OS-9 Porting Guide

Version 3.1

www.radisys.com

World Headquarters
5445 NE Dawson Creek Drive • Hillsboro, OR
97124 USA
Phone: 503-615-1100 • Fax: 503-615-1121
Toll-Free: 800-950-0044

International Headquarters
Gebouw Flevopoort • Televisieweg 1A
NL-1322 AC • Almere, The Netherlands
Phone: 31 36 5365595 • Fax: 31 36 5365620

RadiSys Microware Communications Software Division, Inc.
1500 N.W. 118th Street
Des Moines, Iowa 50325
515-223-8000

Revision A
November 2001

Copyright and publication information

This manual reflects version 3.1 of OS-9.

Disclaimer

Reproduction notice

November 2001

Table of Contents

Chapter 1: Porting Steps Summary and Reference

This guide walks you through the process of porting OS-9 to custom hardware.

This chapter includes the following topics:

Before Beginning the Port Steps

The OS-9 manuals use these terms for computer systems, in a specific way:

host	The development system used to edit and re-compile OS-9 source files.
target	The system to which you intend to port OS-9.

The OS-9 operating system includes the OS-9 kernel, `init` module, ticker, real time clock, I/O manager, file managers, device drivers, device descriptors, utilities, and other system modules.

Complete the following steps before you port to your target:

Step 1. Obtain all the documentation that came with your board.

Determine the following:

a. Number of communication ports available on the target and host. To complete installation of OS-9, you probably need one serial port for console communication and either one serial or one Ethernet port for debugging communications.

b. Tickers available on the target. You need one high-level, countdown ticker for time-slicing. You need a second ticker for low-level timing if you are using Hawk user-state debugging on the running system.

Step 2. Test and verify your hardware. You need:

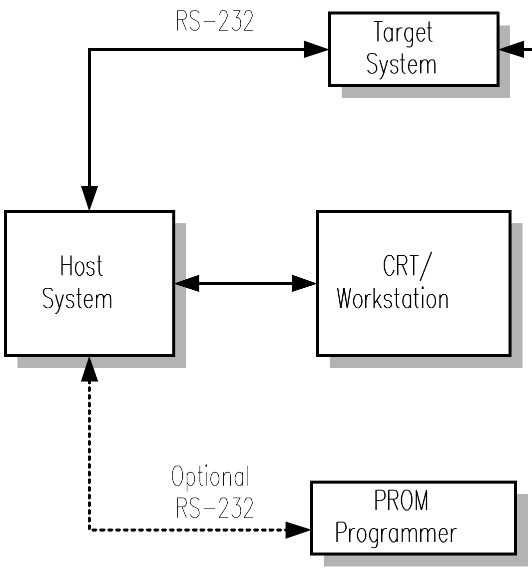
- The target board
- Communication cables
- Power supply cord
- Hardware debugger software

Test your hardware before beginning the porting process so you are not trying to simultaneously debug the hardware and the software. This manual explains the steps for debugging the port of the operating system but does not tell you how to debug hardware problems.

While debugging your hardware, determine if there are board hardware features to help you in the debugging process. For example, see if there is an LED you can light or a bell you can ring.

Figure 1-1 shows a typical host and target interconnection.

Figure 1-1 One Typical Host and Target Interconnection



Note

Use 9600 baud or the highest possible data rate for RS-232 links to maximize download speed. The default is 9600 baud. The X-On/X-Off protocol is used for flow control.

For More Information

Refer to ***OS-9 for the <target> Board Guide*** or ***Getting Started with OS-9 for <target>*** for other examples of how hardware can be set up.

Step 3. Install Microware software distribution on host system.

Follow the installation instructions included with your Microware software distribution media.

The distribution media contain all of the files that make-up the:

- OS-9 boot code
- Operating system
- Related utilities

Some files are source code text files. Most of the other files are makefiles and object code files. The files are organized into subdirectories according to major subsystems (ROM, IO, CMDS, for example) in a master directory known as the MWOS structure.

During the installation process, the file system is copied into the MWOS directory structure. You need to use a hard disk based system with sufficient storage capacity to contain the entire file system.

Microware has adopted this general directory structure across all of its product lines. The files in the distribution package assume this specific file and directory organization. They do not compile and link correctly if the organization is different.

Microware uses the file name suffixes shown in the following table to identify file types:

Table 1-1 Microware File Name Suffixes

Suffix	Definition
`.a`	Assembly language source code.
`.c`	C language source code.
`.cc`	C++ language source code.
`.d`	Definitions (`defs`) source code (for assembly).
`.des`	EditMod description files.
`.edm`	Editmod generated C header file.
`.h`	C header file source code.
`.i`	Microware intermediate code (I-code) files.
`.il`	Microware intermediate code libraries.
`.l`	Library files.
`.m`	Macro files.
`.ml`	Module list files, including `coreboot.ml` and `bootfile.ml`, which create the boot images.
`.o`	Assembly language source from the compiler back end.
`.r`	Relocatable object code (for linker input), created by the assembler.

Table 1-1 Microware File Name Suffixes (continued)

Suffix	Definition
`.tpl`	Makefile templates.
`none`	Object (binary) files.

Note

In general, OS-9 does not require file name suffixes. However, certain utilities, such as µMACS and `cc` or `xcc`, do require file name suffixes to determine the mode of operation.

Porting Steps Summary

Before you begin this section, you should have completed the pre-porting steps.

For More Information

If you want more details about OS-9, the modules involved in the porting process, and what occurs in OS-9 during the booting process, see **OS-9 Boot Code Overview**.

Phase I - Prepare a port directory

Step 1. **Create a port directory** for your board in `<MWOS>/OS9000/<CPU Family>/PORTS`, where `<MWOS>` is the tree in which you have installed your OS-9 product(s) and `<CPU Family>` is the name of the CPU family to which the CPU on your board belongs. See **Chapter 2: Creating Target Port Directories** for a full description of the MWOS tree and the supported CPU directories.

Step 2. **Create a *systype.h* file** by copying it from one of the example ports directories into your working port directory. This example `systype.h` file contains comments and structure that you will use, along with the explanation in **Chapter 3: Porting the Boot Code**, to fully define the board specific definitions used throughout the porting process.

Phase II - Create the Low-Level System

Step 3. **Copy the bootstrap code** sources from one of the example directories into your port directory and modify for the memory layout of your board. Write customized startup code to initialize your board's memory and devices. **Chapter 3: Porting the Boot Code** walks you through this process.

Step 4. **Create a low-level serial driver** appropriate for your board's serial device, using the one of the example sources, and perhaps one of the drivers included in the OS-9 for Embedded Systems source library.

This low-level serial driver provides the basic I/O service to the serial hardware for displaying the OS-9 bootstrap message, and resident RomBug debugging. **Chapter 4: Creating Low-Level Serial I/O Modules** discusses the steps required to provide serial support for the boot code.

Note

This overview assumes that you have a serial device on your target board.

Optional Phase III - Set Up Hawk System-State Debugging

If you want to use `sndp`, or Hawk system-state debugging, instead of RomBug for the remainder of your port, proceed with Step 5. If you would rather continue using RomBug for system-state debugging, skip to Step 8.

Step 5. **Create a second serial port or an Ethernet port driver** to use as the communications link for debugging.

- To create a low-level serial driver, see **Chapter 4: Creating Low-Level Serial I/O Modules**.
- To create a low-level Ethernet driver, see **Chapter 5: Creating a Low-Level Ethernet Driver**.

Step 6. **Create a low-level timer module** to support Hawk debugging communications. **Chapter 6: Creating a Low-Level Timer Module** discusses this issue in detail.

Step 7. **Configure and test Hawk** by including the following components in the boot module list and verifying the Hawk connection:

a. The Hawk support modules

b. The low-level serial or Ethernet driver

c. The low-level timer

For More Information

See ***Using Hawk*** for information on configuring Hawk.

Phase IV - Create the High-Level System

Step 8. **Create an initial Init module** and boot image with `shell` as the first executable process and `term` as the system console for debugging purposes. **Chapter 7: Creating an Init Module** discusses the Init module in detail.

Step 9. (optional) **Create a PIC driver** for each programmable interrupt controller on your board, if your board uses programmable interrupt controllers. Create a library of calls that access your PIC(s) to provide a transparent way for drivers to enable/disable interrupts on your board. Refer to **Chapter 8: Creating PIC Controllers** for detailed information on these steps.

Step 10. **Write a high-level serial driver** for use as your system console. **Chapter 9: Creating an SCF Device Driver** walks you through the details. If you would rather avoid writing a high-level driver for the initial board port, see **Chapter 10: Using Hardware-Independent Drivers**.

If you complete the previous steps, you have completed a port to your target board. The OS-9 shell should run on your target board as a single-tasking operating system. Complete the following step to add multi-tasking and time-slicing to the basic port.

Step 11. **Create a system ticker** to enable time-slicing and multi-processing. See **Chapter 11: Creating a Ticker** for more details.

Phase V - Adding Features to the Basic Port

The amount of work required to complete your port depends on the number and types of devices present on your board.

Step 12. Perform any additional porting steps, including:

a. **Creating more high-level drivers** for other serial ports, clocks, and any other available devices. Clock creation and debugging is explained in **Chapter 12: Selecting Real-Time Clock Module Support**.

b. **Creating high-level drivers for disk devices.** Once the basic port of a board has been completed (the first two port procedures), a high-level driver for a floppy drive (or other device) can be developed. **Chapter 13: Creating RBF Drivers and Descriptors** discusses how to create device descriptors in detail. Once you know this driver works, you can format a floppy disk and install an OS-9 bootfile on the floppy. At this point, you can create the low-level driver (borrowing heavily from the tested code of the high-level driver) to boot the system from the floppy disk. **Chapter 13: Creating RBF Drivers and Descriptors** describes the steps necessary to create and test disk drivers.

c. **Creating low-level drivers and port-specific booters** to boot from the various devices available on the target. **Chapter 14: Creating Booters** discusses creating disk drivers and booters in detail.

OS-9 Boot Code Overview

The process of booting OS-9 requires an OS-9 bootfile and boot code that initializes the system hardware, locates the OS-9 bootfile, and passes control to the OS-9 kernel.

The bootfile is a collection of the OS-9 system modules merged together into a single image, with the kernel appearing as the first module. This bootfile can exist in ROM, RAM, or flash memory. On a disk-based system, the bootfile is on the boot disk device. Tape devices can also be used as boot devices, with the bootfile on magnetic tape.

The boot code for OS-9 contains the raw machine-code bootstrap routine and a collection of separately linked but inter-dependent modules, organized as OS-9 extension modules. These modules compose the low-level system required to boot the system and provide debugging on the target.

Each low-level system module provides one or more services that may be required for a particular target. By compiling these services into separate, configurable modules, the low-level system can be rich and flexible without inflating the memory requirements for the core bootstrap code. You can build a minimal system by including only the low-level system modules required for booting.

Note

The file `boot.c` in `<MWOS>\OS9000\SRC\ROM\` contains the following macro:

```
#define BOOTSTRAP_EDITION 62
```

In this example, the number "62" corresponds to the last entry in the edition history of the low-level boot for OS9000. The edition # will be incremented in future OS releases if/when changes are made to the bootstrap code.

Bootstrap Code (romcore)

The bootstrap code is made from a number of different files that are compiled and linked together to produce the final binary object code, `romcore`. Some of the code is not target platform-specific and is supplied in intermediate code form (files with `.i` or `.il` suffixes) or relocatable object code form (files with `.r` or `.l` suffixes). To create the bootstrap code, you need to edit a few source files. Next, you use the `make` command (`os9make` on Windows) to compile and link these files with the other intermediate and relocatable files to create the `romcore` binary image file.

The bootcode follows these steps to boot OS-9:

Step 1. Initialize the basic CPU hardware and devices to a known, stable state.

Step 2. Locate and initialize each boot module to make all boot services available.

Step 3. Determine the location and extent of the target's RAM and ROM memory.

Step 4. Call a system debugger if one is configured.

Step 5. Call the configured system booter module to find the OS-9 bootfile.

Step 6. Transfer control to the OS-9 kernel.

Low-Level System Modules

The `romcore` bootstrap image is merged with several low-level system modules to produce the final boot image to be burned into PROM, or loaded into RAM, NVRAM, or flash memory, prior to booting the target system.

Note

`romcore` is the only part of the system that is not a module.

Because some of the low-level system modules provide services, they are supplied as linked memory modules in binary form. For some modules, both target-independent binary modules and source code are provided so you can make target specific changes. You should use target-independent modules for your initial port of OS-9. As more of the port is accomplished, these modules can be rebuilt to more directly target your system.

For the initial port, you need to ensure that low-level serial driver modules exist to handle the console I/O port and an auxiliary communications port. You may be able to use the example drivers for the common serial devices directly. If not, the example source code provides a guide for creating your own driver.

If you plan to use Hawk tools for downloading and remote system-state debugging, you need to ensure an appropriate low-level network driver is available. A low-level SLIP driver was provided for use with your serial port. In addition, example drivers are provided for some Ethernet devices. You use these drives directly or modify them to support your network device.

A brief description of the distributed low-level system modules, grouped by service follows:

Configuration Modules

You can use the configuration modules to configure the boot system. These modules provide a way for other low-level system modules to retrieve configuration parameters describing how they should function. The low-level system modules are *soft-coded* to use the configured values retrieved by calling the configuration module services.

`cnfgdata`	Target-specific data module containing the configuration parameters. The definitions of these parameters are set in the `systype.h`, `default.des` (where applicable), and `config.des` files.

Note

While all the other low-level system modules are organized as OS-9 extension modules, `cnfgdata` is an OS-9 data module.

`cnfgfunc`	Target-independent module that retrieves configuration parameters from the `cnfgdata` boot data module. This module could be modified to return target-specific overrides of the default information in `cnfgdata`. For example, you could override `cnfgdata` values with NVRAM or switch/jumper settings.

Boot Modules

These are the modules responsible for selecting the appropriate system boot routine and using it to locate the OS-9 bootfile from the appropriate device.

`bootsys`	Target-independent module providing two services: a booter registration routine and the booter selection/execution routine. •The registration routine installs device specific booter modules onto a list of available booters as either an auto-booter or menu-booter.

	•The booter selection/execution routine is called as part of the OS-9 booting process. It either selects the appropriate auto-booter or prompts you to choose a booter from the registered menu-booters to use for booting the system. Next, it calls that booter to retrieve the OS-9 bootfile, passing parameters you enter and any defaults found for the booter in the `cnfgdata` module.
`portmenu`	Target-independent module that retrieves a list of names of configured auto and menu booters from the configuration data module. `portmenu` checks each named booter against the list of available booters and, if found, registers it through the `bootsys` registration service.
`<booter>`	Any of the port specific booter modules capable of locating and loading the OS-9 bootfile from its target device. During initialization, each booter installs itself on a list of available booters.
`override`	Target-independent booter module that enables overriding of the autobooter. If the space bar is pressed within 3 seconds after the bootstrap message displays, a boot menu is displayed. Otherwise, booting proceeds with the first autobooter.
`srecord`	Target-independent booter module that receives a Motorola S-record format file from the communications port and loads it into memory.
`flashb`	Target-independent booter support module that assists in reprogramming flash memory. `flashb` relocates the console, downloader, and flash programming modules from flash memory to RAM. This enables a new booter to overwrite that flash memory location. `flashb` calls the

	flash-specific module to program each sector, and optionally, calls a downloader module to read data for programming into flash memory.
`romboot`	Target-independent booter module that locates the OS-9 bootfile in the special memory list. Like all booters, `romboot` installs itself on the list of available booters when initialized.
`restart`	Target-independent booter module that restarts the boot process, if it is called.
`rombreak`	Target-independent pseudo-booter meant to drop the system into the configured system-state debugger.
`parser`	Target-independent booter support module providing argument-value pair parsing services.
`fdman`	Target-independent booter support module providing general booting services for RBF file systems.
`pcman`	Target-independent booter support module providing general booting services for PCF file systems (PC FAT file systems).
`scsiman`	Target-independent booter support module providing general SCSI command protocol services.
`<low-level SCSI module>`	Target-specific booter support module providing SCSI host-adaptor access services.
`IDE`	Target-specific standard IDE support including PCMCIA ATA PC cards.
`FDC765`	PC style floppy support.

Serial Communication Modules

Two serial ports are used by the low-level system. The system console displays boot status messages, error messages, boot menus, and debugger messages from the target-resident debugger. The auxiliary communications port is a download port for communicating with a host system.

`console`	Target-independent module providing high-level I/O hooks into the low-level entry points of the console serial driver. The available functions include `getchar()`, `getc()`, `putchar()`, `putc()`, `gets()`, and `puts()`.
`conscnfg`	Target-independent module that retrieves the name of the low-level driver to use for the console from the configuration data module. After finding the driver on a list of available drivers, `conscnfg` installs it as the console serial driver. You can modify this module to perform target-specific console configuration instead of using a `cnfgdata` module.
`commcnfg`	Target-independent module that retrieves the name of the low-level driver to use for the auxiliary communication port from the configuration module. After finding the driver on the list of available drivers, `commcnfg` initializes it as the communication serial driver. You could modify this module to perform target-specific communications port configuration instead of using a `cnfgdata` module.
`io<serial>`	Any of the target-specific low-level serial drivers. The low-level serial driver services include device initialization and de-initialization, read a byte, write a byte, and get status. Each low-level serial driver will, during module initialization, install itself on a list of available serial drivers.

`iovcons`	A low-level virtual console driver that is hardware independent because it transfers I/O requests to the low-level network modules (TCP/IP stack). `iovcons` provides a `telnetd`-like interface to the low-level system console. You can use the `telnet` command to link to the target processor board to obtain a TCP/IP connection over which the OS-9 boot messages and RomBug I/O occurs. This removes the need for a direct serial connection to the target by providing a remote console.

Low-Level Network I/O Modules

`protoman`	Target-independent protocol module manager. This module provides the initial communication entry points into the protocol module stack.
`lltcp`	Target-independent low-level transmission control protocol module.
`llip`	Target-independent low-level internet protocol module.
`llslip`	Target-independent low-level serial line internet protocol module. This module uses the auxiliary communications port driver to perform serial I/O.
`lludp`	Target-independent low-level user datagram protocol module.
`llbootp`	Target-independent low-level BOOTP protocol booter module.
`ll<ether>`	Target-specific low-level Ethernet driver module.
`hlproto`	High-level hook into the protocol manager of the low-level system. This module is used when the low-level system is to be used for user-state debugging through FasTrak.

Timer Modules

The timer modules are port specific modules that use some counter/timer device of the target to provide a polling time-out mechanism for other low-level system modules. The services provided are:

- Initialization - perform any required timer initialization.
- De-initialization - de-initialize timer.
- Set time-out value - set a time-out value from the time of the call.
- Get time-out value - get the time remaining until the time-out expires.

Debugger Modules

The OS-9 configuration provides for either target-resident or remote system-state debugging, depending on the debugging method and tool you select.

`dbgentry` — Target-independent module that provides a hook from the boot code and OS-9 kernel's `_os_sysdbg()` system call to the low-level debug server.

Note

`dbgentry` must be present in the low-level system for debugging capability.

`dbgserv` — Target-independent debug server module. The debug server contains services providing the following debugging facilities:

- Monitoring exception vectors
- Setting breakpoints
- Setting watchpoints

- Executing at full speed (until it encounters a breakpoint, watchpoint, or exception)
- Tracing by single instruction
- Tracing by multiple instructions

Note

The debug server must also be present in the low-level system if any system-state debugging is required prior to the OS-9 kernel being executed.

`usedebug`	Target-independent module that retrieves the flag from the configuration data module indicating whether the debugger is called during system startup. You can modify this module to perform target-specific debugger configuration instead of using a `cnfgdata` module.

For More Information

Refer to ***Using RomBug*** for more information about the available features.

`RomBug`	Target-independent debugger client module that provides interactive, target-resident debugging using the serial console device for the user interface. `RomBug` uses the I/O services available through the `console` module to read commands and display output, and uses the services of `dbgserv` to perform the required debugging tasks.

Note

The use of `RomBug` requires a low-level serial device to be available as the system console.

`sndp`	Target-independent system-state network debugging protocol module. This module acts as a debugging client on the target, invoking the services of `dbgserv` to perform debug tasks. Its user interface, however, is a low-level network connection to a Hawk client on the development host. That is, `sndp` is viewed as a debug server from the standpoint of the remote, host-resident Hawk debugger.

Note

The use of `sndp` requires the appropriate low-level network driver and protocol modules for the communication link.

For More Information

See the ***Using Hawk*** manual for information on the features of the Hawk debugger.

Notification Module

Hawk relies on the low-level communication modules and a network driver for remote system-state debugging both before and after OS-9 is up and running. Once the OS-9 system has booted, you can use either high-level networking drivers and protocols (SPF, for example) or low-level communications, to perform remote user-state debugging on the target. The high-level drivers and protocols do not use the same communications path as the low-level communications.

Regardless of the communications path, if the system drops into system-state, the low-level drivers/protocols must be used to communicate with the host.

Some low-level system modules require that they be informed when a transition takes place between high and low-level states in order to do special maintenance.

The `notify` module provides the following services:

Table 1-2 notify Module Services

Service	Description
Registration	Any low-level system module requiring notification of a state change can call `notify`. The calling module passes the address of a routine to be called in the event of such a state change, and the registration routine includes it on a list of such routines to be called.
De-registration	A low-level system module can call `notify` to cause its routine to be removed from the list of routines to be called in the event of a state change.
Notification	The debugger calls `notify` when a state change takes place. `notify` passes over its list of routines requiring notification, and calls each in turn.

Miscellaneous Module

`flshcache`	Target-specific boot module that provides cache flushing routines appropriate for the target hardware.

Low-Level System Configuration

For each example target platform, the file `coreboot.ml` contains a list of the low-level system modules along with `romcore` to create the boot image. For your initial port, use the configuration given in the example ports. You will need to change the `coreboot.ml` file to use the appropriate low-level serial device drivers for your console and communications ports, and the appropriate booters and low-level communications drivers that apply to your target.

Note

You may also want to replace the target-resident `RomBug` debugger with the modules appropriate for use with `sndp` and the remote Hawk debugger.

OS-9 Boot Process Overview

The booting process occurs in three phases, and are similar to the steps you take in porting OS-9. The following sections provide background information on porting and the phases of the boot process.

Power up To the Debugger Prompt

When power is supplied to the processor, or when a reset occurs, the processor begins executing from a fixed address. The initial value in the OS-9 boot code is a label, `cold`:. This label is defined in the bootstrap source code file `btfuncs.a`.

Once `btfuncs.a` starts executing, it:

1. branches to the label `sysinit`: in the source file `sysinit.c`. `sysinit` initializes any port specific hardware devices and then branches back to the label `sysreturn` in `btfuncs.a`.
2. initializes the stack pointer. This relies on the memory lists defined in the bootstrap source file `rom_cnfg.h` to determine the first available RAM memory area, as well as the top-of-stack offset into it.

For More Information

See **Chapter 3: Porting the Boot Code** for information on creating the `sysinit.c` file and the `rom_cnfg.h` header file for your port.

3. calls the `sysinit1()` routine in `sysinit.c`. The `sysinit1()` routine completes the initialization of target-specific hardware devices. Before returning control back to `btfuncs.a`, it calls `rompak1()` to determine if an `initext` module is present for further hardware initialization.

4. initializes the bootstrap global data pointer and stack pointer. This relies on the memory lists defined in the bootstrap source file `rom_cnfg.h` to determine the first available RAM memory area.
5. initializes the bootstrap global data. The `callidata()` routine in `p2privte.l` is called to initialize the global data for the bootstrap code.
6. Transfers control to `hard_reset()` in the `boot.c` source file.
7. If control is returned, which only happens if it is impossible to boot the system, control is transferred back to the `cold`: label, and the process repeats.

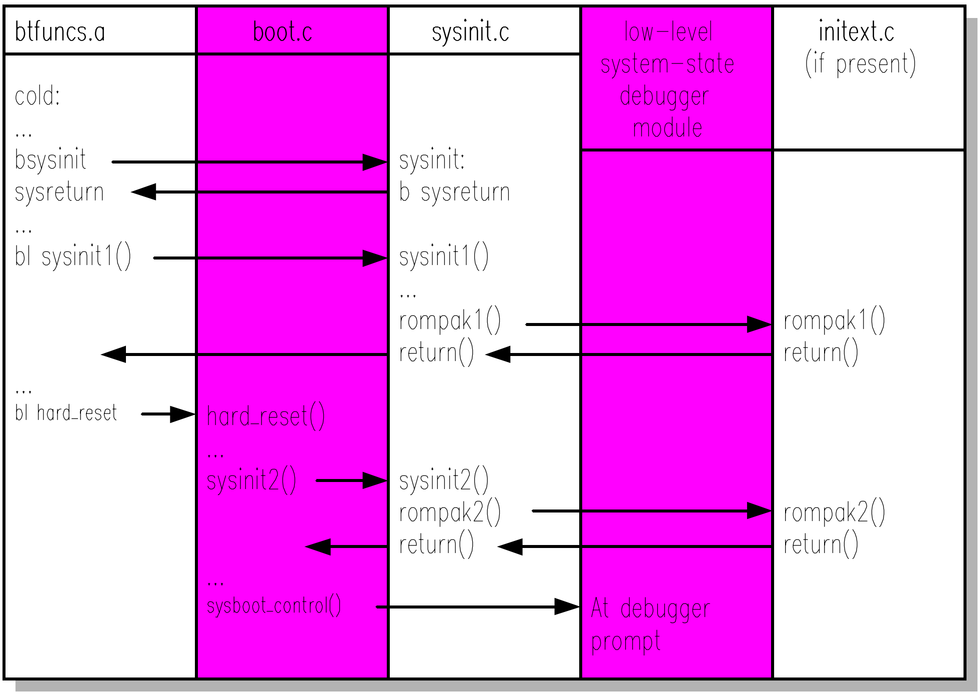
When `boot.c` gets control in `hard_reset()` it:

1. initializes the vector table for the processor. This is done through a call to the `initvects()` routine in the `cbtfuncs.c` file.
2. determines the processor type and floating point unit (fpu) type. These are calls to `getfpu()` and `getcpu()` in `btfuncs.a`.
3. searches for and initializes the low-level system modules through a call to `rominfo_control()` in `romsys.l`. The `rominfo` record structure is initialized, then the memory immediately following the bootstrap code is searched for valid, contiguous low-level system modules, and each one that is found is initialized. During initialization, the low-level system modules add tables and pointers to their services onto the `rominfo` record structure.
4. performs RAM and special memory searches, and if needed, enables memory parity checking. The memory search routines use both bus errors and pattern matching to determine the sizes of valid RAM and ROM memory segments available on the system. This relies on the memory list defined in `rom_cnfg.h` to determine the memory areas to search.
5. inserts the bootstrap global data area and stack area into the consumed memory list.

6. Calls the `sysinit2()` routine in `sysinit.c`. The `sysinit2()` routine performs any target-specific initialization that relies on the completion of the previous steps. There may not be any, but before `sysinit2()` returns, it calls `rompak2()` to determine if an `initext` module is present for further target-specific initialization.
7. Initiates the configured low-level debugger by calling the `sysboot_control()` routine from `romsys.l`. If a low-level debugger is configured, enabled, and available, it is called at this point by the `sysboot_control()` function. The debugger displays a processor register display, and a prompt.

The major steps of this phase are shown in **Figure 1-2**. The following figure illustrates the first step in the boot process:

Figure 1-2 Chart of Files and the Subroutines they Contain



Debugger Prompt to the Kernel Entry Point

On return from the debugger (once you have requested booting be continued) the bootstrap code:

1. calls the boot system to find the OS-9 bootfile. `sysboot_control()` invokes the boot service provided by the `bootsys` module to oversee the location of the OS-9 bootfile by the configured booter(s). This boot service calls each registered auto-booter in turn until one is successful in locating a valid OS-9 bootfile. If there are no auto-booters, or if all fail to find a bootfile, you are presented with a menu listing of all registered menu-booters and prompted to select one. The specified booter is called and the process is repeated until a selected booter is successful in locating an OS-9 bootfile.
2. transfers control to the OS-9 kernel. The coldstart entry point of the kernel module is calculated and control is transferred to the kernel for completion of the boot.

Kernel Entry Point to the Shell Prompt

The kernel's coldstart routine finishes the task of booting OS-9. It reads the OS-9 configuration module, `init`, and using the system configuration data stored within the kernel:

1. initializes system global data (commonly referred to as the system globals).
2. adds the colored memory list to the memory lists found by the bootstrap code.
3. builds the kernel's RAM memory from the RAM memory list.
4. builds the module directory by searching for modules in the special memory list.
5. executes all configured extension modules from the `PREIO` extensions list.

6. initializes system data tables such as the path table and process table.
7. opens the system console.
8. changes directories to the system device.
9. executes all configured extension modules from the EXTENS extension list.
10. creates the first process to be executed.
11. transfers control to the system execution loop to begin process scheduling.

The OS-9 system is now booted and executing as expected.

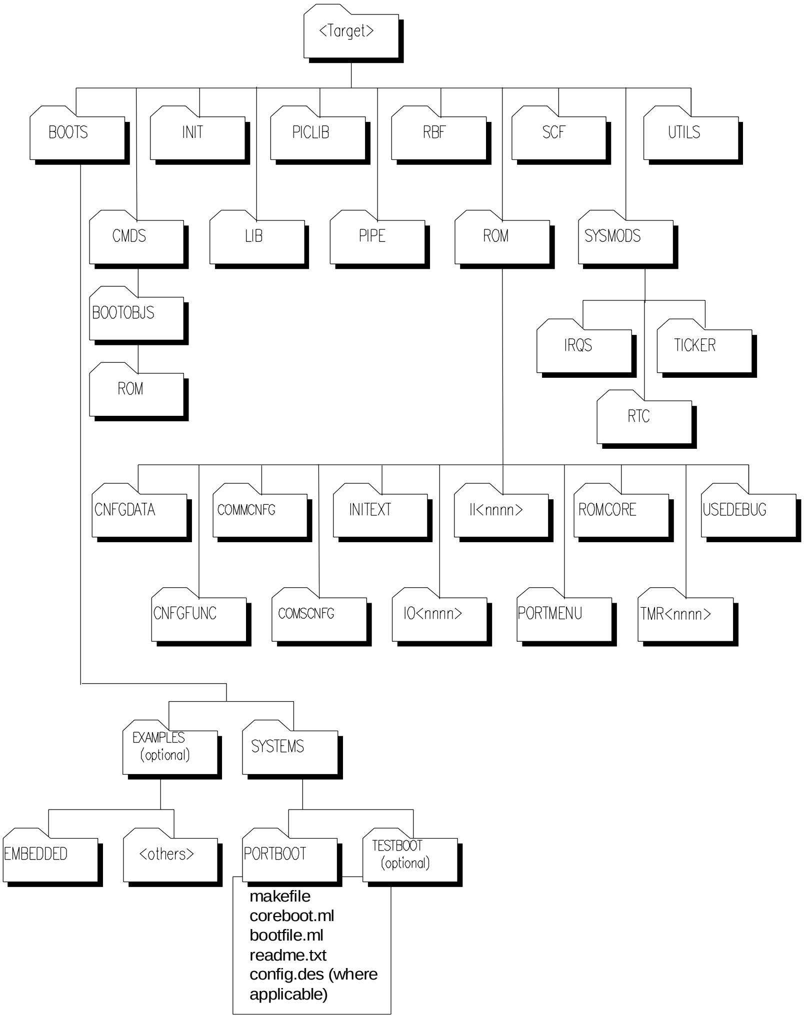
Chapter 2: Creating Target Port Directories

This chapter includes the following topics:

<MWOS>/OS9000 Ports Directory Structure

The following figure shows only the directories referred to in this guide. The MWOS structure includes other directories and files. For a list of files and directories included in your software distribution, refer to your board guide or ***Getting Started With OS-9 for Embedded Systems***.

Figure 2-1 <MWOS>/OS9000 Porting Directories and Files



Creating Target Port Directories

The OS-9 boot code sources, driver sources, and system modules (such as the kernel) consist of many files when installed on your system.

Microware provides example source files for several different types of device drivers, including serial, tickers, and real-time clocks. You only need support for the hardware platform your target has available so you can ignore drivers that are not relevant.

Step 1. Determine the following hardware information before beginning the porting procedure:

- What I/O devices will you use?
- How are these devices mapped into memory?
- How is the memory organized?
- What does the memory map of the entire system look like?

Step 2. Create your own working directory structure in which to design and build your port. Start by creating a subdirectory in `MWOS/OS9000/<CPU Family>/PORTS`. (`<CPU Family>` is a specific processor family directory like PPC or 80386.) This is the root of your target platform's directory structure. If your target platform is based on a processor for which there already exists a processor-specific ports directory, then your target directory can be created there instead. For example, if your target system is built on a PowerPC 603 CPU, you could choose to develop your port in `MWOS/OS9000/603/PORTS`.

Step 3. Create the necessary directories for your target and copy the following files from the corresponding directories in on the example ports as a starting point. Each target port directory structure is somewhat different depending upon the configuration of the target platform.

- `BOOTS/SYSTEMS/PORTBOOT`
- `CMDS/BOOTOBJS/ROM`
- `ROM/CONSCNFG/makefile`

- `ROM/COMMCNFG/makefile`
- `ROM/PORTMENU/makefile`
- `ROM/USEDEBUG/makefile`
- `ROM/ROMCORE/RELS`
- `ROM/ROMCORE/makefile`
- `ROM/makefile`

The `BOOTS/SYSTEMS/PORTBOOT/coreboot.ml` file contains the list of names of modules to be merged with `rom` when building the boot image.

The makefile in `ROM` invokes the makefiles in each of its appropriate subdirectories to build the bootstrap code and low-level system modules. Some of the subdirectories are disabled by default. For the initial target port, uncomment the values for the `CONSCNFG`, `COMMCNFG`, `PORTMENU`, and `USEDEBUG` macros.

Once this target port directory structure is in place, the bootstrap code can be ported.

Chapter 3: Porting the Boot Code

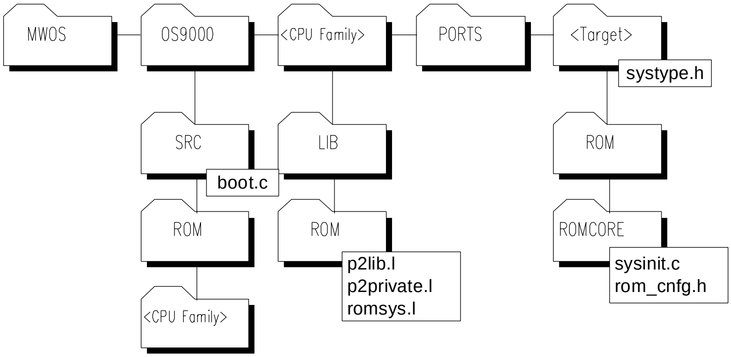
This chapter includes the following topics:

- **Porting the Bootstrap Code**
- **Configuring the Low-Level System Modules**
- **The ROM Image**

Porting the Bootstrap Code

The source files, `boot.c` and all of the files in the `<CPU Family>` subdirectory of the `ROM` directory, are used to build the bootstrap code.

Figure 3-1 <MWOS>/OS9000 Bootstrap Source Code Directories



These files, and the port-specific `sysinit.c` source file, are compiled and linked together with the distributed libraries to build the bootstrap code. The distributed libraries include:

- `p2privte.l`
- `p2lib.l`
- `romsys.l`

For More Information

See **Appendix A: The Core ROM Services**, for more information about the distribution libraries.

