Home

OS-9 for 68K Processors OEM Installation Manual

Version 3.3

RadiSys
THE POWER OF WE

www.radisys.com
Revision B • July 2006

Table of Contents

Chapter 1: Getting Started

This chapter includes the following topics:

- **Developing a Plan**
- **The Make Utility**
- **Common File Name Suffixes**
- **Checking the Contents of the Distribution**
- **Structure of the Distribution Package on the Host System**
- **OS-9 Macro Routines**
- **Additional Reference Materials**

Developing a Plan

You have chosen OS-9 for 68K, the world's leading real-time operating system for Motorola 68000-based real-time and embedded systems. Now we hope you find it easy to actually port OS-9 to your new target system. But to do that, it is important you take a little time to develop a plan for accomplishing this.

If you have not already realized it, you need to determine what your development environment will be. This includes such things as:

- What kind of host development system you use to edit and re-compile OS-9 source files.
- What additional development equipment is needed to test your port of OS-9 on your target and how this equipment is connected to your host development system. This is closely tied to the mode of operation you use to port the OS-9 Boot ROMs to your target.

We strongly suggest you read through at least the first three chapters of this manual before attempting to start the port. This should give you a good perspective on what is required to accomplish the port, and should help you develop a better plan.

Before installing OS-9 for 68K, you need to understand two terms:

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

The Host System Hardware

The host system can be any of the following:

- A 68000 family-based computer with at least 2MB RAM and OS-9 for 68K
- Any 286 PC (or greater) running DOS

Note

The installation procedure may vary at times according to the type of development system being used. This is noted when important.

You also need the following on the host system:

- A hard disk. The directory structure of the files supplied in the distribution package assume the host system has a hard disk. This is for storage capacity, not speed. If you use floppy disks, you must rearrange and edit many of the source files and make files. Microware does not guarantee OS-9 can be rebuilt on a host system with only floppy disks.
- Extra RS-232 serial ports for communicating with the target system, PROM programmer, and any PROM or microprocessor emulation systems you choose to use.
- A PROM programmer that can accept data from the host system because you have to make one or more PROMs. Many commercial PROM programmers and emulators, interfacing through RS-232 serial links, accept programming data in the form of Motorola standard *S-records*. S-records are simply binary data, usually object programs, converted to ASCII hex characters in a standardized format.

Note

The Microware-provided software (the `binex` and `exbin` utilities) can convert data to S-record format if necessary.

- A 68000 emulation system (optional). If possible, the emulator should have at least 128K overlay memory. The emulator provides handy real-time debugging facilities, and the overlay memory is a convenient substitute for making ROMs during the testing process.

- PROM emulators (optional). This type of device is most useful with a target known to be functional and an existing resident debugger that does not have downloading capability or when no debugger exists and no emulation system is available.

The Host System Software

The OS-9 Developer's Kit is a source release for Original Equipment Manufacturers (OEMs) designed to be installed on a host system. Use of the OS-9 Developer's Kit requires a separately available toolkit designed for the host system. The types of toolkits available are:

- Hawk for Windows 95/NT
- A resident toolkit for OS-9 systems

Each of the above toolkits includes the Ultra C compiler, assembler and linker, and all utilities necessary to rebuild OS-9.

The Target System Hardware

The target system should consist of the following hardware:

- A 68000 family CPU.
- At least 128K RAM; 512K is recommended.
- At least 64K ROM capacity or an emulator with 64K of overlay memory; however, 128K is required if you plan to use ROMbug. The 64K ROM is for convenience in bringing up OS-9. If the system is disk-based, the eventual target system can use as little as 32K for a boot ROM.
- Two serial I/O ports; one for a terminal and one for communications with the host system. These are only required for the porting process.
- Any other I/O devices OS-9 must eventually support (optional). These are not used in the initial installation steps.

An existing debugger on a functional target can be used in lieu of an emulation system for debugging the OS-9 boot ROMs until ROMbug is functional enough to be used. In this type of configuration, the OS-9 boot

ROM image can be built to run from RAM. However, some mechanism must exist to get the image into RAM, either by downloading through a serial port (using the existing debugger) or by accessing memory from another processor in the same system (a master CPU in a VMEbus system, for example).

Pre-Porting Steps

Before you port OS-9 for 68K:

- Make sure the hardware works. It is difficult to simultaneously debug the hardware and the software. If the target system is an untested prototype, use the assembler to make a simple stand-alone test ROM that just prints a message on a terminal to verify basic hardware functionality. Using emulators and logic analyzers aids in simulation of hardware and software.

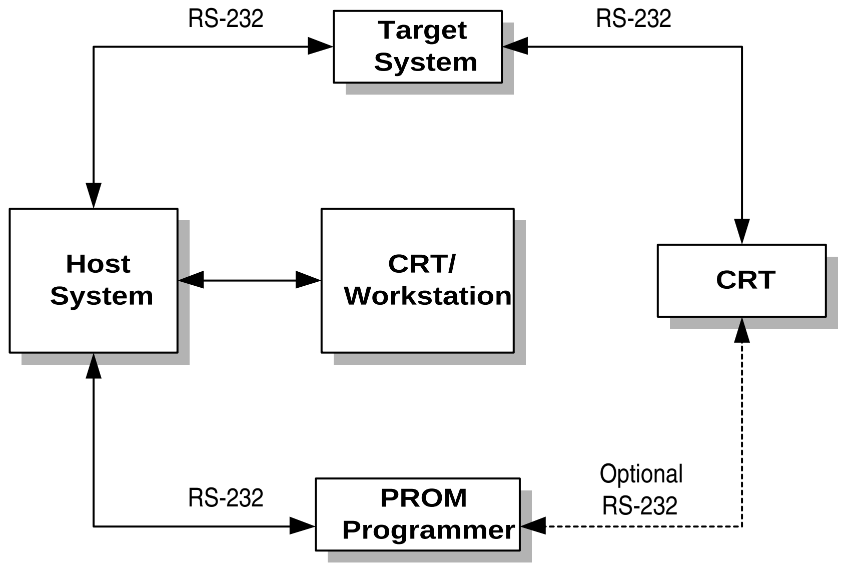
Note

The time invested in writing basic diagnostic software that fully exercises memory, I/O devices, and interrupts is often well worth it.

- Hook up the serial ports that link the host to the target system, and, if possible, test the communications link using existing software that already runs on your host system.

The following is a typical host and target interconnection:

Figure 1-1 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.

If you are porting to a slow processor (for example, 68000 8 MHz), you may have to lower the baud rate in order for the processor to keep up with the transfer.

The X-On/X-Off protocol is used for flow control.

The Make Utility

While you are porting OS-9 for 68K to the target system, you use the `make` utility extensively. The OS-9 `make` utility uses *makefiles* to re-assemble and link many major parts of OS-9. Makefiles simplify software creation and maintenance.

We strongly recommend you use and maintain the makefiles as you port OS-9. The makefiles for each major subsystem are located in the subsystem's highest level directory and are usually named `makefile`.

For More Information

Familiarize yourself with the description of the `make` utility provided in ***Using OS-9 for 68K Processors*** if you are using an OS-9 based host system.

Knowing how the makefiles work is a key to understanding a port. In order for the port to fit into your particular hardware configuration, use flags to conditionalize the code that is assembled/compiled. These flags are fully explained later in this manual. Customize these makefiles to fit your hardware configuration.

Common File Name Suffixes

Microware uses the following file name suffixes to identify file types:

Table 1-1 File Name Suffixes

Suffix	Definition
`.a`	Assembly language source code.
`.c`	C language source code.
`.d`	Definitions (`defs`) source code (for assembly).
`.h`	C header file source code.
`.i`	Microware intermediate code (I-code) files.
`.il`	Microware intermediate code libraries.
`.l`	Library files.
`.m`	Macro files.
`.o`	Assembly language source from the compiler backend.
`.r`	Relocatable object code (for linker input), created by the assembler.
none	Object (binary) files.

Note

In general, OS-9 for 68K does not require file name suffixes. However, certain utilities, such as µMACS and `cc`, do require file name suffixes to determine the mode of operation.

Checking the Contents of the Distribution

You should become familiar with the contents of the distribution package provided by Microware. Verify it is:

- Complete
- The correct version for your host system

The distribution software consists of a set of OS-9 diskettes, discs, or tape cartridges. Refer to the MWOS directory structure described in this chapter for the organization of the shipping/development directory structure.

Structure of the Distribution Package on the Host System

The distribution package contains a large number of files comprising the operating system and its utilities. A few files are source code text files. Most others are object code files. The files are organized into subdirectories according to major subsystems (`ROM`, `IO`, `CMDS`, and so forth).

A master directory called `MWOS` is created. The entire distribution package file system should be copied intact into this directory structure. We have assumed you 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. This allows all source products to reside together in a single directory and provides a means for sharing code across all operating system products.

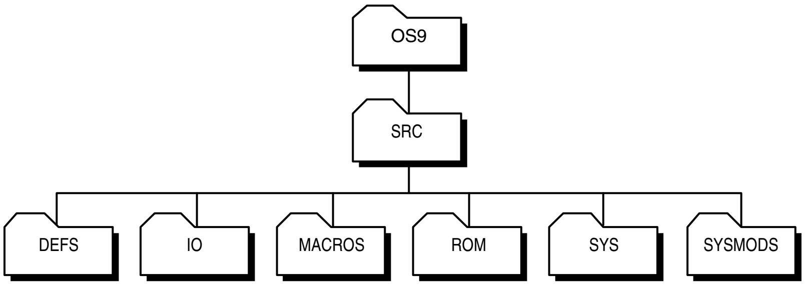
Note

The files in the distribution package assume this specific file and directory organization. They can not assemble and link correctly if the organization is not correct.

MWOS/OS9/SRC Directory Structure

Taking a closer look at `MWOS/OS9/SRC` we see:

Figure 1-2 MWOS/OS9/SRC Directory Structure



These directories are as follows:

Table 1-2 MWOS/OS9/SRC Directories

Directory	Contains
`DEFS`	Files of definitions that apply system-wide, or are target independent. These are both assembler `.d` and C `.h` include files.
`IO`	Sources for all I/O subsystems including file-managers, drivers, and descriptors. The file's subdirectories are organized by subsystem (detailed below).
`IOMAN`	Source for the IOMan module (if you purchased a license for IOMan source), whose functionality was integral to the kernel in previous releases.
`KERNEL`	Source for all kernel variants (if you purchased a license for kernel source).
`LIB`	Sources for all system and subsystem libraries.

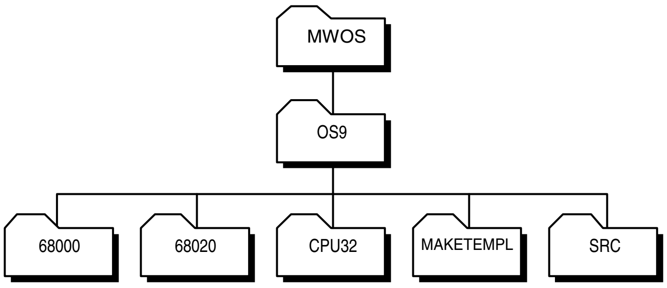
Table 1-2 MWOS/OS9/SRC Directories (continued)

Directory	Contains
`MACROS`	Files of assembly language macro definitions that apply system-wide or are target independent.
`ROM`	Sources for rebuilding all boot ROM components, except for a few that share source with SCSI drivers in IO.
`SYS`	A repository for files and scripts that would end up residing in the OS-9 SYS directory on a root device.
`SYSMODS`	Sources for system extension modules.

MWOS/OS9 Directory Structure

The top-most directory structure is as follows:

Figure 1-3 MWOS/OS9 Directory Structure



These directories are as follows:

Table 1-3 MWOS/OS9 Directories

Directory	Contains
`SRC`	The source files for the OS-9 drivers, descriptors, system modules, defs, and macros. It is intended to be a source directory containing hardware-specific code written to be reuseable from target to target. It is not intended to be the repository for final object modules built from this source, although intermediate object files may be found within its subdirectories.
`MAKETMPL`	A directory for common makefile *templates* (include files for makefiles). In this release, any templates found in this directory apply only to makefiles for ISP and related products.
`68000`, `68020`, and `CPU32`	These remaining directories can be thought of as object directories for target processor architectures or families. It is in these directories that processor-family-specific objects are deposited when built, and where target-specific source code, makefiles, and final objects reside.

OS-9 Macro Routines

The macros in the `SRC/MACROS` directory are designed to be useful, general purpose macros for driver/file, manager/kernel development. Do not place macros pertaining to specific drivers, for example, in this directory.

Note

Do not edit these macros. Many varied source files use these macros, and your changes may have unforeseen consequences to other users.

The following list summarizes each macro's purpose. If you add any macros to this directory, please update this list accordingly.

Table 1-4 OS-9 Macros

Name	Description
`btf.m`	Create branch if true/false instruction sequences, for situations where `Scc` instructions are used to manipulate flags.
`ldbra.m`	Make a `dbra` loop using a 32-bit value.
`longio.m`	Define access methods for devices.
`nvram.m`	Provides NVRAM access.

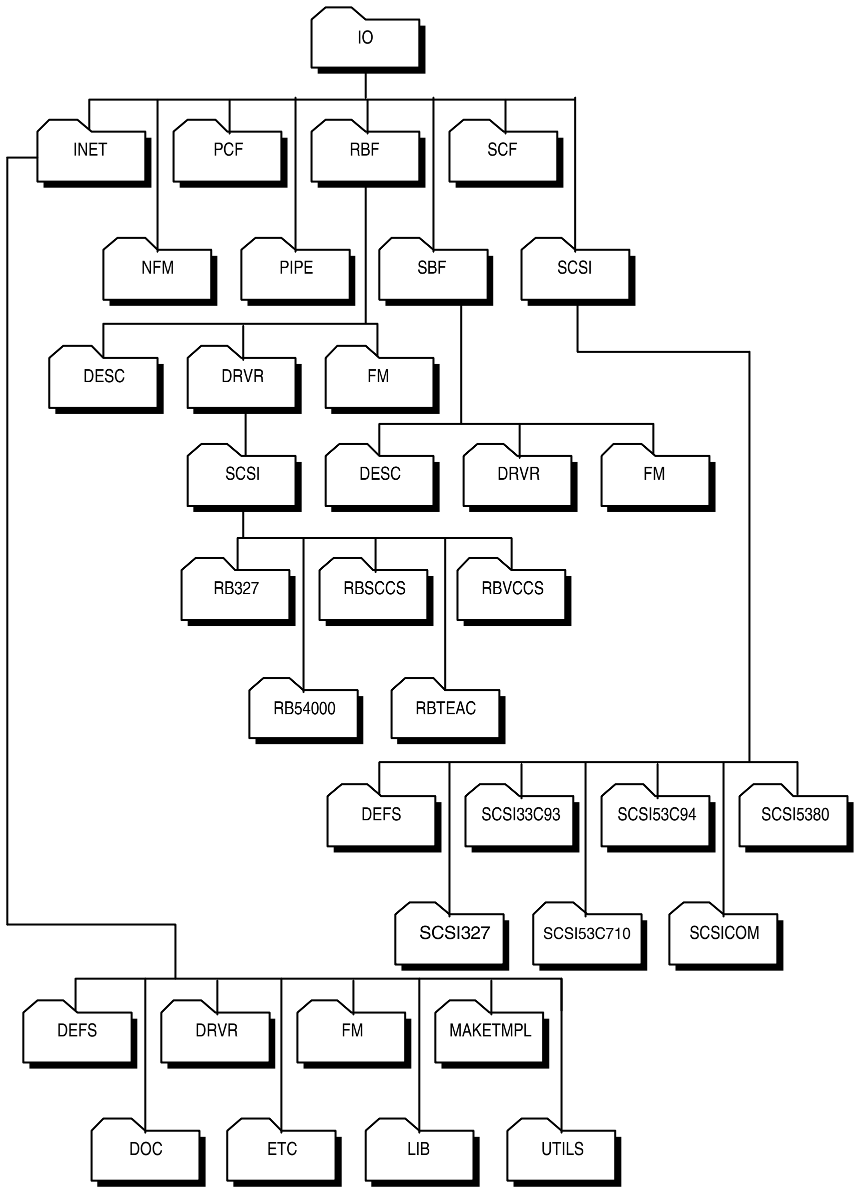
Table 1-4 OS-9 Macros (continued)

Name	Description
os9svc.m	Make a system call quickly in a driver or file manager. This is generally useful only for system calls that do not return parameters (such as `F$Sleep [0]` and `F$Send`). This call heavily relies on intimate knowledge of the kernel, so it should not be considered as a replacement for performing system calls via `Trap#0` (for example `OS9 F$xxx`).
sysglob.m	Get the system global data pointer.
sysboot.m	Bootstrap routines. It allows several bootstrap modules to be used together without getting name clashes for `SysBoot`.
rompak.m	Set for `SysInit` ROM extension code.
reach32.m	Make a 32-bit PC-relative branch.

