target system/USB Host.
Note

This procedure assumes that you have access to an Ethernet network for loading the USB Host software from the Windows development system to the target system. If you do not have access to a network, you can load the USB Host software via FTP across the serial connection using OS-9 commands and your terminal emulation program.
Example Commands

Checking for USB Devices

Once the USB Host software is loaded onto your OS-9 target system/USB Host, you can check the system for existing USB devices. To see what devices are plugged into the USB, type the following command in the terminal emulation program window.

```
$ usbdevs
```

Following is an example response from the command:

```
Bus #0, Root Hub, Address 1,
[1] <empty>

Bus #1, Root Hub, Address 1,
[1] <empty>
[2] <empty>

Bus #2, Root Hub, Address 1,
[2] <empty>
[3] <empty>
[4] <empty>
```

The above example shows the three root hubs (two USB v1.1 controllers and one USB v2.0 controller). A USB keyboard is plugged into a USB v1.1 controller and a USB mass storage (Flash disk) device is plugged into the USB v2.0 controller. The keyboard and disk has been both been assigned address 2, but on different busses.

Getting Device Information

You can view information about USB devices on the system. For example, to learn more about the USB keyboard device in the example above, type the following command in the terminal emulation program window. Note that the bus number must be specified so that the device address is not ambiguous:

```
$ usbdevs -a=2 -b=0
```
Following is an example response from the command:

Address 2, NOVATEK: ORTEK USB Keyboard (vendor 1444, product 38705)
  Device Descriptor: max_packet 8, protocol 0, release 0.1, configurations 1
  Config. Descriptor (1): interfaces 2, value 1, iconfig 0
    attributes 0xa0, max power 100 mA
  Interface Descriptor 1: NOVATEK
    alt. setting 0, num eps 1,
    class 3, subclass 1, protocol 1, iInterface 4
  Interface Descriptor 2: NOVATEK
    alt. setting 0, num eps 1,
    class 3, subclass 1, protocol 2, iInterface 4
$ usbdevs -a=2 -b=2

Following is an example response from the command:

Address 2, SanDisk Corporation: U3 Cruzer Micro: 0000051015079136 (vendor 1921, product 21506)
  Device Descriptor: max_packet 64, protocol 0, release 0.2, configurations 1
  Config. Descriptor (1): interfaces 1, value 1, iconfig 0
    attributes 0x80, max power 200 mA
  Interface Descriptor 1: alt. setting 0, num eps 2,
    class 8, subclass 6, protocol 80, iInterface 0

Checking for Data Transmission

You can determine if a USB device is sending data over the USB. For example, to determine if the USB keyboard device in the example above is sending keyboard data over the USB, type the following commands in the terminal emulation program window:

$ tmode nopause
$ dump /ukbd0

After typing the commands, type on the USB keyboard. Following is an example response from the command:

          Addr  0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F  0  2  4  6  8  A  C  E
          -------- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- -------
00000000  0000  0f00  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  ............
00000010  0000  0f00  0000  0000  0000  0d00  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  ............
            ***     2. duplicate lines ***
00000040  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  ............
00000050  0000  0d00  0000  0000  0000  0f00  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  ............
00000060  0000  0d00  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  ............
00000070  0000  1c00  0000  0000  0000  1c00  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  ............
00000080  0000  0000  0000  0000  0000  5100  0000  0000  0000  0000  0000  0000  0000  0000  0000  0000  ............

22 USB Host SDK for OS-9
You can press Ctrl-C to exit dump.
Mouse Through MAUI®

To use a USB Mouse as a MAUI® input device complete the following steps:

Step 1. Load the following special modules on the OS-9 target machine:

- Standard MAUI PS/2 Mouse protocol module.
  C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\MAUI\mp_bsptr
- CDB Module that defines a USB Mouse for MAUI
  C:\MWOS\OS9000\<PROCESSOR>\PORTS\<BOARD_PORT>\CMDS\BOOTOBJS\MAUI\cdb_usb

Step 2. Load the following MAUI modules on the OS-9 target. These modules are included with OS-9.

OS9000/<PROCESSOR>/CMDS/maui
OS9000/<PROCESSOR>/CMDS/BOOTOBJS/maui_inp
OS9000/<PROCESSOR>/CMDS/BOOTOBJS/maui_win
OS9000/<PROCESSOR>/CMDS/BOOTOBJS/mfm
OS9000/<PROCESSOR>/CMDS/BOOTOBJS/mauidev
OS9000/<PROCESSOR>/CMDS/BOOTOBJS/mauidrvr
OS9000/<PROCESSOR>/CMDS/MAUIDEMO/inp

Step 3. Type the following commands in the terminal emulation program window:

$ maui_inp &
$ tmode nopause
$ inp -i=/um0/mp_bsptr

Following is an example response from the command:

Opening device '/um0/mp_bsptr'
Send signal to 'inp' to end test
Expected device id 0x3fa8018
Step 4. Move the mouse, or click buttons on the mouse.

Following is an example response from the command:

```
+------------------------------------------------------+
Device type: +++ Pointer +++ Device ID:  0x3fa8018
| Sub-type: 0x1
|          INP_PTR_DOWN
| Button changed: 1
| Button status 1 (0x1)
| New position (0,0)
| Simulating keysym: INP_KEY_NULL (0x0)
+------------------------------------------------------+
Device type: +++ Pointer +++ Device ID:  0x3fa8018
| Sub-type: 0x2
|          INP_PTR_UP
| Button changed: 1
| Button status 0 (0x0)
| New position (0,0)
| Simulating keysym: INP_KEY_NULL (0x0)
+------------------------------------------------------+
```

Step 5. You can press Ctrl-C to exit inp
Chapter 2: Using USB Host for OS-9

This chapter provides a description of the OS-9 implementation for USB host. It includes the following sections:

- Overview
- Hardware Controller Driver
- USB Management Driver
- Logical Device Drivers
- Standard OS-9 LDD Drivers
- User-State Daemon Process
Overview

The stack for the OS-9 implementation of USB Host consists of the following three main components:

- Hardware Controller Drivers
- USB Management Driver
- Logical Device Drivers

Dividing the USB Host responsibilities between these components provides maximum modularity and flexibility, enables easy maintenance, and ensures performance. Each component is described in the following sections of this chapter.

Figure 2-1 provides a visual overview of the USB Host stack. Figure 2-2 shows the overall USB Host architecture as it relates to an OS-9 system.

Figure 2-1 USB Host Stack
Figure 2-2  USB Host Architecture

OS-9 User-State Process

Direct Access to USB from OS-9 System-State Process

OS-9 File Manager

OS-9 File Manager

OS-9 File Manager

USB Logical Device Driver (Provides OS-9 Access to USB Device)

USB Logical Device Driver

USB Driver Interface (USBDI)

USBMAN (Device Independent)

USB Host Controller Driver Interface (HCDI)

USBHCD (Host Controller Driver)

USB Host Controller Hardware
The hardware controller driver is responsible for initializing the USB hardware, scheduling transfers on the USB, managing the root hub, and notifying logical device drivers when a transfer has completed. This driver is given tasks to perform by usbman through the HCDI interface.

The HCDI interface is a series of function pointers into the Hardware Controller Driver to open and close pipes, allocate DMA memory, and perform transfers on the USB. There are two classifications of function pointers—bus methods and pipe methods.

### Bus Methods Structure

Following is the bus methods structure:

```c
struct usbd_bus_methods {
    usbd_status (*open_pipe)(struct usbd_pipe *pipe);
    void (*soft Intr)(void *);
    void (*do_poll)(struct usbd_bus *bus);
    usbd_status (*allocm)(struct usbd_bus *bus, u_int32_t **_dma,
        u_int32_t bufsize);
    void (*freem)(struct usbd_bus *bus, usb_dma_t *dma);
    struct usbd_xfer *(*allocx)(struct usbd_bus *bus);
    void (*freex)(struct usbd_bus *bus, struct usbd_xfer *x);
};
```

### Bus Methods Structure Fields

- **open_pipe**
  
  Notifies the Hardware Controller Driver of a new transfer pipe to a device on the USB. This call modifies the methods and methods_gp fields of the given pipe structure.

- **soft_intr**
  
  Notifies the Hardware Controller Driver there are potentially aborted transfers to be cleaned up.
Using USB Host for OS-9

**allocm**
Allocates memory suitable for DMA. This modifies the `dma` parameter. This will return `USBD_NORMAL_COMPLETION` on success, or `USBD_NOMEM` if no memory available.

**freem**
Frees memory allocated by `allocm`.

**allocx**
Allocates a transfer handle, and returns it.

**freex**
Frees a transfer handle allocated by `allocx`.

**Pipe Methods Structure**

The pipe methods structure below is initialized after calling open_pipe in the bus methods structure.

```c
struct usbd_pipe_methods {
    usbd_status      (*transfer)(usbd_xfer_handle xfer);
    usbd_status      (*start)(usbd_xfer_handle xfer);
    void           (*abort)(usbd_xfer_handle xfer);
    void           (*close)(usbd_pipe_handle pipe);
    void           (*cleartoggle)(usbd_pipe_handle pipe);
    void           (*done)(usbd_xfer_handle xfer);
};
```

**Bus Methods Structure Fields**

- **transfer**
  Performs a transfer on the USB.

- **start**
  Starts the next transfer to the device.

- **abort**
  Aborts a transfer on the USB.

- **close**
  Closes a transfer. The transfer must not be active to call this (i.e. use `abort` first).

- **cleartoggle**
  Clears the data toggle back to 0.

- **done**
  Called after successfully completing a transfer.

The common names for the Hardware Controller Drivers begin with `usbhcd`. The device descriptors for these drivers are in the form `usbhc?` where `?` is either no character, ‘2’, ‘3’, or ‘4’. `usbman` will attempt to open
usbhc, usbhc2, usbhc3, and usbhc4 (in that order) when initializing the USB stack. Typically, the drivers are organized such that low or full speed drivers are opened first and any high speed driver is opened last. This driver can be initialized with the iniz command (for example iniz /usbhc). Upon doing so, the Hardware Controller Driver will initialize the hardware and begin generating Start Of Frame packets every 1ms on the USB. The recommended method for initializing the USB stack, however, is to start the usbd daemon process.

The hardware controller driver is the only board specific module required for the OS-9 USB Stack. Consequently, it is found in the CMDS\BOOTOBJ directory of the board PORT directory.
USB Management Driver

The USB Management Driver, `usbman`, is a nullfm driver that implements the management layer of the USB Host software. It has the following responsibilities:

- Maintains bus topology
- Implements USBDI interface for LDDs
- Performs USB explore
- Implements hub driver
- Manages plug-n-play

`usbman` communicates directly to the Hardware Controller Driver through the HCDI interface and other setstat/getstat calls.

`usbman` is located in the following directory:

```
OS9000/<PROCESSOR>/CMDS/BOOTOBJS/USBH/usman
```

The `usbman` descriptor is located in the following directory:

```
OS9000/<PROCESSOR>/CMDS/BOOTOBJS/USBH/usb
```

Bus Explore

Most of the responsibilities of `usbman` revolve around a bus explore. The process is started by plugging in or removing a device from the USB. Below is a short description of the sequence of events in a bus explore:

Step 1. The hub driver, as a part of `usbman`, receives notification that its pipe has transferred data. The interrupt service routine for the hub driver sends a signal to the USBD daemon process indicating that a USB explore is required.
**Note**
The explore of the USB may take several seconds, thus necessitating the use of a process context for the explore.

---

**Step 2.** usbd wakes up and performs an explore setstat into usbman. The explore code in usbman performs a depth first search on the USB starting with the root hub.

**Step 3.** The explore code inspects each port on every hub, one at a time, to determine if any change is present. A change may be either something plugged in or removed, or an overcurrent condition.

- **Device Removed**
  
  If a device was removed, the `detach` LDD routine is called for the driver that is assigned to the device. The control pipe is then closed, and any memory is removed. If the device was a hub, then each downstream device will have its `detach` LDD routine called, followed by closing the control pipe and memory reclamation.

- **Device Inserted**
  
  If a device was inserted, usbman opens a control pipe and gathers basic information about the device. usbman then attempts to match an available LDD to this device using the `match` routine. If a driver matches, then the `attach` LDD routine is called, and this LDD is no longer considered available.

- **Overcurrent**
  
  If a port on a hub is overcurrent, it is treated as if the device was removed. However, the port may not be used again unless the entire hub is removed from the USB and re-inserted.

USB Addresses are assigned by usbman. There is no rule that a particular device will always be assigned a particular address. In addition, there is no order for matching a driver to a new device.
Plug and Play

Plug and play is accomplished in the OS-9 USB Host stack through a usbman callout mechanism. usbman makes this call to one of three possible functions: match, attach, or detach. Essentially, the call is initiated when there is a device modification; usbman recognizes the modification and calls the appropriate function to notify the LDD.

For example, suppose a device were removed from USB. At this point, usbman would call the detach function, which would then tell the available LDD to change the device information.