To port the boot code, you must create additional files to support the source files and libraries. The sample target port directories contain examples of these files that you can use as a guide.

Table 3-1 Bootstrap Code Files You Need to Create

File Name	Content Summary
`systype.h`	Target system, hardware-dependent definitions.
`rom_cnfg.h`	The bootstrap memory list and stack definitions. ROM console and boot device record definitions and the ROM memory lists.
`sysinit.c`	Target specific hardware initialization your system may require following a system reset.

WARNING
Do not modify the other bootstrap source code files. If you alter these files, the port code may not function correctly.

The rom_cnfg.h File

The `rom_cnfg.h` header file contains the target system definitions only used for the bootstrap code. This includes patchable memory locations containing the following information:

- Top of the bootstrap stack
- Size of memory reserved for low-level system modules
- Bootstrap memory lists

For More Information

Some processors may require additional steps. See your ***Getting Started With OS-9 for <target>*** for your processor-specific porting information.

Bootstrap Stack Top and Boot Module Memory

The bootstrap code allocates memory from the first RAM memory segment of the system into three parts, as shown in **Figure 3-1 <MWOS>/OS9000 Bootstrap Source Code Directories**. The bootstrap code allocates the global data area and the stack area for its own use. It reserves the special memory pool for the low-level system modules to use.

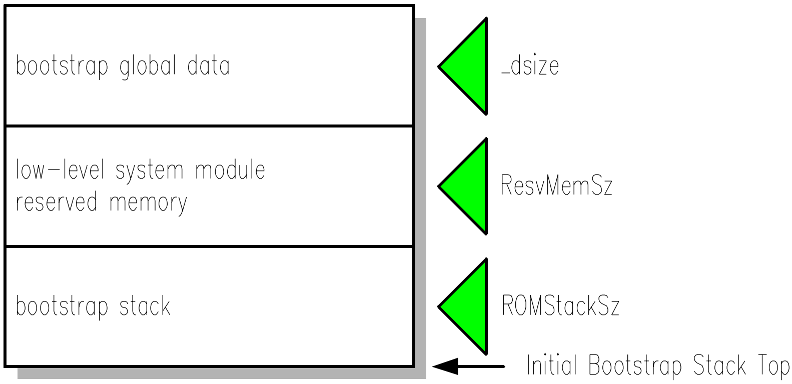
The definitions for the size of the bootstrap stack area (`ROMStackSz`) and the boot module memory pool (`ResvMemSz`) are given in `rom_cnfg.h` as shown in the following example:

```
_asm("
ROMStackSz equ $4000 KB
ResvMemSz equ $20000 128KB
romstack:
 dc.l _dsize+ResvMemSz+ROMStackSz
 dc.l ROMStackSz size of ROM stack
");
```

The linker produces a link map for the `romcore` bootstrap image when it is built. Using this map, the offset of `romstack` can be found. Once this address is known, a 32-bit value at that address can be patched to change the size of the memory area reserved for low-level system modules. Additionally, by patching in the proper 32-bit values at that address, and the following address, the size of the bootstrap stack area can be changed.

Figure 3-2 shows the memory diagram of this first RAM segment.

Figure 3-2 First RAM Memory Segment Allocated by the Bootstrap Code



Bootstrap Memory Lists

The ROM memory list is made of pairs of 32-bit integers specifying start and end boundaries for memory lists. The first list is used to map the system's available RAM memory. The second list is used to map special memory regions treated as ROM memory and searched in a non-destructive fashion. Special memory areas may include ROM, flash, or NVRAM memory. For example:

```
/*
*memory search list
*/
_asm("
memlist
    dc.l $4000,$80000  first memory segment includes
    ROM data area and stack
    dc.l $400000, $1000000  second memory segment
    dc.l 0
    dc.l $fff40000, $fff80000  ROM search area
    dc.l 0,0,0,0,0  extra fields for patching lists
");
```

In this example the bootstrap code:

1. Uses RAM from the beginning of the first memory segment for its data area and stack. (The PowerPC vectors are initialized at $0-$4000.)
2. Searches for RAM memory following its stack to $80000.
3. Searches for RAM memory in the range $400000 to $1000000.

The next zero word terminates the RAM search list.

The ROM search list follows the RAM search list. In this example, the ROM search list causes the bootstrap code to search for ROM memory between $FFF40000 and $FFF80000.

These memory lists are used by the `boot.c` source file when it builds a table of available memory. Each list is searched for valid memory segments, and each valid segment is added to the memory table.

Note

The 32-bit integer in `memlist` represents “start” and “end” boundaries for memory lists. As a general rule, avoid using all zeros or all “f’s” for these boundaries.

Note

Avoid inserting unnecessary spaces in your `rom_cnfg.h` file. Though the compilation may complete error-free with extra spaces, it may still cause build errors unnoticed until boot time.

The RAM Search

The first part of the search list defines the areas of the address space where the bootstrap code should normally search for RAM memory. This reduces the time it takes for the system to perform the search. It also prevents the search (and also OS-9) from accessing special use or reserved memory areas such as I/O controller addresses or graphics display RAM.

The first entry, or bank, in this list must point to a block of RAM large enough for storing:

- Bootstrap global data
- Memory required by the low-level system modules
- Start-up bootstrap stack
- System global data

If the system boots from a disk or another device, the first bank needs to be large enough to also hold the size of the bootfile loaded from that device, as well as any buffers required by the boot drivers.

The RAM memory search is performed on each area in the search list by:

1. Reading the first four bytes of every 8K memory block of the area.
2. Writing a test pattern sequence. Memory is initialized to repetitions of the pattern, `Dude` (0x44756465).
3. Reading the area again for comparison. If the read matches what was written, the search assumes this was a valid RAM block and is added to the system free RAM list.

The Special Memory Search

The second part, or the special memory part of the search list, is strictly a non-destructive memory search. This is necessary so that the memory search does not overwrite modules downloaded into RAM or NVRAM.

During the porting process, you should temporarily include enough RAM (at least 256K) in the special memory list to download parts of the boot file. If this download area has parity memory, you may need to do one of the following:

- Manually initialize it.
- Disable the CPU's parity, if possible.
- Include a temporary routine in the `sysinit.c` file.

The RAM and special memory searches are performed by `boot.c` during the booting process.

The systype.h File

The `systype.h` file is an include file used in building several of the low-level system modules and OS-9 system modules. This file should be viewed as the common location for all port specific hardware definitions and configuration parameters.

The main sections of the systype.h file include:

- Ticker and real time clock definitions
- Low-level system module configuration definitions
- Hardware specific macros and definitions

For support of the bootstrap code, it is important to include in the systype.h header file any target-specific hardware definitions you want to use as you write the hardware initialization routines in the sysinit.c source file. Such definitions might include hardware specific bit layouts, address offsets, or initial values.

The sysinit.c File

The sysinit.c file should contain all special hardware initialization your system requires after a reset or system reboot. The sysinit.c file consists of these different sections, or entry points:

- sysinit
- sysinit1
- sysinit2
- sysreset

The sysinit Entry Point

The first entry point, sysinit, is called almost immediately after a reset by btfuncs.a. sysinit performs the minimum hardware actions the system may require to enable memory or initialize necessary devices during start up.

This routine does not return through the typical return machine instruction. The return to btfuncs.a is made directly by a branch to the sysreturn: label.

The sysinit routine is always a complete embedded assembly routine.

WARNING
At this point, the stack register has not been initialized to point to a stack area. The `sysinit` code must be written assuming no stack exists.

The sysinit1() Routine

The first C-routine, `sysinit1()` completes any necessary hardware initialization that was not required to be done by the `sysinit` assembly routine. In addition, it makes the call to `rompak1()` to activate any initialization routines in the `initext` module (described later in this section).

While a stack is present during `sysinit1()` execution, no static storage is available.

The sysinit2() Routine

The second C-routine, `sysinit2()`, is used for any system initialization required after calling `sysinit1()`. Often, this routine consists of a routine that calls `rompak2()` and returns, as most systems can perform all their required initialization during the first call to `sysinit` and `sysinit1()`. `sysinit2()` is called after `funcs.a` and `boot.c` have:

- initialized the vector table (for vectors in RAM) and the exception jump table.
- performed the memory searches.

The sysreset() Routine

The third C-routine, `sysreset()`, is installed as a service to enable the low-level system modules, in particular the low-level debugger, a way of initiating a software reset on the target. `sysreset()` performs any special hardware actions the system requires before attempting a software reset, for example a cache flush. It then initiates the proper instructions to reset the system, or if such a reset is not supported by the target, branches back to the `Cold`: entry point in `btfuncs.a` to initiate the reboot sequence.

The initext Module

The `initext` module is a separately linked portion of hardware initialization code providing a modular functional extension to the `sysinit1()` and `sysinit2()` routines described previously.

It is provided in source form, enabling an end-user to add hardware initialization routines specific to a target configuration that would be inappropriate to include in the base `romcore` module because of hardware modularity requirements. For example, a peripheral device implemented on a card plugged into the host bus may require specific initialization immediately following a CPU reset in the case where a bus reset could not be asserted by the processor in the `sysreset()` routine described above. This initialization code might be appropriately implemented in the `initext` module rather than a `romcore` module, since the end-user may have obtained the port from an OEM providing the base target platform.

There are two entry points to the `initext` module, `rompak1()` and `rompak2()`. When the `initext` module is present in the system immediately following the `romcore` module, `rompak1()` would be executed by `sysinit1()`, and `rompak2()` would be executed by `sysinit2()`, provided those routines attempt to call the rompak routines.

Note

Note the following:

- `rompak1()` is executed prior to ROM module scan.
- `rompak2()` is executed after ROM module scan and all ROM modules have been painted.
- No static storage is available for the `initext` module.

The `initext` module is built in a `ROM/INITEXT` subdirectory within the target port directory. You should defer implementation of your base `initext` module until after your initial port is completed. When you decide to start on your `initext` module, use the sources and makefile from an example port as a reference.

Configuring the Low-Level System Modules

Once the bootstrap code is ported and your low-level serial I/O drivers are ready, you need to provide some configuration data to define what your initial port looks like.

The OS-9 booting process relies on the use of a configuration data module (`cnfgdata`) to define certain default parameters used in the boot. The configuration data module provides for great flexibility in designing your system, but is not required for a simple port. We recommend you keep your initial port as simple as possible.

If you are planning to use the Hawk remote debugger during the porting process, you must use the configuration data module. Read carefully about the configuration module and the low level network configuration before attempting such a port.

For the simple port using the target resident RomBug debugger, you do not need a configuration module. Configuring the simple port involves:

1. Adding to `systype.h` the definitions the low-level system modules use as default configuration values for system console and communications ports.
2. Modifying the boot module makefiles to disable use of the configuration data module for the first port stage.
3. Modifying the boot module list found in `coreboot.ml` to reflect the low-level system modules required for your system.

Adding Configuration Information to systype.h

`systype.h` should be modified to include definitions for the symbols `CONSNAME` and `COMMNAME`.

The symbol CONSNAME gives the name of the console device record that the console configuration module (conscnfg) will, by default, select for use as the system console. Similarly, COMMNAME is used by commcnfg as the default for the communication port. For example:

```
#define CONSNAME     COMM1NAME
#define COMMNAME     "MVME1603:com2"
```

Modifying Low-Level System Module makefiles

For your initial port, disable use of the configuration data module. Later chapters discuss how to build and use this module.

Modify each of the following makefiles copied earlier from an example port.

```
<Target>/ROM/COMMCNFG
<Target>/ROM/CONSCNFG
<Target>/ROM/PORTMENU
<Target>/ROM/USEDEBUG
```

These makefiles contain the definition of a macro called SPEC_COPTS that is defined to include the C option -dUSECNFGDATA. Comment this option out of the macro definition. For example, change the first line into the second line:

```
SPEC_COPTS = -d<option1> -d<option2> -dUSECNFGDATA
SPEC_COPTS = -d<option1> -d<option2> #-dUSECNFGDATA
```

Modifying coreboot.ml

The file coreboot.ml, copied from an example port, contains a list of low-level system modules included in the boot image when it is built.

To finish the configuration of your initial port, use the asterisk (*) to comment out the use of the configuration modules cnfgdata and cnfgfunc, and replace the low level I/O modules names in this list with the ones appropriate for your target. The I/O modules used in the example ports are usually named io<device>.

Do not remove the `console`, `conscnfg`, or `commcnfg` module names, and be sure to add the appropriate low-level serial I/O module names after `console`, but before the `conscnfg` or `commcnfg` module names.

Note

Once the new port is proven, the console and communication ports can be removed if desired.

WARNING

Do not change the order of the low-level system module names or the system may not boot.

The ROM Image

The OS-9 ROM image is a set of files and modules that collectively make up the operating system. The specific ROM image contents can vary depending on hardware capabilities and user requirements of the system in use.

To simplify the process of loading and testing OS-9, the ROM image is divided into two parts--the low-level image, called `coreboot`; and the high-level image, called `bootfile`.

Coreboot

The coreboot image is generally responsible for initializing hardware devices and locating the high-level (or bootfile) image as specified by its configuration. It is also responsible for building basic structures based on the image it finds and passing control to the kernel to bring up the OS-9 system.

Bootfile

The bootfile image contains the kernel and other high-level modules (initialization module, file managers, drivers, descriptors, applications). The image is loaded into memory based on the device you select from the boot menu. The bootfile image normally brings up an OS-9 shell prompt, but can be configured to automatically start an application.

Building the ROM Image

Once you have ported the bootstrap code, written (or copied) the sources and makefile for your low level serial I/O modules, and configured your system, you are ready to build the ROM image.

To build the ROM image, complete the following steps:

Step 1. Use the makefile `<Target>/ROM/makefile` to build your low-level system modules. This makefile forces a make within each of the subdirectories included in its `TRGTS` macro to build the low-level system modules.

Step 2. Use the makefile `<Target>/BOOTS/SYSTEMS/PORTBOOT/makefile` to build your boot image. This makefile not only creates the `rom` file, but also oversees the creation of the coreboot and bootfile.

WARNING

There must be at least four bytes of padding between the coreboot and bootfile images in the merged `rom` file.

Note

You may get errors when running make. If these problems are not related to low-level system modules, you can ignore the errors. This is because you only need the `coreboot` file for testing and it is created before the make exits with errors while trying to build the `rom` file.

Chapter 4: Creating Low-Level Serial I/O Modules

This chapter includes the following topics:

Creating the Low-Level Serial I/O Modules

While it is not absolutely necessary to have a serial I/O console device on your system, it is strongly recommended that your initial port include both a console device and an auxiliary serial I/O communications device.

The console I/O routines are used by the bootstrap code and low-level system modules for error messages, and by the debugger and menu-booters for interactive I/O. The communications port is used by the debuggers as a download and talk-through port. The communications port can also be used as the SLIP device for low level network communications with the Hawk remote debugger.

Source code is provided for several low-level serial modules that you can configure and use in your system without modification. If your target has a serial device for which no I/O module already exists, use the example sources as a guide to write your own. If both the console port and communications port use the same type of hardware interface, you only need to build one low-level I/O module.

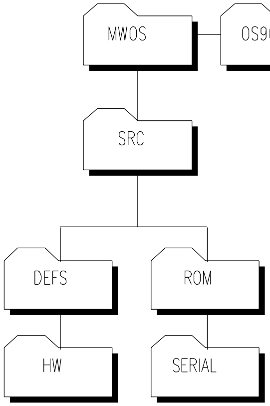
Note

If you are writing your own low-level serial driver, be advised that in order to use Hawk's module download feature you will need to implement the polled interrupt service routine, `cons_irq()`.

The distributed low-level serial I/O module sources are in `MWOS/SRC/ROM/SERIAL`.

Create a subdirectory for your own source code if you are building your own I/O module.

Figure 4-1 Low-Level Serial I/O Source Code Directories for Creating a Module



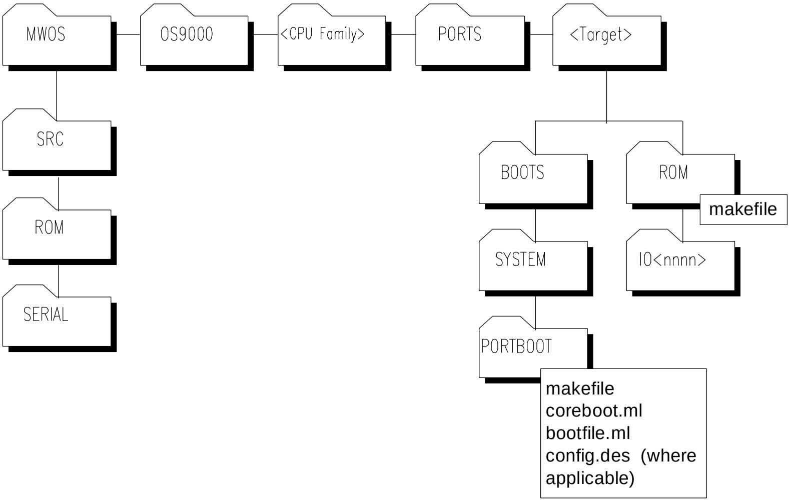
In addition to the directories listed earlier, each example port directory contains `<Target>/ROM/IO<nnnn>` directories containing makefiles used to build the low-level I/O module used in the port. You need to create such a directory and makefile for your serial devices in your ports directory. Use the example makefiles as a guide.

Device specific include files (`<xxxx>.h`) are normally kept in the `MWOS/SRC/DEFS/HW` directory. These are typically chip-specific definitions and are to be shared by both low-level (ROM) and high-level (OS) drivers.

Building the Low-Level Serial I/O Modules

The makefile for your I/O module should be created in a properly named subdirectory of your ports `ROM` directory (for example, `<Target>/ROM/IO<nnnn>`). Use the makefiles from the example ports as a guide.

Figure 4-2 Low-Level Serial I/O Source Code Directories for Building a Module



To add your low-level serial I/O module to the system:

Step 1. Edit the makefile, `<Target>/ROM/makefile.`

Step 2. Add your device directory name to the list of targets used to define the `TRGTS` macro.

Step 3. Add the low-level serial I/O module name into the `corboot.ml` file in the `PORTBOOT` directory.

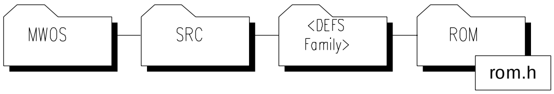
By doing this, your low level I/O module is rebuilt along with the bootstrap code and the rest of the low-level system modules when:

- `<Target>/ROM/makefile` is invoked and included in the `rom` file,
- and, `<Target>/BOOTS/SYSTEMS/PORTBOOT/makefile` is invoked creating the boot image `coreboot`.

The Console Device Record

A console device (`consdev`) record is maintained for each low level serial I/O device included with the low-level system modules. This record is used to access the services of the I/O module, and to maintain lists of such devices. The definition of `consdev` appears in the header file, `rom.h`, and appears here for illustration.

Figure 4-3 Console Device Record Directory




```
struct consdev {
   idver     infoid;                                 /* structure version tag */
   void      *cons_addr;                             /* port address of I/O device*/
   u_int32   (*cons_probe)(Rominfo, Consdev),        /* h/w probe service */
             (*cons_init)(Rominfo, Consdev),         /* initialization */
                                                     /* service */
             (*cons_term)(Rominfo, Consdev);         /* de-initialization service*/
   u_char    (*cons_read)(Rominfo, Consdev);                /* read service */
   u_int32   (*cons_write)(char, Rominfo, Consdev),         /* write service */
            (*cons_check)(Rominfo, Consdev);             /* character check service */
   u_int32   (*cons_stat)(Rominfo, Consdev, u_int32),
             (*cons_irq)(Rominfo, Consdev),
             (*proto_upcall)(Rominfo, void*, char*);
   u_int32   cons_flags;                                    /* device flags */
   u_char    cons_csave,                             /* read ahead stash */
             cons_baudrate,                          /* communication baud rate */
             cons_parsize,                           /* parity, data bits, stop bits */
             cons_flow;                              /* flow control */
   u_int32   cons_vector,                            /* interrupt vector */
             cons_priority,                          /* interrupt priority */
             poll_timeout;
   u_char    *cons_abname,                           /* abreviated name */
             *cons_name;                             /* full name and description */
   void      *cons_data;                             /* device specific data */
   void      *upcall_data;
   Consdev   cons_next;                              /* next serial device in list*/
   u_int32   cons_level;                             /* interrupt level */
   int       reserved;
};
```

Low-Level Serial I/O Module Services

The following entry points describe the services required of each low-level serial I/O module to support the booting process.

Table 4-1 Entry Points

Function	Description
`cons_check()`	Check I/O Port
`cons_init()`	Initialize Port
`cons_irq()`	Polled Interrupt Service Routine for I/O Device
`cons_probe()`	Probe for Port
`cons_read()`	Read Character from I/O Port
`cons_stat()`	Set Status on Console I/O Device
`cons_term()`	De-initialize Port
`cons_write()`	Write Character to Output Port
`notification_handler()`	Handle Callback from Notification Services

cons_check()

Check I/O Port

Syntax

```
u_int32 cons_check(
    Rominfo    rinf,
    Consdev    cdev);
```

Description

`cons_check()` interrogates the port to determine if an input character is present and returns the appropriate status.

Parameters

`rinf`	points to the `rominfo` record structure.
`cdev`	points to the console device record for the device.

cons_init()

Initialize Port

Syntax

```
u_int32 cons_init(
    Rominfo   rinf,
    Consdev   cdev);
```

Description

`cons_init()` initializes the port. It resets the device port, sets up for transmit and receive, and sets up baud rate, parity, bits per type, and number of stop bits. `cons_init()` also registers a notification handler described below, with the notification services.

Parameters

`rinf`	points to the `rominfo` record structure.
`cdev`	points to the console device record for the device.

cons_irq()

Polled Interrupt Service Routine for I/O Device

Syntax

```
u_int32 cons_irq(
   Rominfo   rinf,
   Consdev   cdev);
```

Description

`cons_irq()` is an interrupt service routine installed for the device performing the following polling interrupt service on receipt of a device interrupt:

Step 1. Disables further interrupts on the device.

Step 2. Clears the interrupt from the device.

Step 3. Initializes the low-level polling timer.

Step 4. Sets the polling time-out value and loops through the process of checking the device and timer until either a character is received or the time-out occurs.

Step 5. Sends a character that is received up the protocol stack by calling the uplink routine installed in the console device structure.

Step 6. Repeats steps 2 through 5 until a time-out occurs.

Step 7. Re-enables device interrupts and returns.

Parameters

`rinf`	points to the `rominfo` record structure.
`cdev`	points to the console device record for the device.

cons_probe()

Probe For Port

Syntax

```
u_int32 cons_probe(
    Rominfo   rinf,
    Consdev   cdev);
```

Description

`cons_probe()` tests to see if the hardware described by the console device record `cdev` is present. This could be a read of an I/O register based on the value of `cons_addr` in the console device record.

Parameters

`rinf`	points to the `rominfo` record structure.
`cdev`	points to the console device record for the device.

cons_read()

Read Character From I/O Port

Syntax

```
u_char cons_read(
   Rominfo   rinf,
   Consdev   cdev);
```

Description

`cons_read()` returns a character from the device's input port. `cons_read()` repeatedly calls `cons_check()` until a character is present. `cons_read()` should not echo the character. The only special character handling it might perform is XON-XOFF processing if the `CONS_SWSHAKE` flag is set in the `cons_flow` field of the console device structure.

Parameters

`rinf`	points to the `rominfo` record structure.
`cdev`	points to the console device record for the device.

cons_stat()

Set Status on Console I/O Device

Syntax

```
u_int32 cons_stat(
   Rominfo   rinf,
   Consdev   cdev,
   u_int32   code);
```

Description

`cons_stat()` changes the operational mode of the I/O module.

Parameters

`rinf`	points to the `rominfo` record structure.
`cdev`	points to the console device record for the device.
`code`	is the low-level setstat code indicating operational mode change. The supported setstat codes are defined in `MWOS/SRC/DEFS/ROM/rom.h` and described as follows:

CONS_SETSTAT_POLINT_OFF

`Indication`	Issued when `hlproto` no longer requires the services of the communications port.
`Operation`	Disable receive interrupts on port.

CONS_SETSTAT_POLINT_ON

`Indication`	Issued when `hlproto` requires the services of the communications port for user-state connections.

`Operation`	Verify configuration of low-level timer, enable receive interrupts on port.

CONS_SETSTAT_ROMBUG_OFF

`Indication`	Issued indirectly through notification services when the RomBug debug client returns control from any breakpoint, exception, or `d_sysdebug` entry.
`Operation`	Restore any applicable port- or chip-specific configuration (including interrupts).

CONS_SETSTAT_ROMBUG_ON

`Indication`	Issued indirectly through notification services when the RomBug debug client gets control on any breakpoint, exception, or `d_sysdebug` entry.
`Operation`	Save any applicable port- or chip-specific configuration (including interrupts). Disable any receive interrupts on port.

CONS_SETSTAT_RXFLOW_OFF

`Indication`	Issued when a driver user (such as `llslip`) needs to restrict the flow of received data.
`Operation`	If hardware handshaking is configured, assert hardware flow control (on), otherwise if software handshaking is configured, send an X-OFF.

CONS_SETSTAT_RXFLOW_ON

`Indication`	Issued when a driver user (such as `llslip`) needs to restore the flow of received data.
`Operation`	If hardware handshaking is configured, turn off hardware flow control, otherwise if software handshaking is configured, send an X-ON.

cons_term()

De-initialize Port

Syntax

```
u_int32 cons_term(
    Rominfo   rinf,
    Consdev   cdev);
```

Description

`cons_term()` shuts the port down by disabling transmit and receive.

Parameters

`rinf`	points to the `rominfo` record structure.
`cdev`	points to the console device record for the device.

cons_write()

Write Character To Output Port

Syntax

```
u_int32 cons_write (
    char       c,
    Rominfo    rinf,
    Consdev    cdev);
```

Description

`cons_write()` writes a character to the output port with no special character processing (for a low-level serial driver that does not use software handshaking).

The sample sources also contain the following serial I/O module entry points to support the user state Hawk remote debugger. For the initial port, it is not necessary to include these entry points because the previous functions are sufficient for support of system-state operation at the low-level. The following entry points support the use of low-level serial I/O module while in user state after the system is booted. This functionality is required for use of the I/O module by the user-state Hawk debugger.

Parameters

c	is the character written to the output port.
`rinf`	points to the `rominfo` record structure.
`cdev`	points to the console device record for the device.

notification_handler()

Handle Callback from Notification Services

Syntax

```
u_void notification_handler(
   u_int32    direction,
   void       *cdev);
```

Description

`notification_handler` issues calls to `cons_stat()` with the `CONS_SETSTAT_ROMBUG_ON` and `CONS_SETSTAT_ROMBUG_OFF` codes.

Parameters

`direction`	is the direction value provided from the notification services: the `NTFY_DIR_TOROM` value indicates a transition into the ROM from the operating system, the `NTFY_DIR_TOSYS` values indicates a transition to the operating system from the ROM.
`cdev`	points to the console device structure for the device.

Starting-up the Low-Level Serial I/O Module

During the early stages of system bootup, the bootstrap code searches for and initializes all low-level system modules included in the boot image. The initialization entry point for the low-level system modules is supplied in a relocatable (.r) file. This entry point branches to the C function `p2start()` which you need to provide for each of your low-level I/O modules. The initialization routine performs these tasks:

- Allocates/initializes the console device record for the device.
- Makes the entry points for its services available through the `consdev` record.
- Initializes configuration data for the I/O device.
- Installs its `consdev` record on the list of I/O devices in the console services record.

An example `p2start()` routine for a low level I/O module follows. (The console device record is allocated in the module's static data area.)

```
consdev    cons_r;    /* allocate console device record */

error_code p2start(
Rominfo rinf,         /* bootstrap services record structure pointer */
u_char *glbls)        /* bootstrap global data pointer */
{
    Cons_svcs    console = rinf->cons;
                      /* get the console services record pointer*/
    Consdev      cdev;
                      /* local console device structure pointer */


     /* verify that a console services module has been initialized */

    if (console == NULL)
        return (EOS_NOCONS);
                      /*cannot install w/o the console services record*/

     /* initialize device record for our device */

    cdev = &cons_r;   /* point to our console device record */
    cdev->struct_id = CONSDEVID;     /* id and version tags */
    cdev->struct_ver = CDV_VER_MAX;
                            /* export our service routine entry points */
    cdev->cons_probe = &io16450_probe;
    cdev->cons_init = &io16450_init;
```

```
    cdev->cons_term = &io16450_term;
    cdev->cons_read = &io16450_read;
    cdev->cons_write = &io16450_write;
    cdev->cons_check = &io16450_check;

    /*  The following services are not required for the initial port */
    /*
    cdev->cons_stat = &io16450_stat;
    cdev->cons_irq = &io16450_irq;
    */

    /* initialize the device configuration data */
    cdev->cons_addr = (void *)COMM2ADDR;
                                /* base address of I/O port */
    cdev->cons_baudrate = CONS_BAUDRATE_9600;
                                /* communication baud rate  */
    cdev->cons_vector = COMMVECTOR;         /* interrupt vector */
    cdev->cons_priority = COMMPRIORITY;     /* interrupt priority */
    cdev->poll_timeout = 2000;
                               /* polling routine timout value*/
    cdev->cons_abname = (u_char *)COMM2ABNAME;
                               /* abreviated device name */
    cdev->cons_name = (u_char *)COMM2NAME;     /* device name */

    /* install the record structure on the list of available I/O modules */
    cdev->cons_next = console->rom_conslist;
    console->rom_conslist = cdev;

    return (SUCCESS);
}
```

The default value definitions used to initialize the device configuration data should be placed in the target-specific `systype.h` header file, leaving the I/O module source code portable across platforms.

If the same I/O module is used with the console and communications ports, an additional console device record, (for example, `comm_r`) should be allocated and initialized with the proper data for the communications port. Both console device records should be added to the list of available devices.

Note

The console and communications port configuration modules (`conscnfg` and `commcnfg`), using the configuration data module (`cnfgdata`), determine which console device record is selected as console and communications port.

Chapter 5: Creating a Low-Level Ethernet Driver

Low-level Ethernet drivers enable communications between the target and the host. Ethernet drivers support boot device and debugger operations, and can provide other functionality, such as console services.

Low-level Ethernet drivers communicate to low-level IP (`llip`), receiving and sending data as required. `llip` also communicates with the low-level TCP (`lltcp`) and low-level UDP (`lludp`) protocols, forwarding datagrams up to the appropriate protocol and receiving datagrams to be delivered to the low-level driver. `lltcp` and `lludp` communicate with the `protoman` module handling the protocol services to communicate with network booters, virtual consoles, and debugger modules.

This chapter includes the following topics:

Creating a Low-Level Ethernet Driver

Use the following steps to create a low-level Ethernet driver.

Step 1. Obtain information about the Ethernet chip on the target board.

- Get data book from the manufacturer.
- Obtain packet drivers for the chip to test out on a PC. Several packet driver collections are available on the World Wide Web, on FTP sites, and by mail.
- Obtain a reference board with the supported chip.
- Determine the chip's memory management map for mbufs.
- Determine how the information is transmitted, for example in a circular buffer or FIFO buffer.

Step 2. Review the supplied example Ethernet drivers to find the one that most closely fits the capabilities and requirements of the Ethernet chip on your target board. For an example Ethernet driver, see the `l121040` file in the `<MWOS>/SRC/ROM/PROTOCOLS` directory.

Step 3. Edit the example you selected to include the information specific to the target Ethernet chip. See **Required Ethernet Driver Functions** for the `proto_srvr` structure and a list of the entry point services.

Step 4. Add the driver to your boot code.

Step 5. Remake the boot code.

Step 6. Test communications using the Ethernet driver you created.

Required Ethernet Driver Functions

The following sections define the required functions for implementing a low-level Ethernet driver.

Proto_srvr Structure

This structure, defined in `rom.h`, is common to all protocols and drivers and identifies the modules in the low-level `protoman` protocol list.

```
struct proto_srvr {
     idver        infoid;              /* id/version for proto_srvr */
#if  defined(NEWINFO)
     Proto_srvr next;                  /* next protocol stack in list */
     u_int32    proto_type_id;         /* protocol id */
     error_code (*proto_install)(Rominfo, u_char *),
                                       /* Installation */
                (*proto_iconn)(Llpm_conn, u_int32),
                                       /* initiate conn */
                (*proto_read)(Llpm_conn, u_int32, LlMbuf *),
                                       /* read conn */
                (*proto_write)(Llpm_conn, u_int32),
                                       /* write conn */
                (*proto_status)(Llpm_conn, u_int32, void *),
                                       /* get status */
                (*proto_tconn)(Llpm_conn, u_int32),
                                       /* terminate conn */
                (*proto_deinstall)(Rominfo),
                                       /* De-installation */
                (*proto_timeout)(Rominfo, Proto_srvr),
                                       /*timeout processing*/
                (*proto_upcall)(Rominfo, Proto_srvr, void*);
                                       /* LL ISR upcall */
     void       *proto_data;           /* server local data */
                                       /* structure ptr */
     u_int32    proto_data_size,       /* protocol's data area size */
                proto_conn_cnt;        /* number of active */
                                       /* connections */
     Consdev    proto_cons_drvr;       /* llvl serial comm console */
                                       /* (slip) */
     u_int16    proto_mtu,             /* Max Xmission Unit for */
                                       /* protocol */
                proto_hdr_len,         /* Space requirements for */
                                       /* header */
                proto_tlr_len;         /* Space requirements for 8*/
                                       /* trailer */
     u_char     proto_flags;           /* Protocol status & type */
                                       /* flags */
```

```
     u_char     proto_rsv1;            /* align on longword boundary */
     u_int32    proto_addr;            /* V1 only - IP address, null */
                                       /* except drivers */
     u_char      *proto_globs;         /* Pointer to protocol srvr */
                                       /* globals */
     u_int32    proto_vector,          /* vector for lldrivers */
                proto_priority;        /* llisr priority */
     void       *proto_port_addr;      /* lldriver port address */
     /* fields added at V2 */
     u_char     proto_ipaddr[16];      /* Extended IP address */
     u_char     proto_hwaddr[16];      /* Physical (MAC) address */
     u_int32    proto_irqlevel;        /* IRQ level for low-level */
                                       /* (drivers */
     char       *proto_drv_name;       /* name identifier of protocol */
                                       /* /driver */
     u_int32     proto_rsv2[6];        /* reserved for emergency */
                                       /* expansion */
#else
     int        reserved;
#endif
};

/* values for proto_flags
 */
#define PVR_RELIABLE           0x01    /* reliable protocol */
#define PVR_LLISR_REG_REQ      0x02    /* request LLISR registration */
#define PVR_LLISR_REG_ERR      0x04    /* the LLISR reg req failed */

/* The following flag is to be used to indicate which driver to use, if
 * the interface IP address does not match that specified during the bind. */

#define PVR_DRV_USEME          0x08
#define     PVR_BOOTDEV        0x10    /* To indicate interface */
                                       /* booted from */
#define     PVR_MWRSV0         0x20
/* We might use these for distinguishing protocols/drivers at some point */
#define PVR_DRIVER             0x40
#define PVR_PROTOCOL           0x80

/* Reserved Flags for Microware for proto_rsv1 field of proto_srvr */
#define PVR_MWRSV1             0x01
#define PVR_MWRSV2             0x02
#define PVR_MWRSV3             0x04
#define PVR_MWRSV4             0x08

/* For OEM User use */
#define PVR_OEM1               0x10
#define PVR_OEM2               0x20
#define PVR_OEM3               0x40
#define PVR_OEM4               0x80

/* subcodes for implementation by proto_status()
 */
#define SS_IntEnable           0x01
#define SS_IntDisable          0x02
```

```
#define SS_RombugOn            0x03
#define SS_RombugOff           0x04
```

The Low-Level Ethernet Driver Entry Point Services

In each of the entry points of the driver module, do the following:

Step 1. Save the current global variables pointer.