MWOS/OS9/SRC/IO Directory Structure

Taking a closer look at `MWOS/OS9/SRC/IO` we see:

Figure 1-4 MWOS/OS9/SRC/IO Directory Structure



Almost all of the file manager subsystems contain at least two additional subdirectories:

`DESC` (except for `INET`)	Hholds descriptor sources.
`DRVR`	Holds driver sources.
`FM`	Holds file manager source if you purchased a license for file manager source.

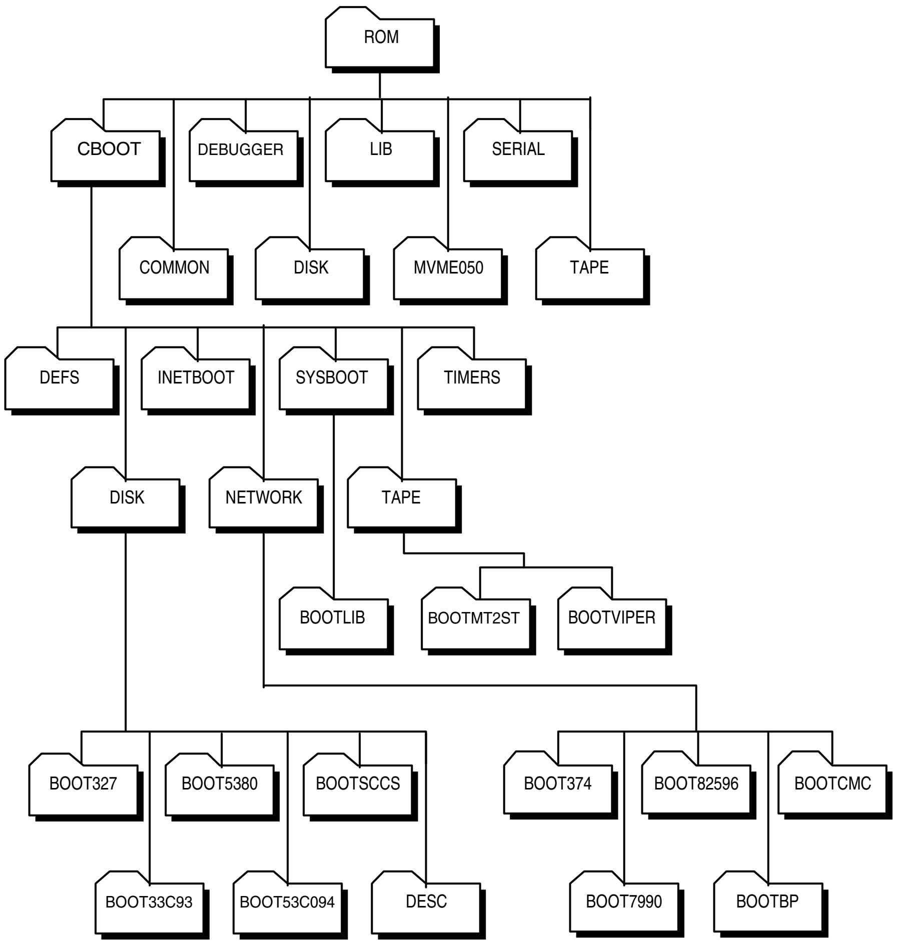
Some file manager subsystem directories contain additional subdirectories for additional functional modularization. For example, the `RBF/DRVR` directory has a `SCSI` subdirectory holding yet more subdirectories for each high-level `SCSI` driver.

In addition to the file manager subsystems, there is a `SCSI` directory for low level `SCSI` drivers whose usage spans across several file managers. See the `SCSI` system notes in Appendix D for more information about `SCSI` drivers.

MWOS/OS9/SRC/ROM Directory Structure

Taking a closer look at `MWOS/OS9/SRC/ROM` we see:

Figure 1-5 MWOS/OS9/SRC/ROM Directory Structure



These directories are as follows:

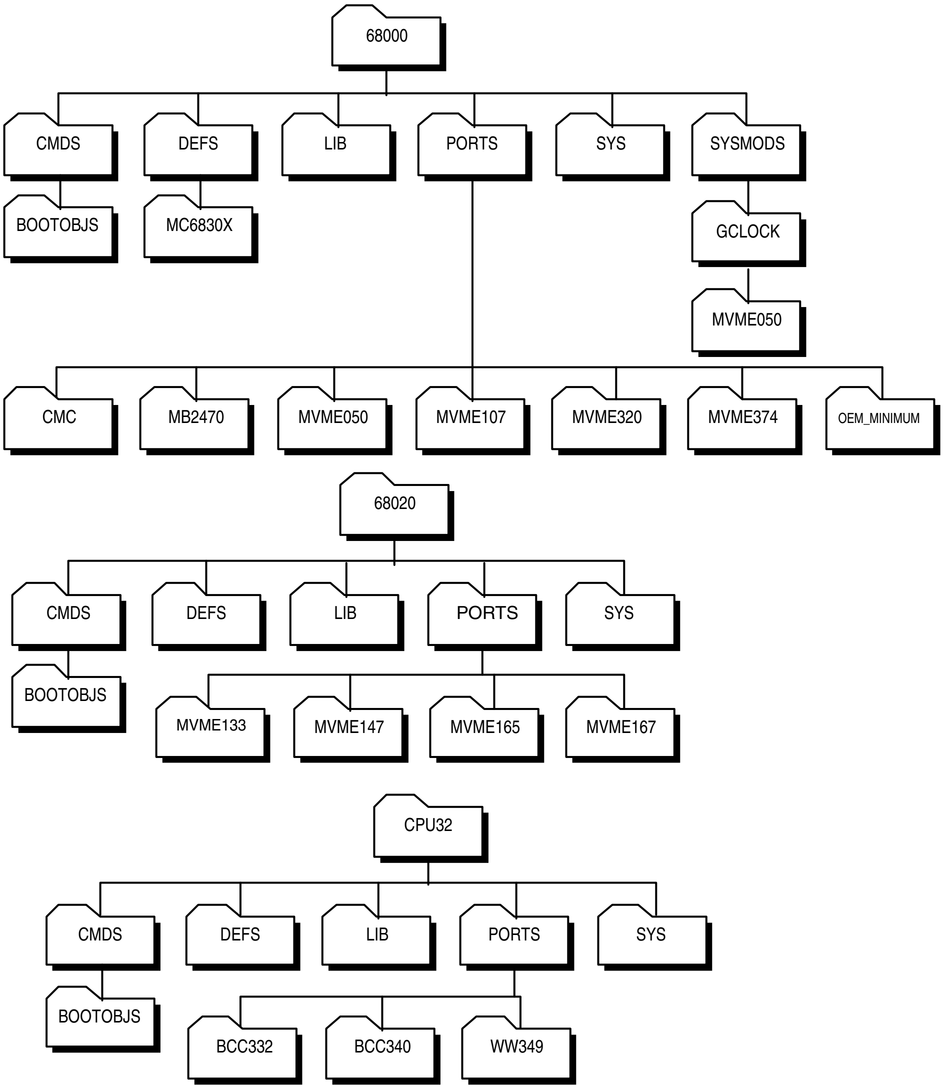
Table 1-5 MWOS/OS9/SRC/ROM Directories

Directory	Contains
`CBOOT`	Contains almost all of the boot code written in C (except for some SCSI driver whose source is shared with the normal running system drivers). As can be seen in the above diagram, it has a subdirectory structure contained within it.
`CBOOT/DEFS`	Include (`.h`) files for interface and media-independent definitions.
`CBOOT/DISK`	Boot disk driver and descriptor source subdirectories.
`CBOOT/INETBOOT`	BOOTP client source.
`CBOOT/NETWORK`	BOOTP network driver source subdirectories.
`CBOOT/SYSBOOT`	General purpose booters and common code libraries.
`CBOOT/TAPE`	Boot tape driver source subdirectories.
`CBOOT/TIMER`	BOOTP timer sources.
`COMMON`	Common assembler sources for all boot ROMs.
`DEBUGGER/ROMBUG`	ROMbug debugger source.
`DISK`	Assembly language boot disk drivers.

Table 1-5 MWOS/OS9/SRC/ROM Directories (continued)

Directory	Contains
`LIB`	Intermediate object libraries for linkage into target ROM images.
`MVME050`	Assembly language system initialization support routines for the MVME050.
`SERIAL`	Assembly language low-level console and communications port drivers.
`TAPE`	Assembly language boot tape drivers.

Figure 1-6 Object Directories



As you can see, there is a different subdirectory structure for each processor family in the 68000 architecture. Commands and system modules common across all 68000 families reside in `68000/CMDS` and `68000/CMDS/BOOTOBJS`. Similarly, descriptors for VMEBus peripherals (MVME050, MVME320, and MVME374) applying to all 68000 families reside in the respective directory in `68000/PORTS`. Clock drivers specific to the MVME050 are built in `68000/SYSMODS/GCLOCK/MVME050`.

Each `PORTS` directory contains directories for example ports to various target VMEBus processors (MVME107 in `68000/PORTS`; MVME133_4, MVME147 and MVME165 in `68020/PORTS`; BCC332, BCC340, and WW349 in `CPU32/PORTS`).

Table 1-6 MWOS Object Directories

Directory	Contains
`CBOOT/SYSBOOT`	General purpose booters and common code libraries.
`CBOOT/TAPE`	Boot tape driver source subdirectories.
`CBOOT/TIMER`	BOOTP timer sources.
`COMMON`	Common assembler sources for all boot ROMs.
`DEBUGGER/ROMBUG`	ROMbug debugger source.
`DISK`	Assembly language boot disk drivers.
`LIB`	Intermediate object libraries for linkage into target ROM images.
`MVME050`	Assembly language system initialization support routines for the MVME050.
`SERIAL`	Assembly language low-level console and communications port drivers.
`TAPE`	Assembly language boot tape drivers.

Additional Reference Materials

If you are not familiar with OS-9, review some of the other Microware manuals. All of the manuals listed here are pertinent to the installation process and are included with the software distribution.

- ***Using OS-9 for 68K Processors***
- ***OS-9 for 68K Processors Technical I/O Manual***
- ***OS-9 for 68K Processors Technical Manual***
- ***OS-9 for 68K PC File Manager (PCM) Manual***
- ***OS-9 for 68K OEM SSD Add-On Pak***
- ***Utilities Reference Manual***
- ***Using RomBug Manual***
- ***Using the Source Level Debugger***
- ***Getting Started with Microware Hawk***
- ***Using Microware Hawk***
- ***Microware Hawk Programming Reference***
- ***Using Hawk Macros***

Review these books until you have a basic idea of how OS-9 works and how it is organized. You should be familiar enough with these manuals so you can easily locate essential information for reference.

Other reference books may also be useful depending on your system's configuration. You can order ***OS-9 Insights*** and the ***OS-9 Primer*** from your Microware distributor.

Depending on your hardware configuration, you may find some or all of the following reference books useful. You can order these reference books directly from Motorola or through most bookstores:

- ***MC68020 32 Bit Microprocessor User's Manual***
  Prentice-Hall
- ***MC68030 Enhanced 32 Bit Microprocessor User's Manual***
  Prentice-Hall

- ***MC68881/MC68882 Floating Point Coprocessor User’s Manual***
  Prentice-Hall
- ***MC68851 User’s Manual***
  Prentice Hall
- ***CPU32 Reference Manual***
  Motorola
- ***MC68332 SIM User’s Manual***
  Motorola
- ***TPU Reference Manual***
  Motorola
- ***Programmer’s Reference Manual***
  Motorola

You can order this reference book from Signetics or Philips:

16/32 Bit Highly-Integrated Microprocessor SCC68070 User Manual
Philips; Parts I (hardware) and II (software)

Chapter 2: Porting OS-9 for 68K

This chapter includes the following topics:

Getting Started

Once you have installed all of OS-9 for 68K's boot code sources, driver sources, and system modes (such as the kernel), the sheer volume of files may overwhelm you.

For More Information

You should keep in mind Microware provides example source files for many different types of device drivers, whether they be serial, disk controller, tickers, or real-time clocks. You only need what your target hardware has available. If you need the disk space, you can get rid of the rest. (Remember, your Microware distribution tape, disc, or disks still contain all of the files.) This can considerably narrow down your focus of porting.

Knowing your hardware well makes it easier for you to port OS-9 to it. The following information is extremely helpful during the porting procedure:

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

Understanding the OS-9 for 68K Booting Process

Although the OS-9 system itself (the kernel, file managers, and processes) is very modular in its architecture, the boot code is different and a distinction is made between the OS-9 system and the OS-9 boot code. You can think of the OS-9 boot code as one program, consisting of several different files, that gets linked together and burned into ROM in order to bring up the OS-9 system.

A *bootfile* must exist in order to boot OS-9. This bootfile is simply merged OS-9 system and program modules, with the kernel usually being the first module.

Note

The bootfile *must* contain the kernel.

This bootfile can exist:

- In ROM
- On a disk
- On a tape
- Any other type of media

The purpose of the boot code is to:

- Set the hardware into a known, stable state
- Set up certain table and memory configurations
- Find the bootfile and start executing the kernel

Three steps are necessary to boot OS-9 for 68K. These are covered in the following pages.

Step 1: Power Up the ROMbug Prompt

Once you supply power to the 68000 processor or a reset occurs, the processor:

- Performs a longword read cycle at address 0.
- Places the result in the `a7` register (stack pointer).
- Performs a longword read cycle at address 4.
- Places the result into the program counter (PC) register.
- Starts executing instructions as it normally does.

Note

Step 1 is the most difficult step to complete, and unless you have an emulator or existing debugger on your running target, much of this step is done *blind*. However, once ROMbug is available, it is a good debugging tool for the remainder of the port.

Many computer boards have address logic that maps these first two reads to wherever the ROM is actually located. Then, the address mapping returns to the board’s standard memory map.

Once this has been done, the processor can execute machine language instructions like it normally does. The initial PC value in the OS-9 boot code is a label called `Reset:`. This label is defined in the `boot.a` file.

For More Information

You can think of `boot.a` as the kernel for booting. It is prewritten and you do not have to modify it. **Chapter 3: Step One: Porting the Boot Code**, contains additional information about `boot.a`.

For more information about `sysinit.a`, refer to **Chapter 3: Step One: Porting the Boot Code**.

Once `boot.a` starts executing, it:

Step 1. Sets up a few variables.

Step 2. Branches to a label called `SysInit`.

`SysInit` is defined in the `sysinit.a` file. Although examples of `sysinit.a` are available from the boot code source, you must modify this file to initialize specific hardware devices on the target board. `SysInit` branches back to `boot.a`.