More information on the match, attach, and detach functions is provided in the following sections.

Match

match is called by usbman when there is an attempt to assign a device on the USB to an available LDD. This function is called after a device is plugged into the bus or after a driver registers with usbman.

In addition, match is passed as a device structure and an interface structure. Both of these represent the current state of the device on the USB. The match routine should look at these two parameters (device structure and interface structure) to determine whether or not the driver can communicate with the device.

Below is a sample prototype of the match function:

```c
int os9_match(struct usbd_device *dev,
usbd_interface_handle iface)
```

The match function may perform transfers on the USB over the control pipe, since that has already been established by usbman. Such transfers would likely be to retrieve endpoint or vendor-specific descriptors. The configuration and interface for the device should not be set at this time. usbman will loop on each interface in a configuration (for each configuration).
The match function should return 0 if the device does not match what the driver expects. If the driver can communicate with the USB device, the match function should return any non-zero value.

**Attach**

The attach function is called by usbman after a successful call to the match function. Attach should open any relevant transfer pipes and perform any other setup required to initialize the device. This function will return a value from the usb_status enumerated type (located in usb.h). Below is a sample prototype for the attach function.

```c
usbd_status os9_attach(usbd_device_handle dev, usbd_interface_handle iface)
```

**Note**

If the attach function returns an error, the detach function will not be called. This means that the attach function must properly deallocate resources allocated prior to the error condition.

**Detach**

The detach function is called by usbman if the device is removed from the USB, or if the driver is de-registering itself with usbman. This function is responsible for deallocating any resources acquired in the attach routine. Normally, this means closing pipes and freeing memory. Below is an example detach function prototype:

```c
usbd_status os9_detach(usbd_device_handle dev)
```
Registering with usbman

The following routines perform plug and play on the USB for OS-9. These routines are provided a way for usbman to call back into the LDD. Each LDD registers its functions with usbman when it initializes. Below is the plug and play structure followed by a brief description of each field.

```c
typedef struct {
    usbd_status (*detach)(struct usbd_device *dev);
    usbd_status (*attach)(struct usbd_device *dev, usbd_interface_handle iface);
    int (*match)(struct usbd_device *dev, usbd_interface_handle iface);
    void *gp;    /* ldd global pointer */
    void *dev_data;  /* (ldd) device specific data */
} usbd_ldd_t;
```

detach

This is called when a device is removed from the USB. This routine should close any interrupt, bulk, or isochronous pipes and any other resources allocated in the attach routine. usbman will close the control pipe.

attach

This is called after a successful return from match. This routine should open any pipes required for this device to function. It may also perform transfers over the control pipe.

match

This routine will determine if the given device and interface are appropriate for this LDD. If no match is possible, then return UMATCH_NONE. Otherwise, return UMATCH_IFACECLASS. This routine may also perform transfers over the control pipe. However, do not attempt to change the interface. If the given interface, iface, is not suitable, return UMATCH_NONE. The usbman explore routine will iterate over all interfaces.

gp

This is the LDD global pointer, and should be set properly by the LDD before registering the attach/match/detach routines with usbman.
This is for specific use by the LDD. In some circumstances, it is useful to place information here in the attach routine.
Logical Device Drivers

A Logical Device Driver (LDD) implements code to support a particular USB device like a mouse, keyboard, or printer. It is intended that each LDD support the standard OS-9 interface as much as possible. These drivers interface to usbman using the USBDI interface. LDDs may use any OS-9 file manager, including nullfm.

LDD Initialization

Each LDD must perform the following steps once during initialization:

Step 1. Open /usb. This opens a path to usbman so that this LDD may use the USBDI interface.

Step 2. Perform a GS_USB_USBMAN_IFACE getstat to retrieve function pointers that implement the USBDI interface.

Step 3. Perform a SS_USB_LDD_METHODS setstat to register attach, match, detach routines with usbman.

LDD De-Initialization

Perform the following steps to de-initialize an LDD:

Step 1. Perform SS_USB_LDD_METHODS setstat (with enable field set to 0) to remove registration with usbman.

Step 2. Close path to /usb.
Suggested OS-9 Interface

It is suggested that each LDD support the standard OS-9 interface. Below is a list of setstats/getstats that each LDD should implement, if possible.

**Setstats**

- **SS_SENDSIG**: Send signal on data registration.
- **SS_RELEASE**: Remove SS_SENDSIG registration.

**Getstats**

- **SS_READY**: Return number of bytes ready for read.

Plug-n-play

Each LDD must register an attach, match, and detach routine with `usbman`. These routines facilitate plug-n-play under OS-9. Following is a code snippet showing how to register these routines.

```c
usbd_ldd_t mouse_ldd = {os9_detach_mouse, 
os9_attach_mouse, 
os9_match_mouse, 
NULL, /* gp */
NULL};  /* dev_data */

/* register attach/match/detach with usbman */
methods_pb.enable = 1;
mouse_ldd.gp = get_static();
methods_pb.ldd = &mouse_ldd;
err = _os_setstat(usb_path, SS_USB_LDD_METHODS, &methods_pb);
```

Removing registration with `usbman` should only occur in the term part of the driver. Following is an example:

```c
/* un-register with usbman */
methods_pb.enable = 0;
methods_pb.ldd = &mouse_ldd;
(void) _os_setstat(usb_path, SS_USB_LDD_METHODS, &methods_pb);
```
Standard OS-9 LDD Drivers

The OS-9 USB Host Stack ships with the following Logical Device Drivers:

- **USB Mouse**
- **USB Keyboard**
- **USB Printer**
- **USB Mass Storage**
- **USB Mass Storage**

**USB Mouse**

The USB Host Mouse driver is implemented as a `nullfm` Driver. It supports the standard OS-9 interface for read, `SS_RELEASE`, `SS_SENDSIG`, and `SS_READY`. The standard OS-9 utilities, such as `dump`, can be used with this driver. This driver attaches to any device that declares itself to be a HID Mouse device with an x and y report. The driver and its descriptors are found in the following locations:

- **Source Directory:**
  `SRC/DPIO/NULLFM/DRVR/USBH/UMS`
- **Driver Location:**
  `OS9000/<PROCESSOR>/CMDS/BOOTOBS/USBH/ums`
- **Descriptor Location:**
  `OS9000/<PROCESSOR>/CMDS/BOOTOBS/USBH/um0`
  `OS9000/<PROCESSOR>/CMDS/BOOTOBS/USBH/um1`
Data Format

The USB Host mouse driver generates PS/2 style data. Each mouse movement and/or button press is represented by 3 bytes. PS/2 only allows for 3 buttons and 8 bits of movement per data sample. Following is the data format:

Byte 0: oy ox sy sx 1 b3 b2 b1
Byte 1: x7 . . . . . . . . x0 - signed x data
Byte 2: y7 . . . . . . . . y0 - signed y data

B1 button 1 down
B2 button 2 down
B3 button 3 down
Oy overflow in y direction
Ox overflow in x direction
Sy sign bit in y direction
Sx sign bit in x direction

Use With MAUI

To use the USB Mouse with MAUI, the correct protocol module cdb is required. The USB Mouse uses the mp_bsptr protocol module. This is the standard PS/2 mouse protocol module. Since the USB Mouse driver generates PS/2 data, mp_bsptr is very functional.

For applications to be aware of the USB Mouse, a cdb entry must be added. Following is a code snippet that shows a USB Mouse entry in a cdb.a file. This file is found in the following location:

OS9000/<PROCESSOR>/PORTS/<BOARD>/MAUI/CDB

pect cdb,(5<<8)+1,$8000,212,0,entry
org 0
entry:
  (Other entries here)
dc.b "5:/um0/mp_bsptr:TY="ptr":",13 * USB Mouse
ends
Testing the USB Mouse

The USB Mouse can be tested in two ways. The first, and simplest method, is using the OS-9 dump utility. Following is an example of using OS-9 dump:

```
$ tmode nopause
$ dump /um0
(Move the mouse and press buttons)
Addr 0 1 2 3 4 5 6 7 8 9 A B C D E F 0 2 4 6 8 A C E
-------- ---- ---- ---- ---- ---- ---- ---- ---- ----------------
00000000 0900 000b 0000 0900 000b 0000 0a00 0008 ..............
00000010 0000 0803 0108 0403 0806 0408 0603 0806 ..............
00000020 0308 0403 0803 0308 0002 08ff 0208 fe01 ..............
(Ctrl-C to exit)
Error #000:177
```

The second method for testing the mouse is to use the MAUI inp demo software. Following is an example of using inp:

```
$ mauli_inp &
$ tmode nopause
$ inp -i=/um0/mp_bsptr
Opening device '/um0/mp_bsptr'
Send signal to 'inp' to end test
Expected device id 0x3fa8018
+---------------------------------------------+
Device type: +++ Pointer +++ Device ID: 0x3fa8018
 | Sub-type: 0x4
 | | INP_PTR_MOVE
 | Button changed: 0
 | Button status 0 (0x0)
 | New position (-64,117)
 | Simulating keysym: INP_KEY_NULL (0x0)
+---------------------------------------------+
Device type: +++ Pointer +++ Device ID: 0x3fa8018
 | Sub-type: 0x1
 | | INP_PTR_DOWN
 | Button changed: 2
 | Button status 2 (0x2)
 | New position (-64,117)
 | Simulating keysym: INP_KEY_NULL (0x0)
+---------------------------------------------+
Device type: +++ Pointer +++ Device ID: 0x3fa8018
 | Sub-type: 0x2
 | | INP_PTR_UP
 | Button changed: 2
 | Button status 0 (0x0)
 | New position (-64,117)
 | Simulating keysym: INP_KEY_NULL (0x0)
+---------------------------------------------+
(Ctrl-C to exit)
```
USB Keyboard

The USB Host Keyboard driver is implemented as a nullfm Driver. It supports the standard OS-9 interface for read, SS_RELEASE, SS_SENDSIG, and SS_READY. The standard OS-9 utilities, such as dump, can be used with this driver. This driver attaches to any device that declares itself to be a HID Keyboard that uses the BOOT Protocol. The driver and its descriptors are found in the following locations:

- **Source Directory:**
  
  SRC/DPIO/NULLFM/DRVR/USBH/UKBD

- **Driver Location:**
  
  OS9000/<PROCESSOR>/CMDS/BOOTOBJS/USBH/ukbd

- **Descriptor Location:**
  
  OS9000/<PROCESSOR>/CMDS/BOOTOBJS/USBH/ukbd0
  OS9000/<PROCESSOR>/CMDS/BOOTOBJS/USBH/ukbd1

**Data Format**

The USB Keyboard uses an 8-byte data format. Below is a C-style structure describing the format. A special protocol module, named mp_usbkbd was created to handle this exact format.

```c
#define KEYSLOTS 6
typedef struct {
    u_int8 modifiers;
    #define MOD_CONTROL_L0x01
    #define MOD_CONTROL_R0x10
    #define MOD_SHIFT_L0x02
    #define MOD_SHIFT_R0x20
    #define MOD_ALT_L0x04
    #define MOD_ALT_R0x40
    #define MOD_META_L0x08
    #define MOD_META_R0x80
    u_int8 reserved;
    u_int8 keycode[KEYSLOTS];
} UKBD_DATA;
```
The USB Keyboard can handle up to 6 characters pressed at a time. The keycode array represents “down” keys. "Up" keys must be deduced from consecutive packets. That is to say, if a particular key is "down", and then is not present in the keycode array on the next packet, then the key is declared “up”.

For More Information
For more information about the keyboard data packet, please refer to the Device Class Definition for Human Interface Devices (HID) at www.usb.org.

Use With MAUI
To use the USB Keyboard with MAUI, the correct protocol module and an updated cdb module will be required. The USB Keyboard uses the mp_usbkbd protocol module. This is found in the following location:

SRC/MAUI/MP/MP_USBKBD

For applications to be aware of the USB Keyboard, a cdb entry must be added. Below is a code snippet that shows a USB Keyboard entry in a cdb.a file. This file is found in the following location:

OS9000/<PROCESSOR>/PORTS/<BOARD>/MAUI/CDB

psect cdb,(5<<8)+1,$8000,212,0,entry
org 0
entry:
   (Other entries here)
dc.b "5:/ukbd0/mp_usbkbd:TY="ptr":",13       * USB Keyboard
ends

The mp_usbkbd protocol module turns separate LEDs when the Caps Lock, Num Lock, or Scroll Lock key is pressed.
The key repeat functionality (keys that repeat while holding down a particular key) is not implemented. According to the USB HID specification, auto-repeating keys while they are down is a function of the USB Software, not the keyboard. Currently, this feature does not exist in the OS-9 Keyboard driver.