Step 2. Set the global variables pointer to the driver's variables when it is called (before accessing them).

Step 3. Restore the original global variables pointer at all exit points.

This can be done using the `swap_globals` function provided in the `p2lib` library.

Table 5-1 Entry Points

Function	Description
`proto_deinstall()`	Low-level driver de-installation entry point
`proto_iconn()`	Low-level driver initiate connection entry point
`proto_install()`	Installs the low-level ethernet driver
`proto_read()`	Low-level driver polled read entry point
`proto_status()`	Low-level driver status entry point
`proto_tconnl()`	Low-level driver terminate connection entry point

Table 5-1 Entry Points (continued)

Function	Description
`proto_timeout()`	Low-level driver timeout entry point
`proto_upcall()`	Low-level driver upcall for interrupt processing
`proto_write()`	Low-level driver write entry point

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

proto_deinstall()

Low-Level Driver De-installation Entry Point

Syntax

```
error_code (*proto_deinstall)(Rominfo rinf);
```

Description

`proto_deinstall()` is the low-level driver de-installation entry point. It takes the driver `proto_srvr` off the protoman protocols/driver list. The service de-initializes the chip and frees the memory allocated for the buffers. It also removes its name from the notification services list.

Parameters

`rinf`	points to the `rominfo` structure.

proto_iconn()

Low-Level Driver Initiate Connection Entry Point

Syntax

```
error_code (*proto_iconn)(
   Llpm_conn    conn_entry,
   u_int32      index);
```

Description

`proto_iconn()` is the low-level driver initiate connection entry point. This service performs the driver related connection specific initialization.

Parameters

`conn_entry`	is not used in the drivers but is present because the protocols also use the same prototypes. This entry point is called by `hlproto`, to turn on/off the interrupts. It is also called by the notification handler routine.
`index`	points to the appropriate `proto_srvr` (tcp, ip, udp, slip).

proto_install()

Installs the Low-Level Ethernet Driver

Syntax

```
error_code (*proto_install)(
   Rominfo   rinf,
   u_char    *globs);
```

Description

`proto_install()` installs the low-level Ethernet driver module. The service initializes the chip and masks the interrupts. It initializes the `proto_srvr` structure, sets all the entry points, and installs itself on the protocol list in the low-level protocol manager structure. Each driver must allocate the memory for the receive buffers and save the pointer.

Each driver has to allocate its own pool of *mbufs*. Set the `PVR_LLISR_REG_REQ` and `PRM_LLISR_REG_REQ` bits so `hlprotoman` can register the LLISRs to run in interrupt driven mode. The `PVR_DRIVER` flag in `proto_flags` indicates the module is a driver module. If the service knows the IP address, it sends a gratuitous ARP.

Parameters

`rinf`	points to the `rominfo` structure.
`globs`	points to the module global variables. You should save this pointer in the `proto_globs` field of the `proto_srvr` structure so you can access the module global variables.

proto_read()

Low-Level Driver Polled Read Entry Point

Syntax

```
error_code (*proto_read)(
   Llpm_conn    conn_entry,
   u_int32      index,
   LlMbuf       *rmb);
```

Description

`proto_read()` is the low-level driver polled read entry point. It polls the chip and returns if it has a good packet or if it was called with the low-level connection entry flag set to indicate `nonblocking` read, and the timer expires.

The suggested algorithm, while waiting for a packet, is to periodically check the timer routine if a `nonblocking` read is specified and returns if the timer reaches a value of zero, or if it receives a valid packet. In the latter case, the service processes the Ethernet packet before passing it up the stack.

Parameters

`conn_entry`	is not used in the drivers but is present because the protocols also use the same prototypes. This entry point is called by `hlproto`, to turn on/off the interrupts. It is also called by the notification handler routine.
`index`	points to the appropriate `proto_srvr` (tcp, ip, udp, slip).
`rmb`	points to the global mbuf pool.

proto_status()

Low-Level Driver Status Entry Point

Syntax

```
error_code (*proto_status)(
   Llpm_conn    conn_entry,
   u_int32      code,
   void         *ps);
```

Description

`proto_status()` is the low-level driver status entry point.

Parameters

`conn_entry` is not used in the drivers but is present because the protocols also use the same prototypes. This entry point is called by `hlproto`, to turn on/off the interrupts. It is also called by the notification handler routine.

`code` specifies what the caller expects to be done. It can have the following values:

- `SS_IntEnable` to enable interrupts (called by `hlproto`).
- `SS_IntDisable` to disable interrupts (called by `hlproto`).
- `SS_RombugOn` to indicate a change from user to system state (called by the notification handler).
- `SS_RombugOff` to indicate a change from system to user state (called by the notification handler).

`ps` points to the `proto_srvr` structure.

proto_tconnl()

Low-Level Driver Terminate Connection Entry Point

Syntax

```
error_code (*proto_tconn)(
    Llpm_conn    conn_entry,
    u_int32      index);
```

Description

`proto_tconn()` is the low-level driver terminate connection entry point. This service does the driver related connection specific termination (converse of `proto_iconn()`).

Parameters

`conn_entry`	is not used in the drivers but is present because the protocols also use the same prototypes. This entry point is called by `hlproto`, to turn on/off the interrupts. It is also called by the notification handler routine.
`index`	points to the appropriate `proto_srvr` (tcp, ip, udp, slip).

proto_timeout()

Low-Level Driver Timeout Entry Point

Syntax

```
error_code (*proto_timeout)(
   Rominfo      rinf,
   Proto_srvr   ps);
```

Description

`proto_timeout()` is the low-level driver time-out entry point. This entry point is called by the `hlproto` thread to provide for any kind of time-out needed. The sample drivers do not use this and, therefore, it is nulled out in `proto_install()`.

Parameters

`rinf`	points to the `rominfo` structure.
`ps`	points to the `proto_srvr` structure.

proto_upcall()

Low-Level Driver Upcall For Interrupt Processing

Syntax

```
error_code (*proto_upcall)(
    Rominfo     rinf,
    Proto_srvr  pd,
    void*       c);
```

Description

`proto_upcall()` is the low-level driver upcall routine for interrupt processing. It is called on the interrupt context from the `commonIRqEntry` point in `hlproto`. This service is used primarily with receive interrupts. If the service receives a valid IP packet, it updates the ARP table to eliminate sending out an ARP packet. If it is an ARP packet, the service processes it, replies to it if `proto_upcall()` is the destination address, and also saves the sender's hardware address. The `arp_tblupdate()` function updates the tables, if needed. If the service receives an IP packet, it calls the `proto_upcall()` entry point of the next protocol on the stack (IP for now).

Before doing any interrupt processing, this service restores the interrupt status register and the mask register so it does not miss other packets while processing one.

Parameters

`rinf`	points to the `rominfo` structure.
`pd`	points to the `proto_srvr` structure.
`c`	data (packet, character) being passed. This is typecast void because each **level** typecasts it.

proto_write()

Low-Level Driver Write Entry Point

Syntax

```
error_code (*proto_write)(
   Llpm_conn    conn_entry,
   u_int32      index);
```

Description

`proto_write()` is the low-level driver write entry point.

When called from the next upper layer protocol module on the stack, (IP for now), the service puts the Ethernet headers in place and hands them to the chip to send out on the wire. The service masks the interrupts during the entire processing time and does not return until the packet has been sent out on the wire.

Parameters

`conn_entry`	is not used in the drivers but is present because the protocols also use the same prototypes. This entry point is called by `hlproto`, to turn on/off the interrupts. It is also called by the notification handler routine.
`index`	points to the appropriate `proto_srvr` (tcp, ip, udp, slip).

Additional Utility Functions

The following utility functions are used with mbufs:

Table 5-2 Utility Functions

Function	Description
`find_n_init_mbuf()`	Find and initialize an mbuf
`init_eth_mbuf()`	Initialize an mbuf

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

find_n_init_mbuf()

Find and Initialize an mbuf

Syntax

```
error_code find_n_init_mbuf(
   u_char    *rmb,
   LlMbuf    *mb);
```

Description

`find_n_init_mbuf()` finds and initializes an `mbuf`.

This function returns an `ENOBUF` error if it cannot find an `mbuf`.

Parameters

`rmb`	points to the global mbuf pool.
`mb`	points to the returned `mbuf` so it can be used.

init_eth_mbuf()

Initialize an mbuf

Syntax

```
void init_eth_mbuf();
```

Description

The `init_eth_mbuf()` function is called from `proto_install()` to initialize an `mbuf` after allocating memory for the mbuf pool.

Low-Level ARP

The ARP included with the low-level Ethernet driver has minimal functionality.

Low-level Ethernet drivers do not avoid sent ARP requests. Whenever a driver receives an ARP/IP packet, it saves the sender's hardware address (if the packet is directed to this driver), assuming the driver has sent a request, since it wants to communicate with the driver. The low-level Ethernet driver processes the ARP request and replies to the sender. The driver also updates an ARP table without removing any entries.

Table 5-3 Low-Level ARP Functions

Function	Description
`arpinit()`	Low-level ARP init function
`arpinput()`	ARP input processing routine
`arpresolve()`	Resolves hardware addresses
`arptbl_update()`	Update ARP table
`arpwhohas()`	ARP packet request for hardware address
`in_arpinput()`	ARP input processing and replying function

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

arpinit()

Low-Level ARP init Function

Syntax

```
error_code arpinit(Rominfo rinf);
```

Description

`arpinit()` function allocates memory for the ARP table and ARP buffer and initializes the buffer.

Parameters

`rinf`	points to the `rominfo` structure.

arpinput()

ARP Input Processing Routine

Syntax

```
void arpinput(
   Proto_srvr   psrvr,
   LlMbuf       mb,
   Rominfo      rinf);
```

Description

`arpinput()` is the ARP input processing routine. The routine checks for common length and type. Only IP protocol packets are processes when `in_arpinput()` is called.

Parameters

`psrvr`	points to the `proto_srvr` structure.
`mb`	points to the received packet.
`rinf`	points to the `rominfo` structure.

arpresolve()

Resolves Hardware Addresses

Syntax

```
error_code arpresolve(
    Llpm_conn    conn_entry,
    u_char       *desten);
```

Description

arpresolve() looks into the ARP table and, if successful in finding the entry for the destination address in the Llpm_conn conn_entry, copies the hardware address to that destination address, desten. If arpresolve() cannot find the entry, it returns a non-zero value. This service is called from the proto_write() routine, and assumes it is always able to resolve the address without ever having to send an ARP request. If however, it does have to send requests, it calls arpwhohas() to broadcast the request. In this case the proto_write() function would have to be suspended until arpresolve() gets a response and is able to resolve the hardware address.

Parameters

conn_entry	is not used in the drivers but it is present because the protocols also use the same prototypes. This entry point is called by hlproto, to turn on/off the interrupts. It is also called by the notification handler routine.
desten	is the destination address.

arptbl_update()

Update ARP Table

Syntax

```
error_code arptbl_update(
    Proto_srvr   psrvr,
    LlMbuf       mb,
    Eth_header   eth);
```

Description

The ARP table update function is called from the driver's `proto_read()` and `proto_upcall()` routines. It performs ARP table updates if the sender included this service's Ethernet address (through this service's gratuitous ARP or other means) and did not make an ARP request. This prevents this service from having to make ARP requests.

This service compares this address to its own address to determine if the packet was directed to it.

In addition, packets that are not directed to this service are filtered by returning ERROR, preventing the service from searching the stack in the interrupt context.

Parameters

`psrvr`	points to the `proto_srvr` structure.
`mb`	points to the packet received.
`eth`	points to the Ethernet address of the packet received.

arpwhohas()

ARP Packet Request For Hardware Address

Syntax

```
error_code arpwhohas(
   Proto_srvr        psrvr,
   struct in_addr*   addr,
   Rominfo           rinf);
```

Description

`arpwhohas()` broadcasts an ARP packet and asks for the hardware address of the machine with the supplied IP address, `addr`.

This is used only in `proto_install()` when the driver does a gratuitous ARP informing the world of its hardware address. This function can be used in the future for sending ARP requests.

Parameters

`psrvr`	points to the `proto_srvr` structure.
`addr`	is the IP address.
`rinf`	points to the `rominfo` structure.

in_arpinput()

ARP Input Processing and Replying Function

Syntax

```
void in_arpinput(
    Proto_srvr   psrvr,
    LlMbuf       mb,
    Rominfo      rinf);
```

Description

`in_arpinput()` is called by `arpinput()`. If the ARP request is directed to this function, it caches the sender's hardware address and replies to the request with its hardware address. If the ARP table is full, the request is discarded.

Note

Currently, there is no mechanism to reuse the stale entries. This means requests may be discarded if the table is full.

Parameters

`psrvr`	points to the `proto_srvr` structure.
`mb`	points to the packet received.
`rinf`	points to the `rominfo` structure.

Other Functions

Additional functions include:

Table 5-4 Additional Functions

Function	Description
`in_broadcast()`	Determines if Address is a Broadcast Address

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

in_broadcast()

Determines If Address Is a Broadcast Address

Syntax

```
int in_broadcast(LLpm_conn conn_entry);
```

Description

`in_broadcast()` determines if the destination address in the `Llpm_conn` pointed to by `conn_entry` is a broadcast address. This does not handle subnetting, however. The function returns a non-zero value if the address is a broadcast address, and a zero value (`SUCCESS`) if not.

Parameters

`conn_entry`	is not used in the drivers but is present because the protocols also use the same prototypes. This entry point is called by `hlproto`, to turn on/off the interrupts. It is also called by the notification handler routine.

Chapter 6: Creating a Low-Level Timer Module

This chapter includes the following topics:

Creating the Timer Module

A timer module is required whenever timing services are required. The following list includes examples of when you should use a timer module:

- Low-level network protocols are being used for booting.
- An autobooter has been configured with a specified delay.
- User-state Hawk debugging must be done using low-level communications.
- The high-level driver is `scllio` and it is operating in interrupt driven mode.

Low-level timers are polled instead of interrupt driven. A simple programmable counter is usually adequate. The timer services values are in terms of microseconds, though the counter resolution for a timer does not need to be that small. If the counter resolution is greater than a microsecond, the timer services would have to guarantee at least the specified time had elapsed, perhaps rounding up to the next value given the counter resolution. It is not generally advisable to use the same device for the system ticker as for the low-level timer. However, under some circumstances, it may be done.

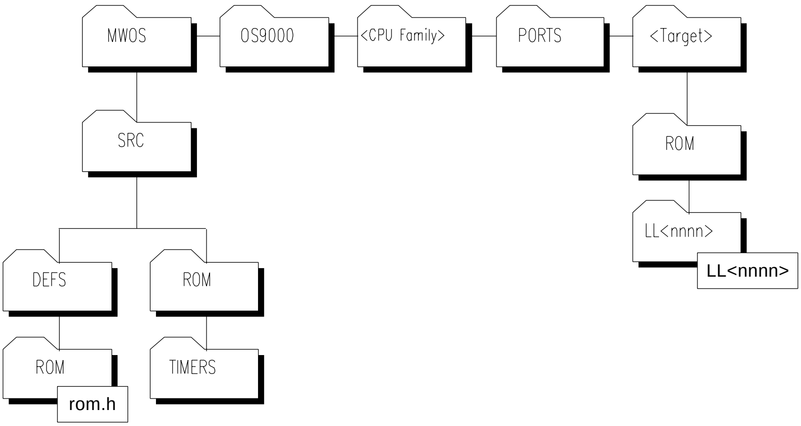
For More Information

See **Chapter 11: Creating a Ticker** for more information about tickers.

An example of a software timer can be found in the `MWOS/SRC/ROM/TIMERS/SWTIMER` directory. This example needs to be calibrated to the target platform, given a fixed CPU speed and caching configuration. The software timers have no upper bound on elapsed time, but the specified time must have elapsed. You may be able to configure and use the source code for one of the included example low-level timer modules without modification. If your target has a counter/timer for which no timer module already exists, use the example sources as a guide to write your own timer module.

The low-level timer module sources are in the MWOS/SRC/ROM/TIMERS directory. Create a subdirectory for your own source code if you are writing your own timer module. Try to keep your source specific to the particular counter device and not introduce target-specific constants.

Figure 6-1 Creating a New Low-Level Timer Module Directory



In addition to the source directories, each example port directory contains <Target>/ROM/LL<nnnn> directories containing makefiles used to build the low-level timer module used in the port. You need to create such a directory and makefile for your timer module in your ports directory. Use the example makefiles as a guide.

The Timer Services Record

A timer module establishes a single timer services record for the system. This record is used to access the services of the timer module and to maintain any necessary state information. The definition of the `tim_svcs` record is in the header file, `MWOS/SRC/DEFS/ROM/rom.h` as follows:

Timer Services Record

```
typedef struct tim_svcs {
     idver      infoid;                  /* id/version for tim_svcs */
     error_code (*timer_init)(Rominfo); /* initialize the timer */
     void       (*timer_set)(Rominfo, u_int32);
                                        /* set timeout value & start */
     u_int32    (*timer_get)(Rominfo);
                                         /* get time left, zero = */
                                         /* expired */
     void       (*timer_deinit)(Rominfo);
                                         /* de-initialize timer */
     void       *timer_data;             /* local data structure */
     u_int32    rom_delay;               /* delay loop counter, 1us */
                                         /* delay */
     int        reserved;                /* reserved for emergency */
                                         /* expansion */
} tim_svcs, *Tim_svcs;
```

Low-Level Timer Module Services

The following entry points describe the services required of each low-level timer module.

Table 6-1 Timer Module Entry Points

Function	Description
`timer_deinit()`	De-initialize timer
`timer_get()`	Get the Time remaining
`timer_init()`	Initialize the timer
`timer_set()`	Arm the timer

timer_deinit()

De-initialize Timer

Syntax

```
void timer_deinit(Rominfo rinf);
```

Description

Deactivate the timer.

Parameters

`rinf`	points to the `rominfo` structure.

timer_get()

Get the Time Remaining

Syntax

```
u_int32 timer_get(Rominfo rinf);
```

Description

Determine the amount of time remaining. If the time-out has elapsed, stop the counter and return a zero value.

Parameters

`rinf`	points to the `rominfo` structure.

timer_init()

Initialize Timer

Syntax

```
error_code timer_init(Rominfo rinf);
```

Description

Initialize the hardware for operation. Ensure the timer is not already initialized.

Parameters

`rinf`	points to the `rominfo` structure.

timer_set()

Arm the Timer

Syntax

```
void timer_set(
    Rominfo    rinf,
    u_int32    timeout);
```

Description

Begin timing with the `timeout` value specified. Set the counter to the corresponding value.

Parameters

`rinf`	points to the `rominfo` structure.
`timeout`	is the value at which to begin the countdown.

Starting the Low-Level Timer Module

During the early stages of system bootup, the bootstrap code searches for and starts low-level system modules included in the boot image. The start-up entry point for the low-level system modules is supplied in a relocatable (`.r`) file in the distribution. This entry point branches to the C function `p2start()` you need to provide for your timer module. The start-up routine should perform these tasks:

Step 1. Ensure no other timer module has been installed.

Step 2. Allocate and initialize the timer services record. Allocation may be done passively by defining the timer services record as a module global variable.

Step 3. Make the entry points for its services available through the timer services record.

Step 4. Allocate and initialize any device-specific data structure.

Step 5. Install the timer services structure into the `rominfo` record.

Building the Low-Level Timer Module

Create the makefile for your timer module in a properly named subdirectory of your port's ROM directory (for example, `<Target>/ROM/LL<nnnn>`). Use the makefiles from the example ports as a guide.

Complete the following steps to add your low-level timer module to the system:

Step 1. Edit the `makefile` file in `<Target>/ROM`.

Step 2. Add your timer directory name to the list of directory names used to define the `TRGTS` macro.

Step 3. Add the timer module name into the `coreboot.ml` file in `<Target>/BOOTS/SYSTEMS/PORTBOOT`.

By doing this, you ensure your timer module is rebuilt along with the bootstrap code and the rest of the low-level system modules when:

- `<Target>/ROM/makefile` is invoked and included in the `rom` file
- `<Target>/BOOTS/SYSTEMS/PORTBOOT/makefile` is invoked creating the boot image `coreboot`

Chapter 7: Creating an Init Module

This chapter includes the following topics:

Creating an init Module

Init modules are non-executable modules of type `MT_SYSTEM`. An init module contains a table of system start-up parameters. During start-up, init specifies the initial table sizes and system device names, but init is always available to determine system limits. It must be in memory when the system is booting and usually resides in the `sysboot` file or in ROM.

An init module begins with a standard module header. The module header's `m_exec` offset is a pointer to the system's constant table. The fields of this table are shown here and defined in the `init.h` header file. Within the `INIT/default.des` file is a section for the init module variables that need to be modified for a particular system.

For More Information

See the ***OS-9 Device Descriptor and Configuration Module Reference*** for a list of the init fields and the procedures for configuring the init module. See your target's board guide for the init modules specific to your board.

Init Macros

The macros defined here override the default macros contained in the file `/h0/MWOS/OS9000/SRC/DESC/init.des`.

The following macros must be set in the `INIT/default.des` file and do not have defaults in the `init.des` file.

Table 7-1 Init Module Override Macros from `INIT/default.des` File

Name	Description and Example

`INSTALNAME`	A processor-specific character string used by programs such as `login` to identify the system type.
	`#define INSTALNAME “Motorola MVME1603”`
	`#define INSTALNAME “PC-AT Compatible 80386”`

`TICK_NAME`	A processor-specific character string identifying the tick module name. The tick module handles the periodic interrupts for OS-9`s time slicing and internal timings. `#define TICK_NAME “tk1603”` `#define TICK_NAME “tk8253”`
`RTC_NAME`	A character string identifying the real time clock module name. `#define RTC_NAME “tk8253”`
`SYS_START`	A character string identifying the name of the first process to start after the system boots. `#define SYS_START “CMDS/shell”`

Table 7-1 Init Module Override Macros from `INIT/default.des` File (continued)

Name	Description and Example
`SYS_PARAMS`	A character string containing the parameters to be passed to the first process. `#define SYS_PARAMS “\n”`
`CONS_NAME`	A character string identifying the console terminal descriptor module name. `#define CONS_NAME “/term”`
`SYS_DEVICE`	A character string identifying the initial mass storage device descriptor module name. This must be defined, but can be a null string if none exists. `#define SYS_DEVICE ““`

Optional Macros

The following describes macros that can be modified. These macros do not have to be included in the `INIT/default.des` file because they have default values defined in `init.des`. However, if your first port does not include a ticker (explained in **Chapter 11: Creating a Ticker** and **Chapter 12: Selecting Real-Time Clock Module Support**) then you should define the `COMPAT` macro with a value made up of at least the `B_NOCLOCK` flag.

Table 7-2 Init Module Optional Macros with Default Values

Name	Description and Example

`MPUCHIP`	A processor-specific number identifying the MPU chip; for example, 403, 603 or 80386.
	`#define MPUCHIP 603`
	`#define MPUCHIP 80386`

`OS_VERSION`	A number defining the version of the operating system. Default value is the currently shipped version. `#define OS_VERSION 2 /* version 2.x */`
`OS_REVISION`	A number defining the revision of the operating system. Default value is the currently shipped revision. `#define OS_REVISION 0 /*rev. x.0*/`

`OS9K_REVSTR`	A processor-specific character string identifying the operating system.
	`#define OS9K_REVSTR “OS-9000/PowerPC(tm)”`
	`#define OS9K_REVSTR “OS-9000 V2.1 for Intel x86”`

`SITE`	A customer defined number. An example of the use of this number would be to denote the location where the operating system was installed. Default value is `0`. `#define SITE 0`

Table 7-2 Init Module Optional Macros with Default Values (continued)

Name	Description and Example
`PROCS`	A number specifying the initial number of entries in the process table. Must be divisible by 64. Default value is `64`. `#define PROCS 64`
`PATHS`	A number specifying the initial path table size. Must be divisible by 64. Default value is `64`. `#define PATHS 64`
`SLICE`	Is the number of clock ticks for each process' time slice. The actual duration for a time slice is this number times the tick rate. Default value is 2. `#define SLICE 2`
`SYS_PRIOR`	A number defining the priority of the initial process. Default value is `128`. `#define SYS_PRIOR 128`
`MINPTY`	A number defining the system minimum executable priority. See the ***OS-9 Technical Manual*** for a explanation of priority. Default value is `0`. `#define MINPTY 0`
`MAXAGE`	A number defining the system maximum age. See the ***OS-9 Technical Manual*** for an explanation of priority. Default value is `0`. `#define MAXAGE 0`

Table 7-2 Init Module Optional Macros with Default Values (continued)

Name	Description and Example
EVENTS	A number specifying the initial event table size. Must be divisible by 8. Default value is 32. `#define EVENTS 32`
COMPAT	The `compat` word contains bit flags that are configuration parameters for the operating system. Default value is 0x50. The `init.h` file defines the flags that can be used: `B_GHOST` Do not retain ghost (sticky) modules if set `B_WIPEMEM` Patternize allocated/returned memory if set `B_NOCLOCK` Do not automatically set system clock `B_EXPTBL` Do not automatically expand system tables `#define COMPAT   B_WIPEMEM | B_GHOST`

Table 7-2 Init Module Optional Macros with Default Values (continued)

Name	Description and Example
`EXTENSIONS`	A character string containing the names of OS-9 extension modules executed as the system is booting and after the OS-9 I/O system has been initialized. These modules do not need to be present in the boot file but are executed if present. OS-9 system modules provided are: `cache` Provides cache enabling and flushing `fpu` Provides software floating point math, if necessary `ssm` Provides memory protection `#define EXTENSIONS "OS9P2 ssm"`
`PREIOS`	A character string containing the names of the OS-9 extension modules to be executed prior to the initialization of the OS-9 I/O system. `#define PREIO “picirq”`
`IOMAN_NAME`	A character string identifying the name of the module handling I/O system calls. `#define IOMAN_NAME`
`SYS_TIMEZONE`	A number specifying the local time zone in minutes from Greenwich Mean Time. Default value is `0`. `#define SYS_TIMEZONE 0`
`MAX_SIGS`	A number specifying the maximum number of signals that can be queued for a process at any given time. Default value is 32. `#define MAX_SIGS 32`

Table 7-2 Init Module Optional Macros with Default Values (continued)

Name	Description and Example
`MEMLIST`	The offset to *colored* memory list. `#define MEMLIST memlist`
`MEMTBL`	The colored memory list. `#define MEMTBL`

Chapter 8: Creating PIC Controllers

This chapter includes the following topics:

Reviewing the PowerPC Vector Code

The vector code information discussed in this section relates to PowerPC processors only. See **Chapter 9: Creating an SCF Device Driver** if you are not using OS-9 for a PowerPC processor.

Architecture

The PowerPC vector code consists of a table of 256- byte entries, one for each vector. Each entry contains the exception handling code for that vector. When an exception occurs, the processor saves the current program counter (PC) and the current machine state register (MSR), then transfers control to the appropriate vector. The PC is loaded with the address of the vector and the MSR has the same value as before except that the applicable exception and address translation enable bits are cleared. Consult the user manual for your hardware platform for specific exception processing information.

OS-9 Vector Code Service

The standard OS-9 PowerPC vector code, located in the `MWOS/OS9000/SRC/SYSMODS/VECTORS`, directory is divided into two categories of service, the external interrupt code and the general exception code. The main difference in the two sets of vector code is the software stack used when the high-level C code exception handler is called. The IRQ vector code saves the current state on the current process system stack and then switches to a dedicated IRQ service stack. If the system was already in an IRQ context, the dedicated IRQ stack and the current system stack are the same and the vector code does not change the stack. The interrupt service code continues to use the IRQ stack. The general exception code uses the current process system stack throughout the context of the exception.

The standard exception handlers save registers `r0-r14`, `lr`, `ccr`, `ctr`, `xer`, `srr0`, and `srr1`. Both exception handlers use the same registers to save the context of the system and dispatch to the appropriate high-level handler. The vector code associated with the system call vector functions similar to the general exception vector code, except the system call vector code does not change the value of `r3` (as stated in the `r3` definition in this section) prior to calling the high-level exception handler.

The following list describes the important register usage in the handlers:

`sprg0`	Prior to the exception, the `sprg0` register contains a pointer to the kernel's global static storage area. The software IRQ stack is located just below the kernel's globals.
`sprg1`	Prior to the exception, the `sprg1` register contains a pointer to the top of the current processes system state stack.
`sprg2`	This register is used by both categories of handlers as a temporary register for preserving the state of the current process condition codes register.
`sprg3`	This register is also used by both categories of handlers as a temporary register for saving the current stack pointer.
`r1`	Upon calling the high-level C code exception handler, `r1` contains the stack pointer for use for the duration of the exception handling. It is also pre-decremented by eight bytes to account for the stack space required by the C code handler to save the content of the link register and the current value of the stack pointer. The Ultra C/C++ compiler normally allocates these eight bytes for subroutine calls.

Note

The OS-9 operating system assumes the `r1` register points to a software stack. If the exception is coming from user state, then `r1` is assumed to point to the current process user-state stack. If the exception is coming from system state, then `r1` is assumed to point into either the IRQ stack or the current process system-state stack.

`r2`	Upon calling the high-level C code exception handler, `r2` points to the static storage area associated with the handler. This is the same static storage pointer specified in the `F_IRQ` service request used to install the exception handler.
`r3`	This register, like `r2`, also contains the pointer to the exception handler's static storage area specified in the `F_IRQ` service request. This is true for all of the exception handlers except the system call vector code. This handler leaves `r3` unchanged because it is assumed to hold a pointer to the service requestor's parameter block.
`r4`	This register, for all of the exception handlers, contains a pointer to the *short stack* generated by the vector table code. It contains the partially saved state of the processor at the time of the exception. The complete content of this stack is described in the `regppc.h` header file (located in the `MWOS/OS9000/PPC/DEFS` directory). This stack image is passed as a parameter to the target C code exception handler to allow handlers to gain access to the conditions of the exception if necessary. If additional registers other than the ones saved in the *short stack* are to be modified by the exception handler, then

	the handler must save the content of those registers prior to modification. However, the format of the *short stack* cannot be modified.
`r5`	This register contains the vector number of the exception that just occurred. It is passed as a parameter to the exception handler, which may be useful to the handler.
`lr`	The link register is used by the exception handlers to dispatch to the target C code exception handler. The C code handler is called using the `blrl` instruction so the link register is updated with the return address to the vector exception handler. The C code handler then saves the current link register value on the stack in the eight-byte location allocated by the vector code. The return code of the handler restores the link register and returns to the vector code.

Note

The C compiler, by default, generates code to save registers `r14-r31`, if the code generated uses any of the registers.

Initialization

The vectors are initialized twice during the full booting sequence. The first initialization occurs during the low-level or bootstrap booting process. The OS-9 low-level boot code initializes the vectors so it can catch any exceptions that may occur during this portion of the booting sequence. The second and final initialization occurs during the high-level or kernel's boot stage. Here the kernel links to the `vectors` module and calls its execution offset entry point (where the vectors initialization code resides). The vectors are initialized by copying the exception code from the `vectors` module into each 256-byte vector table entry. Each block of the vectors code has a unique label associated with the first and last instruction of the code. These labels are used by the initialization code to copy the vectors code into the vector table entries requiring that block of code.

In addition to copying the vector code into the tables, there are usually three other operations the initialization code must perform for most of the vectors. There may be other initialization requirements dictated by the complexity of the hardware platform. This description assumes the simplest case and describes what is required of the vector code.

1. The first additional operation is to patch the instruction loading the vector number of the associated vector with an immediate effective address mode. The target instruction is identified with a specific label the installation code can use to calculate the offset to use for the patch operation. The immediate value of the target instruction is modified to contain the vector number passed to the C code handler.
2. Another immediate form load instruction must be patched to contain the value of the offset of the exception table entry structure within the kernel's exception service routine table (also known as the interrupt polling table) for the target vector. Each entry in the exception service routine table is a four-byte pointer to the first of a list of exception table structures associated with the vector as defined by the `excpt.h` header file (in the `MWOS/OS9000/SRC/DEFS` directory).

The patch value is calculated by adding the offset of the beginning of the kernel's exception service routine table to the vector number multiplied by four. This offset to the exception service routine list for the vector is patched into the vector code in order to save execution time and vector code space in dispatching to the target service routines. Again, each of these patchable instructions can be located within the vector table entry by using the instruction's label to calculate the offset of the instruction within the vector code.

3. The last four-byte word of each vector table is patched with the offset into the associated vector, the location where the OS-9 low-level debugger is allowed to take over the vector. In most cases, this is the location of the actual `blrl` instruction dispatching to the C code handler. The low-level debugger uses this offset value to dynamically patch the vector code to allow itself to monitor exception and breakpoints as instructed.

Interrupt Vector

The vector code for the interrupt vector is typically unique from the code for the other vectors. Since many boards have different external interrupt control mechanisms, the code handling the specifics of the interrupt control is located in an OS-9 extension module specific to the port. In this case the interrupt vector entry contains the usual portion of vector code that switches to the current process' system stack, and saves the current state of all of the volatile CPU registers on the stack. The interrupt code then switches to the system's interrupt stack prior to dispatching to the specialized interrupt controller support code.

For More Information

Refer to **Interrupt Controller Support** for more information about the port-specific extension module.

Modifying the Interrupt Vector

The standard exception code for each of the vectors performs the same series of state-saving operations. A defined set of registers is preserved on the exception stack prior to calling the C code handler for the given exception. The set of general registers saved is defined by the subroutine calling conventions used by the Ultra C/C++ compiler. The compiler always treats registers `r0`, `r3`-`r13`, `xer`, `ctr`, `lr`, and `ccr` as volatile registers and register `r1` and `r2` as dedicated registers. The compiler also uses a caller register-save algorithm for subroutine calls.

The calling block must save the current value of any of the volatile registers it wants to preserve because the called subroutine is always allowed to destroy the content of the set of volatile registers. This is why the vector exception handlers preserve these registers. The exception code must be written to assume that the content of all of the volatile registers will be destroyed by the C code handlers.

Because of these conventions, the vector exception handlers are not coded to maximize efficiency but rather to maintain the integrity of the process context state. If for some reason a dedicated application requires a decrease in exception latency from what the standard exception handlers provide, it is possible to modify the vector exception handlers and the C code handlers to achieve these requirements.

The Ultra C/C++ compiler is capable of generating code using a callee register-save subroutine calling convention. In this case, the code is generated to preserve the contents of any of the registers it expects to destroy. This allows the C code exception handlers to be compiled to preserve the content of the registers it uses, making it possible to reduce the burden of context saving required by the vector exception handler.

The vector exception handler can be written to use a bare minimum of registers to dispatch to the C code handler, thus reducing its context save operation to only the set of registers it modifies in getting to the C code handler. While this makes it possible to reduce the latency in servicing an exception, this callee-save convention is not more efficient in the case where many C code handlers reside on the same vector and have to be polled to locate the target handler.