`boot.a` then:

Step 1. Determines on which processor it is running.

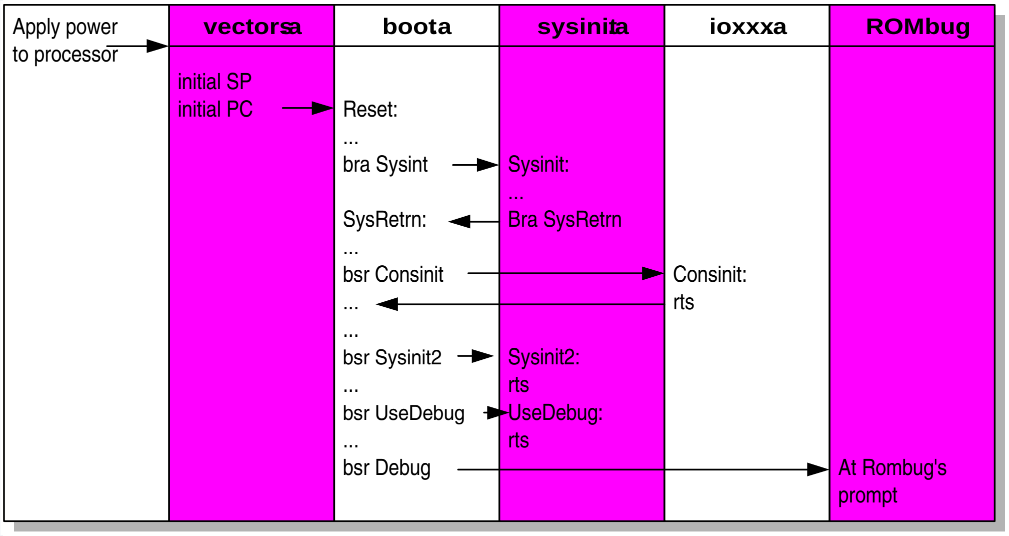
Step 2. Performs memory searches.

Step 3. Calls `ConsInit` in `ioxxx.a` to initialize the console port.

Step 4. Calls `SysInit2` and `UseDebug`, which are also defined in the `sysinit.a` file.

After returning to `boot.a`, the ROM debugger is called to give a register dump of the processor and prompt for more instructions. The following diagram illustrates this process:

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



For More Information

`Boot.a` is covered in more detail in **Chapter 3: Step One: Porting the Boot Code**.

Step 2: ROMbug Prompt to Kernel Entry

`boot.a` branches to the `SysBoot` routine. `SysBoot`:

Step 1. Prompts the operator for the boot media or (optionally) auto-boots from predetermined media (target specific)

Step 2. Finds the bootfile

Step 3. Finds the kernel

Step 4. Returns a pointer to the kernel in the `a0` register

Once SysBoot has found the bootfile and the kernel's pointer is returned to `boot.a`, `boot.a`:

Step 1. Sets up the registers according to the kernel's specifications

Step 2. Jumps to the execution entry point in the kernel

Step 3: Kernel Entry Point to $ Prompt

The cold part of the kernel finishes the task of booting OS-9. It sets up variables in the system global data table (commonly referred to as the *system globals*). It also:

- Builds the kernel's RAM memory pools by searching the memory list
- Builds the module directory by searching colored memory ROM areas, special memory areas, and ROM memory areas
- Initializes system tables (such as the device path table)

From here, it does the following:

Step 1. Open the console device

Step 2. `Chd` to the system device

Step 3. Execute any P2 modules from the Init module's `Extens` list

Step 4. Fork the first process

The cold part of the kernel then disinherits the first process and exits by calling the kernel's system execution loop. The OS-9 system should now be booted and executing as expected.

For More Information

For more information about the kernel's cold routine, refer to **Chapter 4: Step Two: Bringing Up the Kernel and Console I/O**.

The Four Porting Steps

Four steps are required to port OS-9 on your target hardware. The following chapters explain these procedures in greater detail.

Step 1. **Porting the boot code.**
This procedure includes steps 1 and 2 of the OS-9 boot process. The files needed to accomplish this are `vectors.a`, `boot.a`, `ioxxx.a`, `ioyyy.a`, `sysinit.a`, `systype.d`, `syscon.c`, `bootio.c`, and the `sysboot` and `rombug` libraries. This step includes:

- Hardware dependent initialization and configuration (`sysinit.a`).
- ROMbug.
- The ability to boot from ROM or an image downloaded into RAM. You must define key labels in `systype.d` and the makefile to correctly configure the code for your particular target hardware.

For More Information

Chapter 3: Step One: Porting the Boot Code, contains more information about the files needed.

Note

For your initial port of OS-9 to your target, we strongly recommend you first create a ROM/RAM based system to reduce the complexity of the port (downloading target-specific modules into RAM through ROMbug's communication port from the development system). Later, as more of the port is accomplished, you can incorporate other booting methods. For this reason, source for a simple ROM/RAM boot routine has been included in **Appendix F: Example ROM Source and Makefiles**. This simple menu booter is `syscon.c`.

Step 2. **Porting the OS-9 kernel and basic I/O system.**
This involves more modification to the `systype.d` file. You need to make an `Init` module and high-level serial drivers and descriptors for your particular hardware. Once this is complete and is working, a ROM-able OS-9 system exists.

For More Information

The `Init` module is a data module from which the kernel configures itself. For more information about the Init module, refer to Chapter 2, ***The Kernel***, in the ***OS-9 for 68K Technical Manual.***

Step 3. **Creating customized I/O drivers and finishing the boot code.**
In this porting procedure, more high-level drivers are developed and debugged for other serial ports, disk drivers and controllers, clocks, and any other available devices. Once the high-level drivers are working, you can modify the boot code to boot from the various devices available. The C boot routines are good in this regard.

For example, once the basic port of a board has been completed (porting procedure's 1 and 2), a high-level driver for a floppy drive (or other installable media) is developed next. Once it is known to work, you can format a floppy disk and install an OS-9 bootfile on the floppy. At this point, you can create a low-level driver for C boot (which may use much of the same logic and code as the high-level driver) that boots the system from the floppy.

Step 4. **Testing and Validation**
This involves the final testing and verification of the complete system.

Your distribution package was designed to follow this procedure.

Chapter 3: Step One: Porting the Boot Code

This chapter includes the following topics:

RadiSys.

MICROWARE SOFTWARE

Introduction

This chapter deals with the first step of porting OS-9 for 68K. This involves creating and installing a ROM that contains the system initialization code and a special ROM debugger (ROMbug).

About the Boot Code

In a sense, the name *boot* code can be misleading. The boot code does not try to boot the system by reading data from a disk; this comes in a later step. At this point, the boot code has the following functions:

- initialize the basic CPU hardware into a known, stable state
- determine the extent and location of RAM and ROM memory
- provide low-level console I/O
- call the ROMbug debugger

The ROMbug debugger is located in the same part of the ROM as the boot code. The ROMbug debugger can download software from the host system. It provides powerful debugging facilities such as:

- Tracing
- Single instruction stepping
- Setting breakpoints

The ROMbug debugger remains in place for the entire porting process. It can also be used to help debug all of your applications, especially any system state or driver code. However, for your final production ROM, you may wish to exclude ROMbug.

The ROM is made from a number of different files linked together to produce the final binary object code. The vast majority of the code is not system dependent and therefore is supplied in relocatable object code form (files with `.r` or `.l` suffixes). You only have to edit a few source files. You then use the `make` command to assemble these files and link them with the other `.l` files to create the ROM binary image file.

How to Begin the Port: The Boot Code

The first step in porting OS-9 is to port the boot code, or basically the code always residing in the ROM. To do this, you need to create several files in a new `PORTS/<target>` directory:

Table 3-1 Ports Directory Files

Name	The File Should Contain
`systype.d`	The target system, hardware-dependent definitions.
`sysinit.a`	Any special hardware initialization your system may require after a reset occurs.

Note

These files are specific to your particular hardware. `systype.d` and `sysinit.a` are covered later in this chapter.

The files provided in **Appendix F: Example ROM Source and Makefiles** are code to a working example and will not work for your particular hardware. However, these are minimal examples and can be reworked to match your hardware if necessary. Create these files in your own `PORTS/<target>` directory in one of the processor family object directories.

In most cases, you do not need to write the low level drivers, `ioxxx.a` and `ioyyy.a`, because the Development Kit contains code to many existing devices. If you have a device for which code has not been written, the entry points needed for drivers are documented later in this chapter.

Note

Do not modify the other files, such as `vectors.a`, `boot.a`, and `sysboot.a`. Altering these files may cause the port to not function.

Once you have properly adjusted the `systype.d` and `sysinit.a` files, use the `make-f=rombug.make` command to produce a ROM image file.

Testing the Boot Code

To test the boot code:

Step 1. Burn a set of ROMs with this image.

Step 2. Turn on your hardware.

Step 3. See if a ROM debugger prompt comes up.

- If the ROM debugger prompt does come up, you have successfully completed the initial port and are ready to continue.
- If it does not come up, look at **Appendix B: Trouble Shooting**.

ROM Image Versions

Generally, two slightly different makefiles exist in the `PORTS/<target>` directory: `rombug.make` and `rom.make`.

1. **rombug.make: Full boot menu with ROMbug.**
   Contains all the C boot functionality with the ROMbug ROM debugger. This is a large image found in `PORTS/<target>/CMDS/BOOTOBJS/ROMBUG/rombug`.

2. **rom.make: Full boot menu.**
   Contains the C boot functionality without a ROM debugger. This image is much smaller than the ROMbug image alone. Find it in the `PORTS/<target>/CMDS/BOOTOBJS/NOBUG/rom`. This could be considered the final production version.

Component Files of the ROM Image

The `rombug.make` and `rom.make` makefiles create the ROM image by combining and linking several sets of files to make the binary object code:

- **The common target startup (`rom_common.l`).**
  This is built from target-independent source files (`vectors.a` and `boot.a`) in the `SRC/ROM/COMMON` directory.

Table 3-2 Common Target Startup Source Files

Source	Relocatable	Contents
`systype.d`		System-wide hardware definitions
`boot.a`	`boot.r`	Standard system initialization code
`vectors.a`	`vectors.r`	Exception vector table

- **The low-level serial IO code (`rom.serial.l`)**
  This is built from target-independent source files (`ioxxx.a`, and `ioyyy.a`, if needed) in the `SRC/ROM/SERIAL` directory.

Table 3-3 Low-level IO Serial Source Files

Source	Relocatable	Contents
`ioxxx.a`	`ioxxx.r`	Console device primitive I/O routines*
`ioyyy.a`	`ioyyy.r`	Communication port I/O routines*

* The actual names of the files ioxxx.a and ioyyy.r vary according to the hardware device type. For example, a driver for a Motorola 6850 has the name io6850.a, and so on.

- **The target-specific startup and bootmenu code (`rom_port.l`)**
  This is built from target-specific source files (`sysinit.a`, `syscon.c`, and `bootio.c`) in the `PORTS/<target>` directory.

Table 3-4 Target-specific Startup and Bootmenu Code Source Files

Source	Relocatable	Contents
`sysinit.a`	`sysinit.r`	Custom initialization code
`syscon.c`	`syscon.r`	Custom initialization code
`bootio.c`	`bootio.r`	I/O support routines for `binboot()`

- **The CBoot libraries (`sysboot.l` and `romio.l`)**

Table 3-5 C Boot Libraries

Source	Relocatable	Contents
	`sysboot.l`	`sysboot` library routines.
	`romio.l`	I/O routines for CBoot and ROM debugger.

- **The debug files (`rombug.l`).**
  This code is used during the port; you can exclude it from the final production boot ROM. All debug files are provided in relocatable format. The source code to the debug files is not supplied with the Developers Kit because you do not need to edit or assemble these files.

Table 3-6 Debug Libraries

Source	Relocatable	Contents
	`rombug.l`	Full featured ROM debugger

Note

Not all of the relocatable files listed are supplied in the distribution package; some are created during the porting process.

WARNING

Read the rest of this chapter before you begin editing the `systype.d` file!

The Defsfile File

The `defsfile` file acts as a *master* `include` file to include all definition (`.d`) files within assemblies in the `PORTS/<target>` directory. `defsfile` typically includes `<oskdefs.d>` (from `SRC/DEFS`) and `systype.d` (from `PORTS/<target>`) at a minimum.

The Oskdefs.d File

The `oskdefs.d` file is OS-9's system-wide symbolic definitions file. It can be found in the `SRC/DEFS` directory. `oskdefs.d` defines some of the names used in `systype.d`.

Note

Do not edit `oskdefs.d`. `oskdefs.d` is used for generic system-wide target-independent definitions only. If system specific definitions are needed, edit `systype.d`.

You should make a listing of both `systype.d` and `oskdefs.d`. Study them so you understand how they are used and how they are related. If you have undefined name errors when assembling various other routines later, the files were probably not included or were not configured properly.

Notice that many hardware-dependent values and data structures are defined as macros in `systype.d`. These macros are used in many other parts of the boot ROM as well as files used in later stages of the installation. In particular, device driver and descriptor source files reference these macros.

The Systype.d File

The `systype.d` file should contain the target system, hardware-dependent definitions. This includes:

- Basic memory map information
- Exception vector methods (for example, vectors in RAM or ROM)
- I/O device controller memory addresses
- Initialization data

Note

Target-specific definitions are all included in the `systype.d` file. This allows you to maintain all target system specific definitions in one file.

You must create a `systype.d` file before you re-assemble any other routines.

`systype.d` is included in the assembly of many other source files by means of the assembler's `use` directive. You need to make a new `systype.d` file defining your target system as closely as possible, using the sample file provided in the distribution package. Some definitions are not used until later in the porting process, so some of these definitions are not covered until later in this manual.

`systype.d` consists of five main sections used when porting OS-9:

1. ROM configuration values.
2. Target system specific definitions.
3. Init module `CONFIG` macro.
4. SCF device descriptor macros and definitions.
5. RBF device descriptor macros and definitions.

The ROM configuration values and the target system specific definitions are the only sections important for the boot code. Therefore, these section are covered in this chapter. **Chapter 4: Step Two: Bringing Up the Kernel and Console I/O** covers the remaining sections.

The ROM Configuration Values

The ROM configuration values are normally listed at the end of the `systype.d` file. These values are used to construct the boot ROM and consist of the following:

- Target specific labels
- Target configuration values
- Low level device values
- Target system memory definitions

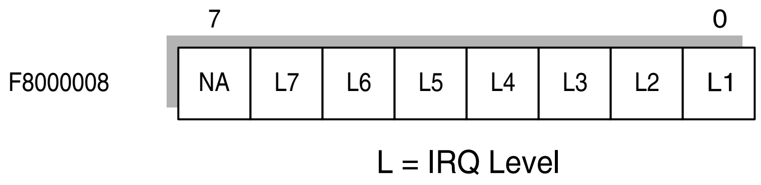
Target Specific Labels

Target specific labels are label definitions specific for your target hardware. They can define:

- Memory locations for special registers on your hardware.
- Specific bit values for these registers.