Testing the USB Keyboard

The USB Keyboard can be tested in two ways. The first method uses the standard OS-9 dump utility. Following is an example of using OS-9 dump:

```bash
$ dump /ukbd0
```

The second method for testing the USB Keyboard is to use the MAUI inp demo software. Following is an example of using inp:

```bash
$ maui_inp &
$ tmode nopause
$ inp -i=/ukbd0/mp_usbkbd
Opening device '/ukbd0/mp_usbkbd'
Send signal to 'inp' to end test
Expected device id 0x3fa8018
```

```bash
Device type: +++ Key +++ Device ID:    0x3fa8018
| Sub-type: 0x4
|          |       |
|          | INF_KEYMOD_DOWN
| Keysym received: INF_KEY_NULL (0x0)
| Key modifiers: 0x1
|           | Shft CapL Ctrl Alt Meta Num Scrl
|           | L R  L R  L R  L R  L R  Lock Lock
|           | x

Device type: +++ Key +++ Device ID:    0x3fa8018
| Sub-type: 0x8
```

```bash
|          | INF_KEYMOD_UP
| Keysym received: INF_KEY_NULL (0x0)
| Key modifiers: 0x0
```
USB Printer

The USB Host Printer driver is implemented as a nullfm Driver. It supports the standard OS-9 interface for write, SS_RELEASE, SS_SENDSIG, and SS_READY. The standard OS-9 utilities, such as merge, can be used with this driver. The driver and its descriptor are found in the following locations:

- **Source Directory**
  SRC/DPIO/NULLFM/DRVR/USBH/ULPT

- **Driver Location**
  OS9000/<PROCESSOR>/CMDS/BOOTOBJ/USBH/ulpt

- **Descriptor Location**
  OS9000/<PROCESSOR>/CMDS/BOOTOBJ/USBH/ulp0

The printer driver attaches to any device advertising itself as a uni-directional or bi-directional printer. The OS-9 USB Printer Driver does not modify the data sent to the printer. That is to say, the data the application writes to the printer must be understood by the printer. The ulpt driver does not massage the data.
For More Information
Information about USB printers is located at www.usb.org.

Testing the USB Printer
Following is an example of how to test a printer using the OS-9 merge utility. A sample text file can be found in the following location:

SRC/DPIO/NULLFM/DRVR/USBH/ULPT/sample.txt

$ merge sample.txt>/ulp0

Note
Many USB Printers that accept ASCII text require a <CR><LF> at the end of each line, and a Ctrl-L as a Form Feed character. A sample text file (sample.txt) exists in the source directory for the printer driver.

There is also a usbprint utility that can be used to print a file. Following is an example command for usbprint:

$ usbprint sample.txt

Note
The default print device is /ulp0.
USB Mass Storage

The USB Mass Storage driver is implemented as a *nullfm* Driver. It supports the standard OS-9 interface for a disk device (either Windows FAT format or OS-9's native RBF format). The driver and its descriptors are found in the following locations:

- **Source Directory**
  
  OS9000/SRC/IO/RBF/DRVR/USBDISK

- **Driver Location**
  
  OS9000/<PROCESSOR>/CMDS/BOOTOBJ/USBH/udiskd

- **Descriptors Location**
  
  OS9000/<PROCESSOR>/CMDS/BOOTOBJ/USBH/DESC/muh* (for PCF)
  OS9000/<PROCESSOR>/CMDS/BOOTOBJ/USBH/DESC/uh* (for RBF)

There are a large number of device descriptors for various uses.

- Since USB Mass Storage devices can appear and disappear dynamically, the device descriptors refer to disk 0 as the first disk device located on the busses, disk 1 as the second disk located on the busses, and so forth, up to 3 for the fourth disk located.

- The disks have partitions - partition 1 is the first partition and partition 2 is the second.

- USB Mass Storage devices can be formatted for use with PCF (Windows/MS-DOS format) or RBF (OS-9's native disk format). Descriptor names that begin with m (for MS-DOS) are for use with the PCF file manager.

- Descriptors with a single digit before any extension refer to the entire device, including the partition table itself.

- Some files contain simplified descriptor names historically used to refer to hard disks (e.g. h0 or h1).

- Some descriptors are format enabled - allowing the format command to rewrite the file structure of the device.

The following are some examples that illustrate the general format for the descriptor file names.
muh0 - PCF format descriptor for the entire first available disk
uh11fmt - RBF format descriptor for the first partition of the second available disk with formatting enabled
muh22.h2 - PCF format descriptor for the second partition of the third available disk with a module name of h2.

**Testing USB Mass Storage Devices**

Following is an example of how to test USB Mass Storage devices. This example uses a 1GB Flash disk and a 250GB external hard disk, both pre-formatted for Windows.

$ iniz muh0
$ iniz muh1
$ dir /muh0 /muh1

Directory of /muh0 01:30:30
Documents       LaunchU3.exe    System
-vspcache.dir

Directory of /muh1 01:30:30
21-Apr-06       24-Apr-06       25-Apr-06       26-Apr-06       27-Apr-06
28-Apr-06       CMDS            Recycled        System Volume Information

$ chd /muh0
$ mkdir CMDS
$ chd CMDS
$ copy /muh1/CMDS/procs
$ dir

Directory of . 16:49:38
procs

$
Generic USB Driver

The Generic USB Driver (spugen) enables applications to configure and transfer data directly to a device on the USB. Only bulk and interrupt pipes are supported, and there is no intention of supporting isochronous pipes. spugen is a SoftStax® (SPF) driver, and requires edition 269 or greater of the SPF file manager. The driver and its descriptors are found in the following locations:

- **Source Directory:**
  SRC/DPIO/SPF/DRVR/USBGEN
- **Driver Location:**
  OS9000/<PROCESSOR>/CMDS/BOOTOBJS/USBH/spugen
- **Descriptor Location:**
  OS9000/<PROCESSOR>/CMDS/BOOTOBJS/USBH/ugen0
  OS9000/<PROCESSOR>/CMDS/BOOTOBJS/USBH/ugen1

Plug-n-Play

With respect to plug-n-play, spugen registers its attach, match, and detach routines like any other Logical Device Descriptor. However, spugen matches to any device. In addition, usbman will only attempt to match the generic driver with a device after all other drivers have been given an opportunity to match. Therefore, the desired configuration is to initialize (iniz) all non-generic devices as well as spugen. In this way, any device plugged into the USB will first try to attach to regular LDDs and will then try to attach to spugen.

Accessing Endpoints with spugen

spugen is a special LDD because it allows a direct connection to the control pipe, and also allows a direct connection to a specific endpoint on the USB device. For example, opening /ugen0 will open the control pipe on the device. An application can then request configuration information or make requests to the device.
To open a specific endpoint on a USB device, append a # character followed by the endpoint number after the device name. For example, /ugen0#1 will open endpoint 1 on the USB device attached to /ugen0. /ugen1#2 will open endpoint 2 on the USB device attached to /ugen1.

The application can request information about the device by making various setstat calls into the spugen driver using the control pipe. In this way, the application can determine how many endpoints a device has, and the type of device, for example a printer mouse, or camera.)

**Testing spugen**

Following is a list of steps for testing spugen with a USB mouse. Before you start, make sure that the following SPF modules are on your OS-9 target. This can be determined by running the mdir utility on the USB Host machine.

```
OS9000/<PROCESSOR>/CMDS/BOOTOBS/SPF/spf
OS9000/<PROCESSOR>/CMDS/mbinstall
```

**Step 1.** Type the following commands at the OS-9 prompt:

```
$ usbd &
$ usbdevs
```

Following is an example response from the command:

```
$ usbdevs
Bus #0, Root Hub, Address 1,
[1] <empty>
[2] Address 2, Fellowes Inc.: Fellowes 5 Button
Bus #1, Root Hub, Address 1,
[1] <empty>
[2] <empty>
Bus #2, Root Hub, Address 1,
[1] <empty>
[2] <empty>
[3] <empty>
[4] <empty>
```

This response shows that a mouse is present on USB bus #0 (low and full-speed bus) at address 2.
Using USB Host for OS-9

Step 2. Type the following commands at the OS-9 prompt:

$ iniz /ugen0
$ ugenstat

Following is an example response from the command:

Device Descriptor: 12011001 00000008 25251389 22500102 0001
Fellowes Inc. Fellowes 5 Button
Number of Configurations: 1
Config Descriptor 1: 09022200 010100a0 32
  Full Descriptor: 09022200 010100a0 32
  09040000 01030102 00
  09210001 00012248 00
  07058103 08000a

Number of interfaces: 1
Interface Descriptor 0: 09040000 01030102 00

Number of endpoints: 1
Endpoint Descriptor 0: 07058103 08000a

This response shows that the UGEN driver is attached to the mouse. By decoding the configuration and endpoint data, this mouse has only one endpoint, numbered 1.

Step 3. Type the following commands at the OS-9 prompt:

$ dump "/ugen0#1"

Following is an example response from the command if the mouse is then moved:

| Addr | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F | 0 | 2 | 4 | 6 | 8 | A | C | E |
| 00000000 | 0000 | ff00 | 00ff | 0100 | 00fb | 0000 | 00fd | 0300 | ................{...}..|
| 00000010 | 00fe | 0500 | 0000 | 0100 | 00f6 | 0f00 | 00f5 | 1600 | ....................v...u..|
| 00000020 | 00f3 | 1800 | 00f6 | 1800 | 00f8 | 1200 | 00f6 | 0a00 | ....................s...v...x...v...|
| 00000030 | 00f5 | 0b00 | 00f7 | 0900 | 00f8 | 0800 | 00fa | 0400 | ................u...w...x...z...|
| 00000040 | 00fa | 0400 | 00fd | 0200 | 00fd | 0100 | 00fe | 0100 | ...................z...}...}...|
| 00000050 | 00ff | 0000 | 0001 | 0000 | 0000 | ff00 | 0004 | ff00 | ..................|
| 00000060 | 0004 | ff00 | 0006 | fe00 | 0007 | fe00 | 0008 | ff00 | ..............~..~.....|
| 00000070 | 0008 | 0000 | 000b | ff00 | 000d | 0000 | 000e | 0000 | ..................|

(Ctrl-C to exit)
For More Information

For information regarding the data format of the device, configuration, interface, and endpoint descriptors, please refer to the USB specifications, which can be found at www.usb.org.
Reference API

An Application may make many getstat/setstat calls into spugen to either query information about the device, or to set the device configuration. Below is a list of these, and their purposes. Since spugen is a SoftStax (SPF) driver, the standard SPF getstat/setstat parameter block is used. Structures used for ugen getstat/setstat values can be found in the following location:

SRC/IO/USBH/DEFS/usb.h and SRC/DEFS/HW/usb_host.h.

/* generic getstat/setstat parameter block */
struct spf_ss_pb {
    u_int32 code;/* setstat module code*/
    u_int32 size;/* size of mod_param*/
    void* param; /* module parameter block*/
    u_int8 updir; /* gs/ss going up the stack flag */
        #define SPB_GOINGUP1/* Param blk is going up stack*/
        #define SPB_GOINGDOWN 0/* Param blk going down stack*/
    u_int8 rsv[3];/* RESERVED FOR FUTURE USE!*/
};
GS_USB_GET_CONFIG
Get current Device Configuration Value

Syntax
int config;
err = _os_getstat(path, GS_USB_GET_CONFIG, &config);

Description
Get current device configuration value.

Return Value

EIO I/O error retrieving configuration information from device.
SUCCESS Retrieved configuration value.
GS_USB_GET_ALTINTERFACE
Get Alternate Interface Value

Syntax

struct usb_alt_interface ai;
err = _os_getstat(path, GS_USB_GET_ALTINTERFACE, &ai);

Description
Get alternate interface value.

Return Value

ENIVAL No interface selected for this device.
EIO Error retrieving alternate interface.
SUCCESS Retrieved alternate interface value, and assigned to ai->alt_no.
GS_USB_GET_NO_ALT
Get Number of Alternate Interfaces

Syntax
struct usb_alt_interface ai;
err = _os_getstat(path, GS_USB_GET_NO_ALT, &ai);

Description
Get number of alternate interfaces.

Return Value
ENIVAL No interface selected for this device.
EIO Error retrieving alternate interface.
SUCCESS Retrieved number of alternate interfaces, and assigned to ai->alt_no.
GS_USB_GET_DEVICE_DESC
Get Device Descriptor

Syntax

```c
usb_device_descriptor_t dev_desc;
err = _os_getstat(path, GS_USB_GET_DEVICE_DESC, &dev_desc);
```

Description

Get device descriptor.

Return Value

- **EINVAL**  
  No device descriptor available.
- **SUCCESS**  
  Returns device descriptor.
GS_USB_GET_CONFIG_DESC
Get Current Configuration Descriptor

Syntax

```c
struct usb_config_desc config_desc;
err = _os_getstat(path, GS_USB_GET_CONFIG_DESC, &config_desc);
```

Description
Get current configuration descriptor.