In this case, each of the C code handlers being compiled for the callee-save mode saves and restores all of the registers used in the body of the handler. As each C code handler is called by the dispatcher, it saves and restores multiple registers in determining the need to service the exception.

By the time the target C code handler is located, many more context preservation and restoration operations may have been performed than in the more general caller register-save compiler convention. This reduced context saving scheme for the vectors code should only be used under controlled circumstances where latency can be kept to a minimum and only one or two C code handlers are associated with a given exception or interrupt.

If this technique is used, there are certain restrictions on kernel and debugger usage, because a *short stack* frame is expected to be present under these circumstances. These are:

1. The debugger cannot be used to monitor the interrupt exception. However, breakpoints can still be processed within the interrupt service routine because they cause their own exceptions that create the *short stack* for debugger operations.
2. The interrupt vector code, after receiving control back from the interrupt service routine, would directly return control back to the interrupted thread of execution itself, instead of calling the kernel exit routine.

An exception to this would be if the interrupt service routine changed a task state that would require a task switch (for example, sent a signal). Then the interrupt vector code would have to build a short stack after the interrupt service routine completed, and call the kernel exit routine to cause the task switch to occur.

Interrupt Controller Support

Since the PowerPC architecture defines only one vector entry for interrupt processing, it is typical for a target platform to implement one or more external interrupt controller(s) to control and prioritize multiple interrupts external to the processor. OS-9 allows controlling code for this target-dependent interrupt controller structure to be modularized independently of the standard vector dispatching code and the device drivers.

The controlling code can be divided into two classes, interrupt enable/disable, and interrupt acknowledge/ dispatch. Example interrupt enable/disable functions are implemented in library functions accessible to device drivers.

The interrupt acknowledge and dispatch functions are implemented as system extension modules that install themselves as an interrupt handler on the interrupt vector. An example `picirq` module implements the acknowledge and dispatching code for *8259-like* interrupt controllers.

The dispatching code in an interrupt controller module maps the interrupt line to a *logical interrupt vector* and then searches the interrupt polling table associated with the logical vector for handlers to execute until one of them returns a value other than `EOS_NOTME` in register `r3`. Device drivers would then register the interrupt service routine on the logical interrupt vector (during device initialization) instead of the physical vector.

Another example `vmeirq` module implements the acknowledge and dispatching code for a VMEchip2/vmepci bridge chip set used on the MVME1603 reference target. The interrupts from the VMEchip2 are run through the bridge chip and cascaded into the main interrupt controller. As a result, the `vmeirq` module installs its acknowledge and dispatching handler on one of `picirq`'s logical interrupt vectors. Device drivers servicing the VME interrupts then install their handlers on the logical vectors serviced by `vmeirq`. This demonstrates how cascaded interrupt controllers of differing types can be supported.

Note

The interrupt controller module required for your port should be added to the `PREIO` extension list of the `init` module.

Chapter 9: Creating an SCF Device Driver

This chapter includes the following topics:

Alternatives for Creating a Console I/O Driver

You must have an OS-9 driver module for your console device. There are three options for creating a console I/O driver and descriptor.

1. For the initial port to a board, you can use `scllio` instead of creating a high-level SCF driver. See **Chapter 10: Using Hardware-Independent Drivers**, for more information on using this hardware-independent, high-level driver during the initial port to a board.

   If you use this option, you can copy the `SCF/SCLLIO/DESC` from one of the example port directories into the `<Target>` port directory you created. This serves as your console driver for the initial board port and you can use the remainder of this chapter later when you want to create a high-level SCF driver.

2. If you want to use a high-level SCF driver for your console I/O driver, you can use the procedures in the **Creating an SCF Driver/Descriptor** section to find and use a Microware-supplied serial driver example.

3. If you want to use a high-level SCF driver for your console I/O driver, but Microware did not provide one matching the serial device driver chip on your board, you can use the **Creating an SCF Driver/Descriptor** section and the referenced material in this chapter to create a driver and build a descriptor.

Creating an SCF Driver/Descriptor

This section summarizes the steps required to build a device descriptor for a new board. You will be referred to more detailed procedures for the specific steps involved in writing an SCF device driver and building a descriptor if Microware does not supply one you can use.

Step 1. Create a `<Driver>` directory in the port-specific `<Target>/SCF` directory where `<Driver>` is the name of the serial device driver chip on your board.

Step 2. Create `DRVR` and `DESC` directories in the `<Target>/SCF/<Driver>` directory, along with makefiles, to build the drivers and descriptors. You can use the example makefiles as a reference.

Step 3. Check the Microware-supplied driver and driver-specific descriptor sources included in the `MWOS/OS9000/SRC/IO/SCF/DRVR` directory for one based on the same target device your platform uses.

Step 4. If you find a driver matching the chip on your board, check the makefiles (copied from examples in Step 2) to make certain they point to the correct source files for the device driver. Go to Step 6.

Step 5. If you do not find a device driver example for the serial chip on your board, see the following sections for information on creating a device driver:

- **Creating SCF Device Drivers** for specific information on device driver static storage and subroutines.
- **Using SCF Device Descriptor Modules** for information on how the device driver you write will use the SCF device descriptor modules.

Step 6. Create a new directory in `MWOS/OS9000/SRC/IO/SCF/DRVR` for the device driver.

Step 7. Build a new device descriptor for the driver. See **Building SCF Device Descriptors** for specific procedures.

Step 8. Set up the proper configuration labels for the device within the `systype.h` file for the driver and the configuration files for the descriptor. See **Building SCF Device Descriptors** for specific procedures.

For More Information

Refer to the ***Utilities Reference*** for more information about `EditMod`, and the `ident` and `fixmod` utilities.

Creating SCF Device Drivers

This section describes the data structures and subroutines comprising an SCF device driver. The first section describes the driver's static storage structure definition and the second section describes the subroutines required for an SCF driver.

Before you write a device driver, you should also understand how the driver uses the device descriptor. This information is explained in the **Using SCF Device Descriptor Modules** section.

SCF Device Driver Static Storage

This section describes the device driver's static storage structure definition. The structure definition of the driver static storage is found in `scf.h` and shown on the following page. This structure contains the information SCF needs to initialize and call the device driver.

Like all other OS-9 device drivers, SCF device drivers use a standard executable memory module format with a module type of device driver. Every driver maintains a driver static storage area for each device with a unique port address. The driver static storage area always contains the following five items:

1. The first seven long words of the driver's dispatch table structure must contain the address of the standard driver functions. SCF drivers may declare additional variables separate from this structure, but it is critical that this structure be identified as the sharable portion of the driver's static storage by equating the name of the structure with the `_m_share` label as shown in the following example. This portion of every SCF driver static storage must be the same.
2. A variable used by drivers to keep track of the number of times the driver has been attached. This variable can determine when to properly terminate the device.
3. A pointer to the device list entry for the specific device.
4. The number of interrupt service routines for the driver.

5. A table of interrupt service routine entries containing the hardware vector offset of the associated interrupt and the address of the service routine completes the driver static storage.

Note

SCF assumes the first interrupt entry in the table is the input interrupt service routine.

The static storage of the driver is a combination of the driver static storage structure and any other variables the driver declares.

IOMAN allocates and initializes the driver’s entire static storage at attach time and also performs the following functions:

- Locates the driver’s dispatch table structure within the driver’s static storage information by using the `m_share` field of the driver’s module header.
- Adds this offset value to the beginning of the driver’s static storage to locate the shared structure. This value is contained in the `v_dr_stat` field in the device list entry associated with the device and is used by SCF in calling the driver.

```
_asm("_m_share: equ scf_drvr_stat");
                          /* identify the driver’s shared statics */
typedef struct scf_drvr_stat {
    error_code  (*v_init)(),
                          /* address of driver’s init function */
                (*v_read)(),
                          /* address of driver’s read function */
                (*v_write)(),
                          /* address of driver’s write function */
                (*v_getstat)(),
                          /* address of driver’s get_status function */
                (*v_setstat)(),
                          /* address of driver’s put_status function */
                (*v_terminate)(),
                          /* address of driver’s terminate function */
                (*v_entxirq)();
                          /* address of driver’s "entxirq" function */
                          /* i.e. (enable transmitter interrupts) */
    Dev_list    v_dev_entry;
                          /* device list entry pointer for device */
                          /* (initialized by SCF before calling drvr) */
```

```
    u_int16     v_attached,
                          /* driver attached flag (maintained by drvr) */
                v_rsrvd[7];
                          /* reserved for future use */
    u_int32     v_irqcnt;
                          /* number of interrupt service routines */
    irq_entry   v_irqrtns[8];
                          /* interrupt service routine entries */
} scf_drvr_stat;
```

Table 9-1 SCF Device Driver Static Storage

Name	Description
`v_init`	This field contains the address of the driver's initialization routine. The initialization routine is responsible for performing the actual initialization of the device hardware. SCF calls this routine when an `I_ATTACH` service request is made.
`v_read`	This field contains the address of the driver's read routine. The driver's read routine is only called if the driver's input operates in polled mode. For more information, refer to the `v_pollin` field of the logical unit static storage structure definition (**Table 9-4** on page 162).
`v_write`	This field contains the address of the driver's write routine. The driver's write routine is only called if the driver's output operates in polled mode. For more information, refer to the `v_pollout` field of the logical unit static storage structure definition (**Table 9-4** on page 162).
`v_getstat`	This field contains the address of the driver's get status routine. The driver's get status routine is only called for `getstat` service requests that are defined to call the driver and unknown `getstat` function codes.

Table 9-1 SCF Device Driver Static Storage (continued)

Name	Description
`v_setstat`	This field contains the address of the driver's set status routine. The driver's set status routine is only called for `setstat` service requests that are defined to call the driver and unknown `setstat` function codes.
`v_terminate`	This field contains the address of the driver's terminate routine. The terminate routine is responsible for performing the actual de-initialization of the device hardware. SCF calls this routine when an `I_DETACH` service request is made.
`v_entxirq`	This field contains the address of the driver's enable transmit interrupts routine. The enable routine is responsible for enabling the device's transmitter interrupts so the device can begin its asynchronous output. SCF only calls the enable routine when data is available for transmission and the transmit interrupts are disabled. For more information, refer to the `v_outhalt` field in the logical unit static storage structure definition (**Table 9-4** on page 162).
`v_dev_entry`	This field points to the device list entry for this device.
`v_attached`	The driver uses this field to keep track of the number of attach operations performed on the device. The driver should increment it every time the init routine is called, and decrement it for every terminate call. This allows the driver to know when it should truly initialize/de-initialize the hardware.

Table 9-1 SCF Device Driver Static Storage (continued)

Name	Description
`v_irqcnt`	This fields specifies the number of interrupt service routines required by the device driver.
`v_irqrtns`	This array contains the addresses and associated vector numbers of the interrupt service routines of the driver. The driver may use this array to install its interrupt service routines on the system's interrupt polling table. The first entry (if any) is the read IRQ. The second entry (if any) is the write IRQ. This array contains the addresses and associated vector number offsets (from the base vector number of the device) of the interrupt service routines of the driver. The base vector number is usually zero. However, for some smart devices, there can be multiple IRQs. The actual vector number value the driver uses to install the routine on the system polling table is the sum of the vector number in the logical unit static storage (`v_vector`) and the routine vector offset.
`v_rsrvd`	This array is reserved for future use.

SCF Device Driver Entry Subroutines

The standard driver subroutines and their parameters follow:

Table 9-2 SCF Subroutines

Function	Description
`ENABLE TRANSMITTER INTERRUPTS`	Enable the device’s *Ready to Transmit* interrupts
`GETSTAT`	Get device status
`INIT`	Initalize device hardware
`IRQ SERVICE ROUTINE`	Service device interrupts
`READ`	Read next character
`SETSTAT`	Set device status
`TERMINATE`	Terminate device
`WRITE`	Write a character

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

ENABLE TRANSMITTER INTERRUPTS

Enable the Device's Ready to Transmit Interrupts

Syntax

```
error_code entxirq(Dev_list device_entry);
```

Description

The enable transmitter interrupts routine is called by SCF and the driver when there is data in the output buffer and the `v_outhalt` field of the output device's logical unit static storage indicates the *ready to transmit* interrupts are disabled. The init routine should initialize this field and the interrupt service routine(s) should maintain it properly. Also, the enable transmitter interrupts routine should flag that the transmitter interrupt is enabled by setting the `OH_IRQON` bit of the `v_outhalt` field.

Parameters

`device_entry`	points to the device list entry.

GETSTAT

Get Device Status

Syntax

```
error_code getstat(
    I_getstat_pb    ctrl_block,
    Scf_path_desc   path_desc,
    Dev_list        device_entry);
```

Description

These routines are wildcard calls used to get the device parameters specified by the `getstat` service requests. Many SCF-type requests are handled by IOMAN or SCF. Any `getstat` functions not defined by them are passed to the device driver. If the function code specified in the *control block* is not recognized by the driver, the driver returns an `EOS_UNKSVC` (unknown service code) error.

Parameters

`ctrl_block`	is the `I_GETSTAT` control block.
`path_desc`	points to the path descriptor.
`device_entry`	points to the device entry.

INIT

Initialize Device Hardware

Syntax

```
error_code init(Dev_list device_entry);
```

Description

The INIT routine must:

1. Install driver interrupt service routine(s) on the system interrupt polling table using the `F_IRQ` service request.
2. Initialize the device control registers with the functionality specified by the logical unit options section.
3. Output a null byte to get the transmitter interrupts activated. The transmitter interrupts should not actually be enabled until later when SCF has data to output and calls the driver's *enable-transmitter interrupts* routine.

Parameters

`device_entry`	is the device list entry for the device.

IRQ SERVICE ROUTINE

Service Device Interrupts

Syntax

```
error_code input_irq(Dev_list device_entry);

error_code output_irq(Dev_list device_entry);
```

Description

Although the interrupt service routine(s) is not included in the driver's entry point table and not called directly by SCF, it is an important routine in interrupt-driven device drivers. It functions as follows:

1. Query the device to determine if the device caused the interrupt. If the device did not cause the interrupt, exit immediately with an `EOS_NOTME` error.
2. Service the device interrupt (receive/transmit data). This routine puts its data into or get its data from the buffers defined in the logical unit static storage.
3. Wake up any process waiting for I/O to complete by checking the `v_wake` field of the logical unit static storage. It sends a wakeup signal to the process specified by this field and then clears the field.
4. If the device is ready to send (assuming it is servicing an output interrupt) and the output buffer is empty, it disables the device's *ready to transmit* interrupts. It also flags the interrupts as disabled by clearing the `OH_IRQON` bit and setting the `OH_EMPTY` bit of the `v_outhalt` flag field of the logical unit static storage.
5. If a pause character is received, sets the `v_pause` field of the logical unit static storage of the output device to a non-zero value.
6. If a keyboard interrupt or keyboard quit character is received, sends the associated signal to the process specified in the `v_lproc` field of the logical unit static storage.
7. If an X-ON or X-OFF character is received, enables or disables transmitter interrupts.

8. If the input buffer has reached the *high water mark* as specified by the `v_maxbuff` field of the logical unit static storage and X-OFF is enabled, prepares to send an X-OFF character.

Parameters

`device_entry`	points to the device list entry.

READ

Read Next Character

Syntax

```
error_code read(
   Scf_path_desc  path_desc,
   Dev_list       device_entry);
```

Description

The READ routine for drivers that have interrupt driven input returns without error. The read routine for drivers with polled input performs the same functions as an input interrupt service routine (X-ON/X-OFF flow control, keyboard interrupt, keyboard quit) except it polls the hardware for the next character.

Parameters

`path_desc`	points to the path descriptor.
`device_entry`	points to the device list entry.

SETSTAT

Set Device Status

Syntax

```
error_code setstat(
   I_setstat_pb   ctrl_block,
   Scf_path_desc  path_desc,
   Dev_list       device_entry);
```

Description

Setstats are wildcard calls that set the device parameters specified by the `setstat` service requests. Many SCF-type requests are handled by IOMAN or SCF. Any `setstat` functions not defined by them are passed to the device driver. If the function code specified in the *control block* is not recognized by the driver, the driver returns an `EOS_UNKSVC` (unknown service code) error.

Parameters

`ctrl_block`	is the `I_SETSTAT` control block.
`path_desc`	points to the path descriptor.
`device_entry`	points to the device entry.

TERMINATE

Terminate Device

Syntax

```
error_code terminate(Dev_list device_entry);
```

Description

The terminate routine performs the following functions:

1. De-initializes the hardware, disabling the device interrupts.
2. Removes the interrupt service routine(s) from the system interrupt polling table.

Parameters

`device_entry`	points to the device list entry.

WRITE

Write a Character

Syntax

```
error_code write(
    Scf_path_desc  path_desc,
    Dev_list       device_entry);
```

Description

The write routine for drivers that have interrupt driven output returns without error. The write routine for drivers with polled output performs the same functions as an output interrupt service routine except it polls the hardware to transmit the next character.

Parameters

`path_desc`	points to the path descriptor.
`device_entry`	points to the device entry.

Using SCF Device Descriptor Modules

The SCF device descriptor consists of four parts:

- The OS-9 module header
- The common information required by IOMAN for all descriptors
- The path descriptor options
- The logical unit static storage

Along with the common IOMAN information, the `scf_desc` structure contains the offset for the name of an output device to be used, if different from the input device. SCF examines this structure when processing an `OPEN` request. This structure is defined in `scf.h`:

```
typedef struct scf_desc {
    dd_com
        dd_descom;      /* common device descriptor variables */
    u_int32
        dd_outdev;      /* alternate output device name offset */
    u_int16
        dd_rsvd_scf[2]; /* reserved space */
} scf_desc;
```

Table 9-3 SCF Device Descriptors

Name	Description
`dd_descom`	This is the common information structure IOMAN requires be in all device descriptors.
`dd_outdev`	This is the offset to the name of the output device to be used instead of the input device. If this field is non-zero, SCF attaches to this device, initializes it, and issues an `SS_OPEN setstat` request to the device's driver.

SCF Logical Unit Static Storage

This section describes the definitions of the logical unit (device) static storage area for SCF-type devices. The structure definition of the device static storage is found in `scf.h`. IOMAN copies the initial values from the device descriptor module into the logical unit static storage when a path to the device is opened. This structure contains the important variables used by the device driver and SCF to communicate and transfer data.

Device Static Storage Structure Definition Example

```
typedef struct scf_lu_stat {
    hardware_vector  v_vector;     /* IRQ vector number */
    u_char           v_irqlevel,   /* IRQ interrupt level */
                   v_priority,  /* IRQ polling priority */
                   v_pollin,    /* polled input flag; 1=polled, 0=IRQ driven */
                   v_pollout,   /* polled output flag; 1=polled, 0=IRQ driven */
                   v_inhalt,       /* input halted flag */
                   v_hangup,       /* set non-0 when data carrier is lost */
                   v_outhalt;      /* output IRQ's disabled when non-zero */
    u_int16        v_lu_num,       /* logical unit number */
                   v_wait;         /* indicates process is waiting on I/O */
    u_int32        v_irqmask,      /* Interrupt mask word */
                   v_savirq_fm,    /* previous interrupt mask word (SCF only) */
                   v_savirq_dv,    /* prev. interrupt mask word (driver only) */
                   v_savirq_ll;    /* reserved for future use */
    process_id     v_wake,         /* ID of process waiting I/O operation */
                   v_busy,         /* ID of process currently using device */
                   v_lproc,        /* # of the last process to use this unit */
                   v_sigproc[3],   /* process to signal on SS_SENDSIG request;
                                     signal code; associated (system) path # */
                   v_dcdoff[3],    /* process to signal on SS_DCOFF request;
                                     signal code; associated (system) path # */
                   v_dcdon[3];     /* process to signal on SS_DCON request;
                                     signal code; associated (system) path # */
    Scf_lu_stat    v_outdev;       /* output device's static storage pointer */
    u_int32        v_pdbufsize,    /* SCF's path buffer size for this device */
                   v_maxbuff;      /* input buffer maximum (high water mark) */
    u_int32        v_insize,       /* size of input buffer */
                   v_incount;      /* number of bytes in input buffer */
    u_char         *v_inbufad,     /* input buffer address */
                   *v_infill,      /* input buffer next-in pointer */
                   *v_inempty,     /* input buffer next-out pointer */
                   *v_inend;       /* input buffer end of buffer pointer */
    u_int32        v_outsize,      /* size of output buffer */
                   v_outcount;     /* number of bytes in output buffer */
    u_char         *v_outbufad,    /* output buffer address */
                   *v_outfill,     /* output buffer next-in pointer */
                   *v_outempty,    /* output buffer next-out pointer */
```

```
                  *v_outend;      /* output buffer end of buffer pointer */
    lock_id       v_lockid;       /* I/O lock identifier */
    u_int32       v_use_cnt;      /* logical unit user count */
    u_int32       v_resrvd[5];    /* reserved space */
    Scf_path_opts v_pdopt;        /* ptr to path descriptor options section */
    scf_lu_opts   v_opt;          /* logical unit options section */
#ifdef DEV_SPECIFICS
    DEV_SPECIFICS                 /* driver specific static variables */
#endif
} scf_lu_stat;
```

Table 9-4 SCF Logical Unit Static Storage Fields

Name	Description
v_vector	**Interrupt Vector** This field contains the associated interrupt vector number for the device. **Note:** The ***OS-9 Configuration Reference*** uses hardware_vector.
v_irqlevel	**Interrupt Level** This field contains the interrupt level of the device.
v_priority	**Interrupt Priority** This field contains the polling priority of the device.
v_pollin	**Polled Input Flag** This field indicates whether the device's input operates in interrupt or polled mode. If the driver uses polled mode, SCF calls the driver's READ routine for every character. A non-zero value indicates polled mode. A zero value indicates interrupt driven input.

Table 9-4 SCF Logical Unit Static Storage Fields (continued)

Name	Description
`v_pollout`	**Polled Output Flag** This field indicates whether the device's output operates in interrupt or polled mode. If the driver uses polled mode, SCF calls the driver's `WRITE` routine for every character. A non-zero value indicates polled mode. A zero value indicates interrupt driven output.
`v_inhalt`	**Input Halted Flag** This field indicates whether or not input to the device has been halted. It is non-zero if an X-OFF character has been sent and input halted.
`v_hangup`	**Data Carrier Lost Flag** This field is non-zero when the *data carrier* line has been lost, indicating a lost connection.

Table 9-4 SCF Logical Unit Static Storage Fields (continued)

Name	Description
`v_outhalt`	**Output Halt Flag** This field indicates the status of output from the device. SCF uses this field to decide when to call the driver's *enable transmit IRQ* routine to begin output. Bits 2 - 4 are undefined. Bits 5 and 6 are user-definable. Bits 0, 1, and 7 are defined as follows: Bit 0 (0x01) — Indicates an X-OFF has been received and output has been halted. Bit 1 (0x02) — Indicates the output buffer is empty and output has been halted. Bit 7 (0x80) — Indicates transmitter interrupts are enabled. It is important that the device driver clears this bit whenever definitions for these bits are in the `scf.h` header file
`v_lu_num`	**Logical Unit Number** This field contains the logical unit number. **Note:** The ***OS-9 Configuration Reference*** uses `v_lun`.

Table 9-4 SCF Logical Unit Static Storage Fields (continued)

Name	Description
`v_wait`	**I/O Wait Flag** This field indicates whether a process is waiting for I/O on this logical unit. Definitions for this field are located in the `scf.h` header file. The values of this field are defined as follows: `0` No processes waiting on the device. `1` A process is waiting on input to the device. `2` A process is waiting on output from the device.
`v_irqmask`	**Interrupt Mask** This field contains the interrupt mask used for masking interrupts to the level of the device. **NOTE:** Interrupts should be masked as little as possible and only for critical sections of the device driver.
`v_savirq_fm`	**Previous Interrupt Status (SCF use)** SCF uses this field for saving the current state of the interrupt status register prior to masking interrupts.
`v_savirq_dv`	**Previous Interrupt Status (Driver use)** SCF device drivers use this field for saving the current state of the interrupt status register prior to masking interrupts.
`v_wake`	**Waiting Process ID** This field contains the process identifier of any process waiting for the device to complete I/O. `0` indicates there is no process waiting.

Table 9-4 SCF Logical Unit Static Storage Fields (continued)

Name	Description
`v_busy`	**Current Process ID** This field contains the process identifier of the process currently using the device. SCF uses this field to prevent more than one process from using the device at a time. **NOTE:** `v_busy` is always equal to `v_lproc` or is zero.
`v_lproc`	**Last Process ID** This field contains the process identifier of the last process to use the device. The interrupt service routine sends this process the proper signal when an *interrupt* or *quit* character is received.
`v_sigproc`	**Signal Process Information (for data ready)** This field contains the process identifier, the signal code to send, and the associated system path number for the process that made an `SS_SENDSIG setstat` call (send signal on data ready).
`v_dcdoff`	**Signal Process Information (for DCD false)** This field holds the process identifier, the signal code to send, and the associated system path number for the process that made an `SS_DCOFF setstat` call (send signal on DCD false).
`v_dcdon`	**Signal Process Information (for DCD true)** This field holds the process identifier, the signal code to send, and the associated system path number for the process that made an `SS_DCON setstat` call (send signal on DCD true).

Table 9-4 SCF Logical Unit Static Storage Fields (continued)

Name	Description
`v_outdev`	**Output Device Static Storage Pointer** This points to the logical unit static storage structure of the output (echo) device. In most cases, a device is its own echo device. However, it may not be, as in the case of a keyboard and a memory mapped video display.
`v_pdbufsize`	**Path Buffer Size** This field contains the size of the path buffer SCF uses for this device.
`v_maxbuff`	**Maximum Data For Path Buffer** This field is a *high water marker* for the path buffer. The device driver should send an X-OFF character to the transmitter when the path buffer fills up to this point.
`v_insize`	**Device Input Buffer Size** This field contains the size of the input buffer for this device (logical unit).
`v_incount`	**Current Byte Count in Input Buffer** This field contains the number of bytes currently in the input buffer. The device driver updates this field as it places characters in the input buffer. SCF updates this field when it removes characters from the input buffer.
`v_inbufad`	**Beginning of Input Buffer Pointer** This field contains a pointer to the beginning of the input buffer for this logical unit.

Table 9-4 SCF Logical Unit Static Storage Fields (continued)

Name	Description
`v_infill`	**Next Data Input Pointer (to Input Buffer)** This field contains a pointer to the *next-in* position for the input buffer for this logical unit. The device driver uses and maintains this pointer to place characters in the input buffer.
`v_inempty`	**Next Data Output Pointer (from Input Buffer)** This field contains a pointer to the *next-out* position for the input buffer for this logical unit. SCF uses and maintains this pointer to remove characters from the input buffer.
`v_inend`	**End of Input Buffer Pointer** This field contains a pointer to the end of the input buffer for this logical unit.
`v_outsize`	**Output Buffer Size** This field contains the size of the output buffer for this logical unit.
`v_outcount`	**Current Byte Count in Output Buffer** This field contains the number of bytes currently in the output buffer. SCF updates this field as it places characters in the output buffer. The device driver updates this field as it removes characters from the output buffer.
`v_outbufad`	**Beginning of Output Buffer Pointer** This field contains a pointer to the beginning of the output buffer for this logical unit.

Table 9-4 SCF Logical Unit Static Storage Fields (continued)

Name	Description
`v_outfill`	**Next Data Input Pointer (to Output Buffer)** This field contains a pointer to the *next-in* position for the output buffer for this logical unit. SCF uses and maintains this pointer to place characters in the output buffer.
`v_outempty`	**Next Data Output Pointer (from Output Buffer)** This field contains a pointer to the *next-out* position for the output buffer for this logical unit. The device driver uses and maintains this pointer to remove characters from the output buffer.
`v_outend`	**End of Output Buffer Pointer** This field contains a pointer to the end of the output buffer for this logical unit.
`v_lockid`	**Resource Lock ID** This field contains the resource lock identifier for this logical unit. SCF uses this field to arbitrate exclusive access to this logical unit.
`v_use_cnt`	**Logical Unit User Counter** This field can be used by the driver to record the number of users using a given logical unit. This provides better control over devices supporting more than one unit.
`v_pdopt`	**Path Descriptor Option Pointer** This field contains a pointer to the path descriptor options section for this path.

Table 9-4 SCF Logical Unit Static Storage Fields (continued)

Name	Description
`v_opt`	**Logical Unit Options** This field is the structure containing the logical unit options for this logical unit. These options are described following this section.
`DEV_SPECIFICS`	**Device Specific Variable MACRO** This is a C language macro. The author of a device driver can expand this macro to include additional variables in the logical unit static storage structure. The additional field can be defined in a header file for the device driver being written. The fields are included in the structure when the device descriptor for the logical unit is created.

SCF Logical Unit Static Storage Options

This section describes the definitions of the device options (logical unit options) for SCF-type devices. The structure definition of the device options is shown here. This structure is defined in `scf.h`. IOMAN copies the device options from the device descriptor module into the logical unit static storage when a path to the device is attached. The device options may be changed afterwards using the `SS_LUOPT` function of `I_GETSTAT` and `I_SETSTAT` service requests or from the keyboard using the `xmode` utility.

```
typedef struct scf_lu_opts {
     u_int16    v_optsize;       /* size of logical unit options section */
     u_char     v_class,         /* device type; 0 = SCF */
                v_err,           /* accumulated errors */
                v_pause,         /* immediate pause request */
                v_line,          /* lines left until end of page */
                v_intr,          /* keyboard interrupt character */
                v_quit,          /* keyboard quit character */
                v_psch,          /* keyboard pause character */
                v_xon,           /* X-ON character */
                v_xoff,          /* X-OFF character */
```

```
                v_baud,          /* baud rate */
                v_parity,        /* parity */
                v_stopbits,      /* stop bits */
                v_wordsize,      /* word size */
                v_rtsstate,      /* RTS state: disable = 0; enable = non-zero */
                v_dcdstate,      /* current state of DCD line */
                v_reserved[9];   /* reserved for future use */
} scf_lu_opts;
```

Table 9-5 SCF Logical Unit Static Storage Options

Name	Description
`v_optsize`	**Options Section Size** This field specifies the size of the logical unit options section.
`v_class`	**Device Type (DT_SCF = 0)** This field specifies the device type. This should be zero for SCF. The device types are defined in the `io.h` header file.
`v_err`	**Accumulated Errors** This field is used to accumulate I/O errors. Typically, the IRQ service routine uses it to record errors so they can be reported later when SCF calls one of the device driver routines.
`v_pause`	**Pause Flag** This field tells SCF when there is an immediate pause request from the input device. It causes SCF to suspend output from `I_WRITLN` until a pause character is entered from the input device.
`v_line`	**Lines Before End of Page** This field contains the number of lines left to output until a page pause occurs (end-of-page).

Table 9-5 SCF Logical Unit Static Storage Options (continued)

Name	Description
`v_intr`	**Keyboard Interrupt Character** This field specifies the keyboard interrupt character. When a keyboard interrupt character is entered, a keyboard interrupt signal is sent to the last user of this unit. It terminates the current I/O request (if any) with an `EOS_BSIG` error. This field is normally set to a <control>C character.
`v_quit`	**Keyboard Quit Character** This field specifies the keyboard quit character. When a keyboard quit character is entered, a keyboard quit signal is sent to the last user of this unit. It terminates the current I/O request (if any) with an `EOS_BSIG` error. This field is normally set to a <control>E character.
`v_psch`	**Keyboard Pause Character** This field specifies the keyboard pause character. When this character is entered during output, output is suspended before the next end-of-line. This also deletes any *type ahead* input for `I_READLN`.
`v_xon`	**X-ON Character** This field specifies the transmit on (X-ON) character. When this character is received, output is resumed, assuming it was suspended by a transmit off character. **NOTE:** X-ON and X-OFF are required for software handshaking for some devices.

Table 9-5 SCF Logical Unit Static Storage Options (continued)

Name	Description
`v_xoff`	**X-OFF Character** This field specifies the transmit off (X-OFF) character. When this character is received, output is suspended until a transmit on character is received. **NOTE:** X-ON and X-OFF are required for software handshaking for some devices.
`v_baud`	**Baud Rate** This field sets the baud rate as follows: 0 = HardwIred 1 = 50 baud 2 = 75 baud 3 =110 baud 4 =134.5 baud 5 =150 baud 6 = 300 baud 7 = 600 baud 8 = 1200 baud 9 = 1800 baud A = 2000 baud B = 2400 baud C = 3600 baud D = 4800 baud E = 7200 F = 9600 baud 10 = 19200 baud 11 = 31250 baud 12 = 38400
`v_parity`	**Parity** This field specifies the parity to be used. 0 = no parity 1 = odd parity 2 = even parity 3 = mark parity 4 = space parity

Table 9-5 SCF Logical Unit Static Storage Options (continued)

Name	Description
`v_stopbits`	**Stop Bits** This field specifies the number of stop bits to be used. 0 = 1 stop bit 1 = 1 1/2 stop bits 2 = 2 stop bits
`v_wordsize`	**Bits Per Character** This field specifies the number of bits per character.
`v_rtsstate`	**RTS Line State** This field controls the state of the RTS line. It is useful for drivers wanting to use hardware handshaking. When this field is zero, the RTS line is disabled. When it is non-zero, it is enabled.
`v_dcdstate`	**Current DCD Line State** This field indicates the state of the DCD Line.

SCF Path Descriptor

This section describes the definitions of the path descriptor for SCF-type devices. The structure definition of the path descriptor is shown here. This structure is defined in `scf.h`. SCF initializes the path descriptor options section from the specified device descriptor module when a path is opened to an SCF device. The path descriptor options can later be changed using the `SS_PATHOPT` function of the `I_GETSTAT` and `I_SETSTAT` service requests or from the keyboard using the `tmode` utility.

```
typedef struct scf_path_desc {
    struct   pathcom pd_common;   /* common path descriptor structure */
    Dev_list pd_outdev;           /* device tbl pointer for echo device */
    u_char   *pd_ubuf,            /* user buffer base address */
             *pd_pbuf,            /* path buffer base address */
             *pd_pbufpos;         /* current path buffer position */
    u_int32  pd_endobuf,          /* end of buffer position */
             pd_curpos,           /* cursor position counter */
             pd_reqcnt,           /* number of bytes requested by the caller */
             pd_evl;              /* readln end of visible line counter */
    u_char   pd_echoflag,         /* flag if echoing output is ok for this device */
             pd_lost;             /* non-zero if path has become dead */
                                  /* (ie: data-carrier-detect lost) */
    u_int16  pd_reserved[7];      /* reserved space */
    scf_path_opts pd_opt;         /* SCF path descriptor options */
} scf_path_desc;
```

Table 9-6 SCF Path Descriptor Fields

Name	Description
`pd_common`	**Common Path Descriptor Variables** This field is the structure containing the path descriptor variables IOMAN requires for all path descriptors. These variables are described in the first chapter of this manual.
`pd_outdev`	**Device Table Pointer for Echo Device** SCF uses this field for calling the echo device to echo input and output characters in polled mode.

Table 9-6 SCF Path Descriptor Fields (continued)

Name	Description
pd_ubuf	**User Buffer Base Address** This field saves the user's buffer pointer on read, readln, write, and writeln requests.
pd_pbuf	**Path Buffer Base Address** This field points to the input buffer for the path. It is the buffer associated with input and its editing functions.
pd_pbufpos	**Current Path Buffer Position** This field points to the current input position in the path buffer.
pd_endobuf	**End of Buffer Position** This field contains the last character position of the path buffer.
pd_curpos	**Cursor Position Counter** SCF uses this field to maintain the current location of the cursor on input.
pd_reqcnt	**Number of Bytes Requested** This field contains the total number of bytes requested on a read or readln request.
pd_evl	**End of Visible Line Counter** SCF uses this field to maintain the logical end-of-visible line when performing the editing functions of a readln request.
pd_echoflag	**Echo Output Flag** A non-zero value in this field indicates echoing input is enabled.