For example, your target hardware processor has a register controlling to which interrupt levels on a bus the board responds. This may be necessary if several target boards are sharing the same bus, and you would like to have different boards handle different interrupt levels. The base of all your control registers on your board starts at address `F800 0000` and the offset to this particular register is 8. The register is a single byte, with each bit corresponding to an interrupt level. Setting the bit enables the interrupt. Conceptually, the register may look something like the following:

Figure 3-1 Interrupt Level Control Register



Your label definitions for this register might look like the following:

```
* Define control registers.
ControlBase equ $f800 0000
.
.
* Other registers defined.
.
.
IRQControl equ ControlBase+8
.
.
Other registers defined.
.
.
* Define Control Register Values
Level1Enable equ %00000001
Level2Enable equ %00000010
Level3Enable equ %00000100
Level4Enable equ %00001000
Level5Enable equ %00010000
Level6Enable equ %00100000
Level7Enable equ %01000000
.
.
DisableAll equ 0
LowlevelEnable equ
Level1Enable+Level2Enable+Level3Enable
HighLevelEnable equ Level4Enable+Level5Enable+Level6Enable
EnableAll equ LowLevelEnable+HighLevelEnable+Level7Enable
```

Note

This is only an example and more than likely is not valid for your hardware. However, it does show you how to handle these definitions.

If your hardware:

- has a lot of special registers such as these, this can be a lengthy list.
- does not have many registers like this, the list can be very short.

You can review the supplied `systype.d` files to see how to define hardware registers. However, the values in the supplied `systype.d` file will not work on your target hardware.

For more information about the use of these labels, refer to the section on the `sysinit.a` file.

Target Configuration Labels

The target configuration labels are needed to configure the boot code properly for your target hardware. The following are a list of these variables:

Table 3-7 Target Configuration Labels

Label	Effect
`ROMBUG`	Specify `ROMbug` is used. The initial stack area is increased in size to accommodate the larger usage by the C drivers, and the size of the ROM global data area is determined dynamically. Several of the vectors are pointed into the `ROMbug` handlers. `Boot.a` also calls the `ROMbug` *initialize data* routine.
`CBOOT`	Specify `CBOOT` technology is to be used. The ROM global data area size is determined dynamically. You can also use this flag to enable *sync-codes* in assembler code. This allows the assembler boot drivers to be interfaced with the `CBOOT sysboot` routines.
`RAMVects`	Specify the vectors are in RAM. This allows `boot.a` to copy the vectors to the appropriate place.
`PARITY`	Specify parity memory is present. `boot.a` initializes parity by writing a pattern into the memory. The `MemList` macro in `systype.d` defines the memory to initialize.

Table 3-7 Target Configuration Labels (continued)

Label	Effect
`MANUAL_RAM`	Specify you must explicitly enable RAM memory. This enabling is usually performed in `SysInit`. Therefore, the 32-bit `bra` to `SysInit` does not work if you have not enabled the RAM. To allow operation in this situation, define `MANUAL_RAM`, and the call to `SysInit` is a straight `bra` instruction. This means the `bra` target *must* be within a 16-bit offset.
`TRANSLATE`	Define the value to use for the boot driver DMA address translation. If the local CPU memory appears at a different address for other bus masters, boot drivers can access the global `TransFact` label to determine the system's address translation factor. If this label is not defined, `TransFact` defaults to `0`.
`VBRBase`	Define the address for the system's Vector Base Register (68020, 68030 68040, and CPU32 processors only). Boot code can access the global `VBRPatch` label defined in `boot.a` to determine where the vectors are located. If this label is not defined, `VBRPatch` defaults to `0`.
`CPUTyp`	Specify the CPU type. Valid values for `CPUTyp` are defined in the next section.

CPUTyp Label and Supported Processors

The large number of variations of processors available from Motorola makes it important to ensure the label `CPUTyp` (defined in `systype.d` for your system) is correctly set, so certain features of the BootStrap code are correctly invoked.

The label `CPUTyp` is used for conditional assembly of portions of the boot code. The actual processor type is detected by the `boot.a` code, and passed to the kernel. If you incorrectly define `CPUTyp`, the processor type passed by the `boot.a` code is still correct; however, some portions of the bootstrap code may have conditional parts missing or incorrectly invoked.

Table 3-8 CPUTyp and Related Processors

CPUTyp Value	Processor	Value Passed to Kernel
68000	68000, 68008, 68301, 68303, 68305, 68306	0
68302	68302	0
68010	68010	10
68020	68020, 68EC020	20
68030	68030, 68EC030	30
68040	68040, 68EC040, 68LC040	40
68070	68070 (aka 9xC1x0-family)	70
68300	68330, 68331, 68332, 68333, 68334, 68340, 68341, 68349, 68360	300
68349	68349	300

Note

The naming conventions for 683XX processors can be confusing. The processors numbered in the range 68301 - 68306 are 68000 core based processors, and thus (from a software point of view) the `boot.a` code takes any value of `CPUTyp` in the range from 68301 to 68309 to be a 68000 processor. The processors in the number range 68330 and up are CPU32 or CPU32+ (aka CPU030) based cores, and thus the `boot.a` code takes any value of `CPUTyp` in the range from 68330 through to 68399 as a CPU32-based processor.

`CPUTyp` having a value of 68302 causes the `boot.a` code to reserve vectors 60 - 63, but otherwise it is treated like a 68000.

The value passed to the kernel is a *biased* value, as the kernel adds a value of 68000 to the value passed up, and then stores this new value in the kernel's system global `D_MPUTyp`.

Low Level Device Configuration Labels

Low level device configuration labels configure the low level I/O. These values are as follows:

Table 3-9 Low-level Device configuration Levels

Label	Effect
`Cons_Addr`	This is the base address of the console device. This is used by the low level `ioxxx.a` serial driver.
`ConsType`	This is used by the `ioxxx.a` code to determine which device is the console.

Table 3-9 Low-level Device configuration Levels (continued)

Label	Effect
`Comm_Adr`	This is the base address of the communications port, or *Comm* port. It is used by the ROM debugger to download S-record files from the host.
`CommType`	This is used by the `ioyyy.a` code to determine which device is the Comm port.

Each individual `ioxxx.a` and `ioyyy.a` driver has its own configuration labels. These labels are defined for each driver within the source of the driver, as well as Appendix C of this manual. Refer to the driver you will use, and set these labels correctly.

You need to define the following labels for the low level disk booter:

- `FD_Vct`
- `FDsk_Vct`
- `SysDisk`

You should define these labels as 0 if you do not have a disk booter.

Target System Memory Labels

Target system memory labels define where system memory is located. The `MemDefs` macro in the `systype.d` file is the mechanism in the boot code to define memory. It consists of two areas:

- General system free RAM
- Special memory

The free RAM is self-explanatory. The special memory definitions are the areas through which the kernel searches for modules when booting.

You need to define the following labels:

Table 3-10 Target System Memory Labels

Label	Description
`Mem.Beg`	The start of system RAM.
`Mem.End`	The end of system RAM.
`Spc.Beg`	The start of the special memory list.
`Spc.End`	The end of the special memory list.

You can define several banks of non-contiguous RAM and special memory. The entire RAM list is null terminated, and the entire special list is null terminated.

Example Memory Definitions

The following is an example `MemDef` memory definition:

```
MemDefs macro
  dc.l Mem.Beg,Mem.End  * 1st RAM bank start/end address
  dc.l 0                * Null terminator
  dc.l Spc.Beg,Spc.End  * 1st special bank start/end addr
  dc.l 0                * Null terminator
  dc.l 0,0,0,0,0,0,0,0  * Additional places for padding
  endm
```

For More Information

Due to the way the boot code has been written, the first RAM bank must be large enough to hold the system globals, the data area for the ROM debugger, and the entire bootfile if booting from a device. Refer to the section on the `boot.a` file later in this chapter for more information.

Note

Since the list is a null terminated list, never define `Mem.Beg` or `Spc.Beg` as `0`. `Mem.Beg` is usually offset by 0x400 bytes to allow room for the vector table. This is especially important if `VBRBase` is set to an area of RAM.The memory location of the vectors and general system RAM memory must not exist in the same place. If you have a ROM bank starting at 0, be sure to offset the `Spc.Beg` by an even number of bytes, usually 2 to 4.

The following is another `MemDef` example. This example has multiple banks of RAM and special areas:

```
MemDefs macro
  dc.l Mem.Beg,Mem.End    1st RAM bank start/end address
  dc.l Mem1.Beg,Mem1.End  2nd RAM bank start/end address
  dc.l Mem2.Beg,Mem2.End  3rd RAM bank start/end address
  dc.l 0                  Null terminator
  dc.l Spc.Beg,Spc.End    1st special bank start/end addr
  dc.l Spc1.Beg,Spc1.End  2nd special bank start/end addr
  dc.l 0                  Null terminator
  dc.l 0,0,0,0,0,0,0,0,   Additional padding for patching
  endm
```

The additional areas for patching allow you to patch the memory list without remaking the ROM image.

Note

As described later in `boot.a`, the RAM search is a destructive search, and the special memory search is a non-destructive, read-only search.

WARNING

During the initial porting phase, it is often customary to define an area of RAM as special memory, in addition to any ROM areas. The reason for this is when you try to debug any high level drivers, either the serial driver or later, the disk driver, it is easier to download the driver to RAM, debug it there, make changes in the source, and when rebooting, download the driver again. This way, you do not need to burn an EPROM every time you change the driver. This special area of RAM must be carved out of the normal RAM list and put as a separate bank of special memory. Once the port is complete and all drivers are debugged, the special RAM area can be returned to the general RAM memory list. Modules needed in the bootlist are covered further in **Chapter 4: Step Two: Bringing Up the Kernel and Console I/O**.

The Vectors.a File

The `vectors.a` file contains definitions for the exception vector table. You normally do not need to edit this file unless your target system has an unusual requirement.

For More Information

Refer to **Appendix D: SCSI-System Notes** for details of the conditional assembly flags used by this file.

Depending on your system hardware, the actual vectors can be located in RAM or ROM. To specify the location of the vectors, define the label `RAMVects` in the `systype.d` file. If ROM space is exceedingly tight, all vectors (except the reset vectors) may be located in RAM. This is only possible if the final production version of the boot ROM has no ROM debugger and the reset vectors are included in ROM. This saves a little ROM space due to lack of duplication.

The Boot.a File

The `boot.a` file contains the system initialization code that is executed immediately after a system reset. You should not need to edit this file. The `sysinit.a` file is reserved as a place for you to put code for any special hardware initialization your system might require after reset.

Steps Boot.a Goes Through to Boot the Kernel

`Boot.a` goes through the following steps to boot the kernel:

Step 1. **Assume a full cold start for growth method.**
The kernel validates modules using a *growth method*.

- With a full growth method, when the kernel validates modules, it first validates the module header and then validates the full module's CRC number.
- With a quick growth method, the kernel simply validates the module header. Although booting is quicker, there is more room for error. A module may be in memory and may be corrupted.

Step 2. **Mask interrupts to level 7.**
Interrupts are masked to ensure the boot code has a chance to run.

Step 3. **Call the SysInit label.**
`SysInit` ensures all interrupts are cleared and the hardware is in a known, stable state.

For More Information

`SysInit` is defined in the `sysinit.a` file.

Step 4. **Clear out RAM.**
Clears out the RAM used for the system globals and the global static storage used by ROMbug and the boot code.

Step 5. **Record growth method in the Crystal global variable.**
This growth method is passed to the kernel when the kernel is jumped to.

Step 6. **Set up 68000 vector table to vbr register or memory location 0 if needed.**
If the vector needs to be copied from the ROM to a RAM area, this is where it occurs. This copy occurs if the `RAMVects` label is defined.

Step 7. **Set up OS-9 exception jump table.**
The exception jump table is an intermediate table between the vector table and the kernel. The `pea` and `jmp` instructions are set up in the table at this time.

Each vector in the vector table points to a particular entry in the exception jump table. Each entry in the exception jump table has the following format:

```
pea #vector_table_address,-(a7)
jmp #vector_exception_handler
```

Step 8. **Initialize global data for RomBug, if needed.**
If you use `RomBug`, its global data needs to be initialized before it can run.

Step 9. **Determine CPU type.**
Possible CPU types include 68000, 68010, 68020, 68030, 68040, 68070, or 68300. The CPU type is saved in the `MPUType` system global variable. When running, the kernel keys off of this variable to determine the type of processor on which it is running.

Step 10. **Branch to the UseDebug label.**
If `UseDebug` returns with the zero bit in the CCR cleared, the ROMbug is enabled.

For More Information

`UseDebug` is located in the `sysinit.a` file.

Step 11. **Initialize ROMbug if it is enabled.**

Step 12. **Run the SysInit2 routine.**
Perform any final hardware initialization.

For More Information

`SysInit2` is also located in the `sysinit.a` file.

Step 13. **Initialize the Console port and print boot strap message.**
This is the first sign the system is doing anything.

Step 14. **Perform RAM and special memory searches of memory and parity enable memory if needed.**
The routines use both bus error and pattern matching to determine RAM and ROM sizes. This relies on the `MemDefs` macro to determine the memory areas to search.

Step 15. **Enter ROMbug if it is enabled.**
The debugger is finally reached. At this point, everything needed to find the kernel has been done.

Step 16. **Call SysBoot label to obtain kernel.**
You determine how this code works. A pointer to the kernel is all that needs to be returned.

Note

There are several routines written to help. `sysboot.a` is a routine that searches the ROM area for the kernel. There is no need to adjust this file, it works as is.

The C boot routines are also available to simplify booting from various devices.

`SysBoot` has the following register conventions when it is jumped to:

Table 3-11 SysBoot Register Conventions

Register	Description
`a1`	Boot ROM entry point.
`a3`	Port address from `DiskPort` label.
`a4`	System free RAM list.
`a5`	Exception jump table pointer.
`a6`	Operating system global data area (4K scratch memory).
`a7`	System ROM list.

When `SysBoot` returns, the following registers must be set as follows:

Table 3-12 Registers Set After SysBoot Returns

Register	Description
`a0`	Pointer to an executable module with a valid header (hopefully, the kernel).
`a4`	Possibly updated free RAM list.
`a5`	Must be intact from above.
`a7`	Possibly updated system ROM list.
`cc`	Carry set, `d1.w` error status if bootstrap failed.

Step 17. **Validate the kernel.**
After `SysBoot` returns to `boot.a` with a pointer to the kernel, `boot.a` validates the kernel header.

Step 18. **Initialize registers for entry to the kernel.**
Before entering the kernel, the registers should have the following conventions:

Table 3-13 Registers Prior to Entering Kernel

Register	Description
`d0.l`	Total RAM found in the system.
`d1.l`	`MPUType`.
`d2.l`	Trapflag for system debug.
`d3.l`	Growth startup method.

Table 3-13 Registers Prior to Entering Kernel (continued)

Register	Description
`d4-d7`	Clear.
`a0`	Kernel entry point.
`a1`	Boot ROM entry point.
`a2-a3`	Clear.
`a4`	System free RAM list.
`a5`	Exception jump table pointer.
`a6`	Operating system global data area (4K scratch memory).
`a7`	System ROM map.

Step 19. **Jump to the kernel's execution point.**

Memory Search Explanations

An important function of `boot.a` is building the system's memory allocation using a memory search list. OS-9 uses this search list to define the usable areas of the target system's RAM and special memory. You do not have to edit `boot.a` to change this table; the table is defined by the `MemDefs` macro in the `systype.d` file.

The RAM Search

The first part of the search list defines the areas of the address space where OS-9 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 that is at least long enough for storing system global data and global data for ROMbug and boot code. This is the area of memory cleared out by Step 4 of the `boot.a` process. If the system boots from disk or another device, then this first bank needs to be large enough to hold:

- The system globals
- The global data needed by the ROMbug and boot code
- The size of the bootfile

Note

Two factors determine the size of the system's ROM global data space:

- The required stack size.
- The amount of `vsect` and initialized data space used by the code.

Memory allocated for initialized and `vsect` data is part of the `bootrom` global data area, and thus permanently allocated for `bootrom` functions. If a boot driver requires large buffers (for example, disk sector blocks), they can be dynamically allocated from and returned to the free memory pool. The `CBOOT` system provides routines to do this. The linker executed in `rom_image.make` reports the actual required global data space.