Return Value

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EINVAL</td>
<td>No configuration descriptor available.</td>
</tr>
<tr>
<td>SUCCESS</td>
<td>Returns device descriptor.</td>
</tr>
</tbody>
</table>
GS_USB_GET_INTERFACE_DESC
Get Interface Descriptor on Device

Syntax
struct usb_interface_desc iface_desc;
err = _os_getstat(path,GS_USB_GET_INTERFACE_DESC,&iface_desc);

Description
Get interface descriptor on device.

- iface_desc.config_index
  Configuration index to use, or -1 for the current configuration.
- iface_desc.interface_index
  Interface index to use, or -1 for the current interface.
- iface_desc.alt_index
  Alternate index to use, or -1 for current alternate interface.

Return Value
EINVAL
No configuration or interface descriptor.
SUCCESS
Returns interface descriptor in iface_desc.desc.
GS_USB_GET_ENDPOINT_DESC
Get Endpoint Descriptor on Device

Syntax

```c
struct usb_endpoint_desc ep_desc;
err = _os_getstat(path, GS_USB_GET_ENDPOINT_DESC, &iface_desc);
```

Description

Get endpoint descriptor on device.

- `ep_desc.config_index`
  Configuration index to use, or -1 for the current configuration.

- `ep_desc.interface_index`
  Interface index to use, or -1 for the current interface.

- `ep_desc.alt_index`
  Alternate index to use, or -1 for current alternate interface.

- `ep_desc.endpoint_index`
  Endpoint index to use.

Return Value

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EINVAL</td>
<td>Could not get information on configuration descriptor.</td>
</tr>
<tr>
<td>SUCCESS</td>
<td>Endpoint descriptor copied to <code>ep_desc.desc</code>.</td>
</tr>
</tbody>
</table>
GS_USB_GET_STRING_DESC
get string descriptor from USB device

Syntax
struct usb_string_desc string_desc;
err = _os_getstat(path,GS_USB_GET_STRING_DESC,&string_desc);

Description
Get string descriptor from USB device.

- string_desc.string_index
  String index from device, configuration, or interface descriptor.

- string_desc.language_id
  Language to use (0 if ASCII).

Return Value
EINVAL          I/O error retrieving string descriptor.
SUCCESS         String descriptor copied to string_desc.desc.
SS_USB_SET_CONFIG
Set the Configuration Index

Syntax
int config_index=1;
err = _os_setstat(path,SS_USB_SET_CONFIG,&config_index);

Description
Set the configuration index.

Note
This must be done before any paths are opened to a specific endpoint, for example /ugen0#1.

Return Value
EPERM                     No write permission on opened path.
EIO                        Error setting configuration.
SUCCESS                   Configuration set to given index.
SS_USB_SET_ALTINTERFACE
Sets the Alternate Interface

Syntax

```c
struct usb_alt_interface alt_iface;
alt_iface.alt_no = 0;
err = _os_setstat(path, SS_USB_SET_ALTINTERFACE, &alt_iface);
```

Description

Sets the alternate interface.

Note

This must be done before any paths are opened to a specific endpoint, for example `/ugen0#1`.

Return Value

- **EPERM**: No write permission on opened path.
- **EIO**: Error setting configuration.
- **SUCCESS**: Configuration set to given index.
SS_USB_DO_REQUEST
Performs a Device Specific Request Over the Control Pipe

Syntax
struct usb_ctl_request req;
err = _os_setstat(path,SS_USB_DO_REQUEST,&req);

Description
Performs a device specific request over the control pipe.

req.addr       Device address.
req.request    Standard 8 byte device request structure initialized.
req.data       Pointer to memory where data returned from the device will be stored.
req.flags      0, or USBD_SHORT_XFER_OK.

Return Value
EPERM            No write permission on opened path
EINVAL           Returned if a SET ADDRESS, SET CONFIGURATION, or SET INTERFACE request is attempted.
EIO              Error setting configuration.
SUCCESS         Request performed.

Any data returned will be stored in the data field. The actual number of bytes returned will be stored in req.actlen.
SS_USB_SET_SHORT_XFER
Allows Short Transfers

Syntax
err = _os_setstat(path,SS_USB_SET_SHORT_XFER,NULL);

Description
Allows short transfers (less than the maximum endpoint length) when reading data from the USB device. This is not for the control pipe, but for other endpoints, such as /ugen0#1.

Return Value
EINVAL
Attempt to set for control pipe (/ugen0), or no interrupt or bulk pipe open for read.
SUCCESS
Allow short reads on this pipe.
User-State Daemon Process

The user-state daemon process, `usbd`, serves the following purposes:

- Initializes the USB Host stack
- Activated to perform bus explore code in `usbdman` when a device is plugged in or removed from the USB.
- Initiates an asynchronous "clear endpoint stall". This can occur if a driver determines an error condition in the interrupt service routine.

To initialize the USB stack, use the following command at the OS-9 prompt:

```
$ usbd &
```

`usbd` will respond to a signal 2 or 3, to shut down the stack. Also, all drivers must be de-initialized for the USB Host Stack to properly terminate.
Chapter 3: USB Host API Reference

This chapter provides a library function reference for USB Host for OS-9. It documents the USBDI interface.

The USBDI interface is the API that implements access to the USBMAN driver. Any USB logical device driver or system-state application accesses the USB through the USBDI API.

The function references are sorted into the following categories:

- Pipe Functions List
- Transfer Functions List
- Interface Functions List
- Device Functions List
- Alphabetical Listing
# Pipe Functions List

## Table 3-1  Pipe Functions

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>usbman_abort_pipe()</code></td>
<td>Abort a Pipe Operation</td>
</tr>
<tr>
<td><code>usbman_clear_endpoint_stall()</code></td>
<td>Clear STALLED Condition</td>
</tr>
<tr>
<td><code>usbman_clear_endpoint_stall_async()</code></td>
<td>Clear STALLED Condition</td>
</tr>
<tr>
<td><code>usbman_clear_endpoint_toggle()</code></td>
<td>Reset Endpoint Toggle</td>
</tr>
<tr>
<td><code>usbman_close_pipe()</code></td>
<td>Close Pipe</td>
</tr>
<tr>
<td><code>usbman_do_request()</code></td>
<td>Perform Transfer Over Control Pipe</td>
</tr>
<tr>
<td><code>usbman_do_request_flags()</code></td>
<td>Perform Transfer</td>
</tr>
<tr>
<td><code>usbman_open_pipe()</code></td>
<td>Create Bulk Transfer Pipe</td>
</tr>
<tr>
<td><code>usbman_open_pipe_intr()</code></td>
<td>Create Interrupt Pipe</td>
</tr>
<tr>
<td><code>usbman_pipe2device_handle()</code></td>
<td>Return Device Handle</td>
</tr>
</tbody>
</table>
## Transfer Functions List

### Table 3-2 Transfer Functions

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>usbman_alloc_buffer()</td>
<td>Allocate a DMA Buffer</td>
</tr>
<tr>
<td>usbman_alloc_xfer()</td>
<td>Allocate a Transfer Structure</td>
</tr>
<tr>
<td>usbman_bulk_transfer()</td>
<td>Perform Bulk Transfer</td>
</tr>
<tr>
<td>usbman_free_buffer()</td>
<td>Free DMA Buffer</td>
</tr>
<tr>
<td>usbman_free_xfer()</td>
<td>Free Transfer</td>
</tr>
<tr>
<td>usbman_get_buffer()</td>
<td>Return Current DMA Buffer Pointer</td>
</tr>
<tr>
<td>usbman_get_xfer_status()</td>
<td>Get Transfer Status</td>
</tr>
<tr>
<td>usbman_setup_default_xfer()</td>
<td>Initialize Transfer Handle</td>
</tr>
<tr>
<td>usbman_setup_isoc_xfer()</td>
<td>Initialize ISOC Transfer</td>
</tr>
<tr>
<td>usbman_setup_xfer()</td>
<td>Assign Fields in Transfer</td>
</tr>
<tr>
<td>usbman_sync_transfer()</td>
<td>Perform Asynchronous Transfer</td>
</tr>
<tr>
<td>usbman_transfer()</td>
<td>Initialize Bulk Transfer</td>
</tr>
</tbody>
</table>
## Interface Functions List

### Table 3-3 Interface Functions

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>usbman_endpoint_count()</code></td>
<td>Return Number of Endpoints</td>
</tr>
<tr>
<td><code>usbman_free_report_desc()</code></td>
<td>Deallocate Memory</td>
</tr>
<tr>
<td><code>usbman_get_config()</code></td>
<td>Request Configuration Descriptor</td>
</tr>
<tr>
<td><code>usbman_get_hid_descriptor()</code></td>
<td>Request HID Descriptor</td>
</tr>
<tr>
<td><code>usbman_get_report()</code></td>
<td>Request HID Report Descriptor</td>
</tr>
<tr>
<td><code>usbman_get_report_descriptor()</code></td>
<td>Request HID Report Descriptor</td>
</tr>
<tr>
<td><code>usbman_interface2device_handle()</code></td>
<td>Return Device Handle</td>
</tr>
<tr>
<td><code>usbman_interface2endpoint_descriptor()</code></td>
<td>Return Endpoint Descriptor</td>
</tr>
<tr>
<td><code>usbman_read_report_desc()</code></td>
<td>Allocate and read the report descriptor</td>
</tr>
<tr>
<td><code>usbman_set_idle()</code></td>
<td>Silence Report on the Interrupt In Pipe</td>
</tr>
<tr>
<td><code>usbman_set_interface()</code></td>
<td>Request Interface Change</td>
</tr>
<tr>
<td><code>usbman_set_protocol()</code></td>
<td>Switch Between Boot and Report Protocol</td>
</tr>
<tr>
<td><code>usbman_set_report()</code></td>
<td>Perform Set Report Request</td>
</tr>
</tbody>
</table>
## Device Functions List

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>usbman_device2interface_handle()</td>
<td>Return Interface Handle</td>
</tr>
<tr>
<td>usbman_get_config_desc()</td>
<td>Get Configuration Descriptor</td>
</tr>
<tr>
<td>usbman_get_config_desc_full()</td>
<td>Request Configuration Descriptor</td>
</tr>
<tr>
<td>usbman_get_device_desc()</td>
<td>Request Device Descriptor</td>
</tr>
<tr>
<td>usbman_get_string_desc()</td>
<td>Request String Descriptor</td>
</tr>
<tr>
<td>usbman_interface_count()</td>
<td>Return Number of Interfaces</td>
</tr>
<tr>
<td>usbman_set_config_index()</td>
<td>Set Configuration Index</td>
</tr>
<tr>
<td>usbman_set_config_no()</td>
<td>Set Configuration</td>
</tr>
</tbody>
</table>
### Table 3-5 Alphabetical Listing of Functions