Table 9-6 SCF Path Descriptor Fields (continued)

Name	Description
`pd_lost`	**Data Carrier Detect Lost Flag** A non-zero value in this field indicates a transition of the data carrier detect line. This is useful for modem support.
`pd_opt`	**Path Descriptor Options** This field is the structure containing the path descriptor options. These options are described in the following section.

SCF Path Descriptor Options Section

The structure definition of the path descriptor options is shown here. This structure is defined in the header file `scf.h`. You can update the path descriptor options using the `SS_PATHOPT` function of the `I_GETSTAT` and `I_SETSTAT` system calls or the `tmode` utility.

```
typedef struct scf_path_opts {
   u_int16       pd_optsize,   /* path options table size */
                 pd_extra;     /* reserved for future use */
   inmap_entry   pd_inmap[32]; /* Input control character mapping table */
   u_char        pd_eorch,     /* end of record character (read only) */
                 pd_eofch,     /* end of file character */
                 pd_tabch,     /* tabulate character (0 = none) */
                 pd_bellch,    /* bell character (for input line overflow) */
                 pd_bspch;     /* backspace echo character */
   u_char        pd_case,      /* case 0 = both ~0 = upper case only */
                 pd_backsp,    /* backspace 0 = backspace
                                       ~0 = backspace,space,backspace */
                 pd_delete,    /* delete 0 = carriage return, line feed
                                           ~0 = backspace over line */
                 pd_echo,      /* echo 0 = no echo */
                 pd_alf,       /* auto-linefeed 0 = no auto line feed */
                 pd_pause,     /* pause 0 = no end of page pause */
                 pd_insm;  /* insert mode 0 = type over ~0 = insert at cursor */
   u_char        pd_nulls,     /* end of line null count */
                 pd_page,      /* lines per page */
                 pd_tabsiz,    /* tabulate field size */
                 pd_err,       /* most recent I/O error status */
                 pd_rsvd[2];   /* reserved */
   u_int32       pd_col,       /* current column number */
```

```
                 pd_time;      /* time out value for unblocked reads */
   Dev_list      pd_deventry;  /* Device table address (copy) */
} scf_path_opts;
```

Table 9-7 SCF Path Descriptor Options

Name	Description
`pd_optsize`	**Path Descriptor Options Size** This is the total size of the SCF path options section.
`pd_inmap`	**Control Character Mapping Table** This is the input control character mapping table. It maps input control characters to the input line editing functions or user-defined control strings (break sequences). The control mapping table is described in detail following this section.
`pd_eorch`	**End of Record Character** This is the end-of-record character—the last character entered on each line for the `I_READLN` system call. Output lines from `I_WRITLN` calls are terminated when this character is sent. Normally, the end-of-record character is set to `$0D`. **NOTE:** If the end-of-record character is set to `0`, `I_READLN` calls never terminate.
`pd_eofch`	**End of File Character** This is the end-of-file character. SCF returns an end-of-file error for `I_READ` and `I_READLN` system calls when this is the first (and only) character input. It can be disabled by setting this value to `0`.

Table 9-7 SCF Path Descriptor Options (continued)

Name	Description
`pd_tabch`	**Tab Character** This is the tabulate character. In `I_WRITLN` calls, SCF expands this character to spaces to make tab stops at column intervals specified by the `pd_tabsiz` field. **NOTE:** SCF does not know the effect of control characters on particular terminals. Therefore, it may expand tabs incorrectly if they are used.
`pd_bellch`	**Bell Character** This is the bell sound character. In `I_READLN` calls, SCF echoes this character to the terminal once for every character input after the input buffer has filled. It is only useful for terminals with sound capability. It can be disabled by setting this value to `0`.
`pd_bspch`	**Backspace Character** This is the backspace *output* echo character. This is the backspace character SCF echoes when it is performing an editing function requiring a backspace, such as move cursor left.
`pd_case`	**Case Mode** This field indicates the casing mode SCF should use for input and output characters. When this field is non-zero, SCF converts all characters in the range `a..z` to `A..Z`.

Table 9-7 SCF Path Descriptor Options (continued)

Name	Description
pd_backsp	**Destructive Backspace Flag** This field indicates whether backspacing (move cursor left) is destructive or non-destructive. If it is 0, a move cursor left input control character causes SCF to echo a pd_bspch character. If it is non-zero, SCF echoes pd_bspch, space, pd_bspch.
pd_delete	**Delete Line Function** This field specifies how SCF implements the delete line editing function. If it is 0, SCF deletes the line by backspace-erasing the line. If it is non-zero, SCF deletes the line by echoing a carriage return/line feed.
pd_echo	**Echo Flag** This field determines whether or not SCF echoes input characters. If it is non-zero, SCF echoes input characters. If it is 0, SCF does not echo input characters.
pd_alf	**Line Feed Flag** This is the automatic line feed flag. If it is 0, a line feed character is echoed after every end-of-record character output by the I_WRITLN service request.
pd_pause	**Page Pause Flag** This field is the end of page pause indicator. If it is non-zero, an auto page pause occurs upon reaching a full screen of output. See pd_page for setting the page length.

Table 9-7 SCF Path Descriptor Options (continued)

Name	Description
`pd_insm`	**I_READLN Input Mode** This field determines the input mode for `I_READLN` calls. If it is `0`, input is in type-over mode. If it is non-zero, input characters are inserted at the cursor position and all characters to the right of the cursor are shifted to the right.
`pd_nulls`	**Padding Characters** This field specifies the number of null padding characters (always `$00`) to be echoed after a carriage return/line feed sequence.
`pd_page`	**Lines per Page** This field specifies the number of lines per page or screen.
`pd_tabsiz`	**Tab Size** This field specifies the tab size.
`pd_err`	**I/O Error Status** This field contains the most recent I/O error status.
`pd_col`	**Current Column Position** This field contains the current column position of the cursor.

Table 9-7 SCF Path Descriptor Options (continued)

Name	Description
`pd_time`	**Time Out For I_READ, I_READLN** This field specifies the time out value (in ticks) for unblocked `I_READ` and `I_READLN` calls. When this field is set to 1 tick, these calls return the number of characters available in the unit's input buffer.
`pd_deventry`	**Device Table Entry Address** This field contains the address of the device table entry for the path.

SCF Control Character Mapping Table

This table maps input control characters to the input line editing functions or user-defined control strings. Each entry in the field directly corresponds to the control character ASCII value in ascending order. The following control characters are mapped in this table: `0x01 - 0x1F` and `0x7F`.

Each entry in the table has the following format:

```
typedef struct inmap_entry {
    u_int16 type,       /* character mapping type */
            func_code;  /* SCF editing function code */
    u_int32 size;       /* size of associated string */
    void    *string;    /* pointer to associated string */
} inmap_entry;
```

Table 9-8 SCF Control Character Mapping Table

Name	Description
`type`	**Mapping Type** The control character mapping type can be one of three values: `IGNORE` This control character is removed from the data stream. `PASSTHRU` This control character is passed on without editing. `EDFUNCTION` This control character is removed from the data stream.

Table 9-8 SCF Control Character Mapping Table (continued)

Name	Description
func_code	**Editing Function Code** If the type field is defined as EDFUNCTION, func_code must be defined. This field can be any of the following function codes:

MOVLEFT	0x00	move cursor to the left (formerly pd_bsp)
MOVRIGHT	0x01	move cursor to the right
MOVBEG	0x02	move cursor to the beginning of the line
MOVEND	0x03	move cursor to the end of the line
REPRINT	0x04	reprint the current line to cursor position
TRUNCATE	0x05	truncate the line at the cursor position
DELCHRL	0x06	delete character to the left
DELCHRU	0x07	delete character under the cursor
DELWRDL	0x08	delete word to the left
DELWRDR	0x09	delete word to the right
DELINE	0x0A	delete the entire line
UNDEF1	0x0B	undefined (reserved)
MODETOGL	0x0C	input mode toggle (type over vs. insert)
UNDEF2	0x0D	undefined (reserved)
ENDOREC	0x0E	end of record (read only)
ENDOFILE	0x0F	end of file

An editing control string or an internal SCF editing function is echoed to the terminal when this character is encountered.

Table 9-8 SCF Control Character Mapping Table (continued)

Name	Description
`size`	**Size of Editing Function String** This field specifies the size of the editing function string to echo to the terminal. If this field is specified as `0`, an editing function built into SCF is executed to perform the editing function. If this field is non-zero, the string pointed to by `string` is echoed to the terminal.
`string`	**Editing Function String Pointer** This field points to the character string to be echoed to the terminal.

Default Mapping Table

The following control character mappings are defined in `scf.des`. They are used whenever a new device descriptor is created.

Table 9-9 SCF Default Mapping

Identifier	Function Type	Function Code	Size	String
0x01 <CTRL> A	EDFUNCTION	MOVEND	0	NULL
0x02 <CTRL> B	EDFUNCTION	MOVLEFT	0	NULL
0x03 <CTRL> C	IGNORE	0	0	NULL
0x04 <CTRL> D	EDFUNCTION	DELCHRU	0	NULL
0x05 <CTRL> E	IGNORE	0	0	NULL

Table 9-9 SCF Default Mapping (continued)

Identifier	Function Type	Function Code	Size	String
0x06 <CTRL> F	EDFUNCTION	MOVRIGHT	0	NULL
0x07 <CTRL> G	PASSTHRU	0	0	NULL
0x08 <CTRL> H	EDFUNCTION	DELCHRL	0	NULL
0x09 <CTRL> I	EDFUNCTION	MODETOGL	0	NULL
0x0A <CTRL> J	PASSTHRU	0	0	NULL
0x0B <CTRL> K	EDFUNCTION	TRUNCATE	0	NULL
0x0C <CTRL> L	EDFUNCTION	DELWRDL	0	NULL
0x0D <CTRL> M	EDFUNCTION	ENDOREC	0	NULL
0x0E <CTRL> N	PASSTHRU	0	0	NULL
0x0F <CTRL> O	PASSTHRU	0	0	NULL
0x10 <CTRL> P	EDFUNCTION	REPRINT	0	NULL
0x11 <CTRL> Q	IGNORE	0	0	NULL
0x12 <CTRL> R	EDFUNCTION	DELWRDR	0	NULL
0x13 <CTRL> S	IGNORE	0	0	NULL
0x14 <CTRL> T	PASSTHRU	0	0	NULL
0x15 <CTRL> U	PASSTHRU	0	0	NULL
0x16 <CTRL> V	PASSTHRU	0	0	NULL

Table 9-9 SCF Default Mapping (continued)

Identifier	Function Type	Function Code	Size	String
0x17 <CTRL> W	IGNORE	0	0	NULL
0x18 <CTRL> X	EDFUNCTION	DELINE	0	NULL
0x19 <CTRL> Y	PASSTHRU	0	0	NULL
0x1A <CTRL> Z	EDFUNCTION	MOVBEG	0	NULL
0x1B <ESC>	EDFUNCTION	ENDOFILE	0	NULL
0x1C	PASSTHRU	0	0	NULL
0x1D	PASSTHRU	0	0	NULL
0x1E	PASSTHRU	0	0	NULL
0x1F	PASSTHRU	0	0	NULL
0x7F <DEL>	EDFUNCTION	DELCHRU	0	NULL

Building SCF Device Descriptors

Making OS-9 device descriptors involves two steps:

Step 1. Modifying the appropriate C macro definitions within the `SCF/<Driver>/config.des` for a specific device descriptor.

Step 2. Making the descriptor using the associated makefile.

The `config.des` file is organized so the macro definitions for a particular descriptor are grouped together. For example, the following section of `config.des` contains the macros that must be defined macros that do not have pre-defined defaults for the SCF `term` descriptor. They are grouped together within a C macro conditional:

```
/* Device descriptor common macros */
#define LUN         1
#define DRVR_NAME   “sc7110”

/* scf macros */
#define IRQLEVEL    0
#define PRIORITY    5
#define INPUT_TYPE IRQDRIVEN
#define OUTPUT_TYPE IRQDRIVEN
/**********************************************************************
 * End of Sc7110 Device Default Definitions     *
 *********************************************************************/

/**********************************************************************
* Term_t1 Sc7110 Descriptor Override Definitions (descriptor for Com1)*
 *********************************************************************/
#if defined (TERM_T1)
/* Module header */
#define MH_NAME “term”

/* Device descriptor common macros */
#define PORTADDR    0x80000480

/* scf macros */
#define VECTOR 0x4c

#endif /* TERM_T1 */
/**********************************************************************
 * End of Term_t1 Sc7110 Descriptor Override Definitions             *
 *********************************************************************/
```

Usually a few fields for every descriptor type must be defined in order to make the descriptor (for example, port address, vector, IRQ level). However, most of the fields of the descriptor structures have pre-defined values. Consequently, you do not need to redefine them. These values seldom change from descriptor to descriptor. If a change in the operational characteristics of a device is desired, redefine the standard macro for the target field in `config.des` and make the descriptor.

Once you have edited the `config.des` file, edit the appropriate makefile by adding the appropriate dependencies and command lines to the makefile. When you have added these lines, make the descriptor. The following is a typical cross hosted make command sequence.

```
$ chd SCF/SC68901/DESC
$ os9make
```

The makefile invokes the `EditMod` utility to create the descriptor. `EditMod` generates device descriptors from description files.

For More Information

The information in this chapter describes how `EditMod` can be used to create device descriptors. `EditMod` can also list or edit the contents of a device descriptor. For more information about this utility, refer to the ***Utilities Reference*** and ***OS-9 Device Descriptor and Configuration Module Reference*** manuals.

SCF Device Descriptor Macros

Refer to the ***OS-9 Device Descriptor and Configuration Module Reference*** for a complete discussion of the fields in the SCF configuration files. **Table 9-10** on page 190 and **Table 9-11** on page 192 contain the SCF macro definitions used for creating SCF device descriptors. Each table gives the name of the field, the name of the macro, an explanation of the macro, and an example definition (in many cases this is the default value set by Microware).

These five macros are common to RBF, SCF, and SBF descriptors.

Table 9-10 RBF, SCF, and SBF Common Descriptors

Name	Description and Example
PORTADDR	**Controller Address** This is the address of the device on the bus. Generally, this is the lowest address that the device has mapped. Port address is hardware dependent. `#define PORTADDR    0xfffe4000`
VECTOR	**Interrupt Vector** This is the vector passed to the processor at interrupt time. Vector is hardware/software dependent. You can program some devices to produce different vectors. `#define VECTOR      80`
IRQLEVEL	**Interrupt Level For the Device** The number of supported interrupt levels is dependent on the processor being used (for example, 1-7 on 680x0 type CPUs). When a device interrupts the processor, the level of the interrupt is used to mask out lower priority devices. `#define IRQLEVEL    4`

Table 9-10 RBF, SCF, and SBF Common Descriptors (continued)

Name	Description and Example
`PRIORITY`	**Interrupt Polling Priority** This value is software dependent. A non-zero priority determines the position of the device within the vector. Lower values are polled first. A priority of 1 indicates the device desires exclusive use of the vector. A priority of 0 indicates the device wants to be the first device on the polling list. OS-9 does not allow a device to claim exclusive use of a vector if another device has already been installed on the vector. Additionally, it does not allow another device to use the vector once the vector has been claimed for exclusive use. `#define PRIORITY    10`
`LUN`	**Logical Unit Number of the Device** More than one device may have the same port address. The logical unit number distinguishes the devices having the same port address. `#define LUN    2     /* drive number */`

The following macros are specific to SCF:

Table 9-11 SCF Macros

Name	Description

`MODE`	**Device Access Capabilities**
	This reflects the operational mode or capabilities of the device. Most SCF type devices use the default value. However, in some cases you should change `MODE` to include the `S_ISHARE` bit signaling the device is non-sharable. For example, an SCF serial printer port should be non-sharable.
	`#define MODE S_ISIZE|S_IREAD|S_IWRITE`
	`/* default device mode capabilities */`

`MAXBUFF`	**Maximum Data for the Input Buffer**
	This defines the *high water mark* of the input buffer. When the input buffer reaches the defined level, the sender is sent an X-OFF character to temporarily halt transmission.
	`#define MAXBUFF OUTSIZE-LOWCOUNT`
	`/* default maxbuff size */`

Table 9-11 SCF Macros (continued)

Name	Description

`INPUT_TYPE`	**Input Type Flag**
	This specifies whether input on the device is interrupt driven or polled. If the device is operated in polled mode, SCF calls the driver's read routine for every character. The two values defined for this field are:
	`#define IRQDRIVEN 0`
	`#define POLLED 1`
	They are defined in `scf.h`. The default for this macro is interrupt driven.
	`#define INPUT_TYPE IRQDRIVEN`

`OUTPUT_TYPE`	**Output Type Flag**
	This specifies whether output on the device is interrupt driven or polled. If the device is operated in polled mode, SCF calls the driver's write routine to transmit every character.
	`#define IRQDRIVEN 0`
	`#define POLLED 1`
	They are defined in `scf.h`. The default for this macro is interrupt driven.
	`#define OUTPUT_TYPE IRQDRIVEN`

`SCFBUFSIZE`	**Path Descriptor Buffer Size** This specifies the size of the path descriptor buffer for all paths opened to the device. The default is 256 bytes. `#define SCFBUFSIZE 256`

Table 9-11 SCF Macros (continued)

Name	Description
`INSIZE`	**Logical Unit Input Buffer Size** This specifies the size of the input buffer for the logical unit. The default is 256 bytes. `#define INSIZE  256`
`OUTSIZE`	**Logical Unit Output Buffer Size** This specifies the size of the output buffer for the logical unit. The default is 256 bytes. `#define OUTSIZE  256`
`KYBDINTR`	**Keyboard Interrupt Function** This specifies the control key to use for the keyboard interrupt function. The default value is <control>C. `#define KYBDINTR  CTRL_C`
`KYBDQUIT`	**Keyboard Quit Function** This specifies the control key to use for the keyboard quit function. The default value is <control>E. `#define KYBDQUIT  CTRL_E`
`KYBDPAUSE`	**Keyboard Pause Function** This specifies the control key to use for the keyboard pause function. The default value is <control>W. `#define KYBDPAUSE  CTRL_W`

Table 9-11 SCF Macros (continued)

Name	Description
`XON`	**XON Function** This specifies the control key to use for the X-ON protocol function. The default value is <control>Q. `#define XON  CTRL_Q`
`XOFF`	**XOFF Function** This specifies the control key to use for the X-OFF protocol function. The default value is <control>S. `#define XOFF  CTRL_S`

`UPC_LOCK`	**Character Case Function**
	This controls the casing of characters. A non-zero value converts input and output characters in the `a...z` to characters in the `A...Z` range. The default value is upper and lower casing.
	`#define UPC_LOCK  PLOFF`
	`/* default to upper and lower case */`

`BSB`	**Backspace Character Interpretation**
	This controls how SCF interprets a backspace character: as a destructive or non-destructive backspace. If this value is zero, SCF echoes a backspace character. If this value is non-zero, SCF echoes a backspace, space, backspace character sequence. The default is a destructive backspace.
	`#define BSB  PLON`
	`/* default to destructive backspace */`

Table 9-11 SCF Macros (continued)

Name	Description

`LINEDEL`	**Delete Line Function**
	This controls how SCF performs a delete line function. A zero value causes SCF to delete a line by backspacing over it. A non-zero value causes a carriage return/line feed sequence to be echoed to delete the line. The default is a destructive line delete.
	`#define LINEDEL  PLON`
	`/* default destructive delete line */`

`AUTOECHO`	**Input Echo Function**
	This controls whether or not input characters are echoed as they are received. A non-zero value causes input to be echoed. A zero value flags no echoing. The default is echo on.
	`#define AUTOECHO  PLON`
	`/* default to echo on */`

`AUTOLF`	**Automatic Line Feed Function**
	This specifies whether or not carriage returns are to be automatically followed by line feed characters. The default is auto line feed on.
	`#define AUTOLF  PLON`
	`/* default to auto line feed on */`

`EOLNULLS`	**Nulls After End-Of-Line**
	This specifies the number of null ($00) padding bytes to be transmitted after a carriage return/line feed sequence. The default value is `0`.
	`#define EOLNULLS  0`
	`/* default to no end-of-line nulls */`

Table 9-11 SCF Macros (continued)

Name	Description

`PAGEPAUSE`	**Page Pause Function**
	This specifies whether or not the automatic page pause facility of SCF is active. A non-zero value causes an auto page pause upon reaching a full screen of output. The default is page pause on.
	`#define PAGEPAUSE  PLON`
	`/* default to page pause on */`

`PAGESIZE`	**Lines Per Page**
	This specifies the number of lines per screen (or page). The default value is twenty-four lines per page.
	`#define PAGESIZE  24`
	`/* default to 24 line/page */`

`TABSIZE`	**Spaces Per Tab**
	This specifies the number of spaces per tab. The default value is 4.
	`#define TABSIZE  4`
	`/* default to 4 spaces/tab */`

`INSERTMODE`	**Input Mode Specification**
	A non-zero value causes input to operate in insert mode. This is, input characters are inserted in the current input line. A zero value causes input to operate in the type-over mode. The default is type-over mode. By using the associated control key, SCF allows you to enter insert mode.
	`#define INSERTMODE  PLOFF`
	`/* default to insert mode off */`

Table 9-11 SCF Macros (continued)

Name	Description

BAUDRATE	**Baud Rate**
	This specifies the baud rate of the device. The default is 9600. The various standard baud rate macros are defined in the `scf.h` header file.
	`#define BAUDRATE  BAUD9600`
	`/* default to 9600 baud */`

LUPARITY	**Parity of Logical Unit**
	This specifies the parity node of the device. The default is no parity. The various standard parity macros are defined in the `scf.h` header file.
	`#define LUPARITY  NOPARITY`
	`/* default to no parity */`

STOPBITS	**Stop Bits**
	This specifies the number of stop bits to be used for transmission. The default number of stop bits is one.
	`#define STOPBITS  ONESTOP`
	`/* default to one stop bit */`

Table 9-11 SCF Macros (continued)

Name	Description

`WORDSIZE`	**Bits Per Character**
	This specifies the number of bits per character to be used for transmission. The default word size is eight bits per byte.
	`#define WORDSIZE  WORDSIZE8`
	`/* default to 8 bits/byte */`

`RTSSTATE`	**Request to Send Flag**
	This determines the state of the `request to send` line for hardware handshaking. The default state is disabled.
	`#define RTSSTATE  RTSDISABLED`
	`/* default to RTS disabled */`

SCF Control Character Mapping

You can also change the input control character mapping. This involves redefining the control character macro in `SCF/<Driver>/config.des` as described previously. The default input control character mapping macros are located in the `scf.des` file.

Device Specific Non-Standard Definitions

Some SCF drivers require device-specific information to be defined within the logical unit static storage structure. The structure definition is needed for driver and descriptor creation in differing forms (C-source include file for the driver and `EditMod` source for the descriptor).

Write the `EditMod` form of the device-specifics record and adapt the driver's makefile to use `EditMod` to generate the C-source include file from the `EditMod` source.

The `sc85x30` example driver does this in `sc85x30.des`:

```
#define DEV_SPECIFIC

data struct device_specific_des {
/* Device specific static variables */
    u_int32    ("u_char *%s") v_irqport, "device hardware irq register pointer";
    u_int32    ("u_char *%s") v_port, "device hardware register pointer";
    u_char     v_autovect, "autovector flag; 0=chip vector 1=autovector";
}, "sc85x30 device specific storage";
string drvr_name = "sc85x30";
```

Next, the makefile uses `EditMod` to create the `sc85x30.edm` file (example follows), that is included by the primary driver include file, `sc85x30.h`.

```
BUILD = $(EDITMOD) -v$(SDIR) -mDEV_SPECIFICS=device_specific_des

$(SDIR)/sc85x30.edm: $(SDIR)/sc85x30.des $(MAKERS)
     $(BUILD) sc85x30.des -o$@
```

In addition to the standard fields described in `systype.h`, you can add specific definitions for particular driver/descriptor combinations.

Use these steps for adding device specific information to a descriptor:

Step 1. Create an `EditMod` source file with the structure definition of the additional information. For example, in `rb5400.des`:

```
struct dev_specific {
    pointer u_int32 ds_ldrvnam = ldrvnam;
    u_int32 ds_scsiopts, "SCSI options"
};

string ldrvnam, "SCSI low-level driver name";
```

Step 2. Change the driver's header file to indicate the driver has device specific information:

```
#define DEV_SPECIFIC
#include <sc8042.edm>    /* include the EditMod generated header file */
typedef struct dev_specific dev_specific;/* create dev_specific type */
```

Step 3. Add the header generation entry to the makefile for the driver. For example,

```
sc8042.h : sc8042.edm

sc8042.edm : sc8042.des
    $(EDITMOD) -h=dev_specific -o=sc8042.edm sc8042.des
```

Step 4. Ensure the driver's header file is included by the `config.des` file when the descriptor is made. Add an `#include` statement if necessary.

Step 5. After following these steps, make the descriptor using the descriptor makefile.

Chapter 10: Using Hardware-Independent Drivers

This chapter includes the following topics:

- **Simplifying the Porting Process**
- **SCF Driver (scllio)**
- **Virtual Console (iovcons)**

Simplifying the Porting Process

An OS-9 driver module is required for your console device. If the Microware-supplied serial drivers include a driver based on the same device your target platform uses, you only need to set up the proper configuration labels for the device within the `systype.h` file. The Microware-supplied driver and driver-specific descriptor sources are located in the `MWOS/OS9000/SRC/IO/SCF/DRVR` directory.

SCF Driver (scllio)

`scllio` is:

- a high-level OS-9 SCF driver satisfying I/O requests by calling into a low-level serial driver
- not associated with any particular hardware device
- a port-independent module

All hardware specific operations are performed by the low-level driver called by `scllio`.

`scllio` can be in polled input or interrupt driven input modes. The `v_pollin` flag in the device descriptor controls the input mode. Output is always polled. As a result, it is not intended that `scllio` replace a high-level serial driver targeting the specific serial port. Instead, `scllio` is designed to be a useful tool in the porting process.

Once the low-level driver has been written, and a RomBug prompt achieved, `scllio` can be configured as the high-level console to bring the system up to a shell prompt before a proper high-level driver is completed. `scllio` is also useful for initial testing of the polled-interrupt mode of a low-level driver. Polled interrupt support is necessary if the low-level driver is to be used to support Hawk communication. This mode is also used by `scllio` when in interrupt driven mode. This is a less complex use of the polled interrupt mode of the low-level driver. `scllio` can be used to test this mode without involving the various network layers of the TCP/IP communications stack.

The low-level device driver called by `scllio` is specified in the device descriptor used with `scllio`. The device descriptor field `v_llconsname` points to a string containing the abbreviated name (the `cons_abname` field of the console device record) of the low-level console you want `scllio` to communicate through. Two special name strings, `consdev` and `commdev`, can be used in this field to specify, respectively, the configured system console device and communication port. These allow generic specification of a high-level console and communication port based strictly on low-level configuration. The reference platform in OS-9 for Embedded Systems contains an example device descriptor for use with `scllio`.

Virtual Console (iovcons)

The low-level virtual console driver, `iovcons`, appears to the caller to be a standard low-level serial driver. Unlike standard serial-drivers, however, `iovcons` does not communicate with a serial hardware device. Instead `iovcons` transfers I/O requests to the low-level communication modules (TCP/IP stack) in the same way daemons supporting the Hawk debugger do. The configuration of the low-level communication system determines whether the output device used is an Ethernet port or SLIP operating over a serial device.

`iovcons` provides a `telnetd`-like interface to the low-level system console. You can `telnet` to the target processor board to obtain a TCP/IP connection over which the OS-9 boot messages and RomBug input/output occurs. This removes the need for a direct serial connection to the target by providing a remote console.

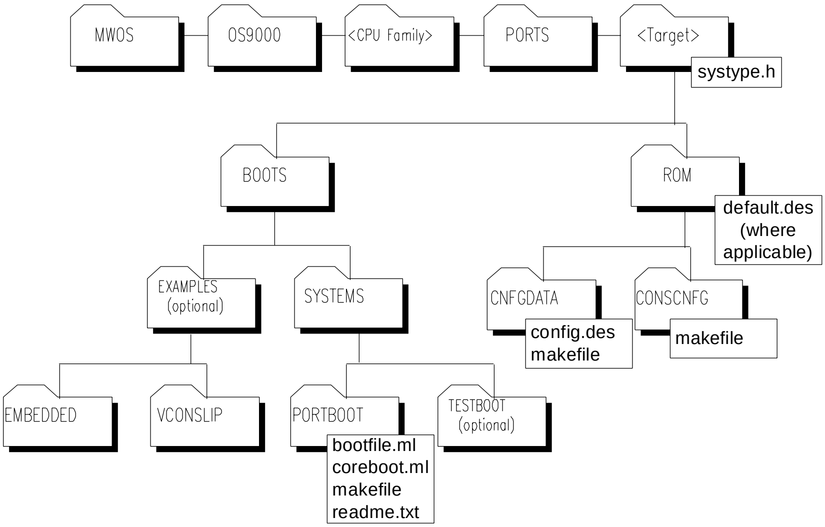
Configuration

Since `iovcons` relies on the low-level networking modules, it must be initialized after these modules in the boot sequence. As a result, the low-level module list used to build the system must be ordered so references to `iovcons` and `conscnfg` appear after the references to the networking modules. The following excerpt from an example `bootfile.ml` file illustrates the required ordering.

```
* Console modules
../../../PPC/CMDS/BOOTOBJS/ROM/console
CMDS/BOOTOBJS/ROM/iosmc
CMDS/BOOTOBJS/ROM/commcnfg
*
* Communications protocol modules
../../../PPC/CMDS/BOOTOBJS/ROM/protoman
../../../PPC/CMDS/BOOTOBJS/ROM/lltcp
../../../PPC/CMDS/BOOTOBJS/ROM/llip
../../../PPC/CMDS/BOOTOBJS/ROM/llslip
*
* Virtual Console
../../../PPC/CMDS/BOOTOBJS/ROM/iovcons
CMDS/BOOTOBJS/ROM/conscnfg
```

The `conscnfg` module looks to the console record in the `cnfgdata` module to determine which low-level driver should be installed as the system console driver. To configure `iovcons` as your system console, declare `VirtualConsole` as the name of your console device in the console port declarations section of `config.des`.

Figure 10-1 <MWOS>/OS9000 scllio and iovcons Directories and Files



The console device record name is specified in the `config.des` (or `default.des`, where applicable) file in the `CNFGDATA` directory. All other fields of the console record are ignored by `iovcons`. The following excerpt from `config.des` provides an example of how to declare a macro.

```
/* Console port */
#define CONS_NAME “VirtualConsole”
```

Chapter 11: Creating a Ticker

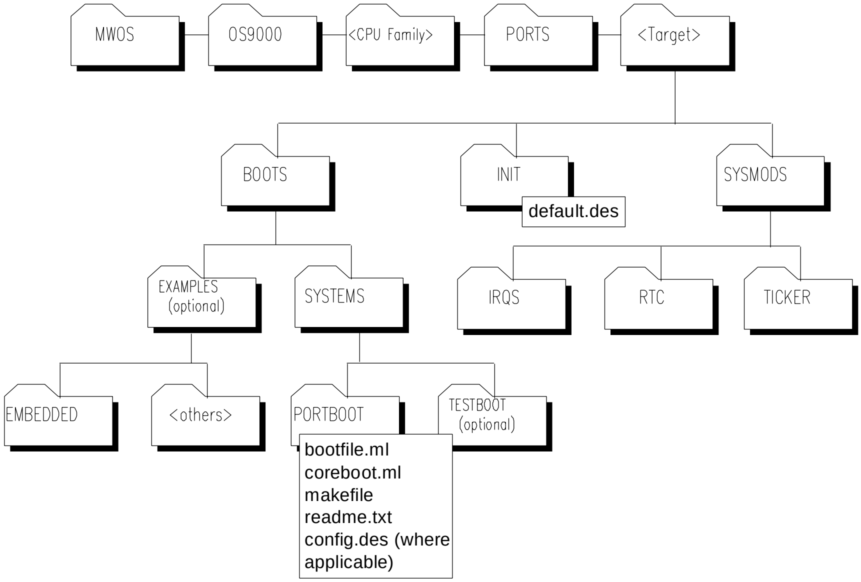
This chapter includes the following topics:

Guidelines for Selecting a Tick Interrupt Device

The interrupt level associated with the timer should be as high as possible. A high interrupt level prevents ticks from being delayed and/or lost due to interrupt activity from other peripherals. Lost ticks cause the kernel's time-keeping functions to lose track of real-time. This can cause a variety of problems in processes requiring precise time scheduling.

The interrupt service routine associated with the timer should be able to determine the source of the interrupt and service the request as quickly as possible.

Figure 11-1 Ticker Setup Directories and Files



Ticker Support

The tick functions for various hardware timers are in the `TICKER` directory.

There are two ticker routines:

- **Tick initialization entry routine**
  This routine is called by the kernel and enables the timer to produce interrupts at the desired rate.
- **Tick interrupt service routine**
  This routine services the tick timer interrupt and calls the kernel's clock service routine.

Note

The ticker module name is user-defined and should be included in the `init` module.

OS-9 Tick Time Setup

You can set the tick timer rate to suit the requirements of the target system. You should define the following variables:

- **Ticks Per Second**
  This value is derived from the count value placed in the tick timer's hardware counter. It reflects the number of tick timer interrupts occurring each second. Most systems set the tick timer to generate 100 ticks per second, but you can vary it. A slower tick rate makes processes receive longer time slices, making multitasking appear sluggish. A faster rate may burden the kernel with extra task-switching overhead due to increased rate for swapping of active tasks.
- **Ticks Per Time Slice**
  This parameter is stored in the `init` module's `m_slice` field. It specifies the number of ticks occurring before the kernel suspends an active process. The kernel checks the active process queue and activates the highest priority active task. The `init.des` module sets this parameter to a default value of 2, but this can be modified by defining the `SLICE` macro in the `default.des` file to the desired value.

  ```
  #define SLICE     2   /* ticks per time slice */
  ```
- **Tick Timer Module Name**
  The name of the tick timer module is specified in the `init` module. Use the `TICK_NAME` macro in the `default.des` file in the `INIT` directory to define this name. For example:

  ```
  #define TICK_NAME "tk8253"
  ```

Tick Timer Activation

You must explicitly start the tick timer to allow the kernel to begin multitasking. This is usually performed by the `setime` utility or by an `_os_setime()` system call during the system startup procedures.

When `_os_setime()` is called, it attempts to link to the tick-timer module name specified in the `init` module. If the tick-timer module is found, the module's entry point is called to initialize the tick timer hardware.

An alternative is to clear the `B_NOCLOCK` bit of the compatibility flag in the `init` module. If this bit is cleared, the kernel automatically starts the tick timer during the kernel's cold start routine. This is equivalent to a `setime -s`.

For More Information

Refer to the ***Utilities Reference*** manual for information about using `setime` or the ***OS-9 Technical Manual*** for information about `_os_setime()`.

Debugging the Ticker

The kernel can automatically start the system clock during its coldstart initialization. The kernel checks the `init` module's `m_compat` word at coldstart. If the `B_NOCLOCK` bit is clear, the kernel performs an `_os_setime()` system call to start the tick timer and set the real time.