The actual RAM memory search is performed by reading the first four bytes of every 8K memory block of the areas given in the search list. If a bus error occurs, it is assumed there is no RAM or special memory in the block. Then, a test pattern is written and read back. If the memory changed, the search assumes this was a valid RAM block and is added to the system free RAM list. As described earlier, you can define the `PARITY` label in the `systype.d` file to initialize memory before any read is performed. This initialization pattern is `$FEEDCODE`, in order to more easily see what RAM was initialized.

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 the memory search does not overwrite modules downloaded into RAM or NVRAM.

During the porting process, temporarily include enough RAM (usually about 64K) in the special memory list to download parts of the boot file. If this download area has parity memory, you may need to:

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

The RAM and special memory searches are performed during Step 14 of the `boot.a` process.

The *Patch* Locations

Two globally available *patch* locations are available for the following functions:

Table 3-14 Functions with Patch Locations

Name	Description
`TransFact`	This is a 32-bit location representing the translation constant between the CPU's address versus a DMA device's address for the same location. The default value is `0`. Boot drivers using DMA should use this value when passing address pointers to/from the DMA device.
`VBRPatch`	This is a 32-bit location you can use to set the VBR of the 68020, 68030, 68040, and CPU32 processors if the vectors are to be located at an address other than the default value of `0`. **NOTE:** Relocating the VBR is *not* supported for the 68000, 68008, 68010, and 68070 processors.

For More Information

Refer to **Chapter 7: Miscellaneous Application Concerns**, for details of the conditional flags overriding the default values.

The ioxxx and ioyyy Files

Two source files contain very low-level I/O subroutines to handle the console I/O port and the communications port.

- The console I/O routines are used by the boot for error messages and by the debugger for its interactive I/O.
- The communications port is used for the download and talk-through functions.

Note

In this manual, the console I/O routine files are referred to as `io.xxx` and `io.yyy`. The actual names of these files usually reflect the names of the hardware interface devices used by the specific target system. For example, a source file for the Motorola 6850 device is called `io6850.a`, a source file for the Signetics 2661 is called `io2661.a`, and so on.

If your target system uses a common type of I/O device, you can probably use a Microware-supplied file directly or with little modification. Otherwise, you need to create a new source file using the supplied files as examples.

Note

The physical I/O port addresses and related information are obtained from `systype.d`. If the console port and the communications port use the same type of device, you can use a single, combined file for both.

I/O Driver Entry Points

The low level I/O drivers are generally polled drivers allowing themselves to force themselves onto the port if necessary. The driver consists of two sides:

- A console side (for connection to an operator's terminal).
- A communications side (for connection to a host system that facilitates downloading object files into the target).

These are commonly referred to as the *Console port* and the *Comm port*, respectively.

Many of Microware's example low-level serial drivers conditionally assemble entry points and support routines for the console side separately from the communications side. The `ConsType` and `CommType` symbol definitions (in `systype.d`) control this conditional assembly. Also, whenever possible, the drivers are written to be port independent (for multi-port devices). The `ConsPort` and `CommPort` symbol definitions (in `systype.d`) then direct the driver to a specific port. These techniques greatly facilitate multi-driver coexistence and code reuse from one target to another. See **Appendix C: Low-level Driver Flags** for the values of these definitions.

The following describes the entry points into the driver:

Table 3-15 I/O Driver Entry Points

Entry Point	Description
`ChekPort`	Check Comm Port
`ConsDeIn`	Deinitialize Console Port from Polled Mode
`ConsInit`	Initialize Console Port
`ConsSet`	Disable Console Port

Table 3-15 I/O Driver Entry Points (continued)

Entry Point	Description
`InChar`	Read Character from Device’s Input Port
`InChChek`	Check Console Port
`InPort`	Read Character from Comm Port
`OutChar`	Output Character to Console Device
`OutPort`	Output Character on Comm Port
`OutRaw`	Output Character to Console Device
`PortDeIn`	Deinitialize Comm Port from Polled Mode
`PortInit`	Set Up and Initialize Comm Port

ChekPort

Check Comm Port

Synopsis

`ChekPort`

Input

None

Output

`d0.l`	character read or `-1` if no data available

Description

`ChekPort` checks the Comm input port to determine if a character is available to be read, and if so, return the character. If no character is available, `ChekPort` must return -1.

This is similar to the `InChChek` routine for the Console port.

ConsDeIn

Deinitialize Console Port from Polled Mode

Synopsis

`ConsDeIn`

Input

None

Output

None

Description

`ConsDeIn` deinitializes the Console port from the polled mode to the interrupt driven I/O the high level drivers use. The ROM debugger calls `ConsDeIn` before resuming normal time sharing. Essentially, `ConsDeIn` should restore the state of the I/O device, which the `ConsInit` function saved.

ConsInit

Initialize Console Port

Synopsis

```
ConsInit
```

Input

None

Output

None

Description

`ConsInit` initializes the Console port. It should reset the device, set up for transmit and receive, and set up baud rate/parity/bits per byte/number of stop bits and desirable interrupts on the device.

ConsSet

Disable Console Port

Synopsis

`ConsSet`

Input

None

Output

None

Description

`ConsSet` disables the console port from causing interrupts. It is called each time the debugger is called, but is intended to disable interrupts from occurring primarily after the system has been booted up and the system debugger is being used (to trace through system code or when the `break` utility is called). `ConsSet` should save the state of the device so `ConsDeIn` can restore it.

Synopsis

`InChar`

Input

None

Output

`d0.b`	character to read

Description

`InChar` reads a character from the device's input port. If a character is not present, `InChar` must loop until one is. After the character is read, a branch to `OutChar` is necessary to echo the character. If the I/O driver is being written for the obsolete Debug ROM debugger, you need to convert all lowercase characters to uppercase. The ROMbug ROM debugger has no requirements.

InChChek

Check Console Port

Synopsis

`InChChek`

Input

None

Output

`d0.l`	Character read or `-1` if no data available

Description

`InChChek` checks the console input port to determine if a character is available to be read, and if so, return the character. If no character is available, `InChChek` must return -1.

This is similar to the `ChekPort` routine for the Comm port.

InPort

Read Character from Comm Port

Synopsis

`InPort`

Input

None

Output

`d0.b`	Character read

Description

`InPort` reads a character from the Comm port. If no character is available, it must wait until one is available.

OutChar

Output Character to Console Device

Synopsis

`OutChar`

Input

`d0.b`	character to write

Output

None

Description

`OutChar` outputs a character to the console device. Before outputting the character, the input port should be read for an X-Off character. If an X-Off character is present, `OutChar` should delay until the character is no longer present in the input port. `OutChar` also needs to check the output character to see if it is a Carriage Return (`0x0d`) character and if so, output an Line Feed (`0x0a`) character as well.

OutPort

Output Character on Comm Port

Synopsis

`OutPort`

Input

`d0.b`	character to write

Output

None

Description

`OutPort` outputs a character on the Comm port, without considering flow control (X-On and X-Off) or carriage return line feed (CR/LF) combinations.

This is similar to the `OutRaw` routine for the Console port.

OutRaw

Output Character to Console Device

Synopsis

`OutRaw`

Input

`d0.b`	character to write

Output

None

Description

`OutRaw` outputs a character to the console device, without considering flow control (X-On and X-Off) or carriage return line feed (CR/LF) combinations.

This is similar to the `OutPut` routine for the Comm port.

PortDeIn

Deinitialize Comm Port from Polled Mode

Synopsis

`PortDeIn`

Input

None

Output

None

Description

`PortDeIn` deinitializes the Comm port from a polled mode to an interrupt driven mode. This is similar to the `ConsDeIn` routine for the Console port.

PortInit

Set Up and Initialize Comm Port

Synopsis

`PortInit`

Input

None

Output

None

Description

`PortInit` sets up and initializes the Comm port in the same or similar way the `ConsInit` routine initializes the Console port.

The Sysinit.a File

The `sysinit.a` file contains all special hardware initialization your system requires after a reset or system reboot. The `sysinit.a` file consists of three different sections, or *entry points*:

- `SysInit`
- `SInitTwo`
- `UseDebug`

The SysInit Entry Point

The first entry point, `SysInit`, is called almost immediately after a reset by `boot.a`. `SysInit` performs any special hardware actions the system may require during start up. `Sysinit` needs to do the following:

1. Execute a `reset` instruction to reset all system hardware.
2. Copy the reset stack pointer and initial PC vectors from ROM to RAM if the system has its vectors in RAM. `boot.a` initializes the other vectors.
3. Initialize any devices not connected to the reset line.
4. Initialize any CPU control registers and status displays. Example is initialization of VBR register.
5. Attempt to locate and execute the extension code (`initext.a/rompak.m`) if the `ROMPAK1` macro is used.

This routine *does not* return via an `rts` instruction. The return to `boot.a` is made directly by a `bra SysRetrn` instruction.

For More Information

For more information about `ROMPAK1`, refer to the section on `initext.a`.

The SInitTwo Entry Point

The second entry point, `SInitTwo`, is used for any system initialization required after the first call. Often, this routine consists of a simple `rts` instruction, as most systems can perform all their required initialization during the first call to `SysInit`. `SInitTwo` is called after `boot.a` has:

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

Note

If any device still needs to be initialized or setup, this is the place to do it.

If the `ROMPAK2` macro is used, it attempts to locate and execute the extension code associated with the second call to `sysinit` (`initext.a/rompak.m`).

To further explain the IRQ control register example from `systype.d`, you can use the following code segment as an example of writing `SysInit` or `SInitTwo`:

```
* Initial interrupt control register or bus controller.
movea #IRQControl,a0
move.b #EnableAll,(a0)
```

The purpose is to make the code more readable. The included `sysinit.a` files further demonstrate this procedure.

The UseDebug Entry Point

The third entry point, `UseDebug`, indicates whether the ROM debugger is enabled. If `UseDebug` returns the `Zero` flag of the CCR as:

- true, the debugger is disabled.

- false, the debugger is enabled.

Often, whether the ROM debugger is enabled is determined by:

- reading the state of a user-configured switch on the system.
- conditioning the `Zero` flag accordingly.

If no user-configured switch is available, there are two other methods to set the `Zero` flag:

1. Hard code the `UseDebug` routine so it always conditions the `Zero` flag to enable/disable the ROM debugger.
2. Test the optional `CallDBug` flag available in `boot.a`. The least significant bit of this byte may be used as a flag to indicate whether the debugger is enabled. The following code fragment shows how to access and test this flag:

```
UseDebug:btst.b #0,CallDbug(pc) test the debug flag
eori.b #Zero,ccr flip Zero (bit 0=0
       indicates enabled)
rts
```

The Syscon.c File

The `syscon.c` file contains the code needed to build the boot menu the `CBOOT` routines present to the console user when `boot.a` calls the `Sysboot` routine. This file contains the routine `getbootmethod()` that makes repeated `iniz_boot_driver()` calls to register all boot drivers the user can initiate.

In addition, `getbootmethod()` returns an `AUTOSELECT` or `USERSELECT` value to indicate to the `CBOOT` routines whether the user should initiate the boot manually or if the `CBOOT` routines can attempt an auto-boot. It is typical for this kind of a decision to be made by `getbootmethod()` based on either a switch or jumper setting, or perhaps a value in non-volatile memory.

The initext.a File

The `Sysinit` routines provide the basic initialization functions for the system. Sometimes you need to provide application specific (for example, custom hardware that generates an interrupt on power-up) initialization functions. You can include this type of functionality in the normal `Sysinit` code or in the *initialization extension* code, `initext`. Including this code in an `initext` (a separate linked object file) allows greater flexibility for production ROM image building, as you can use a *standardized* boot ROM image and `initext` modules as building blocks for tailoring final ROM configurations.

You can use the example `sysinit.a` file in Appendix F as an example of how to use the `initext` macros, `ROMPAK1` and `ROMPAK2`. These macros are defined in the file `SRC/MACROS/rompak.m`. The `initext` code is *activated* by placing the `initext` routines onto the end of the boot ROM image, so they are located *immediately* after the bootROM image in ROM. Both example makefiles, `rombug.make` and `rom.make` perform this concatenation.

Putting the ROM Together

You are now ready to begin your port. At this point, you should create your own specific files and try to make everything into a final ROM image. Use the example files within this manual as a starting point.

If you have problems when trying to make your image, such as assembler or linker errors, you need to:

1. Verify `systype.d` is configured correctly.
2. Verify `sysinit.a` is referencing the labels within `systype.d` correctly.
3. Make sure the makefile has the correct names of your customized files (`ioxxx.a` and `ioyyy.a`).

After the files have been assembled and linked properly, you can make a ROM or load the code into the emulator overlay memory.

Note

The linker output is a pure binary file. If your PROM programmer or emulator requires S-records, use the `binex` command to convert the data.

If your PROM programmer cannot burn more than one 8-bit wide PROM at a time and your system has the ROMs addressed as 16-bit or 32-bit wide memory, use the `romsplit` utility to convert the ROM object image into 8-bit wide files.

For More Information

Refer to the ***Utilities Reference*** manual for information about using `romsplit`.

After you have installed the ROM code and powered up the system, you should see the following message on the terminal:

```
OS-9/68K System Bootstrap
```

A register dump and a debugger prompt should follow. If the debugger did not come up, you must carefully review the previous steps. Particularly, review:

- The primitive I/O code
- The memory definitions in `systype.d` and `sysinit.a`
- The terminal connections
- The baud rate selections

Chapter 4: Step Two: Bringing Up the Kernel and Console I/O

This chapter includes the following topics:

Preparing the First Stage OS-9 Configuration

In the second step of the porting process, you actually load and run the OS-9 system. Because you are now at the OS-9 system level, you are dealing with the OS-9 modules.

Most of the OS-9 modules needed for the OS-9 system are already supplied. For a basic OS-9 system, use the following modules:

`kernel`	`scf`
`ioman`	`sysgo`
`cio` (recommended)	`shell`
`csl`	`math` (recommended)
`fpu` (`fpsp040` if you are porting to 68040)	

Because these modules are supplied ready to run, you can burn them into ROM within a special memory area.

To complete this step of the port, you need to make or create three other modules within the `IO` directory:

Table 4-1 IO Directory Modules

Name	Description
`Init`	The kernel's configuration data module.
`Term`	A descriptor for a high level console serial driver.
`scxxx`	High level console serial driver.

Note

As with the low level `ioxxx.a` drivers, the `scxxx` signifies a specific high level driver. For example, `sc6850` is the high level driver for the 6850 serial device.

Note

The `IO` directory contains the source to the high level drivers and descriptors.

To create these three modules, you need to:

- Expand the `systype.d` file.
- Create a makefile within the `IO` directory.

As with the low level `ioxxx` driver, there are several source code supplied, high level `scxxx` drivers with the package as well. Also, configuration labels for the `scxxx` driver needs to be defined in `systype.d`. Check the high-level driver sources in `SRC/IO/SCF/DRVR` for the configuration labels applicable to your selected driver.

Note

The `Init` module must be within the same bank of special memory as the kernel. Otherwise, the kernel is not able to find the `Init` module. The serial driver and descriptor can be loaded into a RAM special memory bank for debugging purposes.

When the OS-9 system is running, you can include some standard OS-9 utilities, such as `mfree` and `mdir`, in your special memory areas.