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>usbman_abort_pipe()</td>
<td>Abort a Pipe Operation</td>
</tr>
<tr>
<td>usbman_alloc_buffer()</td>
<td>Allocate a DMA Buffer</td>
</tr>
<tr>
<td>usbman_read_report_desc()</td>
<td>Allocate and read the report descriptor</td>
</tr>
<tr>
<td>usbman_alloc_xfer()</td>
<td>Allocate a Transfer Structure</td>
</tr>
<tr>
<td>usbman_bulk_transfer()</td>
<td>Perform Bulk Transfer</td>
</tr>
<tr>
<td>usbman_clear_endpoint_stall()</td>
<td>Clear STALLED Condition</td>
</tr>
<tr>
<td>usbman_clear_endpoint_stall_async()</td>
<td>Clear STALLED Condition</td>
</tr>
<tr>
<td>usbman_clear_endpoint_toggle()</td>
<td>Reset Endpoint Toggle</td>
</tr>
<tr>
<td>usbman_close_pipe()</td>
<td>Close Pipe</td>
</tr>
<tr>
<td>usbman_device2interface_handle()</td>
<td>Return Interface Handle</td>
</tr>
<tr>
<td>usbman_do_request()</td>
<td>Perform Transfer Over Control Pipe</td>
</tr>
<tr>
<td>usbman_do_request_flags()</td>
<td>Perform Transfer</td>
</tr>
<tr>
<td>usbman_endpoint_count()</td>
<td>Return Number of Endpoints</td>
</tr>
<tr>
<td>usbman_find_edesc()</td>
<td>Return Endpoint Descriptor</td>
</tr>
<tr>
<td>usbman_find_idesc()</td>
<td>Return Interface Descriptor</td>
</tr>
<tr>
<td>usbman_free_buffer()</td>
<td>Free DMA Buffer</td>
</tr>
<tr>
<td>usbman_free_report_desc()</td>
<td>Deallocate Memory</td>
</tr>
<tr>
<td>Function Name</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>usbman_free_xfer()</td>
<td>Free Transfer</td>
</tr>
<tr>
<td>usbman_get_buffer()</td>
<td>Return Current DMA Buffer Pointer</td>
</tr>
<tr>
<td>usbman_get_config()</td>
<td>Request Configuration Descriptor</td>
</tr>
<tr>
<td>usbman_get_config_desc()</td>
<td>Get Configuration Descriptor</td>
</tr>
<tr>
<td>usbman_get_config_desc_full()</td>
<td>Request Configuration Descriptor</td>
</tr>
<tr>
<td>usbman_get_device_desc()</td>
<td>Request Device Descriptor</td>
</tr>
<tr>
<td>usbman_get_device_descriptor()</td>
<td>Return Device Descriptor</td>
</tr>
<tr>
<td>usbman_get_hid_descriptor()</td>
<td>Request HID Descriptor</td>
</tr>
<tr>
<td>usbman_get_no_alts()</td>
<td>Get Number of Alternate Interfaces</td>
</tr>
<tr>
<td>usbman_get_report()</td>
<td>Request HID Report Descriptor</td>
</tr>
<tr>
<td>usbman_get_report_descriptor()</td>
<td>Request HID Report Descriptor</td>
</tr>
<tr>
<td>usbman_get_string_desc()</td>
<td>Request String Descriptor</td>
</tr>
<tr>
<td>usbman_get_xfer_status()</td>
<td>Get Transfer Status</td>
</tr>
<tr>
<td>usbman_interface_count()</td>
<td>Return Number of Interfaces</td>
</tr>
<tr>
<td>usbman_interface2device_handle()</td>
<td>Return Device Handle</td>
</tr>
<tr>
<td>usbman_interface2endpoint_descriptor()</td>
<td>Return Endpoint Descriptor</td>
</tr>
<tr>
<td>usbman_open_pipe()</td>
<td>Create Bulk Transfer Pipe</td>
</tr>
<tr>
<td>usbman_open_pipe_intr()</td>
<td>Create Interrupt Pipe</td>
</tr>
<tr>
<td>usbman_pipe2device_handle()</td>
<td>Return Device Handle</td>
</tr>
<tr>
<td>Function Name</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>usbman_set_config_index()</td>
<td>Set Configuration Index</td>
</tr>
<tr>
<td>usbman_set_config_no()</td>
<td>Set Configuration</td>
</tr>
<tr>
<td>usbman_set_idle()</td>
<td>Silence Report on the Interrupt In Pipe</td>
</tr>
<tr>
<td>usbman_set_interface()</td>
<td>Request Interface Change</td>
</tr>
<tr>
<td>usbman_set_protocol()</td>
<td>Switch Between Boot and Report Protocol</td>
</tr>
<tr>
<td>usbman_set_report()</td>
<td>Perform Set Report Request</td>
</tr>
<tr>
<td>usbman_setup_default_xfer()</td>
<td>Initialize Transfer Handle</td>
</tr>
<tr>
<td>usbman_setup_isoc_xfer()</td>
<td>Initialize ISOC Transfer</td>
</tr>
<tr>
<td>usbman_setup_xfer()</td>
<td>Assign Fields in Transfer</td>
</tr>
<tr>
<td>usbman_sync_transfer()</td>
<td>Perform Asynchronous Transfer</td>
</tr>
<tr>
<td>usbman_transfer()</td>
<td>Initialize Bulk Transfer</td>
</tr>
</tbody>
</table>
usbman_abort_pipe()
Abort a Pipe Operation

Syntax
usbd_status usbman_abort_pipe(usbd_pipe_handle pipe);

Description
Aborts a pipe operation. This function returns USBD_NORMAL_COMPLETION if the operation is successful.

Parameters
pipe A valid open pipe.

See Also
usbman_close_pipe()
usbman_open_pipe()
**usbman_alloc_buffer()**

Allocate a DMA Buffer

**Syntax**

```c
void *usbman_alloc_buffer(
    usbd_xfer_handle  xfer,
    u_int32_t         size);
```

**Description**

 Allocates a DMA buffer for the given transfer handle `xfer`. Returns NULL if the allocation fails; otherwise returns the pointer to the allocated memory.

**Parameters**

- **xfer**: Must be a valid transfer handle; returned from `usbman_alloc_xfer()`.
- **size**: Number of bytes to allocate.

**Modifies**

- `xfer -> dmabuf`: Updated to store reference to allocated memory.
- `xfer -> rqflags`: URQ_DEV_DMABUF flag set.

**See Also**

- `usbman_free_buffer()`
- `usbman_get_buffer()`
**Syntax**

```c
usbd_xfer_handle usbman_alloc_xfer(usbd_device_handle);
```

**Description**

Allocates a `usbd_xfer` structure, and returns it to the calling function.

**Parameters**

- `dev`  
  A valid `usbd_device_handle`.

**See Also**

- `usbman_free_xfer()`
**Syntax**

```c
usbd_status usbman_bulk_transfer(
    usbd_xfer_handle  xfer,
    usbd_pipe_handle  pipe,
    u_int16_t         flags,
    u_int32_t         timeout,
    void              *buf,
    u_int32_t         *size,
    char              *lbl);
```

**Description**

Performs a bulk transfer to or from a device. This call will not return until the transfer is successful, or has timed out. This call returns
*USBD_NORMAL_COMPLETION* if the transfer was successful;
*USBD_INTERRUPTED* if the transfer was interrupted by a deadly IO signal;
*USBD_IOERROR* if a transfer failed; and *USBD_TIMEOUT* if the transfer timed out.

**Parameters**

- **xfer**: A transfer handle allocated with *usbman_alloc_xfer*.
- **pipe**: An open pipe to the device.
- **flags**: 0 means no special flags.
  - *USBD_NO_COPY*: do not copy data from *buf* to DMA buffer.
  - *USBD_FORCE_SHORT_XFER*: force last short packet on write.
- **timeout**: Number of milliseconds to wait for device to respond to transfer.
  - *USBD_NO_TIMEOUT*: wait forever.
USB Host API Reference

*buf

Write: contains data transfer to device.
Read: valid memory location to store data read from device.

*size

Write: number of bytes to transfer to device
Read: number of bytes to read from device (size of buf)

*lbl

Unused.

**Modifies**

This call modifies various fields in xfer.
**usbdman_clear_endpoint_stall()**

Clear STALLED Condition

**Syntax**

```c
usbd_status usbdman_clear_endpoint_stall(
    usbd_pipe_handle pipe);
```

**Description**

Clears the STALLED condition of the device. This will also reset the data toggle to 0. Clearing the endpoint stall is usually not necessary, unless a device has returned `USBD_STALLED` in response to a data transfer. This call returns `USBD_NORMAL_COMPLETION` if successful and `USBD_IOERROR` if the device did not respond.

**Parameters**

- **pipe**
  An open pipe to the device.

**Modifies**

This call sets the toggle state of the pipe to 0.

**See Also**

- `usbdman_clear_endpoint_stall_async()`
- `usbdman_clear_endpoint_toggle()`
**usbman_clear_endpoint_stall_async()**

**Clear STALLED Condition**

**Syntax**

```c
usbd_status usbman_clear_endpoint_stall_async(
    usbd_pipe_handle  pipe);
```

**Description**

Clears the STALLED condition of the device and resets the data toggle to 0. This is identical to `usbman_clear_endpoint_stall`, except that this operation is not performed until some time later. This call will return immediately. This version of the call is useful if the endpoint stall needs to be cleared in interrupt context. This call returns `USBD_NORMAL_COMPLETION` if successful and `USBD_IOERROR` if the device did not respond.

**Parameters**

pipe

An open pipe to the device.

**Modifies**

This function sets the toggle state of the pipe to 0.

**See Also**

`usbman_clear_endpoint_stall()`  
`usbman_clear_endpoint_toggle()`
**Syntax**

```c
void usbman_clear_endpoint_toggle(
    usbd_pipe_handle pipe);
```

**Description**

 Resets the endpoint toggle to 0. Resetting the endpoint toggle is only necessary if resetting the device, or if clearing the endpoint stall.

**Parameters**

- **pipe**
  
  An open pipe to the device.

**Modifies**

This function sets the toggle state of the pipe to 0.

**See Also**

- `usbman_clear_endpoint_stall()`
- `usbman_clear_endpoint_stall_async()`
**Syntax**

```
usbd_status usbman_close_pipe(usbd_pipe_handle pipe);
```

**Description**

Closes pipe and frees interrupt pipe transfer buffer. This function returns
`USBD_NORMAL_COMPLETION` if the operation is successful and
`USBD_PENDING_REQUESTS` in the middle of the operation.

**Parameters**

- **pipe**
  
  A valid open pipe.

**See Also**

- `usbman_abort_pipe()`
- `usbman_open_pipe()`
usbman_device2interface_handle()

Return Interface Handle

Syntax

```c
usbd_status usbman_device2interface_handle(
    usbd_device_handle dev,
    u_int8_t ifaceno,
    usbd_interface_handle *iface);
```

Description

Returns the specified interface handle for the given device. This function returns USBD_NORMAL_COMPLETION if the operation is successful; USBD_NOT_CONFIGURED if there is no configuration descriptor for this device; and USBD_INVAL if the ifaceno parameter is out of range.

Parameters

- **dev**: A valid device handle.
- **ifaceno**: Interface number. This is between 0 and n-1, where n is the number of interfaces.
- **iface**: If successful, the interface handle will be stored in *iface.
**usbman_do_request()**

**Perform Transfer Over Control Pipe**

**Syntax**

```c
usbd_status usbman_do_request(
    usbd_device_handle    pipe,
    usb_device_request_t  *req,
    void                  *data);
```

**Description**

Performs a transfer over the control pipe to the specified device. The data transferred is a fixed 8-byte structure defined by the USB specification. If any data is returned from the device, it is copied into the data parameter. The data parameter must be large enough to hold such information.

This function returns **USBD_NORMAL_COMPLETION** if successful; **USBD_NOMEM** if no memory is available; **USBD_IOERROR** when there is a transfer error to the device; and **USBD_STALLED** if the transfer caused the device to STALL.

**Parameters**

- **pipe**: A valid device handle.
- ***req**: 8-byte request structure that is properly defined.
- ***data**: NULL if no return data; otherwise pointer to return data memory.
usbm an _ do _ request _ flags()  
Perform Transfer

Syntax  
```c
usbd_status usbman_do_request_flags(
    usbd_device_handle pipe,
    usb_device_request_t *req,
    void *data,
    u_int16_t flags,
    int *actlen,
    u_int32_t timeout);
```

Description  
Performs the same function as `usbman_do_request` with the addition of three parameters: `flags`, `actlen`, and `timeout`.

This function returns `USBD_NORMAL_COMPLETION` if successful; `USBD_NOMEM` if no memory is available; `USBD_IOERROR` when there is a transfer error to the device; and `USBD_STALLED` if the transfer caused the device to STALL.

Parameters  
**pipe**    A valid device handle.  
**req**    8-byte request structure that is properly defined.  
**data**    NULL if no return data; otherwise pointer to return data memory.  
**flags**    Flags normally passed to create a transfer handle: `USBD_NO_COPY`, `USBD_SHORT_XFER_OK`, `USBD_FORCE_SHORT_XFER`.  
**actlen**    Receives the number of bytes of data transferred from the device.
timeout

Specifies the time in which to perform the request before aborting the request. Passing 0 specifies no timeout should be used. The timeout value is in terms of milliseconds.
usbman_endpoint_count()

Return Number of Endpoints

Syntax

```c
usbd_status usbman_endpoint_count(
    usbd_interface_handle iface,
    u_int8_t *count);
```

Description

Returns the number of endpoints in the current interface. Upon completion, this function returns `USBD_NORMAL_COMPLETION`.

Parameters

- `iface` A valid interface handle that contains a valid interface descriptor.
- `*count` Receives the number of endpoints in this interface.

See Also

`usbman_interface_count()`
### usbman_find_edesc()

**Return Endpoint Descriptor**

#### Syntax

```c
usb_endpoint_descriptor_t *usbman_find_edesc(
    usb_config_descriptor_t  *cd,
    int                      ifaceidx,
    int                      altidx,
    int                      endptidx);
```

#### Description

Returns the specified endpoint descriptor for the current configuration descriptor. Upon completion, this function returns a pointer to the requested endpoint descriptor, or NULL if not found.

#### Parameters

- **cd**
  - A valid configuration descriptor.
- **ifaceidx**
  - Interface number in the configuration.
- **altidx**
  - Alternate index in the configuration (0 if none).
- **endptidx**
  - Endpoint index in the interface.

#### See Also

- `usbman_find_idesc()`
usbman_find_idesc()
Return Interface Descriptor

Syntax
usb_interface_descriptor_t *usbman_find_idesc(
    usb_config_descriptor_t  *cd,
    int                      ifaceidx,
    int                      altidx);

Description
Returns the specified interface descriptor given a configuration descriptor.

Parameters
*cd            A valid configuration descriptor.
ifaceidx      Interface number in the configuration.
altidx        Alternate index in the configuration (0 if none).

See Also
usbman_find_edesc()
**usbman_free_buffer()**

Free DMA Buffer

**Syntax**

```c
void usbman_free_buffer(usbd_xfer_handle xfer);
```

**Description**

Frees a DMA buffer for the given transfer handle. This should only be called if `usbman_alloc_buffer()` was successfully called on the given transfer handle. No return value.