This automatic starting of the clock can pose a problem during clock driver development, depending on the state of the real-time clock hardware and the modules associated with the tick timer and real-time clock. If the system software is fully debugged, you should not encounter any problems.

The following is a common scenario if you have not already created a real-time clock: *The system has a working tick module, but no real-time clock support.*

If the `B_NOCLOCK` bit in the `init` module's `m_compat` byte is clear, the kernel performs the `_os_setime()` call. The tick timer code is executed to start the tick timer, but the tick module returns an error because it lacks real-time clock hardware.

The system time is invalid, but time slicing occurs. You can correctly set the real time once the system is up. For example, you can run `setime` from the startup file or a shell command line.

For more information about debugging the ticker in a system with a real-time clock see **Chapter 12: Selecting Real-Time Clock Module Support**.

Chapter 12: Selecting Real-Time Clock Module Support

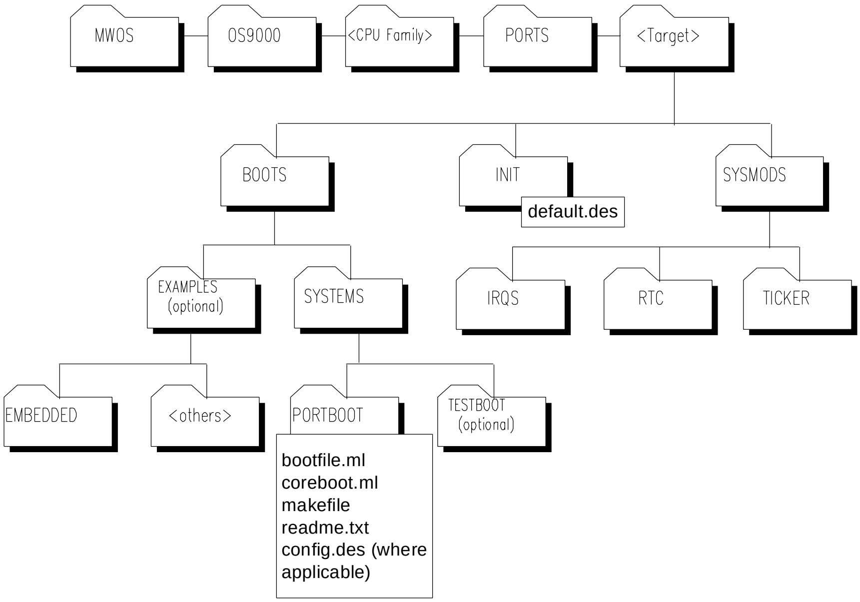
This chapter includes the following topics:

Real-Time Clock Device Support

Real-time clock devices (especially those equipped with battery backup) enable the real time to be set without operator input. OS-9 does not directly support the real-time functions of these devices, although the system tick generator can be a real-time clock device.

The real-time functions of these devices are used with the tick timer initialization. If the system supports a real-time clock, write the tick timer code so the real-time clock is accessed to read the current time or set the time after the ticker is initialized.

Figure 12-1 Real-time Clock Setup Directories and Files



Real-Time Clock Support

The real-time clock functions for various real-time clock devices are in the `MWOS/OS9000/SRC/SYSMODS/RTC` directory. The two real-time clock routines are:

- **Get time**
  This routine reads the current time from the real-time clock device.
- **Set time**
  This routine sets the current time in the real-time clock device.

Automatic System Clock Startup

The kernel can automatically start the system clock during its coldstart initialization. The kernel checks the `init` module's `m_compat` word at coldstart. If the `B_NOCLOCK` bit is clear, the kernel performs an `_os_setime()` system call to start the tick timer and set the real time.

This automatic starting of the clock can pose a problem during clock driver development, depending on the state of the real-time clock hardware and the modules associated with the tick timer and real-time clock. If the system software is fully debugged, you should not encounter any problems.

The following are common scenarios and their implications:

1. **The system has a working tick module and real-time clock support.**
   If the `B_NOCLOCK` bit in the `init` module's `m_compat` byte is clear, the kernel performs the `_os_setime()` call. The tick timer code is executed to start the tick timer running and the real time clock code is executed to read the current time from the device.

   If the time read from the real-time clock is valid, no errors occur and system time slicing and time keeping functions correctly. You do not need to set the system time.

   If the time read from the real-time clock is not valid, the real-time clock code returns an error. This can occur if the battery back-up malfunctions. The system time is invalid, but time slicing occurs. You can correctly set the real time once the system is up.

2. **The system does not have a fully functional/debugged tick timer module and/or real-time clock module.**
   In this situation, executing the tick and/or real-time clock code has unknown and potentially fatal effects on the system. To debug the modules, prevent the kernel from performing an `_os_setime()` call during coldstart by setting the `B_NOCLOCK` flag in the `init` module's `m_compat` word. This enables the system to come up without the clock running. Once the system is up, you can debug the clock modules as required.

Debugging Disk-Based Clock Modules

You should not include any clock modules in the bootfile until they are completely debugged. Use the following steps to debug the clock modules:

Step 1. Make the `init` module with the `B_NOCLOCK` flag in the `m_compat` byte set.

Step 2. Exclude the modules to be tested from the bootfile.

Step 3. Bring up the system.

Step 4. Load the tick/real-time clock modules explicitly.

Step 5. Use the system state debugger or a ROM debugger to set breakpoints at appropriate places in the clock modules.

Step 6. Run the `setime` utility to access the clock modules.

Step 7. Repeat steps three through six until the clock modules are operational.

Use the following steps to include the clock modules when they are operational:

Step 1. Remake the `init` module so the `B_NOCLOCK` flag is clear.

Step 2. Remake the bootfile to include the new `init` module and the desired clock modules.

Step 3. Reboot the system.

Debugging ROM-Based Clock Modules

For ROM-based systems there are two possible situations:

- If the system boots from ROM and has disk support, exclude clock modules from the ROMs until they are fully debugged. They can be debugged in the same manner as for disk-based systems.
- If the system boots from ROM and *does not* have disk support, exclude the clock modules from the ROMs and download them into special RAM until they are fully debugged. Downloading into RAM is required so you can set breakpoints in the modules.

To debug the clock modules:

Step 1. Make the `init` module with the `B_NOCLOCK` flag in the `m_compat` byte set.

Step 2. Program the ROMs with enough modules to bring the system up, but *do not* include the clock modules under test.

Step 3. Power up the system so it enters the ROM debugger.

Step 4. Download the modules to test into the special RAM area.

Step 5. Bring up the system completely.

Step 6. Use the system-state debugger or ROM debugger to set breakpoints at appropriate places in the clock modules.

Step 7. Run the `setime` utility to access the clock modules.

Step 8. Repeat steps three through seven until the clock modules are operational.

When the clock modules are operational:

Step 1. Remake the `init` module so the `B_NOCLOCK` flag is clear.

Step 2. Remake the bootfile to include the new `init` module and the desired clock modules.

Step 3. Reboot the system.

Chapter 13: Creating RBF Drivers and Descriptors

This chapter includes the following topics:

Creating Disk Drivers

Creating a disk driver for your target system is similar to creating a console terminal driver as explained in **Chapter 9: Creating an SCF Device Driver**. However, disk drivers are more complicated. You can use a Microware-supplied sample disk driver source file as a prototype.

If the target system has both floppy disks and hard disks, create the floppy disk driver first, unless they both use a single integrated controller. You can create the hard disk driver after the system is up and running on the floppy.

A test disk must exist with the correct type of OS-9 formatting. If you are using:

- an OS-9 based host system, you can make test disks on the host system.
- a cross-development system, you should obtain sample pre-formatted disks from Microware.

You should make a non-interrupt driver the first time to make your debugging task easier. Make a new download file that includes the disk driver and descriptor modules along with one or two disk-related commands (such as `dir` and `free`) for testing. If you are using the RomBug, include the driver's `.stb` module for easier debugging.

You can add the previously tested and debugged console driver and descriptor modules to your main system boot at this time. This minimizes download time as in the previous step.

Disk drivers make use of the RBF file manager. The Random Block File Manager (RBF) is a re-entrant subroutine package for I/O service requests to random-access devices. Specifically, RBF is a file manager module supporting random-access, block-oriented mass storage devices (disk systems, bubble memory systems, and high-performance tape systems). RBF can handle any number or type of such systems simultaneously. It is responsible for maintaining the logical and physical file structures.

When you write a device driver, do not include MPU/CPU specific code. This makes the device driver portable.

For More Information

Refer to the ***OS-9 Technical Manual*** for more information about device drivers.

RBF supports a wide range of devices having different performance and storage capacities. Consequently, it is highly parameter driven. The physical parameters it uses are stored on the media itself. On disk systems, this information is written on the first sector of track number 0. The device drivers also use the physical parameters stored on sector 0. These parameters are written by the `format` program that initializes and tests the media.

Understanding SCSI Device Driver Differences

This section explains some unique aspects of SCSI device drivers. The basic premise of the SCSI system is to break the OS-9 driver into separate *high-level* and *low-level* areas of functionality. This enables different file managers and drivers to talk to their respective devices on the SCSI bus.

The device driver handles the high-level functionality. The device driver is the module called directly by the appropriate file manager. Device drivers deal with all target-controller-specific/device-class issues (for example, SCSI hard disks or tapes).

Hardware Configurations

The high-level drivers:

Step 1. Prepare the command packets for the SCSI target device.

Step 2. Pass this packet to the low-level subroutine module.

The low-level subroutine module passes the command packet (and data if necessary) to the target device on the SCSI bus. The low-level code does *not* concern itself with the contents of the commands/data; it performs requests for the high-level driver. The low-level module also coordinates all communication requests between the various high-level drivers and itself. The low-level module is often an MPU/CPU specific module, so it can be written as an optimized module for the target system.

The device descriptor module contains the name strings for linking the modules together. The file manager and device driver names are specified in the normal way. The low-level module name associated with the device is indicated through the `ds_ldrvrnam` field in the device-specific portion of the device descriptor. This offset pointer points to a string containing the name of the low-level module.

Example SCSI Software Configuration

An example system setup shows how drivers for disk and tape devices can be mixed on the SCSI bus without interference. The setup includes:

- Micropolis 4221 Hard Disk with embedded SCSI controller addressed as SCSI ID 0
- Archive Viper QIC tape drive with embedded SCSI controller addressed as SCSI ID 4.
- TEAC SCSI floppy disk drive with embedded SCSI controller addressed as SCSI ID 6.
- Host CPU:

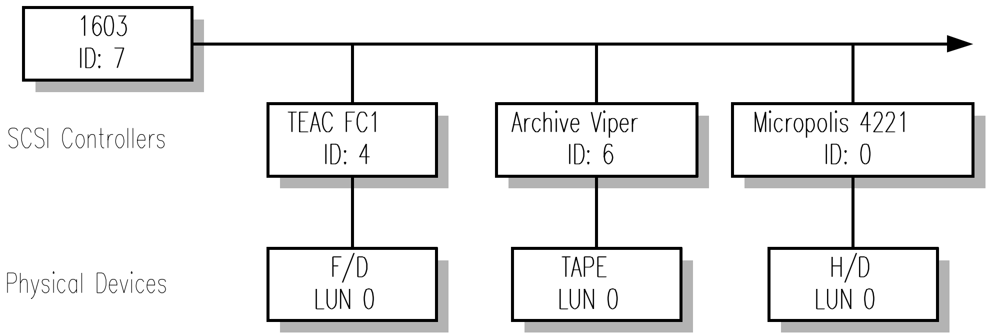
  •MVME1603

  •Uses NCR53C810 or NCR53C825 Interface chip

  •ID of chip is SCSI ID 7

The hardware setup would look like this:

Figure 13-1 SCSI Setup



The high-level drivers associated with this configuration are shown in **Table 13-1**.

Table 13-1 High-Level SCSI Controllers

Name	Handles
RBTEAC	TEAC SCSI floppy devices
SBSCSI	Archive VIPER tape device
RBSCCS	Hard disk device

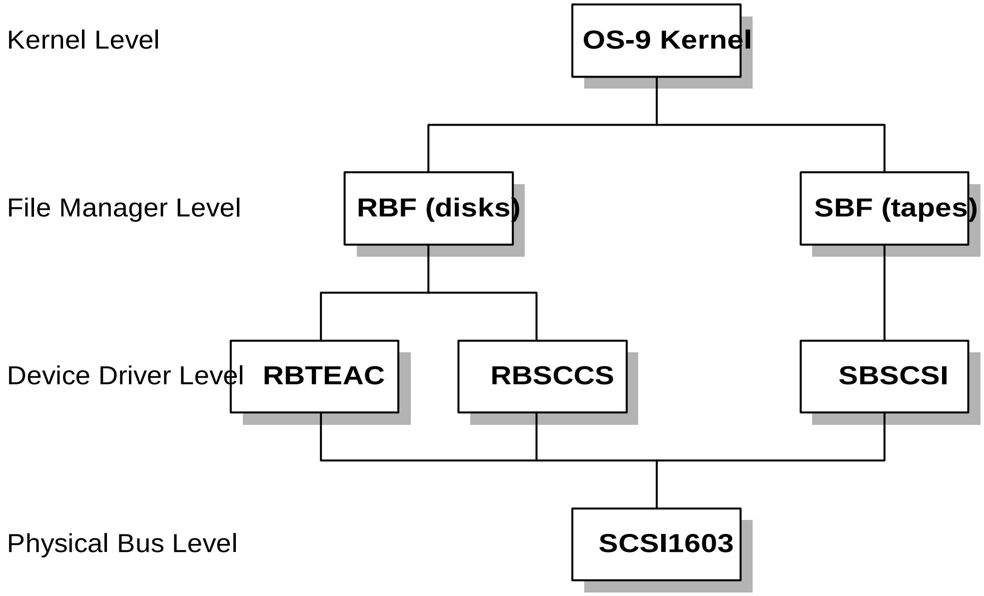
The low-level module associated with this configuration is shown in **Table 13-2**.

Table 13-2 Low-Level SCSI Subroutine Module

Name	Handles
SCSI1603	NCR53C8xx Interface on the MVME1603 CPU

A conceptual map of the OS-9 modules for this system would look like this:

Figure 13-2 OS-9 Modules



Perhaps the most common reconfiguration occurs when you add additional devices of the same type as the existing device. For example, adding an additional disk to the SCSI bus on the MVME1603. To add a similar controller, Micropolis 4220, to the bus, you only need to create a new device descriptor. (The example ports have both `/h0` and `/h1` descriptors that demonstrate the use of additional SCSI disk controller devices.) There are no drivers to write or modify, as these already exist (`RBSCCI` and `SCSI1603`). You need to modify the existing descriptor for the `RBSCCS` device to reflect the second device's physical parameters (such as, SCSI ID) and change the actual name of the descriptor itself.

Testing the Disk Driver

Test the disk driver using the following procedure:

Note
You can omit Steps 1 and 2 if the necessary system modules are in ROM.

Step 1. After a reset, set the debugger's relocation register to the RAM address where you want the system modules (now including the console driver) loaded.

Step 2. Download the system modules. Do not insert breakpoints yet.

Step 3. Set the debugger's relocation register to the RAM address where you want the disk driver and descriptor loaded. Ensure this address does not overlap the area where the system modules were previously loaded.

Step 4. Download the disk driver and descriptor modules. Do not insert breakpoints yet.

Step 5. Type gb to initiate the boot process. If a menu appears, select the *Boot from ROM* option (ro). If all is well, the following message should appear:

```
An OS-9000 kernel was found at $xxxxxxxx
```

This is followed by a register dump and a RomBug prompt. If you do not see this message, the system modules were probably not downloaded correctly or were loaded into the wrong memory area.

Step 6. Type gb again. This executes the kernel's initialization code including the OS-9 module search. You should get another register dump and debug prompt.

Step 7. If you want to insert breakpoints in the disk driver, do so now. This is greatly simplified by attaching to the driver.

Step 8. Type `gb` again. This should start up the system. If all is well and a breakpoint was not encountered first, you should see the following display:

```
Shell $
```

Step 9. Try to run the `dir` utility. If this fails, begin debugging by repeating this procedure with breakpoints inserted in the driver's `INIT, GETSTAT, SETSTAT,` and `READ` routines during Step 8.

Creating RBF Device Drivers

RBF-type device drivers support any random access storage device that reads and writes data in fixed size blocks (for example, disks or bubble memories). The file manager handles all file system processing and passes the driver a data buffer and a logical block number (LBN) for each read or write operation.

Write calls to the driver initiate the block write operation and, if required, a prior *seek* operation. For interrupt driven systems, the controller generates an interrupt when the data has been written from the buffer on to the disk. The driver must suspend itself until the interrupt occurs. DMA operation is preferred if available. If the *verify* flag is set in the path descriptor (`pd_vfy`), the block should be read back and verified.

Drivers for hard disks are relatively simple for two reasons:

- The driver typically works with an intelligent controller.
- The disk format is fixed.

For example, most SCSI type hard disk controllers directly accept OS-9's logical sector number as the physical sector address.

Floppy disk drivers are more complicated. They work with less capable disk controllers and often must handle a variety of disk sizes.

Disk drivers keep a table in the logical unit static variable storage area containing current track addresses and disk format information for each drive (unit). The track addresses are used for controllers with explicit seek commands to determine if the head must be moved prior to a read or write operation. The format data part of each table entry selects density, number of sides, etc.

The `INIT` routine obtains some initialization data from the device descriptor module. Each disk media has similar format information recorded on LBN zero (the `format` utility puts it there). Whenever block zero of a floppy disk is read, the drive's device static storage is updated with the information actually read. This is how the driver automatically adapts to different disk formats. Initialization of the static storage must occur prior to access of any other block on the drive.

RBF Device Driver Storage Definitions

RBF-type device driver modules contain a package of subroutines that perform block oriented I/O to or from a specific hardware controller. Because these modules are re-entrant, one *copy* of the module can simultaneously run several identical I/O controllers.

IOMAN allocates a driver static storage area for each driver and port combination (that may control several drives). The size of this storage area is specified in the device driver module header (`m_data`). RBF requires some of this storage area. The device driver may use the remainder in any manner. IOMAN also allocates a logical unit static storage area for each drive on a controller. The size of this storage area is specified by the device descriptor module (`m_data`). The structure of logical unit static storage is described earlier in this chapter. The format of the part of driver static storage required by RBF is shown here and defined in the header file `rbf.h.` This is the dispatch table pointed to by the `v_dr_stat` field of the device list described in the previous chapter.

```
typedef struct rbf_drv_stat {
     u_int32      funcs,            /* number of functions */
                  (*v_init)(),      /* address of driver init routine */
                  (*v_read)(),      /* address of driver read routine */
                  (*v_write)(),     /* address of driver write routine */
                  (*v_getstat)(),   /* address of driver getstat routine */
                  (*v_setstat)(),   /* address of driver setstat routine */
                  (*v_term)();      /* address of device terminate routine */
     lock_id      v_drvr_rsrc_id;   /* the driver's resource lock ID */
     process_id   v_busy,           /* process using the device */
                  v_wake;           /* for use by the driver */
} rbf_drv_stat, *Rbf_drv_stat;
```

RBF Device Driver Subroutines

As with all device drivers, RBF device drivers use a standard executable memory module format with a module type of `MT_DEVDRVR`.

Within the driver's global static storage resides the dispatch table to the driver functions. Each function should return `0` if the operation was successful. Otherwise, it should return an appropriate error code.

Following is a description of each subroutine.

Table 13-3 RBF Subroutines

Function	Description
`GETSTAT`	Get device status
`INIT`	Initialize device and its static storage area
`IRQ SERVICE ROUTINE`	Service device interrupts
`READ`	Read sector(s)
`SETSTAT`	Set device status
`TERMINATE`	Terminate device
`WRITE`	Write sector(s)

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

GETSTAT

Get Device Status

Syntax

```
error_code getstat(
  void      pb,
  Rbfpd     pd,
  Dev_list  dev);
```

Description

These routines are wildcard calls used to get the device's operating parameters as specified for the OS-9 `getstat` service requests.

Usually all `GetStat` codes return with an `EOS_UNKSVC` (UnKnown Service Request) error.

Parameters

`pb`	is the status parameter block.
`pd`	is the path descriptor.
`dev`	is the device list entry.

INIT

Initialize Device and its Static Storage Area

Syntax

```
error_code (*v_init)(Dev_list dev);
```

Description

The INIT routine must:

1. Check for previous initialization. It must allocate a lock for the driver in the driver static storage and place it in `v_drvr_rsrc_id`.
2. Initialize device control registers (enable interrupts if necessary).
3. If the driver uses interrupts, place the IRQ service routine on the IRQ polling list by using the `F_IRQ` service request.
4. If events are to be used for interrupt signaling, the event should be created and its ID placed in the driver static storage.

Parameters

`dev`	is the device list entry.

IRQ SERVICE ROUTINE

Service Device Interrupts

Syntax

```
error_code irq(Rbf_drvr_stat drvstat);
```

Description

Although this routine is not included in the device driver module branch table and is not called directly by RBF, it is a key routine in interrupt-driven device drivers. Its function is as follows:

1. Poll the device. If the interrupt is not caused by this device, the interrupt service routine should return with an `EOS_NOTME` error code.
2. Service device interrupts.
3. Inform the driver that the interrupt has occurred. This could involve either performing an event set system call or sending a signal, depending on the driver implementation. If the signal method is used, the interrupt service routine must clear the `v_wake` flag in the driver static storage area to notify the driver that the interrupt has indeed occurred.
4. When the IRQ service routine finishes servicing an interrupt, it must return `SUCCESS`. `SUCCESS` is defined in the `const.h` header file.

Note

The IRQ service routine is passed one parameter. This parameter is specified when the driver calls `_os_irq()` to install the service routine on the interrupt polling table. This value is placed in the global pointer register. See the ***Using Ultra C/C++*** manual for the API (global register) used for your processor. This variable should be a pointer to the driver static storage. However, the driver can use this parameter for anything useful.

Parameters

`drvstat`	is the driver static storage.

READ

Read Sector(s)

Syntax

```
error_code read(
   u_int32   blks,
   u_int32   blkaddr,
   Rbfpd     pd,
   Dev_list  dev);
```

Description

The READ routine must:

1. Get the buffer address from `pd_buf` in the path descriptor.
2. Verify the drive number from `pd_drv` in the path descriptor.
3. Compute the physical disk address from the logical block number.
4. Seek to the physical track requested.
5. Read block(s) from the disk into the buffer.
6. Wait for the command to finish.

OS-9 drivers typically use the OS-9 event system to wait for interrupts. The driver read/write routine executes an event wait and the interrupt service routine issues an event signal or event set to inform the driver that the interrupt has occurred. Drivers can also use the more traditional sleep and signal method. To do this, the driver copies the current process ID from `v_busy` in the driver static storage to `v_wake` and does an indefinite sleep (a sleep for 0 ticks). The interrupt service routine then sends a wake up signal to the sleeping process using the ID stored in `v_wake`.

Drivers do not have to be interrupt driven. A driver can simply poll the device waiting for command completion but this hampers time sharing performance. If the disk controller cannot be interrupt-driven, it is necessary to perform a programmed I/O transfer.

Note

Whenever logical sector zero is read, the `idblock` section must be copied to the drive table of logical unit static storage.

If bit number 1 in the `pd_cntl` field is clear, RBF only requests one sector reads. If the bit is set, RBF may request up to `pd_xfersize` bytes of data to be read. RBF divides `pd_xfersize` by the block size to determine the maximum number of blocks that can be transferred. `pd_xfersize` is defined in the path descriptor options section of the device descriptor.

Parameters

`blks`	is the number of blocks to transfer.
`blkaddr`	is the starting block address.
`pd`	is the path descriptor.
`dev`	points to the device list entry.

SETSTAT

Set Device Status

Syntax

```
error_code setstat(
   void       pb,
   Rbfpd      pd,
   Dev_list   dev);
```

Description

These routines are wildcard calls used to get the device's operating parameters as specified for the OS-9 `setstat` service requests.

Typical RBF drivers have routines to handle the `SS_WTRK` and `SS_RESET` `setstat` calls. Usually all `getstat` calls and other `setstat` calls return with an `EOS_UNKSVC` (UnKnown Service Request) error.

Parameters

`pb`	is the status parameter block.
`pd`	is the path descriptor.
`dev`	is the device list entry.

TERMINATE

Terminate Device

Syntax

```
error_code term(Dev_list dev);
```

Description

This routine is called when a device is no longer in use in the system. This is defined as when the link count of its device table entry becomes zero (see `I_ATTACH` and `I_DETACH`).

The TERM routine must:

1. Wait until any pending I/O has completed.
2. Disable the device interrupts.
3. Remove the device from the IRQ polling list.
4. Delete any events used by the driver.
5. Return the lock allocated by the driver in the init routine.

Parameters

`dev`	is the device list entry.

WRITE

Write Sector(s)

Syntax

```
error_code write(
   u_int32   blks,
   u_int32   blkaddr,
   Rbfpd     pd,
   Dev_list  dev);
```

Description

The WRITE routine must:

1. Get the buffer address from `pd_buf` in the path descriptor.
2. Verify the drive number from `pd_drv` in the path descriptor.
3. Compute the physical disk address from the logical block number.
4. Seek to the requested physical track.
5. Write buffer(s) to the disk.
6. Wait for the command to complete.
7. If `pd_vfy` in the path descriptor is equal to zero, read the data back and verify that it is written correctly. We recommend that the compare loop be as short as possible to keep the necessary block interleave value to a minimum.

OS-9 drivers typically use the event system to wait for interrupts. The driver read/write routine executes an event wait and the interrupt service routine issues an event signal or pulse to inform the driver that the interrupt has occurred. Drivers can also use the more traditional sleep and signal method by copying the current process ID from `v_busy` in the driver static storage to `v_wake`. Next, it does an indefinite sleep (a sleep for 0 ticks). The interrupt service routine then sends a wake up signal to the sleeping process using the ID stored in `v_wake`.

Drivers do not have to be interrupt driven. A driver can poll the device waiting for command completion, but this hampers time sharing performance. If the disk controller cannot be interrupt-driven, it is necessary to perform a programmed I/O transfer.

If bit 1 in `pd_cntl` is clear, RBF only requests one block writes. If the bit is set, RBF may request up to `pd_xfersize` bytes of data to be written. RBF divides `pd_xfersize` by the block size to determine the maximum number of blocks that can be transferred. `pd_xfersize` is defined in the path descriptor options section of the device descriptor.

Parameters

`blks`	is the number of blocks to transfer.
`blkaddr`	is the starting block address.
`pd`	is the path descriptor.
`dev`	points to the device list entry.

Using RBF Device Descriptor Modules

The RBF device descriptor consists of four parts:

- The OS-9 module header
- The common information required by IOMAN for all descriptors
- The path descriptor options
- The logical unit static storage

Two of these parts are contained in the following structure. This structure is defined in `rbf.h`:

```
typedef struct rbf_desc {
 dd_com            dd_descom;
 rbf_path_opts     dd_pathopt;
} rbf_desc, *Rbf_desc;
```

Table 13-4 RBF Device Descriptor Structure

Name	Description
`dd_descom`	This is the common information structure IOMAN requires to be in all device descriptors.
`dd_pathopt`	This structure contains the RBF path descriptor options and information IOMAN uses to initialize the device. RBF copies this information into the path descriptor when a file is opened or created.

Logical Unit Static Storage Initialization

IOMAN initializes logical unit static storage from the device descriptor using a declaration of the following structure. This structure is defined in `rbf.h`.

```
typedef struct rbf_lu_stat {
     rbf_drv_info   v_driveinfo;       /* the drive’s information */
     u_char         v_vector,          /* the interrupt vector */
                    v_irqlevel,        /* the interrupt level */
                    v_priority,        /* the interrupt priority */
                    v_unused;          /* unused byte */
     rbf_lu_opts    v_luopt;           /* logical unit options */
     u_int32        v_reserved[2];     /* reserved */
} rbf_lu_stat;
```

Table 13-5 RBF Logical Unit Static Storage Structure

Name	Description
`v_driveinfo`	**Disk Drive Information** RBF maintains information about the media in use in this field. A full description of this structure follows this discussion.
`v_vector`	**Interrupt Vector** This is the vector number of the device interrupt.
`v_irqlevel`	**Interrupt Level** This is the hardware priority of the device interrupt.
`v_priority`	**Interrupt Priority** This is the software (polling) priority of the device interrupt.

Table 13-5 RBF Logical Unit Static Storage Structure (continued)

Name	Description
`v_luopt`	**Device Options** This is the device options section. A full description of this structure follows the discussion on Disk Drive Information.
`v_reserved`	**Reserved** Space reserved for future expansion.

Disk Drive Information

Because RBF supports a wide variety of format options for disk media, it maintains information about the current media being processed in the logical unit static storage for the drive. The structure definition of the drive information is shown here and a description of each field follows. This structure is defined in the header file `rbf.h`.

Note

These values should not be changed from the defaults defined in the descriptor source file.

```
typedef struct rbf_drv_info {
     idblock           v_0;               /* standard ID block stuff */
               /* --> note alignment here <-- */
     lk_desc           v_file_rsrc_lk;    /* the file list resource lock */
     Rbf_path_desc     v_filehd;          /* list of open files on drive */
     lk_desc           v_free_rsrc_lk;    /* free list resource lock */
     struct freeblk    *v_free,           /* pointer to free list structure */
                       *v_freesearch;     /* start search here for free space */
     u_int32           v_diskid;          /* disk ID number */
     fd_segment        v_mapseg;          /* the bitmap segment */
     Idblock           v_bkzero;          /* pointer to block zero buffer */
     u_int32           v_resbit,          /* reserved bitmap block # (if any) */
                       v_trak;            /* current track number */
```

```
     u_int32           v_softerr,        /* recoverable error count */
                       v_harderr;        /* non-recoverable error count */
     struct cachedriv  *v_cache;         /* drive cache information ptr */
     lk_desc           v_crsrc_lk;       /* cache resource lock */
     u_int16           v_numpaths;       /* # of open paths on this device */
     u_char            v_zerord,         /* block zero read flag */
                       v_init;           /* drive initialized flag */
     Rbf_path_opts     v_dopts;          /* copy of the default opts */
     u_char            v_endflag,        /* big/little endian flag */
                       v_dumm2[3];       /* reserved */
     lk_desc           v_fd_free_rsrc_lk; /* FD free list lock*/
     Fdl_list          v_fd_free_list;   /* list of free FD block structures */
     lk_desc           v_blks_rsrc_lk;   /* free block list lock */
     Blockbuf          v_blks_list;      /* list of free block buffers */
     u_int32           v_reserved[4];    /* reserved */
} rbf_drv_info;
```

Table 13-6 RBF Drive Information Structure

Name	Description
`v_0`	**ID Block Structure** This is a copy of the `idblock` structure from the identification sector of the media. The device driver must copy this information from the identification sector every time it is read.
`v_file_rsrc_lk`	**Open File List Lock Descriptor** Lock descriptor structure for locking the open file list.
`v_filehd`	**List of Path Descriptors** This field points to a list of path descriptors, representing the open files on the drive.
`v_free_rsrc_lk`	**Resource List Lock Descriptor** Lock descriptor structure for locking the allocatable resources list.

Table 13-6 RBF Drive Information Structure (continued)

Name	Description
`v_free`	**List of Allocatable Resources** This field points to a data structure, representing the areas on the media free for allocation. RBF searches this data structure when it allocates space for a file.
`v_freesearch`	**Beginning of Free Memory** This field points to the part of the `v_free` data structure for RBF to start searching when it allocates space for a file.
`v_diskid`	**Disk ID** RBF copies the `diskid` field from the `idblock` and stores it in this field. It is used to detect when disks have been changed in a disk drive.
`v_mapseg`	**Allocation Bitmap Segment Information** This field contains the segment information for the RBF allocation map. RBF does not set this field until it needs the allocation map (for an allocation or de-allocation operation).
`v_bkzero`	**Identification Section Pointer** This is a pointer to a buffer containing the identification sector. Only the driver uses this field. RBF never accesses this field.

Table 13-6 RBF Drive Information Structure (continued)

Name	Description
`v_trak`	**Current Track/Cylinder** This is the track/cylinder over which the head is currently positioned. Only the driver uses this field. RBF never accesses this field.
`v_softerr`	**Recoverable Error Count** This is the number of recoverable errors that have occurred on the drive and media. Only the driver uses this field. RBF never accesses this field.
`v_harderr`	**Non-Recoverable Error Count** This is the number of non-recoverable errors that have occurred on the drive and media. Only the driver uses this field. RBF never accesses this field.
`v_cache`	**Data Cache Pointer** This field points to the data caching structure, if caching is being used on the drive.
`v_crsrc_lk`	**Cache Data Lock Descriptor** Lock descriptor structure for locking the disk cache data structure.
`v_numpaths`	**Open Paths On Device** This is the number of open paths on the device.

Table 13-6 RBF Drive Information Structure (continued)

Name	Description
`v_zerord`	**Block 0 Read Flag** RBF drivers use this flag to determine whether or not there is a valid sector 0 buffered. RBF never accesses this field.
`v_init`	**Initialized Drive Flag** This flag indicates that the device has been initialized. RBF drivers use this field to prevent themselves from initializing a device more than once.
`v_dopts`	**Copy of Path Descriptor Options** This is a copy of the path descriptor options. These are detailed in the following section.
`v_endflag`	**Byte Ordering Flag** This flag indicates the byte ordering used by the processor: `BIG_END` Processor uses most significant byte first order `LITTLE_END` Processor uses least significant byte first order
`v_fd_free_rsrc_lk`	**FD Free List Lock Descriptor** Lock descriptor structure for locking the FD free list.
`v_fd_free_list`	**List of Free FD Block Structures** This field points to the list of free file descriptor block structures.

Table 13-6 RBF Drive Information Structure (continued)

Name	Description
`v_blks_rsrc_lk`	**Free Block List Lock Descriptor** Lock descriptor structure for locking the free block list.
`v_blks_list`	**List of Free Block Buffers** This field points to the list of free block buffers used for buffering data blocks.
`v_reserved`	**Reserved for Future Enhancements**

Disk Device Options

This section describes the definitions of the device options for RBF-type devices. The structure definition of the device options is shown here. This structure is defined in the header file `rbf.h`. IOMAN copies the device options from the device descriptor module into the logical unit static storage when the device is attached.

```
typedef struct rbf_lu_opts {
     u_char     lu_stp,          /* step rate */
                lu_tfm,          /* DMA transfer mode */
                lu_lun,          /* drive logical unit number*/
                lu_ctrlrid;      /* controller ID */
     u_int32    lu_totcyls;      /* total number of cylinders */
     u_int32    lu_reserved[4];  /* reserved for future expansion */
} rbf_lu_opts, *Rbf_lu_opts;
```

Table 13-7 RBF Disk Device Option Structure

Name	Description
`lu_stp`	**Step Rate (Floppy disks)** This location contains a code that sets the head stepping rate used with the drive. Set the step rate to the fastest value the drive is capable of to reduce access time. These are the values commonly used: • `0 STEP_30MS` • `1 STEP_20MS` • `2 STEP_12MS` • `3 STEP_6MS`
`lu_tfm`	**DMA Transfer Mode** This is hardware specific. If available, the byte can be set for use of DMA mode. DMA requires only a single interrupt for each block of characters transferred in an I/O operation. It is much faster than methods that interrupt for each character transferred.
`lu_lun`	**Drive Unit Number** This number is used in the command block to identify the drive to the controller. The driver uses this number when specifying the device.
`lu_ctrlrid`	**SCSI Controller ID** This is the ID number of the controller attached to the drive. The driver uses this number when communicating with the controller.