Creating the Init Module

Within the systype.d file is a section called CONFIG, which is commonly referred to as the CONFIG macro. Within this CONFIG macro is all the configuration values and labels assembled and linked into the Init module. The example systype.d file from **Appendix F: Example ROM Source and Makefiles** has an example CONFIG macro. You can modify this for your particular system. The following are the basic variables within the CONFIG macro:

Table 4-2 CONFIG Macro Variables

Name	Description
MainFram	A character string used by programs such as login to print a banner identifying the system. You may modify the string.
SysStart	A character string used by the OS-9 kernel to locate the initial process for the system. This process is usually stored in a module called sysgo. Two general versions of sysgo have been provided in the files: • sysgo.a (for disk-based OS-9). • sysgo_nodisk.a (for ROM-based OS-9).
SysParam	A character string passed to the initial process. This usually consists of a single carriage return.
SysDev	A character string containing the name of the path to the initial system disk. The kernel coldstart routine sets the initial data directory to this device before forking the SysStart process. Set this label to 0 for a ROM-based system. For example, SysDev set 0.

Table 4-2 CONFIG Macro Variables (continued)

Name	Description
`ConsolNm`	A character string containing the name of the path to the console terminal port. Messages to be printed during start up appear here.
`ClockNm`	A character string containing the name of the clock module.
`Extens`	A list of `OS9P2` modules the kernel executes before the system is running. For the initial port, this field is not necessary. However, it must be defined or you get linker errors.

For More Information

For more information about the `Init` module, refer to the ***OS-9 for 68K Technical Manual***.

To change the `Init` module's default values once the port is complete, you can define these changes within the `CONFIG` macro. Refer to the `init.a` source file (located in the `SYSMODS` directory) to see what symbolic labels are used for which `Init` parameters. This allows you to tune your system without modifying the generic `init.a` file.

SCF Device Descriptor Macro Definitions

The SCF device descriptor macro definitions are used when creating SCF device descriptor modules. Seven elements are needed:

Table 4-3 Elements of SCF Device Descriptor Modules

Name	Description
`Port`	**Address of Device on Bus** Generally, this is the lowest address the device has mapped. `Port` is hardware dependent.
`Vector`	**Vector Given to Processor at Interrupt Time** `Vector` is hardware/software dependent. Some devices can be programmed to produce different vectors.
`IRQLevel`	**Interrupt level (1 - 7) for Device** When a device interrupts the processor, the level of the interrupt is used to mask out lower priority devices.
`Priority`	**Interrupt Polling Table Priority** `Priority` is software dependent. A non-zero `priority` is used to determine the position of the device within the vector. Lower values are polled first. A `priority` of `0` indicates the device desires exclusive use of the vector.
`Parity`	**Parity Code for Serial Port** This code sets up the parity number of bits per character, and the number of stop bits for the serial port. This code is explained fully in the SCF section of the ***OS-9 for 68K Processors I/O Technical Manual***.

Table 4-3 Elements of SCF Device Descriptor Modules (continued)

Name	Description
`BaudRate`	**Baud Rate Selection for Serial Port** This is the baud rate for the serial port. This code is explained fully in the SCF section of the ***OS-9 for 68K Processors I/O Technical Manual***.
`DriverName`	**Module Name of Device Driver** This name is determined by the programmer and is used by the I/O system to attach the device descriptor to the driver.

Along with the `Init` module, you can add the `TERM` descriptor to the makefile.

Note
OS-9 does not allow a device to claim exclusive use of a vector if another device has already been installed on the vector, nor does it allow another device to use the vector once the vector has been claimed for exclusive use.

The driver uses these values to determine the parity, word length, and baud rate of the device. These values are usually standard codes device drivers use to access device specific index tables. These codes are defined in the ***OS-9 for 68K Technical Manual***.

Creating a Console I/O Driver

You must create an OS-9 driver module for the console device. There is a good chance Microware has an existing driver based on the same device your target system uses. If this is the case, the set up of the proper configuration labels within the `systype.d` file for the device is all that is required.

Otherwise, you must create a new driver module. The easiest way to create a new driver module is to modify an existing Microware-supplied serial driver.

For More Information

Refer to the ***OS-9 for 68K Technical Manual***, the ***OS-9 for 68K Technical I/O Manual***, and the sample source files supplied for guidance.

Along with the `Init` module and the `term` descriptor, you can also add the serial driver to the makefile.

Once the `Init` module, `term` descriptor, and serial driver have been made, an `ident` on each module should be performed to verify the module owner is `0.0`. If it is not, the `fixmod` utility should be run on the module(s) with the `-u=0.0` option. This changes the module owner to `0.0`.

For More Information

Refer to the ***Utilities Reference*** manual for more information about `ident` and `fixmod`.

Preparing the Download File

After you are confident the console device driver and descriptor modules are in good shape, you can prepare a download file:

Step 1. Merge each of the binary files of the OS-9 modules into a single file. The order they are merged in is not important; however, by convention, the `kernel` is first.

Note
`Init` needs to be set up to be ROM-based. Therefore, set `M$SysDev` to zero.

`kernel`	`init`	`fpu` (or `fpsp040`)
`sysgo`	`shell`	`cio` (recommended)
`csl`	`scf`	`math` (recommended)

Step 2. Merge two new modules into a second file:

```
serial.driver
term.descriptor
```

Note
Actual file names vary according to I/O controller names.

Step 3. Convert the two binary files to S-record files using the `binex` utility. If your version of `binex` asks for a load address, use zero.

For More Information

Refer to the ***Utilities Reference*** manual for more information about `binex`.

We recommend you make, download, and `binex` the two groups of files separately. This saves a lot of downloading time. You can keep the OS-9 standard modules in RAM and just download the driver/descriptor file by itself whenever it changes.

You can also merge the first set of files into the boot ROM image. Wherever you put or load these modules, verify the memory area is defined in the special memory list and not in the RAM list.

Downloading and Running the System

You are now ready to download OS-9 to the target system and (attempt) to run it using the following procedure.

For More Information

Refer to the ***Using RomBug*** for more information on setting the relocation register and downloading S-Records.

ROMbug has the ability to stage the boot in what we call *boot stages*.

Boot stages consist of breaking during the boot process twice in order to help verify everything is all right. The first of the two breaks occur in `boot.a`, just before `boot.a` jumps to the kernel. Here, the registers can be investigated to verify they are all right before continuing. The second of the two breaks is within the `coldstart()` routine of the kernel. At this point, the module directory has been completed, and modules needing to be debugged can have break points inserted at this time.

At each of the two breaks in boot stages, ROMbug displays the registers and gives a prompt.

At each `Rombug:` prompt, enter `gb`.

The following explains the procedure to download system modules to special memory areas.

Note

Download OS-9 to the *special memory area* only. Use the following procedure directly after a reset (at the first prompt).

Only do both steps 1 and 2 if you are downloading the standard system modules. If these modules are in ROM, skip to step 3.

Downloading and Running the System

To download and run the system:

Step 1. Set ROMbug's relocation register to the RAM address where you want the system modules (such as the kernel) loaded.

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

Step 3. Set ROMbug's relocation register to the RAM address where you want the console driver and descriptor loaded. The size of this code varies from less than 1K to as much as 2K. Be careful not to overwrite the system modules.

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

Step 5. Type `gb` for RomBug to start the `sysboot` kernel search. This starts boot stages. If all is well, you should see the following:

```
Found OS-9 Kernel module 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 at the wrong memory area.

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

Step 7. If you are debugging I/O drivers and want to insert breakpoints, do so now.

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

```
Shell
$
```

If the shell does not come up, see the next section for debugging instructions.

Step 9. If you included some utilities (such as `mfree` and `mdir`), you can run them.

Go to **Chapter 5: Step Three: Creating Customized I/O Drivers and Finishing the Boot Code** if the system seems to work properly.

Cold Part of Kernel

The kernel uses a routine called `coldstart()` to boot itself. Before `coldstart()` can run properly, `boot.a` must pass it the following information:

1. **Total RAM found by boot ROM.**
   This is an unsigned integer value of the total amount of ROM `boot.a` found.
2. **The processor (or MPU) type.**
   This is the processor number (68000, 68010, ... 68040) as determined by `boot.a`.
3. **System debugger active flag.**
   This unsigned character is non-zero if you have selected to boot by boot stages.
4. **Warmstart flag.**
   This unsigned character is the growth method determined by `boot.a`.

For More Information

Refer to **The Boot.a File** section in **Chapter 3: Step One: Porting the Boot Code**, for more information about the available growth methods.

5. **The ROM entry point.**
   This is a pointer to the `Reset:` flag in `boot.a`. The kernel uses this pointer if it ever reboots itself.
6. **The RAM list.**
   This is the RAM list found by `boot.a`. This RAM list has the following structure:

```
struct dumbmem {
  struct dumbmem *ptr;  /* ptr to next free block */
  u_int32 size;         /* size of this block     */
}
```

Multiple blocks are defined by adjacent structures together. A NULL pointer terminates the RAM list.

7. **Exception jump table pointer.**
   This is a pointer to the exception jump table for which `boot.a` set up RAM space.

8. **The ROM list.**
   This is the area of ROM found by `boot.a`. Its memory structure is the same as the RAM lists.

The coldstart() Routine

With the preceding parameters, `coldstart()` performs the following steps:

Step 1. **Fill in default values into the system globals.**
The kernel or system global variables are assigned default values in this step.

Step 2. **Determine if this is the correct kernel for the processor.**
The kernel checks the value `boot.a` determined the processor to be with an internal value with which the kernel was made. This determines if it is the correct kernel for the processor.

Step 3. **Set up system exception jump table.**
The kernel fills in the jump addresses in the exception jump table. `Boot.a` allocated space for the exception jump table and filled in the code to push the exception addresses. However, it does not know at the time what address the kernel will be at.

Step 4. **Locate Init module.**
`coldstart()` searches for the `Init` module in the same bank of memory in which the kernel resides. Once `Init` is found, system parameters are copied from it and put into the system globals.

Step 5. **Allocate and initialize system process descriptor, initial module directory, and dispatch table.**
Memory for these tables are allocated and initialized. The system service routines are installed into the kernel at this time.

Step 6. **Find system RAM.**
`coldstart()` searches RAM and builds the kernel's free memory list. Either the RAM `boot.a` found is verified or the colored memory list, if defined, is used instead. Both pattern matching and bus error is used to verify RAM.

Step 7. **Search ROM list for modules.**
`coldstart()` builds the module directory from the ROM list `boot.a` found and from any colored memory having an attribute of `B_ROM`.

Step 8. **Call the ROM debugger.**
The system debugger flag parameter passed to `coldstart()` from `boot.a` is checked. If it is set, `coldstart()` calls the ROMbug. This allows you to set breakpoints to aid in the debugging of drivers for applications.

Step 9. **Allocate memory and initialize system tables.**
`coldstart()` allocates memory and initializes the system tables. These tables include the process descriptor table, IRQ polling table, device table, and path descriptor table. This step also includes setting up the alternate IRQ stack and moving the system stack pointer to the system process descriptor.

Cold2(): Bringing Up the System the Rest of the Way

At this point, the kernel is fully functional. `coldstart()` next calls a routine called `cold2()` to bring the system the rest of the way up.

The `cold2()` routine performs the following steps:

Step 1. **Enable IRQs.**
This part enables the IRQs that `boot.a` disabled. This is necessary because the following steps include the initiation of devices that may need IRQs enabled.

Step 2. **Execute *Pre-IO* modules.**
`cold2()` executes any modules defined in the *Pre-IO* list in the `Init` module.

Step 3. **Execute IOMan modules.**
`cold2()` executes any modules defined in the *IOMan* list in the `Init` module. The default IOMan module supplied by Microware does the following:

- **Initialize the system console**.

  The system console (usually specified as `/term`) is opened. Any errors resulting from the open are displayed as the message:

  ```
  “can’t open console term”
  ```

  The `M$Consol` field in the `Init` module specifies what the console device name is. The label `ConsolNm` from the `systype.d` file sets `M$Console`.

- **Initialize the system device**.
  IOMan performs a `chd` to the system device which initializes the device. The system device is obtained from the `M$SysDev` field in the `Init` module, and the `SysDev` label in the `systype.d` file sets `M$SysDev`.

Step 4. **Execute custom modules.**
`cold2()` executes any modules defined in the `Extens` list in the `Init` module. These are commonly referred to as *P2 modules*.

Step 5. **Fork initial process.**
The `M$SysGo` field is the name of the first executable module. `cold2()` forks the initial process with any parameters defined in the `M$SParam` field of the `Init` module. The `SysStart` label in `systype.d` sets up `M$SysGo`, and the `SysParam` label sets up `M$SParam`.

Step 6. **Start the system clock.**
If specified in the `M$Compat` field of the `Init` module, `cold2()` starts the system clock and ticker.

Step 7. **Call the kernel.**
`cold2()` exits by calling the main part of the kernel itself. At this point, the system is fully booted and operating.

Debugging Hints

If OS-9 does not come up, the system may have one of these common problems:

- The system download file is missing a module or modules.
- The download files were improperly downloaded or the second download file (the driver) overwrote the first.
- The console driver has serious bugs.
- The console descriptor module is not set up correctly or it was forgotten.
- There is a hardware problem related to interrupt (exception) processing.
- The manager, driver, and descriptor modules ownership is not in the super group (0.n).

The most likely problem is a defective driver module. This requires actual debugging work. The best way to debug the driver is to repeat the procedure outlined previously (in the section entitled **Downloading and Running the System**), putting breakpoint(s) at the entry points in the driver's `INIT`, `GETSTAT`, `SETSTAT`, and `WRITE` routines in step 8. You can then trace through the driver as it initializes the hardware and tries to print the shell message. If the system never reaches this point, problems (a), (b), or (d) are likely.

Note

If you suspect serious problems related to interrupts and extensive debugging efforts are not fruitful, try making and running a non-interrupt driven version of the driver. This can definitively isolate the problem if it is interrupt-related. After the simpler version is debugged, you can add the interrupt logic.

Chapter 5: Step Three: Creating Customized I/O Drivers and Finishing the Boot Code

In this step, you produce a version of OS-9 that has ticker drivers, Real-Time clock drivers, disk drivers, and uses a bootstrap to boot OS-9 from a disk.

Note

If the target system is to be ROM-based and without disk support, skip the sections on *Creating Disk Drivers*.

This chapter includes the following topics:

RadiSys.

MICROWARE SOFTWARE

Guidelines for Selecting a Tick Interrupt Device

The interrupt level associated with the timer should be as high as possible. Level 6 is recommended. 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.

OS-9 Tick Timer 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 occuring 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, which may make multitasking appear sluggish. A faster rate may burden the kernel with extra task-switching overhead due to more rapid 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 that can occur before the kernel suspends an active process. The kernel then checks the active process queue and activate the highest priority active task. The `Init` module sets this parameter to a default value of `2`, but this can be modified with the `CONFIG` macro (in the system's `systype.d` file) by setting the `Slice` definition to the desired value.

- **Tick Timer Module Name**
  The name of the tick timer module is specified in the `Init` module. Use the `ClockNm` entry in the `systype.d` file's `CONFIG` macro to define this name. For example:

```
ClockNm dc.b "tk147",0  tick module name
```

Tick Timer Activation

You need to explicitly start the tick timer to allow the kernel to begin multitasking. This is usually performed by the `setime` utility or by a `F$STime` system call during the system startup procedures.

For More Information

Refer to the ***Utilities Reference*** manual for information about using `setime` or the ***OS-9 for 68K Technical Manual*** for information about `F$STime`.

When `F$STime` is called, it attempts to link to the clock module name specified in the `Init` module. If the clock module is found, the module's entry point is called to initialize the tick timer hardware.

An alternative is to clear bit 5 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`.

Real-Time Clock Device Support

Real-time clock devices (especially those equipped with battery backup) allow the real-time to be set without operator input. OS-9 does not explicitly support the real-time functions of these devices, although the system tick generator may 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, the tick timer code should be written so the real-time clock is accessed to read the current time or set the time after the *ticker* is initialized. When `F$STime`'s `month` parameter is `0`, a call is made to read the current time. When the `month` parameter is not `0`, the new time is set in the real-time clock device.

For More Information

Refer to the ***OS-9 for 68K Technical Manual*** for information about `F$STime`.

Microware Generic Clock Modules

To allow maximum flexibility for mixing the various types of tick timer devices and real-time clock devices, and to simplify the implementation of system clock functions, Microware has developed a suite of routines called the *generic clock* routines.

These routines are located in the `MWOS/OS9/SRC/SYSMODS/GCLOCK` directory. They provide three separate levels of support:

- Tickgeneric support
- Ticker support
- Real-time clock support

Tickgeneric Support

The `tickgeneric.a` file performs all common functions for tick and real-time clock initialization. This routine is the main body of the clock system, and it uses the following algorithm:

Step 1. Test if system clock is running. If so, then skip tick timer initialization.

Step 2. Initialize the tick timer:

- Set the system's ticks per second value (`D_TckSec`).
- Add the tick timer to the system interrupt polling table.
- Call the tick timer's initialization routine.

Step 3. Attempt to link to a module called `rtclock`.

Note
You should never need to modify this code because all system specific functions are concentrated in the ticker and real-time clock portions of the generic clock system.

Step 4. If the `rtclock` module is:

- not found, then return:
  - without error if the caller is setting the time explicitly.
  - an error if the caller is asking to read the real time clock.
- is found, then call the module's:
  - `setime` entry if the caller is explicitly setting the time.
  - `getime` entry if the caller is reading the current time.

Ticker Support

The tick functions for various hardware timers are contained in the `tkXXX.a` files. There are two ticker routines:

- **Tick initialization entry routine**
  This routine is called by `tickgeneric` 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.

The `tkXXX.a` and the `tickgeneric.a` files are linked together as a single `tkXXX` module.

Real-Time Clock Support

The real-time clock functions for various real-time clock devices are contained in the `rtcXXX.a` files. The two real-time clock routines are:

Get time	Reads the current time from the real-time clock device.
Set time	Sets the current time in the real-time clock device.

Under the generic clock system, the real-time clock module is always a subroutine module called `rtclock`.

Using Generic Clock Modules

To create system clock modules:

Step 1. Determine the type of tick device to use for the system.

Step 2. Examine the `MWOS/OS9/SRC/SYSMODS/GCLOCK` directory.

- If an existing `tkXXX.a` file supports the system's tick device, this file is the system's tick module.
- If none of the files are appropriate, create a tick module by using an existing version as a model.

Step 3. Examine the existing `rtcXXX.a` files in the `GCLOCK` directory if the system requires real-time support.

- If a `rtcxxx.a` file supporting the tick device already exists, this file is the system's real-time clock module.
- If none of the files are appropriate, create a real-time clock module by using an existing version as a model.

Step 4. Edit the system's `systype.d` file so the following variables describe the system's clock configuration:

Table 5-1 Clock Configuration Variables

Variable	Description
`ClkVect:`	Tick timer vector.
`ClkPrior:`	Tick timer priority on vector (should be highest).
`ClkPort:`	Tick timer base address.
`TicksSec:`	Ticks per second (usually 100).

Table 5-1 Clock Configuration Variables (continued)

Variable	Description
`ClkLevel:`	Tick timer IRQ level (may not be required if timer is at fixed IRQ level).
`RTCBase:`	Real-time clock device address (if using a real-time clock).

Step 5. Set up the `Init` module's `CONFIG` macro to reflect the tick module name and the system *ticks per time slice* value. For example,

`ClockNm dc.b "tk147",0`	Tick module name
`Slice set  4`	Ticks/slice (default is 2 if this field is not specified)

Step 6. Create a makefile specifying the system's tick module and, if necessary, real-time clock. Use the example makefile, `makefile`, in the `GCLOCK` directory as a model.

Step 7. Make the tick module and, if necessary, real-time clock with the `make` utility.

Step 8. Make the `Init` module.

Step 9. Create a bootfile for the system to include the new `Init` module, tick module, and, if necessary, real-time clock module.

Philosophy of Generic Clock Modules

Using generic clock modules has proven to be a successful, flexible method for tailoring OS-9 clock functions to a variety of hardware configurations. The following is a partial list of the benefits of using generic clock modules:

- You only need to write the hardware specific portions of the tick timer code.
- If you want real-time clock support, you only need to write the hardware-specific portions of the code.
- The real-time clock module is only essential to system operation if `F$STime` system calls are made requiring reading the real-time clock. This allows the real-time clock code to be developed independently of the tick timer code.
- You can change the real-time clock hardware without modifying the tick timer code. To use a different real-time clock device:

Step 1. Create the new module.

Step 2. Replace the old real-time clock module in the bootfile with the new one.

Step 3. Re-boot the system.

Automatic System Clock Startup

The kernel can automatically start the system clock during its coldstart initialization. The kernel checks the `Init` module's `M$Compat` byte at coldstart. If the `NoClock` bit is clear (bit 5 = 0), the kernel performs a `F$STime` system call with the `month` parameter equal to `0` 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 three common scenarios and their implications:

1. **The system has a working tick module, but no real-time clock support.**
   If the `NoClock` bit in the `Init` module's `M$Compat` byte is clear, the kernel performs the `F$STime` 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 could run `setime` from the startup file.

2. **The system has a working tick module and real-time clock support.**
   If the `NoClock` bit in the `Init` module's `M$Compat` byte is clear, the kernel performs the `F$STime` 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 function 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 could 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.

3. **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 a `F$STime` call during coldstart by setting the `NoClock` flag in the `Init` module's `M$Compat` byte (bit 5 = `1`). This allows the system to come up without the clock running. Once the system is up, you can debug the clock module(s) as required.

Debugging Clock Modules on a Disk-Based System

Note
Microware highly recommends you exclude the clock modules from the bootfile until they are fully operational.

To debug the clock modules:

Step 1. Make the `Init` module with the `NoClock` flag in the `M$Compat` byte set.

Step 2. Exclude the module(s) to be tested from the bootfile.

Step 3. Bring up the system.

Step 4. Load the tick/real-time clock module(s) explicitly.

Step 5. Use the system state debugger or a ROM debugger to set breakpoints at appropriate places in the clock module(s).

Step 6. Run the `setime` utility to access the clock module(s).

Step 7. Repeat steps 5 to 6 until the clock modules are operational.

When the clock module(s) are operational:

Step 1. Remake the `Init` module so the `NoClock` flag is clear.

Step 2. Remake the bootfile to include the new `Init` module and the desired clock module(s).

Step 3. Reboot the system.

Debugging Clock Modules on a ROM-Based System

For ROM-based systems there are two possible situations:

- If the system boots from ROM and has disk support, you should exclude clock module(s) 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, you should exclude the clock module(s) 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 `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 module(s) under test.

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

Step 4. Download the module(s) 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 module(s).

Step 7. Run the `setime` utility to access the clock module(s).

Step 8. Repeat steps 6 to 7 until the clock modules are operational.

When the clock module(s) are operational:

Step 1. Remake the `Init` module so the `NoClock` flag is clear.

Step 2. Remake the bootfile to include the new `Init` module and the desired clock module(s).

Step 3. Reboot the system.

Creating Disk Drivers

You should now create a disk driver for your target system. This is similar to creating a console terminal driver as in the previous step. However, disk drivers are more complicated. Again, you can use a Microware-supplied sample disk driver source file as a prototype.

For More Information

Refer to the ***OS-9 for 68K Processors I/O Technical Manual*** for further information about disk drivers.

If the target system has both floppy disks and hard disks, you should 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.

You must have a test disk of the correct type with OS-9 formatting. If you are using:

- an OS-9 based host system, this is no problem because you can make test disks on the host system.
- a cross-development system (Windows), you should obtain sample pre-formatted disks from Microware.

We recommend you make a non-interrupt driver for the first time. This can 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 ROM debugger, 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.

Testing the Disk Driver

Test the disk driver using the following procedure:

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.

Note
Steps 1 and 2 are not necessary if the system modules are in ROM.

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 start the `sysboot` kernel search. If all is well, the following message appears:

```
Found OS-9 Kernel module 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. Insert a diskette correctly formatted for OS-9 in the drive and 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 and Testing the Disk Boot Routines

After creating and debugging the basic disk driver, you must create a simple disk boot routine. You may use the sample assembler `bootxxx.a` files as prototypes or write a C Boot driver. To use a C Boot driver, refer to **Appendix A: The CBoot Technology**. However, finish reading this section for needed instructions before continuing.

The basic function of the disk boot routine is to load from a system disk a file called `OS9Boot`, containing the OS-9 component modules. `OS9Boot` is created and specially linked on the system disk by the `os9gen` utility. The system disk almost always has a `CMDS` directory containing the OS-9 standard command set.

For More Information

The `os9gen` utility builds and links the `OS9Boot` file. Refer to the ***Utilities Reference*** manual for more information about how `os9gen` creates the `OS9Boot` file.

The main operations of the disk boot subroutine (in order) are:

Step 1. Read logical sector zero which contains the bootstrap pointers of the `OS9Boot` file. These values are available at offsets `DD_BT` and `DD_BSZ`.

These variables contain:

- the logical sector number of the location of the `OS9Boot` file (`DD_BT`) on the disk
- the size of the bootfile (`DD_BSZ`) itself

Step 2. Call the boot code's memory request routine to obtain memory to hold the `OS9Boot` file.

Step 3. Read the `OS9Boot` file into memory.

Step 4. Place the address and size of the loaded `OS9Boot` data into the OS-9 initial ROM search table. The size returned should be the actual bootfile size, *not* the size rounded up to the next sector.

For More Information

If using `CBoot`, these four operations are performed automatically by the `diskboot.c` routine. See **Appendix A: The CBoot Technology**.

To test and debug the disk boot routines, you must perform the following steps:

Step 1. Prepare a *bootable* OS-9 system disk containing the system OS-9 modules. This disk should have an `OS9Boot` file that includes all the modules you have been downloading, including the new disk driver and descriptor module.

Step 2. Create a *bootable* OS-9 system disk. The method you use depends on if your host system is an OS-9 system or a non-OS-9 system.

- If your host is an OS-9 system and has the same size floppy disks as the target (if not, use the same procedures as a non-OS-9 system) format a floppy and use the `os9gen` utility to create the `OS9Boot` file on it. You can use the same modules as your `romboot` file.
- If your host is a non-OS-9 system, your target system needs to format the floppy and put the bootfile onto the floppy by using `os9gen`.

Step 3. Before using `os9gen`, all of the modules needed for the `OS9Boot` file must reside on a disk somewhere, either in a RAM disk or on the floppy itself. Put these modules on disk by using either the `save` utility to save them from memory to the disk or using `kermit` to transfer the modules. Once these modules are on the disk, use the `os9gen` utility to make the floppy a system disk.

Step 4. Create a low level disk boot driver. To debug this low level boot driver, use the ROMbug ROM debugger. The C Boot routines and the low level driver are linked into a ROM image and tested. (The procedure to debug or test is explained later in this chapter).

The `rom_image.make` file needs to be modified to include this low level boot driver in the `FILES` macro. Also, you need to modify `syscon.c` to add a menu item to start up your new low level disk boot driver. See the files `68020/PORTS/MVME147/SYSCON.C` and `68020/PORTS/MVME147/RECONFIG.C` for examples of how this is done.

Testing the CBoot Disk Boot Module

The following procedure tests and debugs the C Boot disk boot module:

Step 1. Merge the `.stb` file to the end of the ROM image by uncommenting the `RBGSTB` macro in `rombug.make` prior to making the image.

Step 2. Once the image is burned into the eprom and installed in your target, turn the system on and get to `Rombug` prompt.

Step 3. ROMbug automatically finds and attaches to the symbol table information within the `.stb` file

Step 4. Type `or` to enable soft breakpoints.

Step 5. Set up any needed breakpoints within the boot code.

Step 6. Type `gb`. If all goes well, the `CBoot` routines should now read the `OS9Boot` file from the disk into RAM, unless a breakpoint was encountered first. Afterward, you should get another register dump and a ROMbug prompt.

Step 7. At this point, you can use the ROM debugger’s memory dump command to display the modules loaded by the `CBoot` routine.

Step 8. Type `gb` again. This executes the kernel's initialization code including the OS-9 module search. You should get another register dump and ROMbug prompt. At this point, you should verify the entire `OS9Boot` file was loaded and all modules within it found. To do this, follow the steps listed in **Searching the Module Directory** from **Appendix B: Trouble Shooting**.

Step 9. Type `gb` again. This should start up the system. If successful, the following message appears.

```
shell $
```

If the `shell $` prompt does not appear, your target system's module is probably bad. For example, files may be missing or `OS9Boot` is missing required modules. You should go through the normal procedures for debugging.

Further Considerations

Before going on to the next step of testing and validating, the rest of your porting needs to be completed at this point. Any additional drivers and booters should be developed now.

Further information within this manual should be reviewed at this time. Review **Chapter 7: Miscellaneous Application Concerns**, and **Chapter 8: OS-9 Cache Control** (if using 68020, 68030, 68040, or 68349 that uses caching). Review **Chapter 9: RBF Variable Sector Support** if using disks. Review **Appendix D: SCSI-System Notes** if using SCSI.

Once all system software has been developed, proceed to **Chapter 6: Step Four: Testing and Validation**.

Completing the System

After testing the boot routine you must make a new boot/debug ROM. This one has the `sysboot.a` module replaced by your new `bootxxx.a` module. Make the new ROM by repeating the procedure given in **Chapter 3: Step One: Porting the Boot Code**, in the section on **Putting the ROM Together**. To make the new boot/debug ROM, simply enter `make bootdebug`.

Note

If the resulting ROM is too large for your target system, you can make one that omits the talk-through and/or download features by adjusting the `DBG1` macro accordingly.

Step 1. Create and debug additional drivers as required by your target system. The clock driver is a must, and you may also need other drivers for hard disks and parallel ports. A sample clock driver module is included in the distribution package. You can continue to use the ROM debugger for testing these.

Step 2. Add the additional OS-9 modules for pipes and RAM disk, to your `OS9Boot` file and test it. Also, do not forget to edit the `startup`, `password`, and `motd` files as appropriate for your system.

Step 3. If the target system is to be ROM-based, you may want to edit and re-assemble the `init` and/or `sysgo` modules so they directly call your application program (instead of `sysgo` or `shell`) upon startup.

Step 4. Make a final version of the boot ROM for distribution. In most cases, the final version does not have ROMbug. You can create the ROM version by entering:

```
make -f=rom.make
```

Note

You should keep on hand a copy of the previous version that includes the system debugger for future system maintenance.

Chapter 6: Step Four: Testing and Validation

This chapter includes the following topics:

RadiSys.

MICROWARE SOFTWARE

General Comments Regarding Testing

The quickest basic test of a new installation is to start using the system immediately. This usually reveals major problems if they exist. The tests described in this section can help reveal more subtle problems.

If your testing or later use of OS-9 reveals bugs, please report them to Microware so they can be corrected in future releases. Please forward a complete description of the problem and examples, if possible.

Refer to the Preface for information about contacting Microware.

Kernel Tests

These tests check the kernel's basic memory management and multi-tasking functions:

- Run the `mfree` and `mdir -e` commands to verify all installed RAM and ROM memory is accounted for.
- Run multiple background tasks, and then use `kill` to terminate them one-by-one. Verify with the `procs` command.
- Leave the system running overnight with multiple tasks running. Run `mfree` and `procs` at the beginning and end of the test and compare.
- After a system reset, run the `mfree` command and record the exact amount of free memory. Thoroughly exercise the system by running a large number of processes. Kill all processes, and then run `mfree` again, checking for lost memory.
- Set up test cases with two and three active processes and use the `setpr` command to alter process priority. Use the `procs` command to verify correct allocation of CPU time.
- Load, link, and unlink utility modules. Verify link counts using the `mdir` command.