**Parameters**

- **xfer**
  
  Must be a valid transfer handle, returned from `usbman_alloc_xfer()`.

**Modifies**

- **xfer->dmabuf**
  
  Deallocates memory.

- **xfer->rqflags**
  
  Clears the `URQ_DEV_DMABUF` and `URQ_AUTO_DMABUF` flags.

**See Also**

- `usbman_alloc_buffer()`
- `usbman_get_buffer()`
**Syntax**

```c
void usbman_free_report_desc(
    void  *descp,
    int   mem);
```

**Description**

Deallocates memory for a HID report descriptor. `descp` must be a value returned from `usbd_read_report_desc`.

**Parameters**

- `*descp` A report descriptor pointer to `free`.
- `mem` Unused.

**See Also**

`usbman_read_report_desc()`
**usbman_free_xfer()**

Free Transfer

**Syntax**

```c
usbd_status usbman_free_xfer(usbd_xfer_handle xfer);
```

**Description**

Frees `xfer`. Also will free the DMA buffer if present.

**Parameters**

- `xfer` A valid `usbd_xfer_handle` structure that was allocated by `usbd_alloc_xfer()`.

**See Also**

- `usbman_alloc_xfer()`
**Syntax**

```c
void *usbman_get_buffer(usbd_xfer_handle xfer);
```

**Description**

Returns the current DMA buffer pointer for the given transfer handle. If no DMA buffer has been allocated, NULL is returned.

**Parameters**

- **xfer**
  
  Must be a valid transfer handle, returned from `usbman_alloc_xfer()`.

**See Also**

- `usbman_alloc_buffer()`
- `usbman_free_buffer()`
usbman_get_config()
Request Configuration Descriptor

Syntax
usbd_status usbman_get_config(
    usbd_device_handle dev,
    u_int8_t *conf);

Description
Requests the configuration descriptor from the given device. This call will perform a transfer using the control pipe over the USB. This function returns USBD_NORMAL_COMPLETION if successful; USBD_NOMEM if no memory is available; USBD_IOERROR when there is a transfer error to the device; and USBDSTALLLED if the transfer caused the device to STALL.

Parameters

dev
A valid USB device handle.

*conf
Pointer to at least 9 bytes, the size of the standard configuration descriptor.

See Also

usbman_get_config_desc()
usbman_get_config_desc_full()
usbman_get_config_desc()
Get Configuration Descriptor

Syntax
usbd_status usbman_get_config_desc(
    usbd_device_handle dev,
    int confidx,
    usb_config_descriptor_t *d);

Description
Get configuration descriptor from device handle (for example dev->cdesc).

Parameters
    dev              A valid usbd_device_handle.
    confidx          Configuration index.
    *d               Address of storage for the basic configuration description.

See Also
    usbman_get_config()
    usbman_get_config_desc_full()
usbman_get_config_desc_full()
Request Configuration Descriptor

Syntax
usbd_status usbman_get_config_desc_full(
    usbd_device_handle dev,
    int conf,
    void *d,
    int size);

Description
Requests the configuration descriptor from the given device. The configuration index and the amount of data to receive is specified by the conf and size parameters. This function returns USBD_NORMAL_COMPLETION if successful; USBD_NOMEM if no memory is available; USBD_IOERROR when there is a transfer error to the device; and USBD_STALLED if the transfer caused the device to STALL.

Parameters

dev A valid USB device handle.
conf Specifies configuration index for descriptor.
*d Pointer to at least 9 bytes, the size of the standard configuration descriptor.
size Number of bytes in configuration to request.

See Also
usbman_get_config()
usbman_get_config_desc()
**Syntax**
```
usbd_status usbman_get_device_desc(
    usbd_device_handle dev,
    usb_device_descriptor_t *d);
```

**Description**
Requests the device descriptor from the given device. This function returns `USBD_NORMAL_COMPLETION` if successful; `USBD_NOMEM` if no memory is available; `USBD_IOERROR` when there is a transfer error to the device; and `USBD_STALLED` if the transfer caused the device to STALL.

**Parameters**
- **dev**
  A valid USB device handle.
- **d**
  Pointer to 18 bytes, size of the standard device descriptor.

**See Also**
- `usbman_get_device_descriptor()`
**usbman_get_device_descriptor()**

**Return Device Descriptor**

**Syntax**

```c
usb_device_descriptor_t *usbman_get_device_descriptor(
    usbd_device_handle dev)
```

**Description**

Returns the device descriptor retrieved after the device was initially explored.

**Parameters**

- `dev` A valid USB device handle.

**See Also**

`usbman_get_device_desc()`
usbman_get_hid_descriptor()  
Request HID Descriptor

Syntax

```c
usb_hid_descriptor_t *usbman_get_hid_descriptor(
    usbd_interface_handle ifc);
```

Description

Requests the HID descriptor for the given interface handle. The HID descriptor is normally retrieved with the configuration descriptor. This function returns a pointer to the HID descriptor. If no HID descriptor is found, NULL is returned.

Parameters

- **ifc**  
  A valid interface handle.

See Also

- `usbman_get_report()`  
- `usbman_get_report_descriptor()`
**usbman_get_no_alts()**

Get Number of Alternate Interfaces

**Syntax**

```c
int usbman_get_no_alts(
    usb_config_descriptor_t *cdesc,
    int ifaceno);
```

**Description**

Get the number of alternate interfaces in the given configuration descriptor and interface number. Upon completion, this function returns the number of alternate interfaces.

**Parameters**

- `*cdesc` A valid configuration descriptor.
- `ifaceno` Interface number.
**Syntax**

```c
usbd_status usbman_get_report(
    usbd_interface_handle iface,
    int type,
    int id,
    void *data,
    int len);
```

**Description**

Requests the HID report descriptor for the given interface. This will cause a data transfer on the USB. This function returns

*USBD_NORMAL_COMPLETION* if successful; *USBD_NOMEM* if no memory is available; *USBD_IOERROR* when there is a transfer error to the device; and

*USBD_STALLED* if the transfer caused the device to STALL.

**Parameters**

- **iface**: A valid interface handle.
- **type**: `UHID_INPUT_REPORT`, `UHID_OUTPUT_REPORT`, `UHID_FEATURE_REPORT`.
- **id**: HID id.
- **data**: Pointer to memory where report will be stored.
- **len**: Number of bytes of data to retrieve of HID descriptor.

**See Also**

- `usbman_get_hid_descriptor()`
- `usbman_get_report_descriptor()`
usbman_get_report_descriptor()
Request HID Report Descriptor

Syntax
usbd_status usbman_get_report_descriptor(
    usbd_device_handle dev,
    int ifcno,
    int size,
    void *d);

Description
Requests a HID report descriptor for the given device. This will cause a
data transfer on the USB. This function returns
USBD_NORMAL_COMPLETION if successful; USBD_NOMEM if no memory is
available; USBD_IOERROR when there is a transfer error to the device; and
USBD_STALLED if the transfer caused the device to STALL.

Parameters
dev A valid USB device.
ifcno Interface number.
size Number of bytes to request.
*d Pointer to memory to store requested report
descriptor.

See Also
usbman_get_hid_descriptor()
usbman_get_report()
usbman_get_string_desc()
Request String Descriptor

Syntax

```c
usbd_status usbman_get_string_desc(
    usbd_device_handle dev,
    int sindex,
    int langid,
    usb_string_descriptor_t *sdesc,
    int *size);
```

Description

Requests the string descriptor for the given device. This will cause a data transfer on the USB. Upon successful completion, the string descriptor will be stored in `sdesc`. This function returns `USBD_NORMAL_COMPLETION` if successful; `USBD_NOMEM` if no memory is available; `USBD_IOERROR` when there is a transfer error to the device; and `USBD_STALLED` if the transfer caused the device to STALL.

Parameters

- **dev**: A valid device handle.
- **sindex**: String index.
- **langid**: Language ID.
- **sdesc**: Pointer to string descriptor structure.
- **size**: Receives the actual length of the string descriptor.
usbman_get_xfer_status()

Get Transfer Status

Syntax
void usbman_get_xfer_status(
    usbd_xfer_handle     xfer,
    usbd_private_handle  *priv,
    void                 **buffer,
    u_int32_t            *count,
    usbd_status          *status);

Description
Returns information regarding the given xfer transfer handle.

Parameters
xfer A valid xfer handle.
*priv Receiving the private data area for the transfer.
**buffer Receiving the DMA buffer.
*count Receiving the total number of bytes transferred.
*status Returns the transfer status.
usbman_interface_count()
Return Number of Interfaces

Syntax

```c
usbd_status usbman_interface_count(
    usbd_device_handle  dev,
    u_int8_t            *count);
```

Description

Returns the number of interfaces for the current configuration.

Parameters

- **dev**  
  A valid device.
- **count**  
  Receiving the number of interfaces.
usbman_interface2device_handle()

Return Device Handle

Syntax

```c
void usbman_interface2device_handle(
    usbd_interface_handle iface,
    usbd_device_handle     *dev);
```

Description

Returns the device handle for a given interface handle. An interface cannot exist without an associated device handle.

Parameters

- `iface`: A valid interface handle.
- `*dev`: Receives the device handle associated with `iface`. 
**Syntax**

```
usb_endpoint_descriptor_t
*usbman_interface2endpoint_descriptor(
    usbd_interface_handle iface,
    u_int8_t address);
```

**Description**

Returns the endpoint descriptor given an interface handle. Upon completion, this function returns a pointer to an endpoint descriptor, or NULL if the index is out of range.

**Parameters**

- **iface**: A valid interface handle.
- **address**: Endpoint number.
usbman_open_pipe()
Create Bulk Transfer Pipe

Syntax
usbd_status usbman_open_pipe(
    usbd_interface_handle iface,
    u_int8_t address,
    u_int8_t flags,
    usbd_pipe_handle *pipe);

Description
Creates a bulk transfer pipe to the given endpoint. The address (endpoint) will be checked to see if it is valid. This function returns USBD_NORMAL_COMPLETION if the call is successful; USBD_BAD_ADDRESS if the endpoint is invalid; USBD_IN_USE if the pipe is already opened to endpoint, but the caller wanted an exclusive connection.

Parameters
iface
Endpoint on USB bus.

address
Passing USBD_EXCLUSIVE_USE will open the pipe exclusively for the caller.

flags

pipe
A new pipe will be created and returned in this parameter.

See Also
usbman_open_pipe_intr()
**usbd_status usbman_open_pipe_intr(**
    usbd_interface_handle iface,
    u_int8_t address,
    u_int8_t flags,
    usbd_pipe_handle *pipe,
    usbd_private_handle priv,
    void *buffer,
    u_int32_t length,
    usbd_callback cb
    int interval);**

**Description**

Creates an interrupt pipe to the given endpoint.

**Parameters**

- **iface**
  A valid interface.

- **address**
  Endpoint on USB bus.

- **flags**
  `USBD_EXCLUSIVE_USE`: open exclusive pipe.

- **pipe**
  New pipe will be returned in this parameter.

- **priv**
  Parameter passed to interrupt service routine.

- **buffer**
  Data buffer. Must be big enough according to class definition of device.

- **length**
  Bytes in data buffer.

- **cb**
  Interrupt service routine—called when data transfers, or transmission error.

- **interval**
  Polling interval.
See Also

usbman_open_pipe()
**Syntax**

```c
usbd_device_handle usbman_pipe2device_handle(    
    usbd_pipe_handle pipe);
```

**Description**

Returns the device handle associated with the given pipe. Upon completion, this function returns the device handle associated with this pipe.

**Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pipe</td>
<td>A valid pipe handle, created by <code>usbman_open_pipe</code>.</td>
</tr>
</tbody>
</table>
**usbman_read_report_desc()**

Allocate and read the report descriptor

---

**Syntax**

```c
usbd_status usbman_read_report_desc(
    usbd_interface_handle   ifc,
    void                    **descp,
    int                     *sizep,
    usb_malloc_type         mem);
```

**Description**

Calculates the size of the descriptor and allocates memory for it. Returns the Report Descriptor for a HID device (for example a mouse or keyboard).

**Parameters**

- **ifc**
  
  A valid interface handle.

- **descp**
  
  Memory for the report descriptor is allocated and stored in `*descp`.

- **sizep**
  
  The size of the memory allocated is stored in `*sizep`.

- **mem**
  
  Ignored.

**See Also**

`usbman_free_report_desc()`
**usbman_set_config_index()**

Set Configuration Index

**Syntax**

```c
usbd_status usbman_set_config_index(
    usbd_device_handle  dev,
    int                 index,
    int                 msg);
```

**Description**

Sets the configuration index for the given device. This will perform transfers over the USB. This call assumes that no interrupt, bulk, or isochronous pipes are open on `dev`.