Table 13-7 RBF Disk Device Option Structure (continued)

Name	Description
`lu_reserved`	**Reserved for Future Enhancements**
`lu_totcyls`	**Cylinders On Device** This value is the actual number of cylinders on a partitioned drive. The driver uses this value to correctly initialize the drive.

Path Descriptor Options Table

The structure definition of the RBF path descriptor options is shown here. This structure is defined in the header file `rbf.h`.

```
typedef struct rbf_path_opts {
   u_int32  pd_sid,            /* number of surfaces */
            pd_vfy,            /* 0=verify disk writes */
            pd_format,         /* device format */
            pd_cyl,            /* number of cylinders */
            pd_blk,            /* default blocks/track */
            pd_t0b,            /* default blocks/track for trk0/sec0 */
            pd_sas,            /* segment allocation size */
            pd_ilv,            /* block interleave offset */
            pd_toffs,          /* track base offset */
            pd_boffs,          /* block base offset */
            pd_trys,           /* # tries */
            pd_bsize,          /* size of block in bytes */
            pd_cntl,           /* control word */
            pd_wpc,            /* first write precomp cylinder */
            pd_rwr,            /* first reduced write current cylinder */
            pd_park,           /* park cylinder for hard disks */
            pd_lsnoffs,        /* lsn offset for partition */
            pd_xfersize;       /* max transfer size in terms of bytes */
            pd_reserved[4];    /* reserved for future enhancements */
} rbf_path_opts, *Rbf_path_opts;
```

Table 13-8 RBF Path Descriptor Options Table Structure

Name	Description
`pd_sid`	**Heads or Sides*** This indicates the number of surfaces for a disk unit.
`pd_vfy`	**Write Verification** This field indicates whether a write is verified by a re-read and compare. If `pd_vfy` is: • `0` Verify disk write • `1` No verification **NOTE:** Write verify operations are generally performed on floppy disks but not hard disks because of the lower soft error rate of hard disks.

Table 13-8 RBF Path Descriptor Options Table Structure (continued)

Name	Description
`pd_format`	**Disk Type*** OS-9 supports the following format definitions. These are defined in `rbf.h`: `FMT_DBLTRK0` Track 0 is double density. `FMT_DBLBITDNS` Device is double bit density. `FMT_DBLTRKDNS` Device is double track density. `FMT_DBLSIDE` Device is double sided. `FMT_EIGHTINCH` Drive is eight inch. `FMT_FIVEINCH` Drive is five inch. `FMT_THREEINCH` Drive is three inch. `FMT_HIGHDENS` Device is high density. `FMT_STDFMT` Device is standard format. `FMT_REMOVABLE` Media can be removed. `FMT_HARDISK` Device is a hard disk.
`pd_cyl`	**Cylinders** This is the number of cylinders per disk.
`pd_blk`	**Blocks/Track*** This is the number of blocks per track on all tracks except track 0.
`pd_t0b`	**Blocks/Track 0*** This is the number of blocks per track for track 0. This may be different than `pd_blk` (depending on the specific disk format).

Table 13-8 RBF Path Descriptor Options Table Structure (continued)

Name	Description
`pd_sas`	**Segment Allocation Size** This value specifies the default minimum number of sectors to be allocated when a file is expanded.
`pd_ilv`	**Sector Interleave Factor*** Sectors are arranged on a disk in a certain sequential order (1, 2, 3, etc., 1, 3, 5, etc.). The interleave factor determines the arrangement. For example, if the interleave factor is 2, the sectors would be arranged by 2's (1, 3, 5, etc.) starting at the base sector (refer to `pd_soffs`).
`pd_toffs`	**Track Base Offset*** This is the offset to the first accessible track number. Because Track 0 is often a different density, Track 0 is sometimes not used as the base track.
`pd_boffs`	**Sector Base Offset*** This is the offset to the first accessible sector number. Sector 0 is not always the base sector.
`pd_trys`	**Number of Tries** This is the number of times a device tries to access a disk before returning an error.
`pd_bsize`	**Logical Block Size*** This is the logical block size in bytes.

Table 13-8 RBF Path Descriptor Options Table Structure (continued)

Name	Description
`pd_cntl`	**Control Word** This is the control word. It may currently contain the following: `CTRL_FMTDIS` Disables formatting of the device. `CTRL_MULTI` Device is capable of multi-sector transfers. `CTRL_AUTOSIZE` Device size can be obtained from device. `CTRL_FMTENTIRE` Device requires only one format command. `CTRL_TRKWRITE` Device needs a full track buffer for format.
`pd_wpc`	**Write Precompensation Cylinder** This number determines at which cylinder to begin write precompensation.
`pd_rwr`	**Reduced Write Current Cylinder** This number determines at which cylinder to begin reduced write current.
`pd_park`	**Park Cylinder** This is the cylinder at which to park the hard disk's head, when the drive is to be shut down.

Table 13-8 RBF Path Descriptor Options Table Structure (continued)

Name	Description
`pd_lsnoffs`	**Logical Sector Offset*** This is the offset to be used when accessing a partitioned drive.
`pd_xfersize`	**Maximum Transfer Size** This is the maximum size of memory the controller can transfer at one time. The size is specified in bytes.

* This parameter is format specific

Building RBF Device Descriptors

Making OS-9 device descriptors involves two steps:

Step 1. Modify the appropriate C macro definitions within the `RBF/<Driver>/config.des` for a specific device descriptor.

Step 2. Make the descriptor using the associated makefile.

The `config.des` file is organized so the macro definitions for a particular descriptor are grouped together. For example, the following section of `config.des` contains the macros that must be defined (this is, macros that do not have pre-defined defaults) for the RBF `ram` descriptor. They are grouped together within a C macro conditional:

```
/**********************************************************************
 * Ram Device Default Definitions (All associated descriptors)      *
 *********************************************************************/
/* Module header macros */
#define MH_EDIT     0x7

/* Device descriptor common macros */
#define PORTADDR    0
#define DRVR_NAME   "ram"
#define MODE        0xffff

/* rbf macros */
#define BLKSTRK     2048    /* multiplied by system wide BLKSIZE default   */
                            /* of 256 will equal 512 KByte ram disk.       */
/**********************************************************************
 * End of Ram Device Default Definitions                             *
 *********************************************************************/

/**********************************************************************
 * R0 Ram Descriptor Override Definitions                            *
*********************************************************************/
#if defined (R0) /* R0 descriptor */
/* Module header macros */
#define MH_NAME_OVERRIDE    "r0"

/* Device descriptor common macros */
/* rbf macros */
#endif /* R0 descriptor */
/**********************************************************************
 * End of R0 Ram Descriptor Override Definitions                     *
*********************************************************************/
```

Standard Device Descriptor Macros

This section discusses the standard macro definitions used for creating RBF device descriptors. Some of the macros have predefined values you can redefine in `RBF/<Driver>/config.des` file. Others must be defined for every device descriptor. Each discussion gives the name of the macro, an explanation of the macro, and an example definition (in many cases this is the default value set by Microware).

These five macros are common to RBF, SCF, and SBF descriptors.

Table 13-9 RBF, SCF, and SBF Common Descriptors

Name	Description and Example
`PORTADDR`	**Controller Address** This is the address of the device on the bus. This is the lowest address the device has mapped. Port address is hardware dependent. `#define PORTADDR    0xfffe4000`
`VECTOR`	**Interrupt Vector** This is the vector passed to the processor at interrupt time. Vector is hardware/software dependent. You can program some devices to produce different vectors. `#define VECTOR      80`
`IRQLEVEL`	**Interrupt Level For the Device** The number of supported interrupt levels is dependent on the processor being used. When a device interrupts the processor, the level of the interrupt is used to mask out lower priority devices. `#define IRQLEVEL    4`

Table 13-9 RBF, SCF, and SBF Common Descriptors (continued)

Name	Description and Example
`PRIORITY`	**Interrupt Polling Priority** This value is software dependent. A non-zero priority determines the position of the device within the vector. Lower values are polled first. A priority of 1 indicates the device desires exclusive use of the vector. A priority of 0 indicates the device wants to be the first device on the polling list. OS-9 does not allow a device to claim exclusive use of a vector if another device has already been installed on the vector. Additionally, it does not allow another device to use the vector once the vector has been claimed for exclusive use. `#define PRIORITY    10`
`LUN`	**Logical Unit Number of the Device** More than one device can have the same port address. The logical unit number distinguishes the devices having the same port address. `#define LUN    2    /* drive number */`

RBF Specific Macro Definitions

The following macros are specific to RBF:

Table 13-10 RBF Macro Definitions

Name	Description and Example
`STEP`	**Step Rate** This specifies the step rate to use on the RBF device. The following values are commonly used: **Value / 5" and 3" disks / 8" disks** `0` 30ms 15ms `1` 20ms 10ms `2` 12ms 6ms `3` 6ms 3ms Only the device driver uses the step rate value. The particular driver must determine the correspondence between the step value code and the step rate used on the drive. `#define STEP        3`
`SIDES`	**Number of Heads or Sides** This defines the number of heads on the drive. For example, a double-sided floppy drive would have a `SIDES` value of 2. `#define SIDES       2`
`VERIFY`	**Write Verification Flag** If set to a non-zero value, `VERIFY` indicates a read after write verify is desired. A zero value indicates no verify should be performed. It is up to the device driver to perform the verify. `#define VERIFY   0    /* no verify */`

Table 13-10 RBF Macro Definitions (continued)

Name	Description and Example

`FORMAT`	**Driver Format**
	This defines the format of the drive described by the device descriptor. The definitions of the bits in the format word (16 bits) are defined in `rbf.h`:
	`#define FMT_DBLTRK0     0x0001`
	`   /* track 0 is double density */`
	`#define FMT_DBLBITDNS   0x0002`
	`   /* dev is double bit density */`
	`#define FMT_DBLTRKDNS   0x0004`
	`   /*dev is double track density*/`
	`#define FMT_DBLSIDE     0x0008`
	`   /* device is double sided */`
	`#define FMT_EIGHTINCH   0x0010`
	`   /* drive is eight inch */`
	`#define FMT_FIVEINCH    0x0020`
	`   /* drive is five inch */`
	`#define FMT_THREEINCH   0x0040`
	`   /* drive is three inch */`
	`#define FMT_HIGHDENS    0x1000`
	`   /* device is high density */`
	`#define FMT_STDFMT      0x2000`
	`   /* device is standard format */`
	`#define FMT_REMOVABLE   0x4000`
	`    /* media can be removed */`
	`#define FMT_HARDISK     0x8000`
	`   /* device is a hard disk */`
	`#define FORMAT`
	
	`FMT_STDFMT+FMT_FIVEINCH+FMT_DBLSIDE+FMT_DBLTRKDNS+`
	`FMT_DBLKTRK0`

`CYLNDRS`	**Number of Cylinders** This defines the number of cylinders on the drive. `#define CYLNDRS     80`

Table 13-10 RBF Macro Definitions (continued)

Name	Description and Example
`BLKSTRK`	**Blocks Per Track** This defines the number of blocks per track on the drive on all tracks but track 0. `#define BLKSTRK     16`
`BLKSTRK0`	**Blocks Per Track 0** This defines the number of blocks per track on track 0. Some floppy disk formats use a track 0 format that is different from the rest of the media so at least track 0 can be read. `#define BLKSTRK0    16`
`SEGSIZE`	**Minimum Segment Allocation** This defines the minimum number of blocks RBF should allocate when it is enlarging files. `#define SEGSIZE     1`
`INTRLV`	**Block Interleave Factor** This defines the physical interleave used when formatting the disk media. `#define INTRLV      2`

`DMAMODE`	**DMA Transfer Mode**
	This defines the type of DMA to be performed when transferring data to or from the disk device. Only the device driver uses this value.
	`#define DMAMODE    0`
	`/* DMA transfer mode */`

Table 13-10 RBF Macro Definitions (continued)

Name	Description and Example

`TRKOFFS`	**Track Offset**
	This defines the track offset to use when accessing the device. If a track offset of one is used, for example, logical block 0 is the first block on side 0 of track (cylinder) one.
	`#define TRKOFFS   1`
	`/* one track offset */`

`BLKOFFS`	**Block Offset**
	This defines the offset to use when obtaining the physical block number for a device. A value of 1 indicates blocks are numbered from 1 to `BLKSTRK`. A value of 0 indicates blocks are numbered from 0 to `BLKSTRK` - 1.
	`#define BLKOFFS   1`
	`/* one block offset */`

`BLKSIZE`	**Block Size**
	This defines the size in bytes of the blocks used on the media.
	`#define BLKSIZE   256`
	`/* size of a block */`

Table 13-10 RBF Macro Definitions (continued)

Name	Description and Example

CONTROL	**Format Control Flags**
	This defines the settings of various flags affecting the control of the device. The definitions of the flags are defined in `rbf.h`:
	`#define CTRL_FMTDIS    0x0001`
	`   /* device cannot be formatted */`
	`#define CTRL_MULTI     0x0002`
	`   /* can transfer multi sectors */`
	`#define CTRL_AUTOSIZE  0x0004`
	`   /* device can find its size */`
	`#define CTRL_FMTENTIRE 0x0008`
	`   /* can format entire device */`
	`#define CTRL_TRKWRITE  0x0010`
	`   /* do track writes for format */`
	`#define CONTROL        CTRL_MULTI`
	`   /* control word */`

TRYS	**Number of Retries Before Error** This defines the number of retries that should be performed before returning an error. `#define TRYS        7`
SCSILUN	**SCSI Logical Unit Number** This defines the SCSI logical unit number to be used by a device. Only the device driver uses this value. It can be used for things other than the SCSI logical unit number in the case of non-SCSI drivers. `#define SCSILUN     2`
PRECOMP	**First Cylinder for Write Precompensation** This defines the starting cylinder for write precompensation. Only the driver uses this value. `#define PRECOMP     CYLNDRS`

Table 13-10 RBF Macro Definitions (continued)

Name	Description and Example
`REDWRITE`	**First Cylinder for Reduced Write Current** This defines the starting reduced write current cylinder. Only the driver uses this value. `#define REDWRITE    CYLNDRS`
`PARKCYL`	**Park Cylinder** This defines the cylinder where the read/write heads of the drive should be placed when an `_os_ss_sqd() setstat` is performed. Only the driver uses this value. `#define PARKCYL     0`
`LSNOFFS`	**Logical Block Offset** This defines the logical block offset to be used when accessing the device. This value is added to the logical block address RBF passes to the driver. Only the driver uses this value. `#define LSNOFFS     1`
`TOTCYLS`	**Total Number of Cylinders on Drive** This defines the total number of physical cylinders on the drive. This value is useful when working with physical drives that have been split in to a number of logical drives. Only the driver uses this field. `#define TOTCYLS     80`

Table 13-10 RBF Macro Definitions (continued)

Name	Description and Example
`CTRLRID`	**SCSI Controller ID** This defines the SCSI controller ID for the device being accessed. Only the driver uses this field. You can use it for other purposes on non-SCSI devices. `#define CTRLRID     0`
`DRIVERNAME`	**Name of Driver** This defines the name of the RBF driver used to access the device described by the descriptor. `#define DRIVERNAME  “rb5400”`

Device Specific Non-Standard Definitions

In addition to the standard fields described in `rbf.des`, you can add specific definitions for particular driver/descriptor combinations. It is usually done to accommodate specific RBF drivers.

Use these steps for adding device specific information to a descriptor:

Step 1. Create an `EditMod` source file with the structure definition of the additional information. For example, in `rbsccs.des`:

```
struct dev_specific {
    pointer u_int32 ds_ldrvnam = ldrvnam;
    u_int32 ds_scsiopts, "SCSI options"
};

string ldrvnam, "SCSI low-level driver name";
```

Step 2. Change the driver's header file to indicate the driver has device specific information:

```
#define DEV_SPECIFIC
#include <rbsccs.edm>    /* include the EditMod generated header file */
typedef struct dev_specific dev_specific;/* create dev_specific type */
```

Step 3. Add the header generation entry to the makefile for the driver. For example,

```
rbsccs.h : rbsccs.edm

rbsccs.edm : rbsccs.des
    $(EDITMOD) -h=dev_specific -o=rbsccs.edm rbsccs.des
```

Step 4. Ensure the driver's header file is included by `confi.des` when the descriptor is made. Add an `#include` statement if necessary.

After following these steps, make the descriptor using the descriptor makefile.

Chapter 14: Creating Booters

This chapter includes the following topics:

RadiSys. MICROWARE SOFTWARE

Creating Disk Booters

After creating and debugging the basic disk driver, you will probably want to create a disk booter for the same device. You can use the example disk booters as prototypes.

The basic function of the disk boot routine is to provide the device-specific routines needed to load a boot file containing the OS-9 system modules.

1. The boot file is established on the disk as a special file by the `bootgen` utility.
2. A target-independent module, `fdman`, is aware of the standard RBF file system layout and is called by the disk boot routine to find the boot file and initiate the transfer.
3. `fdman` then calls back the disk boot routines to accomplish the transfer of specific blocks of data from the disk.

If the device is a SCSI device:

1. The disk boot data transfer routines call the services of a target-independent `scsiman` module to manage the SCSI command protocol.
2. `scsiman` uses the services of a target-specific low-level host-adapter module to manage the transfer across the SCSI bus.

If you require a SCSI boot implementation on your target, you need to create a host-adapter module specific to your target, using the example modules as prototypes.

Since the boot system can pass both configured and user parameters to booters, a `parser` module is provided to process the argument lists and place the values in parameter structures accessible from the C language.

The `parser`, `fdman`, `scsiman`, and the host-adapter modules are implemented as *pseudo-booters*. During module startup, they build up a standard boot device record (`bootdev`) with null service pointers and install it onto the list of available booters. Instead of using the `bt_data` field to point to module globals, it points to a pseudo-booter-specific record structure holding pointers to the pseudo-booter's services and any applicable data. The services of `fdman` and `scsiman`, and those required of any SCSI host-adapter are listed in the following sections.

The Boot Device (bootdev) Record and Services

Each booter module establishes one or more boot device records on the list of available boot devices in the Boot Services (`boot_svcs`) record. The definition of the `bootdev` record appears in the header file, `MWOS/SRC/DEFS/ROM/rom.h`, and appears here for illustration.

```
typedef struct bootdev bootdev, *Bootdev;

struct bootdev {
     idver     infoid;
     void     *bt_addr;                 /* the port address */

          /* check for device existence */
          u_int32 (*bt_probe) (Bootdev bdev, Rominfo rinf),

          /* initialize boot device */
          (*bt_init) (Bootdev bdev, Rominfo rinf),

          /* read data from boot device */
          (*bt_read) (u_int32 blks, u_int32 blkaddr, u_char *buff,
               Bootdev bdev, Rominfo rinf),

          /* write data from boot device */
          (*bt_write) (u_int32 blks, u_int32 blkaddr, u_char *buff,
               Bootdev bdev, Rominfo rinf),

          /* terminate the boot device */
          (*bt_term) (Bootdev bdev, Rominfo rinf),

          /* bring boot in from device */
          (*bt_boot) (Bootdev bdev, Rominfo rinf);

     u_int32    bt_flags;               /* misc. flags */
     u_char     *bt_abname,             /* abreviated name */
                *bt_name;               /* full name and description */

     void       *bt_data;               /* special data for boot device */
     Bootdev    bt_next;                /* next device in the list */
     Bootdev    bt_subdev;              /* sub-device record */

     u_char     **user_params;          /* user parameter array */
     u_char     **config_params;        /* configuration parameter array */
     u_char     *config_string;         /* configuration parameter string */
     u_int32    autoboot_delay;         /* autoboot delay time */

     u_int32     bt_reserved[4];        /* reserved for emergency expansion */
};
```

The following entry points describe the services required of each boot device. Pseudo-booters provide none of these services.

Table 14-1 Boot Device Entry Points

Function	Description
`bt_boot()`	Boot from device
`bt_init()`	Initialize device
`bt_probe()`	Probe/verify device
`bt_read()`	Read data from device
`bt_term()`	De-initialize device
`bt_write()`	Write data to device

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

bt_boot()

Boot From Device

Syntax

```
u_int32 bt_boot(
    Bootdev    bdev,
    Rominfo    rinf);
```

Description

This is the main entry point called by the boot system when this boot device is selected. At this time any parameters can be parsed, and the `bt_init()` service is called. SCSI device booters are likely to call scsiman's `ll_install()` routine to install the host adapter module. Disk booters are likely to follow with a call to fdman's `read_bootfile()` routine described later. Finally, `bt_term()` is be called before returning control back to the boot system.

Parameters

`bdev`	points to the disk booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

bt_init()

Initialize Device

Syntax

```
u_int32 bt_init(
    Bootdev   bdev,
    Rominfo   rinf);
```

Description

This routine initializes the device as necessary.

Parameters

`bdev`	points to the disk booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

RadiSys. MICROWARE SOFTWARE

bt_probe()

Probe/Verify Device

Syntax

```
u_int32 bt_probe(
    Bootdev    bdev,
    Rominfo    rinf);
```

Description

The boot system calls `bt_probe()` to determine if the device is available. Usually, this routine at least confirms a boot area can be returned back to the boot system. Devices with fixed configuration can also be probed to determine if they exist. Devices that can be reconfigured by the user probably cannot determine this at this time, since the return value is used when presenting the boot menu to determine if the device should be marked as available. SCSI device booters are likely to determine if the `scsiman` module is available as part of the probe.

Parameters

`bdev`	points to the disk booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

bt_read()

Read Data From Device

Syntax

```
u_int32 bt_read(
   u_int32   blks,
   u_int32   blkaddr,
   u_char    *buff,
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

This routine causes block reads to occur. For disk booters, it is likely to be called from `fdman` or `scsiman` routines. Otherwise, it would be called from the booter's own `bt_boot()` routine.

Parameters

`blks`	is the number of blocks to read.
`blkaddr`	is the address of the block on the media.
`buff`	points to the buffer in which to store the data.
`bdev`	points to the disk booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

bt_term()

De-initialize Device

Syntax

```
u_int32 bt_term(
    Bootdev    bdev,
    Rominfo    rinf);
```

Description

This routine deinitializes the device as necessary.

Parameters

`bdev`	points to the disk booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

bt_write()

Write Data To Device

Syntax

```
u_int32 bt_write(
   u_int32   blks,
   u_int32   blkaddr,
   u_char    *buff,
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

This optional routine causes block writes to occur. Currently, it is never called, but the service was defined in case some custom low-level utility required the function of a custom booter.

As with the low-level serial and timer modules, the booter modules are started at a `p2start()` entry point. This entry is responsible for building the necessary `bootdev` records and installing them on the list of available booters. Remember the `portmenu` module services discussed earlier are still required to configure the appropriate booters for autobooting or menu presentation.

Parameters

`blks`	is the number of blocks to read.
`blkaddr`	is the address of the block on the media.
`buff`	points to the buffer in which to store the data.
`bdev`	points to the disk booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

The parser Module Services

Access to the `parser` module services are through the `paman_svcs` structure defined in `MWOS/SRC/DEFS/ROM/parse.h`.

Table 14-2 `paman_svcs` **Functions**

Function	Description
`getnum()`	Convert numeric string to value
`parse_field()`	Parse keyword equals value string from key table entry

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

getnum()

Convert Numeric String To Value

Syntax

```
u_int32 getnum(char *p);
```

Description

`getnum()` converts the numeric string pointed to by the p parameter into a value and returns it.

Parameters

p	points to the numeric string.

parse_field()

Parse Keyword Equals Value String From Key Table Entry

Syntax

```
u_int32 parse_field(
   char       *argv,
   u_int32    *s,
   char       *kf,
   int        ktflag,
   int        j,
   Rominfo    rinf);
```

Description

`parse_field()` compares the string pointed to by the `kf` parameter and the keyword portion of the string (before the equal sign) pointed to by `argv`. If the two are not equal, the service returns FALSE. If they are equal and the `ktflag` value is 1, the service places the pointer of the value portion of the string (after the equal sign) into `s[j]`. If they are equal and the `ktflag` is zero, `parse_field` places the converted numeric value of the value portion of the string (after the equal sign) into `s[j]`. Generally, this service is called within a booter's loop, incrementing through each potential parameter that a booter can recognize.

Parameters

`argv`	points to the keyword.
`s`	points to the value portion of the string.
`kf`	points to the compare string.
`ktflag`	is a flag.
`j`	is an incrementer.
`rinf`	points to the `rominfo` structure.

The fdman Module Services

Access to the `fdman` module services are through the `fdman_svcs` structure defined in `MWOS/SRC/DEFS/ROM/fdman.h`.

Table 14-3 `fdman_svcs` Functions

Function	Description
`fdboot()`	Validate bootfile
`get_partition()`	Locate bootable partition
`read_bootfile()`	Read bootfile from device

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

fdboot()

Validate Bootfile

Syntax

```
error_code fdboot(
   u_char     *addr,
   u_int32    size,
   Bootdev    bdev,
   Rominfo    rinf);
```

Description

`fdboot()` scans a loaded image to determine the validity of a bootfile.

Parameters

`addr`	is the address of the loaded image.
`size`	is the address of the loaded image.
`bdev`	points to the disk booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

get_partition()

Locate Bootable Partition

Syntax

```
error_code get_partition(
   u_int32   lsnoffs,
   u_int8    pari_start,
   u_int8    pari_end,
   u_char    *sect0,
   u_int32   *offs,
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

`get_partition()` finds the first bootable partition on the disk within the specified partition range.

Parameters

`lsnoffs`	is the original logical sector offset of the drive.
`pari_start`	is the starting partition number to scan.
`pari_end`	is the ending partition number to scan.
`sect0`	points to the sector zero buffer.
`offs`	points to the partition offset pointer.
`bdev`	points to the disk booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

read_bootfile()

Read Bootfile From Device

Syntax

```
error_code read_bootfile(
   u_int32   ssize,
   u_int32   lsnoffs,
   u_int8    pari_start,
   u_int8    pari_end,
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

`read_bootfile()` attempts to read in the first bootfile found on the disk within the specified partition range.

Parameters

`ssize`	is the sector size of the disk.
`lsnoffs`	is the original logical sector offset of the drive.
`pari_start`	is the starting partition number to scan.
`pari_end`	is the ending partition number to scan.
`bdev`	points to the disk booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

The scsiman Module Services

Access to the `scsiman` module services are through the `scsi_svcs` structure defined in `MWOS/SRC/DEFS/ROM/scsiman.h`.

Table 14-4 `scsi_svcs` **Functions**

Function	Description
`da_execnoxfer()`	Execute a SCSI command without data transfer
`da_execute()`	Execute a SCSI command with data transfer
`init_tape()`	Initializes a sequential device
`initsccs()`	Initializes a direct access device
`ll_install()`	Install a low-level SCSI host adapter module
`readsccs()`	Reads a direct access device
`rewind_tape()`	Rewinds a sequential device
`sq_execnoxfer()`	Execute a SCSI command without data transfer
`sq_execute()`	Execute a SCSI command with data transfer

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

da_execnoxfer()

Execute a SCSI Command Without Data Transfer

Syntax

```
error_code da_execnoxfer (
   u_int32   opcode,
   u_int32   blkaddr,
   u_int32   bytcnt,
   u_int32   cmdopts,
   u_int32   cmdtype,
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

`da_execnoxfer()` issues a command to direct access devices.

Parameters

`opcode`	is the SCSI command code.
`blkaddr`	is the direct access device block address.
`bytcnt`	is the size of the data transfer in bytes.
`cmdopts`	are option flags (booters should use 0).
`cmdtype`	indicates the type of command, standard or extended (`CDB_STD` or `CDB_EXT`).
`bdev`	points to the booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

RadiSys. MICROWARE SOFTWARE

da_execute()

Execute a SCSI Command With Data Transfer

Syntax

```
error_code da_execute (
   u_int32   opcode,
   u_int32   blkaddr,
   u_int32   bytcnt,
   u_int32   cmdopts,
   u_char    *buff,
   u_int32   xferflags,
   u_int32   cmdtype,
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

`da_execute()` issues a command to direct access devices and manages the subsequent data transfer.

Parameters

`opcode`	is the SCSI command code.
`blkaddr`	is the direct access device block address.
`bytcnt`	is the size of the data transfer in bytes.
`cmdopts`	are option flags (booters should use 0).
`buff`	points to the data buffer.
`xferflags`	specifies the data transfer direction (`INPUT` or `OUTPUT`).
`cmdtype`	indicates the type of command, standard or extended (`CDB_STD` or `CDB_EXT`).
`bdev`	points to the booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

init_tape()

Initializes a Sequential Device

Syntax

```
error_code init_tape(
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

`init_tape()` initializes a sequential device for subsequent access.

Parameters

`bdev`	points to the booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

initsccs()

Initializes a Direct Access Device

Syntax

```
u_int32 initsccs(
    Bootdev   bdev,
    Rominfo   rinf);
```

Description

`initsccs()` initializes a direct access device for subsequent access.

Parameters

`bdev`	points to the booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

ll_install()

Install a Low-Level SCSI Host Adapter Module

Syntax

```
error_code ll_install(
   char        *name,
   u_int8      *portaddr,
   u_int8      selfid,
   u_int8      reset,
   Bootdev     bdev,
   Rominfo     rinf);
```

Description

`ll_install()` installs the low-level SCSI host-adapter module. The port address, `selfid` and `reset` values are placed into the appropriate `llscsi_svcs` record and the host-adapter's `ll_init()` routine is called.

Parameters

`name`	points to the name of the host-adapter module.
`portaddr`	is the address of the SCSI port.
`selfid`	is the host adapter's SCSI identification
`reset`	is a flag to indicate if the host adapter should reset the SCSI bus or not.
`bdev`	points to the booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

readsccs()

Reads a Direct Access Device

Syntax

```
u_int32 readsccs(
   u_int32   numsects,
   u_int32   blkaddr,
   u_char    *buff,
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

`readsccs()` reads data from a direct access device.

Parameters

`numsects`	is the number of blocks to transfer.
`blkaddr`	is the direct access device block address.
`buff`	points to the data buffer.
`bdev`	points to the booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

rewind_tape()

Rewinds a Sequential Device

Syntax

```
error_code rewind_tape(
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

`rewind_tape()` positions a sequential device to the beginning of information.

Parameters

`bdev`	points to the booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

sq_execnoxfer()

Execute a SCSI Command Without Data Transfer

Syntax

```
error_code sq_execnoxfer(
    u_int32   opcode,
    u_int32   blkcount,
    u_int32   opts,
    u_int32   action,
    Bootdev   bdev,
    Rominfo   rinf);
```

Description

`sq_execnoxfer()` issues a command to sequential devices.

Parameters

`opcode`	is the SCSI command code.
`count`	is the size of the data transfer in blocks or bytes.
`opts`	are option flags (booters should use 0).
`action`	is the immediate state flag.
`bdev`	points to the booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

sq_execute()

Execute a SCSI Command With Data Transfer

Syntax

```
error_code sq_execute(
   u_int32   opcode,
   u_int32   count,
   u_int32   opts,
   u_int32   action,
   u_char    *buff,
   u_int32   xferflags,
   u_int32   bytemode,
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

`sq_execute()` issues a command to sequential devices and manages the subsequent data transfer.

Parameters

`opcode`	is the SCSI command code.
`count`	is the size of the data transfer in blocks or bytes.
`opts`	are option flags (booters should use 0).
`action`	is the immediate state flag.
`buff`	points to the data buffer.
`xferflags`	specifies the data transfer direction (`INPUT` or `OUTPUT`).
`bytemode`	indicates if the count is a block or byte count.
`bdev`	points to the booter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

The SCSI host-adapter Module Services

Access to the host-adapter services are through the `llscsi_svcs` structure defined in `MWOS/SRC/DEFS/ROM/scsiman.h`. If a host adapter module requires global variables, a pointer can be kept in the `reserved2` field of the `llscsi_svcs` structure. Each of the following services would need to make `swap_globals()` calls to set the module globals for the duration of the service.

Table 14-5 `llscsi_svcs` Functions

Function	Description
`llcmd()`	Execute a raw SCSI command
`llexec()`	Execute specified SCSI command
`llinit()`	Initializes host adapter interface
`llterm()`	Terminate host adapter interface

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

llcmd()

Execute a Raw SCSI Command

Syntax

```
error_code llcmd(
   u_int8    *cmd,
   u_int8    *dat,
   u_int32   drive_id,
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

`llcmd()` executes the specified SCSI command.

Parameters

`cmd`	points to a raw SCSI command block.
`dat`	points to the data buffer.
`drive_id`	is the target SCSI identification.
`bdev`	points to the host adapter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

RadiSys. MICROWARE SOFTWARE

llexec()

Execute Specified SCSI Command

Syntax

```
error_code llexec(
   Scsicmdblk   cmd,
   u_int32      atn,
   u_int32      llmode,
   Bootdev      bdev,
   Rominfo      rinf);
```

Description

`llexec()` executes the SCSI command contained in `cmd`. The `adn` and `llmode` fields are passed down to the host adapter module from scsiman. However, the host adapter does not need to honor these fields since using SCSI attention or synchronized transfers during boot is not required.

Parameters

`cmd`	points to the SCSI command block.
`atn`	is the attention flag.
`llmode`	is the mode flag.
`bdev`	points to the host adapter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

llinit()

Initializes Host Adapter Interface

Syntax

```
error_code llinit(
    Bootdev   bdev,
    Rominfo   rinf);
```

Description

`llinit()` initializes the low level SCSI controller for usage. Normally `llinit()` is called by the `scsiman` module through the `ll_install()` service.

Parameters

`bdev`	points to the host adapter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

llterm()

Terminate Host Adapter Interface

Syntax

```
error_code llterm(
   Bootdev   bdev,
   Rominfo   rinf);
```

Description

`llterm()` terminates usage of the host adapter module. Any memory explicitly allocated for driver usage can be returned at this time.

Parameters

`bdev`	points to the host adapter's `bootdev` record.
`rinf`	points to the `rominfo` structure.

Configuration Parameters

Some of the standard configuration parameters recognized by the example booter modules follow. Not all booters support all parameters.

Table 14-6 Standard Configuration Parameters Recognized By Example Booter Modules

Keyword Description	Port Address of Interface
`port`	Address of interface (coded as `0xFF00<bus#>` `<device/unit#>` for autoconfigured PCI devices)
`si`	Starting partition index number
`ei`	Ending partition index number
`device`	Name of low-level SCSI host adaptor module
`reset`	SCSI reset flag
`aux_device`	Name of secondary interface

Table 14-6 Standard Configuration Parameters Recognized By Example Booter Modules (continued)

Keyword Description	Port Address of Interface
`aux_port`	Address of secondary interface

`debug`	Debugging flags for SCSI booters - bit values are:
	`SCSI_DEBUG_CMD 1`
	`SCSI_DEBUG_DATIN 2`
	`SCSI_DEBUG_DATOUT 4`
	`SCSI_DEBUG_MSGIN 8`
	`SCSI_DEBUG_MSGOUT 0x10`
	`SCSI_DEBUG_STATUS 0x20`
	`SCSI_DEBUG_INFO 0x40`
	When SCSI debug options are employed it is recommended that the `SCSI_DEBUG_INFO` option be used. This displays useful information as debug information is processed. Debug phases are displayed in the following form:
	`Data Out Phase: {}`
	`Data IN Phase: ()`
	`Command Phase: []`
	When the `SCSI_DEBUG_INFO` flag is used, the following message is display at the start of each SCSI command:
	`SCSI Debug Enabled. DO={} DI=() CMD=[] Drive ID: 0`

Appendix A: The Core ROM Services

The modularity of the boot code is accomplished by grouping the services into subsets and providing access to these subsets through record structures. This appendix describes the core structures and their services for all target systems. Also, the library services available to all modules is included.

This appendix contains the following topics:

The rominfo Structure

The `rominfo` structure is the focal point of all modularized boot code services. It consists of pointers to all the sub-structures, organized by type of service provided. The definition of the `rominfo` structure resides in the include file, `MWOS/SRC/DEFS/ROM/rom.h`, and appears here (simplified) for illustration.