This function returns **USBD_NORMAL_COMPLETION** if successful; **USBD_NOMEM** if no memory is available; **USBD_IOERROR** when there is a transfer error to the device; **USBD_STALLED** if the transfer caused the device to STALL; **USBDINVAL** when a bad configuration descriptor is retrieved from the device; and **USBD_NO_POWER** when the device exceeds available power on the hub.

**Parameters**

- `dev` A valid device handle.
- `index` Configuration index to set.
- `msg` Unused.

**See Also**

`usbman_set_config_no()`
usbman_set_config_no()
Set Configuration

Syntax

```c
usbd_status usbman_set_config_no(
    usbd_device_handle dev,
    int no,
    int msg);
```

Description

Sets the configuration for the given device specified by `config_no`. This will perform transfers over the USB. This call assumes that no interrupt, bulk, or isochronous pipes are open on `dev`.

This function returns `USBD_NORMAL_COMPLETION` if successful; `USBD_NOMEM` if no memory is available; `USBD_IOERROR` when there is a transfer error to the device; `USBD_STALLED` if the transfer caused the device to STALL; `USBD_INVAL` when a bad configuration descriptor is retrieved from the device; and `USBD_NO_POWER` when the device exceeds available power on the hub.

Parameters

- **dev**: A valid device handle.
- **no**: Configuration index to set.
- **msg**: Unused.

See Also

- `usbman_set_config_index()`
usbman_set_idle()
Silence Report on the Interrupt In Pipe

**Syntax**

```c
usbd_status usbman_set_idle(
    usbd_interface_handle iface,
    int duration,
    int id);
```

**Description**

Silences a particular report on the interrupt In Pipe until a new event occurs or until the specified time passes. Valid for an HID device only.

**Parameters**

- `iface` A valid interface handle.
- `duration` Duration of the file.
- `id` Identification for `idle`.

**See Also**

`usbman_set_protocol()`

**For More Information**

For more information refer to the USB HID 1.1 Specification.
usbman_set_interface()
Request Interface Change

Syntax

```c
usbd_status usbman_set_interface(
    usbd_interface_handle iface,
    int altidx);
```

Description

Requests an interface change specified by `iface->index`. This will perform transfers on the USB. This function returns `USBD_NORMAL_COMPLETION` if successful; `USBD_NOMEM` if no memory is available; `USBD_IOERROR` when there is a transfer error to the device; and `USBD_STALLED` if the transfer caused the device to STALL.

Parameters

- **iface**
  A valid interface handle.
- **altidx**
  Alternate interface handle, 0 if none.
**usbmman_set_protocol()**

Switch Between Boot and Report Protocol

**Syntax**

```c
usbd_status usbmman_set_protocol(
    usbd_interface_handle iface,
    int report);
```

**Description**

Switches between the boot protocol and report protocol for an HID device.

**Parameters**

- **iface**
  - Valid interface.
- **report**
  - 0: boot protocol.
  - 1: report protocol.

**See Also**

usbmman_set_idle()

---

**For More Information**

For more information refer to the USB HID 1.1 Specification.
usbman_set_report()
Perform Set Report Request

Syntax

```c
usbd_status usbman_set_report(
    usbd_interface_handle iface,
    int type,
    int id,
    void *data,
    int len);
```

Description

Performs a set report request to the given interface. This function returns USBD_NORMAL_COMPLETION if successful; USBD_NOMEM if no memory is available; USBD_IOERROR when there is a transfer error to the device; and USBD_STALLED if the transfer caused the device to STALL.

Parameters

- **iface**
  A valid interface handle.

- **type**
  UHID_INPUT_REPORT, UHID_OUTPUT_REPORT, UHID_FEATURE_REPORT.

- **id**
  Report value id.

- **data**
  Pointer to memory for request data.

- **len**
  Length of data.

See Also

- usbman_set_idle()
- usbman_set_protocol()
For More Information
For more information refer to the USB HID 1.1 Specification.
**usbman_setup_default_xfer()**

**Initialize Transfer Handle**

**Syntax**

```c
void usbman_setup_default_xfer(
    usbd_xfer_handle xfer,
    usbd_device_handle dev,
    usbd_private_handle priv,
    u_int32_t timeout,
    usb_device_request_t *req,
    void *buffer,
    u_int32_t length,
    u_int16_t flags,
    usbd_callback cb);
```

**Description**

Initializes a transfer handle `xfer` with given parameter values. Upon completion, this function returns nothing.

**Parameters**

- **xfer**: A valid transfer handle returned from `usbman_alloc_xfer`.
- **dev**: A valid USB device associated with the transfer.
- **priv**: Parameter passed to interrupt service routine.
- **timeout**: Milli-seconds to wait before timing out, or `USBD_NO_TIMEOUT`.
- **req**: Device request if using control pipe, otherwise `NULL`.
- **buffer**: Memory to hold transfer.
- **length**: Bytes in `buffer`.
flags

USBD_NO_COPY, USBD_SYNCHRONOUS,
USBD_SHORT_XFER_OK, or
USBD_FORCE_SHORT_XFER.

cb

Function to be called when transfer has
completed.

See Also

usbman_setup_isoc_xfer()
usbman_setup_xfer()
usbman_setup_isoc_xfer()
Initialize ISOC Transfer

Syntax

```c
void usbman_setup_isoc_xfer(
    usbd_xfer_handle     xfer,
    usbd_pipe_handle     pipe,
    usbd_private_handle  priv,
    u_int16_t            *frlengths,
    u_int32_t            nframes,
    u_int16_t            flags,
    usbd_callback        cb);
```

Description

Initializes a transfer handle `xfer` with given parameter values. Upon completion, this function returns nothing.

Parameters

- **xfer**: A valid transfer handle.
- **pipe**: A valid open pipe.
- **priv**: Parameter passed to interrupt service routine.
- **frlengths**: Array of frame lengths.
- **nframes**: Number of frames (elements in `frlengths`).
- **flags**: `USBD_NO_COPY`, `USBD_SYNCHRONOUS`, `USBD_SHORT_XFER_OK`, or `USBD_FORCE_SHORT_XFER`.
- **cb**: Function to be called when transfer has completed.

See Also

- `usbman_setup_default_xfer()`
usbman_setup_xfer()
**usbman_setup_xfer()**

Assign Fields in Transfer

**Syntax**

```c
void usbman_setup_xfer(
    usbd_xfer_handle xfer,
    usbd_pipe_handle pipe,
    usbd_private_handle priv,
    void *buffer,
    u_int32_t length,
    u_int16_t flags,
    u_int32_t timeout,
    usbd_callback cb);
```

**Description**

Initializes a transfer handle `xfer` with given parameter values. Upon completion, this function returns nothing.

**Parameters**

- **xfer**
  A valid transfer handle.

- **pipe**
  A valid open pipe.

- **priv**
  Parameter passed to interrupt service routine.

- **buffer**
  Receiving the DMA buffer.

- **length**
  Bytes in data buffer.

- **flags**
  `USBD_NO_COPY`, `USBD_SYNCHRONOUS`, `USBD_SHORT_XFER_OK`, or `USBD_FORCE_SHORT_XFER`.

- **timeout**
  Number of milliseconds to wait for device to respond to transfer.

- **cb**
  Function to be called when transfer has completed.
See Also

usbman_setup_default_xfer()
usbman_setup_isoc_xfer()
usbman_sync_transfer()
Perform Asynchronous Transfer

Syntax
usbd_status usbman_sync_transfer(
    usbd_xfer_handle req);

Description
Performs a synchronous transfer on the USB. The transfer handle req specifies direction, data, timeout, and transfer type. This call will not return until the transfer has completed successfully, timed out, or a USB error occurs.

This function returns USBD_NORMAL_COMPLETION if successful; USBD_NOMEM if no memory is available; USBD_IOERROR when there is a transfer error to the device; USBD_STALLED if the transfer caused the device to STALL; and USBD_TIMEOUT when no transfer occurred because the time interval expired.

Parameters
req A valid transfer handle.

See Also
usbman_bulk_transfer()
usbman_transfer()
usbd_status usbdman_transfer(usbd_xfer_handle req);

**Description**
Initiates a bulk data transfer, either incoming or outgoing. This function returns USBD_NORMAL_COMPLETION if the operation is successful; USBD_NOMEM if there is no memory to allocate DMA buffer; and USBD_TIMEOUT if the operation timed out.

**Parameters**
- req: A valid usbd_xfer structure as allocated by usbd_alloc_xfer().
Chapter 4: USB Host for OS-9 Utilities

This chapter provides a description of the USB Host for OS-9 utilities. Table 4-1 summarizes the USB utilities.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>usbdevs</td>
<td>Print Current Devices on the USB</td>
</tr>
<tr>
<td>usbprint</td>
<td>Print Source File</td>
</tr>
<tr>
<td>ugenstat</td>
<td>Display Descriptors for Given UGEN Descriptor</td>
</tr>
</tbody>
</table>
usbdevs
Print Current Devices on the USB

Syntax
usbdevs [options]

Source
SRC/IO/USBH/UTILS/USBDEVS

Options
-a [=]<addr> Display device address <addr> information.
-b [=]<bus> Specify the bus on which to access device at <addr>. The default bus number is 0.
-e Display extended information.

Description
This utility prints out the current devices on the USB. This information includes the device descriptor, configuration descriptor, interface descriptor, and any string descriptors. The -a and -b options can be used to select a particular device by USB address/bus and display extended information for that device.

Example
The following example shows three root hubs, two with two ports and one with four ports. A USB v1.1 device is plugged into a USB v1.1 3-port hub. A USB v2.0 Flash disk is plugged into a port on the high-speed bus #2.

$ usbdevs
Bus #0, Root Hub, Address 1,
[1] <empty>
[2] Address 2, Hub (vendor 1228, product 4386)
   [1] Address 3, Fellowes Inc.: Fellowes 5 Button
   [2] <empty>
   [3] <empty>
Bus #1, Root Hub, Address 1,
[1] <empty>
USB Host SDK for OS-9 133

Bus #2, Root Hub, Address 1,

Address 2, SanDisk Corporation: U3 Cruzer Micro: 0000051015079136

Device Descriptor: max_packet 64, protocol 0, release 0.2, configurations 1
Config. Descriptor (1): interfaces 1, value 1, iconfig 0
attributes 0x80, max power 200 mA
Interface Descriptor 1: alt. setting 0, num eps 2,
class 8, subclass 6, protocol 80, iInterface 0

$ usbdevs -a=2 -b=2
Address 2, SanDisk Corporation: U3 Cruzer Micro: 0000051015079136 (vendor 1921, product 21506)
Device Descriptor: max_packet 64, protocol 0, release 0.2, configurations 1
Config. Descriptor (1): interfaces 1, value 1, iconfig 0
attributes 0x80, max power 200 mA
Interface Descriptor 1: alt. setting 0, num eps 2,
class 8, subclass 6, protocol 80, iInterface 0
Syntax
usbprint [options] <source-file> [<printer-device>]

Source
SRC/IO/USBH/UTILS/USBPRINT

Options
- m  Search for source file in module directory.

Description
This utility prints the source file to the specified printer device. If no printer device is specified, it will default to /ulp0.

Example
- Printing using the standard USB printer driver.
  $ usbprint sample.txt /ulp0
- Printing using the Generic USB driver.
  $ usbprint sample.txt "/ugen0#2"
**uugenstat**

Display Descriptors for Given UGEN Descriptor

**Syntax**

uugenstat [device]

**Source**

SRC/IO/USBH/UTILS/UGENSTAT

**Description**

This utility displays the device, configuration, interface, endpoint, and string descriptors for the given UGEN device descriptor. If no descriptor is specified, the default will be /ugen0.

**Example**

The following example shows a mouse attached to /ugen0.

```
$ uugenstat /ugen0
Device Descriptor: 12010001 00000008 03067168 00010422 0001
NOVATEK USB Mouse STD.
Number of Configurations: 1
Config Descriptor 1: 09022200 010100a0 32

Number of interfaces: 1
Interface Descriptor 0: 09040000 01030102 00

Number of endpoints: 1
Endpoint Descriptor 0: 07058103 08000a
```

**For More Information**

The data format printed for the descriptors is defined in the USB 1.1 documentation. This can be found at www.usb.org.
Appendix A: Porting to the USB Host Stack

This chapter details how to port to the USB Host stack. The following sections are included:

- Writing the Logical Device Driver (LDD)
- Writing a Hardware Control Driver
Writing the Logical Device Driver (LDD)

This section will describe how to make a new Logical Device Driver for the USB Host Stack. Any file manager may be used for an LDD, but in this chapter, the driver will be under the NullFM File Manager.

Before you begin, you will need to decide the following information:

- the directory name for the LDD
- the driver name
- the descriptor name

The makefile and all of the source code files for the LDD will reside in the following directory:

/mwos/SRC/DPIO(NULLFM/DRVR/USBH/<YOUR_LDD_DIRECTORY_NAME>

Both the driver and descriptor modules will be located in the following directory:

/mwos/OS9000/<PROCESSOR>/CMDS/BOOTOBJ/USBH

Creating a Directory Structure

The first step in writing an LDD is to create a directory structure for your NullFM driver. This will be the directory in which you will copy and modify files from the sample driver directory (SAMPLE_LDD). Follow the procedure below to create this structure and associated files for your new LDD.

Step 1. Create a new folder in the /mwos/SRC/DPIO(NULLFM/DRVR/USBH directory. This folder will contain the source files and makefiles for your NullFM driver.

Step 2. Create a DEFS directory within the folder you just created. This directory will contain all header files specific to this driver and descriptor.
Step 3. Copy the following files from the SAMPLE_LDD directory (sample driver) into your driver directory:

- drvr.mak
- init.c
- makefile
- rw.c
- desc.mak
- hw.c
- main.c
- os9_dev.c
- stat.c

Step 4. Copy the following files from the SAMPLE_LDD/DEFS directory into the DEFS directory of your driver:

- defsfile.h
- desc.h
- funcs.h
- usbh_desc.h
Implementing your LDD

Below is a step-by-step guide of which code to modify in each file copied from the SAMPLE_LDD directory. This step-by-step guide details an example scenario using a camera driver and descriptor. (ucamera is the driver name, and ucamera0 is the descriptor name.)

Step 1. Modify the drvr.mak file to change the driver name and directory. To do this, change the TRGTS and DRVNAME macros to the name of your LDD driver. Then, change the LOCDRV macro to the source directory name of your LDD. Below is an example that shows the driver name as ucamera and the directory as USBH/UCAMERA.

```
TRGTS= ucamera

LOCDRV= USBH/UCAMERA

DRVNAME= ucamera
```

Step 2. Modify the descriptor name in the desc.mak file. To do this you will need to change the TRGTS macro. Below is an example that shows a descriptor name of ucamera0.

```
TRGTS= ucamera0
```

Note

The descriptor name and driver name must be different.
Step 3. Modify the desc.h file located in the DEF directory. This file contains the basic descriptor information for your LDD NullFM driver. You will need to change the DRIVERNAME definition and the descriptor name pre-processing conditional. Below is an example:

```c
#if defined(ucamera0)

#define DRIVERNAME       "ucamera"
#define FILEMANAGERNAME  "nullfm"
#define VECTOR 0
#define IRQLEVEL 5
#define PRIORITY 20
#define PORTADDR(void*)0x0
#define DEVICE_MODE      FAM_READ|FAM_WRITE

#endif
```

Step 4. Modify the os9_dev.c file to incorporate device specific changes to the os9_match, os9_detach, os9_attach, and the os9_intr routines.

---

For More Information
For more information on these routines, refer to the Logical Device Drivers section of Chapter 2 of this manual.

---

Step 5. If your driver should respond to either a read or write on an open path, modify the rw.c file. In addition, the data_available function should be modified to return the number of bytes available for read.
### Additional File Information

Below is a list of files that may not require direct modification.

<table>
<thead>
<tr>
<th>File</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>makefile</td>
<td>main makefile that builds the driver and descriptor</td>
</tr>
<tr>
<td>init.c</td>
<td>implements driver initialization and termination routines</td>
</tr>
<tr>
<td>hw.c</td>
<td>called during initialization and termination to open a path and register with usbomb</td>
</tr>
<tr>
<td>main.c</td>
<td>main psect for this driver</td>
</tr>
<tr>
<td>stat.c</td>
<td>contains setstat and getstat routines for this driver.</td>
</tr>
<tr>
<td>DEFS/defsfile.h</td>
<td>main include file to include other header files</td>
</tr>
<tr>
<td>DEFS/funcs.h</td>
<td>contains all global function/type definitions for the driver</td>
</tr>
<tr>
<td>DEFS/usbh_desc.h</td>
<td>file that allows you to extend the driver static storage definition</td>
</tr>
</tbody>
</table>
Writing a Hardware Control Driver

This section describes the steps necessary to write a new hardware control driver for the USB Host stack for OS-9.

Note
Before reading this chapter, be certain you have perused Chapter 2: Using USB Host for OS-9 of this manual.

Overview

A USB hardware driver is responsible for initializing the USB hardware, scheduling transfers, and servicing interrupts. The USB manager, usbman, is responsible for scheduling all transfers for the hardware controller driver. It is the responsibility of the hardware driver to perform these transfers and provide notification when the transfers are complete.

Transfer Types

The hardware controller driver must implement following six types of transfer:

- root hub control
- root hub interrupt
- device control
- device interrupt
- device bulk
- device isochronous transfers
Each transfer type has a function block associated with it. This function block allows `usbman` to call directly into the hardware control driver to start transfers, close a pipe, abort a pipe, and other such operations. Below is the definition of the transfer function block located in `usbdivar.h`:

```c
struct usbd_pipe_methods {
    usbd_status     (*transfer)(usbd_xfer_handle xfer);
    usbd_status     (*start)(usbd_xfer_handle xfer);
    void            (*abort)(usbd_xfer_handle xfer);
    void            (*close)(usbd_pipe_handle pipe);
    void            (*cleartoggle)(usbd_pipe_handle pipe);
    void            (*done)(usbd_xfer_handle xfer);
};
```
Porting to the USB Host Stack

Bus Methods Structure

The hardware control driver must also implement a bus methods structure; this is another way that usbman can call directly into the hardware control driver. This structure contains functions for opening a pipe, allocating and freeing memory, and allocating and freeing DMA memory.

Below is the structure definition located in usbdivar.h.

```c
struct usbd_bus_methods {
    usbd_status          (*open_pipe)(struct usbd_pipe *pipe);
    void                 (*soft_intr)(struct usbd_bus *);
    void                 (*do_poll)(struct usbd_bus *);
    usbd_status           (*allocm)(struct usbd_bus *, usb_dma_t *, u_int32_t bufsize);
    void                   (*freem)(struct usbd_bus *, usb_dma_t *);
    struct usbd_xfer *   (*allocx)(struct usbd_bus *);
    void                 (*freex)(struct usbd_bus *,
                               struct usbd_xfer *);
};
```

The bus methods function block is returned by the hardware control driver in response to a GS_USB_BUS_METHODS getstat. Usbman performs this getstat while initializing the USB stack.

Calling usbman

The hardware controller driver may also call into usbman on two occasions: to insert a transfer into the list and to notify usbman when a transfer was completed. These methods are given to the hardware control driver from usbman by the SS_USB_MAN_METHODS setstat. This means the hardware control driver must acknowledge this setstat and store the methods and global pointer for usbman.
Existing Drivers

Because a sample driver does not currently exist, you must start from one of the three existing hardware controller drivers: EHCI, OHCI, PHCI, SL811HST, or UHCI. Below is a brief description of each driver.

EHCI  
commonly used on desktop computers  
(www.usb.org/developers/docs.html)

This driver creates a series of schedules for the hardware to act upon. The EHCI controller generates an interrupt as the various tasks are completed. This driver also relies on the fact that there will be low and/or full-speed driver support (companion OHCI or UHCI controllers). Like OHCI, this driver requires some type of shared memory between the processor and controller.

OHCI  
commonly used on desktop computers  
(www.usb.org/developers/docs.html)

This driver stores an elaborate list of items to transfer and only generates an interrupt after a successful transfer on the USB. The OHCI controller walks the transfer list and schedules USB time in hardware. In addition, this driver requires some type of shared memory between the processor and the controller.

PHCI  
driver for the Philips ISP1161/2 embedded USB Host chip

This hardware is more CPU intensive than the OHCI driver. Software must schedule transfers every millisecond, but more than one transfer may be scheduled. At the end of the frame (one millisecond), the software
must determine which transfers were successful and schedule more transfers on the USB for the next frame.

**SL811HS**

driver for the ScanLogic 811HS USB Host chip

This is the most CPU intensive hardware because the hardware driver must schedule every transfer on the USB. This results in many interrupts per frame (millisecond). SL811HS does not have an integrated root hub. Instead, the driver is notified of a voltage change on the bus, where it must then determine if something was inserted or removed from the root hub.

**UHCI**

commonly used on Intel-based desktop computers (http://www.intel.com/design/USB/UHCI11D.htm)

This driver stores a simple list of items to transfer and generates an interrupt after a successful transfer on the USB. The UHCI controller walks the transfer list that the driver schedules for the USB. In addition, this driver requires some type of shared memory between the processor and the controller.
Implementing the Driver

To implement the driver, complete the following steps:

Step 1. Make a new directory in /mwos/SRC/DPIO/NULLFM/DRVR/USBH and a DEFS subdirectory and copy files from one of the existing drivers.

Step 2. Create a new directory and DEFS subdirectory in the board port to contain the makefiles and board definitions for this driver (/MWOS/OS9000/<PROCESSOR>/PORTS/<BOARD>/NULLFM/YOUR_DRIVER_NAME). Copy port files from an existing USB Host driver into this directory. These makefiles will require some modification in order to redefine any source or include paths.

Step 3. If your driver uses DMA, you will need to define the following symbol: USE_NONCACHED_MEM. This will include code in usb_mem.c to perform memory allocation for DMA memory. The malloc_dma function defined in this file performs an allocation out of a non-cached memory shade. This function will also ensure that the memory allocated is on the proper alignment boundary.

When using the USB_NONCACHED_MEM define, DMA memory allocations occur out of the M_USB_DMA memory shade. To reduce memory fragmentation, the MAUI memory APIs are used. Thus, a MAUI memory shade for M_USB_DMA must be created before using the malloc_dma function. (Refer to init.c in the OHCI, UHCI, or EHCI driver)

Step 4. Update the desc.h file located in /MWOS/OS9000/<PROCESSOR>/PORTS/<BOARD>/NULLFM/YOUR_DRIVER/DEFS. In particular, the VECTOR, IRQLEVEL, PRIORITY, and PORTADDR must be updated to reflect the proper values for the board.

Step 5. Update the USB hardware specific file in the driver. This file contains the hardware initialization, termination, interrupt service routine, and usbman entrypoints. Development of this driver will take time, but can be achieved if tested. The section below contains more information on testing the USB Host driver.
Testing the Driver

Testing a USB Host driver occurs in several phases starting with the most basic test: initializing and de-initializing the driver. Below is a sample command used to initialize your driver on your OS-9 target. You will need your driver, descriptor, and the NullFM File Manager on your OS-9 target.

$iniz /usbhc

After the above command is issued, the init entrypoint in the NullFM driver will be called. When this is complete, perform the following steps:

**Step 1.** Set a breakpoint on this function and step through the code to see if hardware initialization occurred properly.

**Step 2.** Turn on the start-of-frame (SOF) interrupt in the initialization code for your driver. SOF interrupts occur every 1 milli-second; you will know if one has occurred by setting a breakpoint on your interrupt service routine.

**Step 3.** Test termination of the driver by typing the following command:

$ deiniz /usbhc

After this command is issued, the term entrypoint is called. It is important to make sure that the hardware is turned off properly and that interrupts have been masked and memory deallocated. Repeated iniz and deiniz commands can be used to test memory leakage by using the mfree command.

**Step 4.** Determine if a root hub interrupt is being raised. To do this, set a breakpoint in the part of your interrupt service routine that handles the root hub interrupt.

**Step 5.** Iniz your driver and plug in a device like a hub or mouse into the USB port. The root hub interrupt should fire when the device is plugged in. If your hardware does not have an integrated root hub into the chip, refer to the SL811HS driver.
Step 6. Iniz `usbman`. Below is a sample of how to do this. You will need the driver, descriptor, the NullFM file manager, `usbman` driver, and `usbman` descriptor on your OS-9 target.

```bash
$ iniz /usb
```

Iniz-ing `/usb` will cause `usbman` to initialize and iniz your hardware driver. At this point, there will be an exchange of information between `usbman` and your driver via `getstat/setstats`. If this swap of information is successful, your driver and `usbman` have exchanged entrypoints.

Step 7. Start the `usbd` daemon. This opens a path to `usbman` and perform an explore on USB. Using the `-v` option will print out each occurrence of a USB explore. The `usbd` program performs an explore whenever a root hub interrupt occurs.

---

**Note**

It is important to plug in and out a device multiple times to ensure that the root hub interrupt is working properly.

---

The `-v` option command is shown below:

```bash
$ usbd -v
```

At this point, the `usbdevs` program can be used to print out information about devices on the USB.

---

**Note**

As soon as a device is plugged into the USB, an explore should occur.
When the explore is successful, the usbdevs program prints out the configuration information for the device. It is helpful to leave usbd -v running in the foreground on the console and use the usbdevs program on a second serial port (or telnet window).

You should be able to run usbdevs after plugging in or removing a device on the USB. usbdevs will display current topology. If it does not, you have a USB transfer problem.

Step 8. As a final test, perform the tests in Chapter 1: Getting Started with USB Host for OS-9® of this manual once more. This will ensure that control and interrupt pipes are working properly. If you require a device with bulk or isochronous endpoints, you will need to write a separate application to perform the tests relating to those endpoints.