```
typedef struct rominfo {
     idver          infoid;             /* id_version for rominfo */
     Hw_config      hardware;           /* hardware config struct ptr */
     Mem_svcs       memory;             /* memory services struct ptr */
     Rom_svcs       rom;                /* rom services struct ptr */
     Mod_svcs       modules;            /* module services struct ptr */
     Tim_svcs       timer;              /* timer services struct ptr */
     Cons_svcs      cons;               /* console services struct ptr */
     Proto_man      protoman;           /* protocol manager struct ptr */
     Dbg_svcs       dbg;                /* debugger services struct ptr */
     Boot_svcs      boots;              /* boot services struct ptr */
     Os_svcs        os;                 /* OS services struct ptr */
     Cnfg_svcs      config;             /* configuration services struct ptr */
     Notify_svcs    notify;             /* notification services struct ptr */
     u_int32        reserved;
} rominfo, *Rominfo;
```

The `rominfo` structure and all its substructures have an `infoid` field defined as the type `idver`:

```
     typedef struct idver {
          u_int16     struct_id,        /* structure identifier */
               struct_ver;              /* structure version */
          u_int32     struct_size;      /* allocated structure size */
     } idver, *Idver;
```

The `infoid` field provides identification and version information about the structure. Modules explicitly allocating structures through a `rom_malloc` call can also use the `struct_size` subfield to save the actual size of the memory segment allocated. This is useful when actual size differs from the size requested, and for later explicit freeing, where the actual size needs to be known. The version information can be used to determine the existence of added fields as the structures mature from release to release.

Hardware Configuration Structure

The definition of the `hw_config` structure resides in the include file, `MWOS/SRC/DEFS/ROM/rom.h`, and appears here for illustration.

```
typedef struct {

     union hw_config {

          struct cpu68k_config {
               idver        infoid;               /* id/version for hw_config */
               u_int32      cc_cputype,           /* specific cpu type */
                            cc_fputype,           /* specific fpu type */
                            cc_mmutype,           /* specific mmu type */
                            cc_intctrltype;       /* interrupt controller type */
          } cpu68k;

          struct cpu386_config {
               idver        infoid;               /* id/version for hw_config */
               u_int32      cc_cputype,           /* specific cpu type */
                            cc_fputype,           /* specific fpu type */
                            cc_intctrltype;       /* interrupt controller type */
          } cpu386;

          struct cpuppc_config {
               idver        infoid;               /* id/version for hw_config */
               u_int32      cc_cputype,           /* specific cpu type */
                            cc_fputype,           /* specific fpu type */
                            cc_intctrltype;       /* interrupt controller type */
          } cpuppc;

     } cpu;

          /* cache flushing routine */
          void          (*flush_cache)(u_int32 *addr, u_int32 size, u_int8 type,
                        Rominfo rinf);
          int           reserved;          /* reserved for emergency expansion */

} hw_config, *Hw_config;
```

Of the CPU-specific configuration fields, generally only `cputype` and `fputype` are currently used. The other fields are provided for future use.

The `flush_cache()` service is provided by a separate module (`flshcach`) that only needs to be installed if caching is available and expected to be active. The debugger and other modules that build code segments at runtime require this service.

flush_cache()

Flush the Caches

Syntax

```
u_int32 flush_cache(
   u_int32   *addr,
   u_int32   size,
   u_int8    type,
   Rominfo   rinf);
```

Description

Flush the specified cache region.

Parameters

`addr`	points to the region of memory to flush.
`size`	is the size of the region of memory to flush. If zero, all cache tables are to be flushed.
`type`	is the type of cache to be flushed (if applicable). The available values are: • `HW_CACHETYPE_INST` - instruction cache • `HW_CACHETYPE_DATA` - data cache
`rinf`	points to the `rominfo` structure.

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about this function.

Memory Services

The definition of the `mem_svcs` structure is in the include file, `MWOS/SRC/DEFS/ROM/rom.h`.

```
typedef struct mem_svcs {
        idver       infoid;                 /* id/version for mem_svcs */
        Dumb_mem    rom_memlist;            /* the limited memory list */
        Rom_list    rom_romlist;            /* rom memory list */
        Rom_list    rom_bootlist;           /* boot memory list */
        Rom_list    rom_consumed;           /* memory consumed by roms */
        Rom_list    consumed_next;          /* next free consumed list entry */
        Rom_list    consumed_end;           /* last entry in consumed list */
        u_char      *rom_ramlimit;          /* RAM limit (highest address */
        u_int32     rom_totram;             /* total ram found */

              /* get memory */
        u_int32     (*rom_malloc)(u_int32 *size, char **addr, Rominfo),

              /* free memory */
                    (*rom_free)(u_int32 size, char *addr, Rominfo);

              /* clear memory */
        void        (*mem_clear)(u_int32 size, char *addr);

        u_char      *rom_dmabuff;           /* 64k DMA buffer for >16MB systems */
        int         reserved;               /* reserved for emergency expansion */
} mem_svcs, *Mem_svcs;
```

Most of the fields in the `mem_svcs` structure are for internal bookeeping within the raw `romcore` module and the `rom_malloc()` and `rom_free()` services. The `rom_bootlist` entry pointer is used by booters to communicate the location and size of a boot image.

Table A-1 `mem_svcs` Functions

Function	Description
`mem_clear()`	Clear memory
`rom_free()`	Free allocated memory
`rom_malloc()`	Allocate memory

More Info More Information More Information More Information More -6-

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

mem_clear()

Clear Memory

Syntax

```
void mem_clear(
    u_int32    size,
    char       *addr);
```

Description

`mem_clear()` clears memory. Memory allocated from boot memory pools is always cleared.

Parameters

`size`	is the size of the memory region in bytes to clear.
`addr`	is the address of the memory region to clear.

rom_free()

Free Allocated Memory

Syntax

```
u_int32 rom_free(
   u_int32   size,
   char      *addr,
   char      Rominfo);
```

Description

`rom_free()` returns memory to memory pool. If the request is being made after the operating system is up, an `_os_srtmem()` call is made on behalf of the caller.

Parameters

`size`	is the size of the memory region in bytes being returned.
`addr`	is the address of the memory region being returned.
`Rominfo`	is the `rominfo` pointer.

rom_malloc()

Allocate Memory

Syntax

```
u_int32 rom_malloc(
   u_int32   *size,
   char      **addr,
   Rominfo   rinf);
```

Description

`rom_malloc()` allocates memory from the memory pool. If the request is being made after the operating system is up, an `_os_srqmem()` call is made on behalf of the caller.

Parameters

`size`	points to the size of the memory being requested in bytes. If the size is rounded up to some block size multiple during allocation, the value is adjusted to reflect the actual block size allocated.
`addr`	points to where the address of memory allocated is returned.
`rinf`	is the `Rominfo` pointer.

ROM Services

The definition of the `rom_svcs` structure resides in the include file, `MWOS/SRC/DEFS/ROM/rom.h`, and appears here for illustration.

```
typedef struct rom_svcs {

     idver    infoid;                    /* id/version for rom_svcs */
     void     *rom_glbldata,             /* global data pointer */
              *rom_excptjt,              /* exception jump table */
              *rom_initsp;               /* initial stack pointer */
     u_int32  *rom_vectors;              /* the vector table */

     void     (*rom_start)();            /* reset pc */

     u_char   *kernel_extnd;             /* the kernel extension */
     u_char   *debug_extnd;              /* the debugger extension */
     u_char   *rom_extnd;                /* the ROM extension */

     u_int32  (*use_debug)(Rominfo rinf);      /* debugger enable routine */

     char     *rom_hellomsg;             /* hello message pointer */
     int      reserved;                  /* reserved for emergency expansion */

     } rom_svcs, *Rom_svcs;
```

Most of the `rom_svcs` fields are informational. The `rom_hellomsg` field enables runtime customization of the first bootstrap message printed to the console. The `use_debug()` services is provided by the `usedebug` module to indicate if the debugger should be activated just prior to the boot system starting the boot process.

Module Services

The definition of the mod_svcs structure resides in the include file, MWOS/SRC/DEFS/ROM/rom.h, and appears here for illustration.

```
typedef struct mod_svcs {

    idver     infoid;                  /* id/version for mod_svcs */

              /* init module as P2 */
    u_int32   (*rom_modinit)(u_char *modptr, Rominfo rinf),

              /* deinit module */
              (*rom_moddeinit)(),

              /* insert into list */
              (*rom_modins)(u_char *modptr, Mod_list *mleptr, Rominfo rinf),

              /* delete module from list */
              (*rom_moddel)(u_char *modptr, Rominfo rinf);

              /* find module start ptr */
    void      (*rom_findmod)(u_char *codeptr, u_char **modptr);

              /* find module list entry */
    u_int32     (*rom_findmle)(u_char *modptr, Mod_list *mleptr, Rominfo
rinf);

              /* scan for modules */
    void      (*rom_modscan)(u_char *modptr, u_int32 hdrchk, Rominfo rinf);

    Mod_list  rom_modlist;             /* low-level module list */
    char      *kernel_name;            /* pointer to kernel name string */

              /* validate module */
    u_int32   (*goodmodule)(u_char *modptr, u_int32 bootsize,
              u_int32 *modsize, u_int32 kerchk, Rominfo rinf);

    int       reserved[4];             /* reserved for emergency expansion */

} mod_svcs, *Mod_svcs;
```

The most commonly used services are goodmodule() and rom_modscan().

The goodmodule() service is used by most booters to validate the loadfile image. The rom_modscan() service is used to extend the runtime configurability of the low-level system modules.

Table A-2 `mod_svcs` Functions

Function	Description
`goodmodule()`	Validate bootfile modules
`rom_findmle()`	Find module list entry
`rom_findmod()`	Find beginning of module
`rom_moddeinit()`	De-initialize low-level system modules
`rom_moddel()`	Delete module from module list
`rom_modinit()`	Initialize low-level system modules
`rom_modins()`	Insert module into module list
`rom_modscan()`	Scan for modules

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

goodmodule()

Validate Bootfile Modules

Syntax

```
u_int32 goodmodule(
   u_char     *modptr,
   u_int32    bootsize,
   u_int32    *modsize,
   u_int32    kerchk,
   Rominfo    rinf);
```

Description

This service validates a bootfile module, optionally checking if the module is the kernel.

Parameters

`modptr`	is the address of the module.
`bootsize`	is the size of all modules within the boot image.
`modsize`	is a pointer to the returned size of the module in bytes (if it is good).
`kerchk`	is a flag specifying if the module should be checked as the kernel. A non-zero value indicates the module's name must match the kernel name for the service to succeed.
`rinf`	is a pointer to the `rominfo` structure.

rom_findmle()

Find Module List Entry

Syntax

```
u_int32 rom_findmle(
   u_char     *modptr,
   Mod_list   *mleptr,
   Rominfo    rinf);
```

Description

This service returns the module list entry for the specified module.

Parameters

`modptr`	points to the low-level system module.
`mleptr`	points to the returned module list entry pointer.
`rinf`	points to the `rominfo` structure.

rom_findmod()

Find Beginning Of Module

Syntax

```
void rom_findmod(
    u_char    *codeptr,
    u_char    **modptr);
```

Description

This service scans back from the specified code pointer until it finds a module header.

Parameters

`codeptr`	points to code within the module.
`*modptr`	points to the returned address of the module header.

rom_moddeinit()

De-initialize Low-Level System Modules

Syntax

```
u_int32 rom_moddeinit();
```

Description

This service is currently not implemented.

rom_moddel()

Delete Module From Module List

Syntax

```
u_int32 rom_moddel(
   u_char    *modptr,
   Rominfo   rinf);
```

Description

This service deletes a module list entry from the module list and frees it.

Parameters

`modptr`	points to the low-level system module.
`rinf`	points to the `rominfo` structure.

rom_modinit()

Initialize Low-Level System Modules

Syntax

```
u_int32 rom_modinit(
   u_char    *modptr,
   Rominfo   rinf);
```

Description

This routine starts the low-level system module.

Parameters

`modptr`	points to a low-level system module.
`rinf`	points to the `rominfo` structure.

rom_modins()

Insert Module Into Module List

Syntax

```
u_int32 rom_modins(
   u_char    *modptr,
   Mod_list  *mleptr,
   Rominfo   rinf);
```

Description

This service allocates a module list entry and inserts it onto the module list.

Parameters

`modptr`	points to the low-level system module.
`mleptr`	points to the returned module list entry pointer.
`rinf`	points to the `rominfo` structure.

rom_modscan()

Scan For Modules

Syntax

```
void rom_modscan(
  u_char     *modptr,
  u_int32    hdrchk,
  Rominfo    rinf);
```

Description

This service scans for contiguous modules starting at the specified address and starts them in order of occurrence. When a module is not found, the scan terminates.

`rom_modscan()` enables low-level system modules to be found in memory regions other than the base ROM area (for example, external ROM or flash, on PCMCIA, Industry Pak, or other bus carriers), and enables them to be configured depending on the presence or absence of that memory region.

Parameters

`modptr`	is the base address to scan for modules.
`hdrchk`	is a flag to specify if the module header parity should be checked. If the value is non-zero, the header parity is validated.
`rinf`	points to the `rominfo` structure.

p2lib Utility Functions

Three libraries are shipped as part of this distribution:

- `p2privat.l`
- `romsys.l`
- `p2lib.l`

The `p2privte.l` and `romsys.l` libraries are only used by the bootstrap code (`romcore`). The `p2lib.l` library contains functions you can use to customize your own low-level system modules. The `p2lib.l` functions are explained in this appendix.

Table A-3 `p2lib.l` Functions

Function	Description
`getrinf()`	Get the rominfo structure pointer
`hwprobe()`	Check a system hardware address
`inttoascii()`	Convert an integer to ASCII
`outhex()`	Display one hexidecimal digit
`out1hex()`	Display a hexidecimal byte
`out2hex()`	Display a hexidecimal word
`out4hex()`	Display a hexidecimal longword
`rom_udiv()`	Unsigned integer division

Table A-3 `p2lib.l` Functions (continued)

Function	Description
`setexcpt()`	Install exception handler
`swap_globals()`	Exchange current globals pointer

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

getrinf()

Get the Rominfo Structure Pointer

Syntax

```
error_code getrinf(Rominfo *rinf_p);
```

Description

`getrinf()` finds and returns the pointer to the `rominfo` structure from the system globals.

Parameters

`rinf_p`	is the address where `getrinf()` stores the pointer to the `rominfo` structure.

Note

The current globals register needs to be set to point at the system globals when the service is invoked.

hwprobe()

Check a System Hardware Address

Syntax

```
error_code hwprobe(
   void       *addr,
   u_int32    ptype,
   Rominfo    rinf);
```

Description

`hwprobe()` sets up the appropriate handlers to catch machine check exceptions, and probes the system memory at the specified address, attempting to read either a byte, word, or long. In the event of a machine check, an error is returned. `SUCCESS` is returned if the read is successful.

Parameters

`addr`	is the specific memory address you want probed.
`ptype`	is the probe type, either byte, word, or long.
`rinf`	points to the `rominfo` structure.

inttoascii()

Convert an Integer To ASCII

Syntax

```
char *inttoascii(
    u_int32    value,
    char       *bufptr);
```

Description

`inttoascii()` converts its input value to its base 10 ASCII representation stored in `bufptr`. The caller must ensure `bufptr` points to a sufficient storage space for the ASCII representation. `inttoascii()` returns `bufptr`.

Parameters

`value`	is the integer value to be converted.
`bufptr`	points to the location where the ASCII value is stored.

outhex()

Display One Hexidecimal Digit

Syntax

```
void outhex(
  u_char    n,
  Rominfo   rinf);
```

Description

`outhex()` displays one hexidecimal digit on the system console. The lower 4 bits of the character n are displayed using the `putchar()` service of the system console device.

Parameters

n	is the character for which the hex value is to be displayed.
`rinf`	points to the `rominfo` structure.

out1hex()

Display a Hexidecimal Byte

Syntax

```
void out1hex(
   u_char    byte,
   Rominfo   rinf);
```

Description

`out1hex()` displays the hexidecimal representation of a byte on the system console device.

Parameters

`byte`	is the byte for which the hex value is to be displayed.
`rinf`	points to the `rominfo` structure.

out2hex()

Display a Hexidecimal Word

Syntax

```
void out2hex(
  u_init16  word,
  Rominfo   rinf);
```

Description

`out2hex()` displays the hexidecimal representation of a word on the system console device.

Parameters

`word`	is the word for which the hex value is to be displayed.
`rinf`	points to the `rominfo` structure.

out4hex()

Display a Hexidecimal Longword

Syntax

```
void out4hex(
   u_int32   longword,
   Rominfo   rinf);
```

Description

`out4hex()` displays the hexidecimal representation of a longword on the system console device.

Parameters

`longword`	is the longword for which the hex value is to be displayed.
`rinf`	points to the `rominfo` structure.

out8hex()

Display Hexidecimal Quadword

Syntax

```
void out8hex(unsigned long long quadword,
                 Rominfo              rinf);
```

Description

`out8hex()` displays the hexidecimal representation of a quadword (64 bits) on the system console device

Parameters

`quadword`	is the quadword for which the hex value is to be displayed.
`rinf`	points to the rominfo structure.

rom_udiv()

Unsigned Integer Division

Syntax

```
unsigned rom_udiv(
   unsigned     dividend,
   unsigned     divisor);
```

Description

`rom_udiv()` provides an integer division routine that does not rely on the presence of a built-in hardware division instruction.

Parameters

`dividend`	is the number to be divided.
`divisor`	is the number by which the dividend is to be divided.

setexcpt()

Install Exception Handler

Syntax

```
u_int32 setexcpt(
    u_int32    vector,
    u_int32    irqsvc,
    Rominfo    rinf);
```

Description

`setexcpt()` installs an exception handler on the system exception vector table for the specified exception. This is usually used with the `setjmp()` and `longjmp()` C functions to provide a bus fault recovery mechanism prior to polling hardware.

Parameters

`vector`	is the number of the exception for which the handler should be installed.
`irqsvc`	points to the exception handling code you want installed.
`rinf`	points to the `rominfo` structure.

swap_globals()

Exchange Current Globals Pointer

Syntax

```
u_char *swap_globals(u_char *new_globals);
```

Description

`swap_globals()` replaces the caller's global data pointer with a new value and returns the old value.

Parameters

`new_globals`	is the value to be assigned to the global data pointer.

Appendix B: Optional ROM Services

There are several optional categories of service for a final production boot ROM, which can be implemented according to your desired configuration. Since these services are modularized, they may be left out to conserve required ROM and RAM space, or be included to meet a functional requirement.

This appendix includes the following topics:

- **Configuration Module Services**
- **Console I/O Module Services**
- **Notification Module Services**

Configuration Module Services

The configuration services module, `cnfgfunc`, provides access to data built into the configuration data module. The definition of the `cnfg_svcs` structure resides in the include file, `MWOS/SRC/DEFS/ROM/rom.h`, and appears here for illustration.

```
typedef struct cnfg_svcs {

     idver     infoid;     /* id/version for cnfg_svcs */

     /* configuration service */
     error_code  (*get_config_data)(enum config_element_id id, u_int32 index,
               Rominfo rinf, void *buf);

     /* pointer to configuration data module */
     void     *config_data;

     int     reserved;     /* reserved for emergency expansion */

} cnfg_svcs, *Cnfg_svcs;
```

If no low-level system modules require the configuration services, the `cnfgfunc` and `cnfgdata` modules can be omitted.

get_config_data()

Obtain Configuration Data Element

Syntax

```
error_code(
   enum config_element_id id,
   u_int32   index,
   Rominfo   rinf,
   void      *buf);
```

Description

`get_config_data()` returns the value of the configuration element identified by `id` in the caller supplied location specified by `buf`. The following tables list the available identifiers, their definition, and field type/size.

Table B-1 Console Configuration Elements

Configuration Elements	Description	Type/Size
CONS_REVS	structure version	u_int16
CONS_NAME	console name	char *
CONS_VECTOR	interrupt vector number	u_int32
CONS_PRIORITY	interrupt priority	u_int32
CONS_LEVEL	interrupt level	u_int32
CONS_TIMEOUT	polling timeout	u_int32
CONS_PARITY	parity size	u_int8
CONS_BAUDRATE	baud rate	u_int8

Table B-1 Console Configuration Elements (continued)

Configuration Elements	Description	Type/Size
CONS_WORDSIZE	Character size	u_int8
CONS_STOPBITS	Stop bit	u_int8
CONS_FLOW	Flow control	u_int8

Table B-2 Debugger Configuration Elements

Configuration Elements	Description	Type/Size
DEBUG_REVS	Structure version	u_int16
DEBUG_NAME	Default debugger client name	char *
DEBUG_COLD_FLAG	Flag the client should be called at cold start, or not	u_int32

Table B-3 Protoman Configuration Elements

Configuration Elements	Description	Type/Size
LLPM_REVS	Structure version	u_int16
LLPM_MAXLLPMPROTOS	Max. # of protocols on protocol stack	u_int16

Table B-3 Protoman Configuration Elements (continued)

Configuration Elements	Description	Type/Size
`LLPM_MAXRCVMBUFS`	Number of maximum receive mbuffs	`u_int16`
`LLPM_MAXLLPMCONNS`	Max. # of low level protoman connections	`u_int16`
`LLPM_IFCOUNT`	Number of hardware config entries	`u_int32`

Table B-4 Low-Level Network Interface Config Elements

Configuration Elements	Description	Type/Size
`LLPM_IF_IP_ADDRESS`	IP address	`u_int8[16]`
`LLPM_IF_SUBNET_MASK`	Subnet mask	`u_int8[16]`
`LLPM_IF_BRDCST_ADDRESS`	Broadcast address	`u_int8[16]`
`LLPM_IF_GW_ADDRESS`	Gateway address	`u_int8[16]`
`LLPM_IF_MAC_ADDRESS`	MAC (Ethernet) address	`u_int8[16]`
`LLPM_IF_TYPE`	Type of hardware interface	`u_int8`
`LLPM_IF_ALT_PARITY`	Alternate serial port parity	`u_int8`
`LLPM_IF_ALT_BAUDRATE`	Alternate serial port baud rate	`u_int8`

Table B-4 Low-Level Network Interface Config Elements (continued)

Configuration Elements	Description	Type/Size
LLPM_IF_ALT_WORDSIZE	Alternate serial port word size	u_int8
LLPM_IF_ALT_STOPBITS	Alternate serial port stop bits	u_int8
LLPM_IF_ALT_FLOW	Alternate serial port flow control	u_int8
LLPM_IF_FLAGS	Interface flags	u_int16
LLPM_IF_NAME	Name of hardware interface	char *
LLPM_IF_PORT_ADDRESS	Replacement HW interface address	u_int32
LLPM_IF_VECTOR	Interrupt vector number	u_int32
LLPM_IF_PRIORITY	Interrupt priority	u_int32
LLPM_IF_LEVEL	Interrupt level	u_int32
LLPM_IF_ALT_TIMEOUT	Alternate serial port timeout	u_int32
LLPM_IF_USE_ALT	Alternate usage flags	u_int32

Table B-5 Boot System Configuration Elements

Configuration Elements	Description	Type/Size
BOOT_REVS	Structure version	u_int16
BOOT_COUNT	Number of boot system configuration entries	u_int32
BOOT_CMDSIZE	Maximum size of user input string	u_int32

Table B-6 Booter Configuration Elements

Configuration Elements	Description	Type/Size
BOOTER_ABNAME	Abbreviated booter name	char *
BOOTER_NEWAB	Replacement abbreviated name	char *
BOOTER_NEWNAME	Replacement full name	char *
BOOTER_AUTOMENU	Auto/Menu registration flag	u_int8
BOOTER_PARAMS	Parameter string	char *
BOOTER_AUTODELAY	Autoboot delay time (in microseconds)	u_int32

Table B-7 Notification Services Configuration Elements

Configuration Elements	Description	Type/Size
NTFY_REVS	Structure version	u_int16
NTFY_MAX_NOTIFIERS	Maximum number of registered notifiers	u_int32

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about this function.

Console I/O Module Services

The console module provides a high level I/O interface to the entry points of the low-level serial device driver configured as the system console. These services are made available through the console services field of the rominfo structure. Assuming the variable rinf points to the rominfo structure, rinf->cons can be used to reference the console services record.

The header file MWOS/SRC/DEFS/ROM/rom.h contains the structure definitions for the rominfo structure and the console services record, cons_svcs.

The console services are required when any of the following conditions are met:

1. Console dialog is required to boot the system (for example, using a boot menu or menus).
2. Local system-state debugging with RomBug is required.
3. The communications port is required to support downloading or remote debugging.

If none of these are required in the final system, the console module, the corresponding low-level serial modules, and the console and communications port configuration modules can be omitted.

The following services are available through the console services record.

Table B-8 Console Services

Function	Description
rom_fprintf()	Write a printf-style string to the system console
rom_getc()	Read the first character
rom_getchar()	Read the first character from the system console

Table B-8 Console Services (continued)

Function	Description
`rom_gets()`	Read a null-terminated string from the system console
`rom_putc()`	Output one character
`rom_putchar()`	Output a character to the system console
`rom_puterr()`	Write error code to the system console
`rom_puts()`	Write a null-terminated string to the system console

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

rom_fprintf()

Write a Printf-style String to the System Console

Syntax

```
void rom_fprintf(
Rominfo rinf,
char *fmt,
...);
```

Description

`rom_fprintf()` calls the low-level write routine of the console device record configured for use as the system console. `rom_fprintf()` writes the specified printf-style format string to the console device after replacing the printf escapes with the specified variable arguments. The following escapes are recognized:

%%	a single '%' character
%c	8-bit character
%d	32-bit signed integer
%i	32-bit signed integer
%p	pointer value
%s	null terminated character string
%u	32-bit unsigned integer
%x, %X	32-bit unsigned hexadecimal integer (always prints lower-case)

Illegal escapes are simply printed as part of the output and do not consume any of the variable arguments.

Parameters

`rinf`	points to the rominfo structure.
`fmt`	points to the first character of the printf-style string to output.

Example

```
rinf->cons->rom_fprintf(rinf, "value = %x\n", value);
```

rom_getc()

Read the First Character

Syntax

```
char rom_getc(
   Rominfo   rinf,
   Consdev   cdev);
```

Description

`rom_getc()` calls the low-level read routine of the specified console device record to read a single input character from the associated console device.

`rom_getc()` returns the character read.

Parameters

`rinf`	points to the `rominfo` structure.
`cdev`	points to the console device record for the console device to be used.

Example

```
   char ch;
   ch = rinf->cons->rom_getc(rinf, cdev);
```

rom_getchar()

Read First Character From the System Console

Syntax

```
char rom_getchar(Rominfo rinf);
```

Description

`rom_getchar()` calls the low-level read routine of the console device record configured for use as the system console. `rom_getchar()` reads a character from the console. XON or XOFF characters not processed by the low-level read are ignored.

If echoing is enabled for the console, `rom_getchar()` calls `putchar()` to echo this character. The character is then returned by `rom_getchar()`.

Parameters

`rinf`	points to the `rominfo` structure.

Example

```
ch = rinf->cons->rom_getchar(rinf);
```

rom_gets()

Read a Null-Terminated String From the System Console

Syntax

```
char *rom_gets(
    char      *buff,
    u_int32   count,
    Rominfo   rinf);
```

Description

`rom_gets`() calls the low-level read routine of the console device record configured for use as the system console. `rom_gets`() reads a null-terminated string from the console into the buffer designated by the pointer `buff`. The rudimentary line editing feature of `<backspace>` is supported by `rom_gets`().

`rom_gets`() returns to the caller when it receives a carriage return character `(0x0d)`, or when the number of characters designated by `count` has been read.

Parameters

`buff`	points to the input buffer into which the string is read.
`count`	is the integer used as the size of the input buffer including the null termination.
`rinf`	points to the `rominfo` structure.

Example

```
str = rinf->cons->rom_gets(buffer, count, rinf);
```

rom_putc()

Output One Character

Syntax

```
void rom_putc(
   char       c,
   Rominfo    rinf,
   Consdev    cdev);
```

Description

`rom_putc()` calls the low-level write routine of the specified console device record to output a single character to the associated console device.

Parameters

`c`	is the character to output.
`rinf`	points to the `rominfo` structure.
`cdev`	points to the console device record for the console device to be used.

Example

```
rinf->cons->rom_putc(ch, rinf, cdev);
```

rom_putchar()

Output a Character To the System Console

Syntax

```
void rom_putchar(
   char      c,
   Rominfo   rinf);
```

Description

`rom_putchar()` calls the low-level write routine of the console device record configured for use as the system console. `rom_putchar()` writes the specified character to the console. If the character is a carriage return character `(0x0d)`, `rom_putchar()` also writes a line feed character `(0x0a)` to the console.

Parameters

`c`	is the character to output.
`rinf`	points to the `rominfo` structure.

Example

```
rinf->cons->rom_putchar(ch, rinf);
```

rom_puterr()

Write Error Code To the System Console

Syntax

```
void rom_puterr(
    error_code   stat,
    Rominfo      rinf);
```

Description

`rom_puterr()` converts the specified error code to a null terminated ASCII string representation of the form `AAA:BBB:CCC:DDD` and outputs this string to the system console using the `rom_putc()` service.

Parameters

`stat`	is the value of the error code to be displayed
`rinf`	points to the `rominfo` structure.

Example

```
rinf->cons->rom_getchar(status, rinf);
```

rom_puts()

Write a Null-Terminated String To the System Console

Syntax

```
void rom_puts(
    char        *buff,
    Rominfo    rinf);
```

Description

`rom_puts()` calls the low-level write routine of the console device record configured for use as the system console. `rom_puts()` writes a null terminated string to the console device.

Parameters

`buff`	points to the first character of the string to output.
`rinf`	points to the `rominfo` structure.

Example

```
rinf->cons->rom_puts(buffer, rinf);
```

Notification Module Services

The definition of the `notify_svcs` structure resides in the include file `MWOS/SRC/DEFS/ROM/rom.h`.

```
typedef struct notify_svcs {

    idver       infoid;                 /* id/version for notify_svcs */

    /* handler registration service */
    error_code      (*reg_hndlr)(Rominfo rinf, u_int32 priority,
                    void (*handler)(u_int32 direction, void *parameter),
                    void *parameter, u_int32 *hndlr_id);

    /* handler deregistration service */
    error_code      (*dereg_hndlr)(Rominfo rinf, u_int32 hndlr_id);

    /* notification service */
    error_code      (*rom_notify)(Rominfo rinf, u_int32 direction);

    Notify_hndlr    torom_list,     /* ordered lists of handlers */
                    tosys_list,
                    empty_list;     /* empty list of available records */
    u_int32         last_direction; /* direction of last notification call */

    int         reserved;               /* reserved for emergency expansion */

} notify_svcs, *Notify_svcs;
```

The notification services, `reg_hndlr`() and `dereg_hndlr`(), are commonly used from a low-level driver requiring notification to preserve and restore the state of a hardware interface shared between high-level drivers under the control of the operating system and low-level drivers required for remote debugging communications or local console support.

If no low-level drivers require the notification services, then the `notify` module may be omitted.

Table B-9 Notification Services

Function	Description
`dereg_hndlr()`	Remove registration for notification handler
`reg_hndlr()`	Register notification handler

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

dereg_hndlr()

Remove Registration For Notification Handler

Syntax

```
error_code dereg_hndlr(
   Rominfo   rinf,
   u_int32   hndlr_id);
```

Description

This service deregisters a notification handler.

Parameters

`rinf`	points to the `rominfo` structure.
`hndlr_id`	is the handler ID returned when the handler was registered.

reg_hndlr()

Register Notification Handler

Syntax

```
error_code reg_hndlr(
   Rominfo    rinf,
   u_int32    priority,
   void (*handler)(
      u_int32    direction,
      void       *parameter),
   void       *parameter,
   u_int32    *hndlr_id);
```

Description

This service registers a notification handler.

Parameters

`rinf`	points to the `rominfo` structure.
`priority`	specifies the priority of execution relative to the other registered handlers. Lower numbers are executed prior to higher numbers when transitioning from the operating system to the ROM. When transitioning back, the handlers are executed in the opposite order.
`handler`	points to the actual handler being registered. Its parameters are the transition direction and a local parameter pointer.
`parameter`	specifies the parameter value to be passed to the handler on its activation. This typically points to a data structure defined by the handler.
`hndlr_id`	specifies the address where the handler identification is to be returned.

Appendix C: piclib.l Functions

Overview

The functions to enable and disable interrupts on programmable interrupt controllers (PICs) have been externalized into libraries to minimize the platform dependency on driver sources and binaries. There are three types of libraries available for different driver requirements. Examples of them for *8259-like* (PC) PICs are supplied in your OS-9 Embedded release.

The first two types of libraries are for drivers that are to be optimized for a particular target platform. The example libraries are `piclib.il` (for I-code linking and inlined code optimization) and `piclib.l` (for linking with driver relocatable assembler output files during debugging). These libraries are built to be target platform-specific, since the target determines the I/O location of the PIC and mapping of interrupt numbers to vectors is established by the port to the target.

The third type of library is a subroutine module that can be accessed through a helper library linked with the driver. This enables drivers to be distributed in object form with plug-in cards for bus-based systems and remain portable across target platforms with possibly differing interrupt controllers or mappings. The example `picsub` module is built from a special root psect and the `piclib.l` library mentioned above. The example helper libraries are `picsub.il` and `picsub.l`, for both I-code and traditional linking methods.

For CPU boards that do not employ an interrupt controller, the distribution provides the `nopiclib.il` and `nopiclib.l` libraries, and the `nopicsub` subroutine modules. These libraries do nothing but return a SUCCESS status.

The services available to drivers, and the services to be provided by other custom PIC libraries are `_PIC_ENABLE()` and `_PIC_DISABLE()`.

Table C-1 PIC Services

Function	Description
`_PIC_DISABLE()`	Disable interrupt on PIC hardware
`_PIC_ENABLE()`	Enable interrupt on PIC hardware

For More Information

Refer to the ***OS-9 Porting Guide*** Windows® help file included with Hawk for more information about these functions.

_PIC_DISABLE()

Disable Interrupt On PIC Hardware

Syntax

```
error_code _PIC_DISABLE(u_int32 irqno);
```

Description

`_PIC_DISABLE()` disables the appropriate vector on the interrupt controller hardware.

Parameters

`irqno`	is the OS-9 vector number to disable on the PIC.

_PIC_ENABLE()

Enable Interrupt On PIC Hardware

Syntax

```
error_code _PIC_ENABLE(u_int32 irqno);
```

Description

`_PIC_ENABLE()` enables the appropriate vector on the interrupt controller hardware.

Parameters

`irqno`	is the OS-9 vector number to enable on the PIC.

Index

Symbols

A

B

C

D

E

F

G

H

I

K

L

M

N

O

P

R

S

T

U

V

W

X