Serial I/O (SCF) Tests

These tests exercise and verify the correct operating of the serial I/O:

- Exercise and verify correct basic operation of each serial and/or parallel I/O port.
- Run `xmode` on each port to verify each device descriptor has the desired default initialization values.
- Manually test the following operations for each SCF-type driver:
    - Screen Pause Mode
    - Halt output character (`<control>W`)
    - Keyboard abort and keyboard interrupt (`<control>E` and `<control>C`)
    - X-OFF/X-ON flow control (`<control>Q` and `<control>S`)
    - Proper baud rate configuration at all rates if software controllable
- Check for correct operation of a maximum number of I/O ports running simultaneously.

Disk I/O (RBF) Tests

These tests exercise and verify correct operation of the disk system(s). The OS-9 `dcheck` utility is the basic tool used to test the integrity of the disk file structure:

- Test the reading and writing of test patterns using a simple C or Basic program.
- Create and delete files. Verify with `dir` and `dcheck`.
- Create and delete directories. Verify with `dir` and `dcheck`.
- Ensure all sectors on a disk are accessible using a complete physical disk copy such as `copy /d0@ /d1@`. Only the super user may do this.
- Create a large file, then copy and/or merge it several times until the media is full. Then, delete files one by one and use the `free` command to ensure all disk space is properly recovered.
- Format media for all formats supported by your system. Verify with `dcheck`, `free`, and `dir`. Pay particular attention to interleaving. Only the super user may do this.
- Test simultaneous floppy disk and hard disk operations (if your system is so equipped). Especially look for DMA contention problems (if applicable).
- Test the system with multiple drives installed to maximum expansion capability.

Clock Tests

These tests exercise and verify correct operation of the system clock:

- Test the ability to set and reset the date and time using the `setime` and `date -t` commands.
- Test the time of day accuracy against a stopwatch with disk and terminal I/O operations in progress (pre-load and use the `date` command for testing).
- Test the system tick accuracy against a stopwatch with and without disk and terminal I/O operations in progress (pre-load and use the `sleep` command for testing). Use at least a 10-minute test period for a rough test, then a 12 to 24 hour period for a high accuracy test.
- Run multiple concurrent tasks and test proper timeslicing.

Final Tests

Complete the following as your final test:

- Test all other supported I/O devices (if any) that were not included in previous tests.
- Thoroughly exercise the system in multi-user interactive operation if appropriate for your application.
- Compile and/or assemble large programs.

System Configuration Checkout

Complete the following system configuration checkout:

- Verify all standard modules are in the `OS9Boot` file including the RAM disk and pipeline related modules.
- Verify all standard end-user distribution files are on the system disk in the correct directories. This includes the standard utility set in the `CMDS`, `DEFS`, and `SYS` directories. Check these for completeness according to the information provided in your license agreement.
- Set up and/or customize the `motd`, `startup`, and `password` files.

A Final Note

You have completed your first port. If you perform another installation in the future, you will probably take some shortcuts compared to the procedures outlined here. This is expected. It means you have gained a good insight into the system. The reason for this is the technique you followed the first time was not the minimal approach, but it is the least risky and most educational method for your first port.

If you have created new drivers for commonly used peripherals, you may want to donate source code to our master library. This can help save others time and trouble in the future. If you wish to do so, please forward them to Microware. We will make sure credit is given to the authors.

Chapter 7: Miscellaneous Application Concerns

This chapter includes the following topics:

- **Disk Booting Considerations**
- **Soft Bus Errors Under OS-9**

RadiSys.

MICROWARE SOFTWARE

Disk Booting Considerations

You must consider three features for new and existing boot drivers:

- Variable logical sector sizes.
- Boot files exceeding 64K in size.
- Non-contiguous boot files.

Boot Drivers Supporting Variable Sector Size

RBF logical sectors may range in size from 256 bytes to 32768 bytes, in integral binary multiples (256, 512, 1024, ... 32768). This allows the RBF's logical sector size to match the driver's physical sector size. Drivers written under the `CBOOT` system that are called by the `diskboot` front end need not be concerned with these issues because `diskboot` handles these considerations.

For boot code written before OS-9 for 68K Version 2.4, you must address two problems:

- **Determining the physical sector size of the device.**
  If you can query the device for the size of a sector (for example, SCSI Read Capacity), the issue is relatively simple. If not, the issue somewhat depends on the flexibility of the hardware. There are two examples of drivers that may prove helpful in this issue:

Table 7-1 Sample Drivers

Name	Description
`SRC/ROM/DISK/boot320.a`	This driver attempts to read the disk at a sector size of 256. If this fails, it attempts to read the disk at 512 bytes per sector.
`SRC/IO/RBF/DRVR/SCSI/RB5400`	The OMTI 5400 reads in the requested number of bytes as determined by the assign parameters. This allows the driver to read sector 0 and update the path descriptor.

Closely examine the `SRC/ROM/CBOOT/SYSBOOT/diskboot.c` file for assistance in creating a booting algorithm.

- **The logical sector size for the drive.**
  You can use the `DD_LSNSize` field (in logical sector 0) to determine the logical sector size of the drive. `CBOOT/SYSBOOT/diskboot.c` uses the following logic for dealing with disk drives:

Table 7-2

DD_LSNSize	Description
`0`	Implies a pre-2.4 version disk drive. The logical sector size is assumed to be 256. The physical size of the drive is assumed to be described by the path descriptor.
`n`	Implies a version 2.4 or later disk drive and the logical sector size is `n`. The path descriptor determines the physical sector size.

If the logical and physical sector sizes do not match, the driver must provide such a mapping. If the driver is written for use with the `CBOOT` system, this issue is addressed and handled by `CBOOT/SYSBOOT/diskboot.c`, which calls the driver.

Currently, `CBOOT` does not support a physical sector size smaller than the logical sector size. If this were necessary, the driver would need to manage the mapping.

As a whole, boot drivers should support the formats allowed by the high level drivers in the system. In the case of floppy disks, OS-9 high level drivers allow you to create and use floppy disks at various sector sizes. However, the boot for floppies assumes the floppy drive is formatted with 256 byte sectors. This simplifies the driver. It also decreases the number of attempts to read the disk before determining the correct format of the disk. The current suggested format for floppy disks is the OS-9 Universal Format.

Bootstrap File Specifications

Originally, RBF bootstrap files required they be contiguous and less than 64K bytes in size. The `os9gen` utility installed the bootstrap file by enforcing the contiguous data requirement and then updating the media's identification sector (LSN 0) with the bootstrap pointers.

For More Information

Refer to the ***Utilities Reference*** manual for information about using `os9gen`.

The pointers originally used are:

Table 7-3 Bootstrap Pointers

Name	Description
`DD_BSZ`	Word value of bootfile size.
`DD_BT`	3-byte value of the starting LSN of the bootstrap DATA.

At V2.4, the original specifications were expanded so the identification sector pointers are defined in an *upwards compatible* manner, as follows:

Table 7-4 Identification Sector Pointers

Name	Description
DD_BSZ	If DD_BSZ is non-zero, this field contains the size of the bootstrap file, as per the original specification. If this is 0, the DD_BT field is a pointer to the file descriptor (FD) of the bootstrap file. The FD contains the boot file size and the segment pointer(s) for the boot file data.
DD_BT	If DD_BSZ is non-zero, this is the starting LSN of the bootstrap data, as per the original specification. If DD_BSZ is 0, this is the LSN of the file descriptor for the bootfile.

Making Boot Files

Use the os9gen utility to make the bootstrap files. By default, os9gen creates a contiguous boot file that is less than 64K (this follows the original specification).

If you want a large or non-contiguous boot file, use os9gen's -e option.

Bootstrap Driver Support

If your system requires large, non-contiguous bootstrap files, you need to modify pre-V2.4 bootstrap drivers accordingly.

When reading a boot file, the main considerations for the bootstrap driver are as follows:

- Support should be maintained for contiguous, less than 64K boot files because this is os9gen's default.

- Once the bootstrap driver has read the media's identification sector, it should inspect the bootstrap variables to decide whether a bootstrap file is present. If both the bootstrap fields are zero, the media is non-bootable and an appropriate error should be returned. If the bootstrap file is present, the bootstrap driver should determine what type it is.
- If both bootstrap fields are non-zero, the driver is dealing with a contiguous, less than 64K boot file. The driver typically:
  - Allocates memory for the boot file (specified by `DD_BSZ`).
  - Locates the start of the bootstrap data (specified by `DD_BT`).
  - Reads the data.
- If the bootstrap size field (`DD_BSZ`) is `0` and the data pointer (`DD_BT`) is non-zero, `DD_BT` is pointing to the RBF file descriptor associated with the boot file. The driver should then:
  - Read the file descriptor into memory.
  - Inspect the file size (`FD_SIZ`) and segment entries (`FD_SEG`) to determine the boot file's size and location(s) on the disk.

  The driver typically reads each segment until the entire boot file has been read into memory. When loading the boot file into memory, the driver must ensure the data appears in a contiguous manner.

Reading the segment entries of the boot file data requires the bootstrap loader have a reasonable knowledge of the way RBF allocates files. In particular, the last segment entry for the file may be rounded up to the cluster size of the media (RBF always allocates space on a cluster basis). The bootstrap driver can determine the media cluster size from the `DD_BIT` value in the identification sector. While RBF may allocate space on a cluster basis, the bootstrap loader should always read the exact boot file size (rounded up to the nearest sector).

Soft Bus Errors Under OS-9

Some instructions of the MC68000-family of processors are intended to be indivisible in their operation (examples include `TAS` and `CAS`). Systems possessing on-board memory, off-board memory, and allow other bus masters to access the on-board memory can run into deadlock situations when the on-board CPU attempts to access the external bus while the external master is accessing the on-board memory. Often, the bus arbiter breaks the deadlock by returning a bus error to the CPU. This is not a *hard* bus error (like non-existent memory), it is a *soft* bus error. If the instruction is re-run, it typically succeeds, as the deadlock situation has terminated.

The file `SRC/SYSMODS/SYSBUSERR/sysbuserr.a` provides a mechanism to install a soft bus error handler across the bus error jump table entry to allow software to determine the cause of the bus error. The soft bus-error handler can determine whether to re-run the instruction or pass the bus error along to a previously installed handler (such as the MMU code).

To use this facility, create a file `buserr.m` with two macros:

Table 7-5 buserr.m Macros

Name	Description
`INSTBERR`	Hardware enable for soft bus error. Setup hardware to detect soft bus errors.
`BERR`	Bus error handler. Detect whether bus error is soft or hard. If soft, re-run the faulted instruction. Otherwise, call the original handler.

The details of the entry to these macros is documented in `SRC/SYSMODS/SYSBUSERR/sysbuserr.a`.

Chapter 8: OS-9 Cache Control

This chapter includes the following topics:

- **OS-9 Cache Control**
- **System Implementation**
- **Default SysCache Modules**
- **Caching Tables**
- **Custom Configuration for External Caches**
- **ROM Debugger and Caches**
- **Peripheral Access Timing Violations**
- **Building Instructions in the Data Space**
- **Data Caching and DMA**
- **Address Translation and DMA Transfers**

RadiSys.
MICROWARE SOFTWARE

OS-9 Cache Control

Many 68000-family systems now include hardware cache systems to improve system performance. These cache systems are implemented as:

- On-chip caches (68020, 68030, 68040, and 68349 CPUs).
- *External* cache hardware on the CPU.
- An independent module.
- A combination of these methods.

On OS-9 systems, cache control is available in a flexible manner providing you with total control over cache operation. It also allows you to customize cache control for any special hardware requirements your system may have.

System Implementation

To allow maximum flexibility of the cache control operations, a separate system module called `SysCache` contains all of OS-9's system caching functions.

The kernel installs the `SysCache` module as an extension module during system cold-start initialization. The kernel searches for extension modules specified in the `Init` module. If the specified module is found, the kernel calls the module's initialization entry point. For the `SysCache` module, this entry point performs the following functions:

- Replace the kernel's default (no-operation) `F$CCtl` system call with the active version in `SysCache`.
- Flush and enable the system cache hardware.

For More Information

Refer to the ***OS-9 for 68K Technical Manual*** for information about how the kernel works.

Install Cache Operations

To install cache operations in the system, you should:

Step 1. Add the `SysCache` module's name to the `Init` module's extension module list. For example:

```
Extens dc.b "OS9P2 SysCache",0
```

Step 2. Remake the `Init` module.

Step 3. Generate a new bootstrap file for the system which includes the `SysCache` module and the new `Init` module.

Step 4. Boot the system. The system cache function is now enabled.

If caching is not required for the system, you can disable cache operations by excluding the `SysCache` module from the bootfile or not having the `SysCache` module name specified in the `Init` module's `Extens` list.

Default SysCache Modules

Microware provides default `SysCache` modules to simplify your task of implementing cache control. Each version applies to a specific sub-family of the 68000 series CPUs.

The following modules are supplied:

Table 8-1 SysCache Modules Supplied by Microware

CPU Type	Module Name	File Name	Operations Performed
`68000`	`SysCache`	`Cache`	none: no on-chip cache hardware
`68008`	`SysCache`	`Cache`	none: no on-chip cache hardware
`68010`	`SysCache`	`Cache`	none: no on-chip cache hardware
`68070`	`SysCache`	`Cache`	none: no on-chip cache hardware
`68020`	`SysCache`	`Cache020`	on-chip instruction cache
`68030`	`SysCache`	`Cache030`	on-chip instruction and data cache
`68040`	`SysCache`	`Cache040`	on-chip instruction and data cache
`68349`	`SysCache`	`Cache349`	on-chip instruction cache banks.

The 68000 `SysCache` module is essentially a *no-operation* cache control module, as these CPUs do not have any on-chip cache hardware. The module validates the parameters passed to the `F$CCtl` system routine and exits with no error.

The 68020 `SysCache` module controls the on-chip instruction cache for the 68020 CPU.

The 68030 `SysCache` module controls the on-chip instruction and data caches for the 68030 CPU.

The 68040 `SysCache` module controls the on-chip instruction and data caches for the 68040 CPU.

The 68349 `SysCache` module controls the on-chip instruction cache banks for the 68349 CPU.

Caching Tables

The memory management unit for the 68040 has the feature of defining memory areas of specific caching types. These caching types are described as follows:

Table 8-2 Caching Types

Caching Type	Description
Write-through	This is a cache active mode. Basically in write-through mode, whenever a write happens, both the cache and the physical hardware location are updated. Even though this is a caching mode, it is slower than copy back, since the physical hardware is updated on each write. Reads, however, come from the cache as normal.
Copy back	This is a cache active mode. It is the highest level of caching attainable. Both reads and writes are cached, and the physical hardware may or may not be updated with a write. This is the fastest mode possible.

Table 8-2 Caching Types (continued)

Caching Type	Description
Cache inhibited, serialized access	This is a cache inhibited mode. With serialized access, reads and writes happen as expected, unlike with not-serialized accesses. There is no reordering of reads over writes. This is the mode to use when using physical hardware registers.
Cache inhibited not-serialized access	This is a cache inhibited mode. However with this mode, reads may get optimized with respect to writes. Basically the 68040 is trying to keep its pipeline full, and it may reorder a physical read in front of a physical write. This may not be a desirable affect when writing to hardware registers.

The `ssm040` module under OS-9 has the ability to build these tables when OS-9 is booted. It gets the data to build these tables from the `CacheList` entry from within the `init` module.

The system configuration information for the `init` module comes from the `CONFIG` macro in the `systype.d` file. For caching, there is a label named `CacheList`. Following this `CacheList` label are the specific `CacheType` macro invocations for the `systype`. The `CacheType` needs three parameters, the beginning address, ending address, and caching mode.

For OS-9, the caching mode is defined as follows:

- For write-through: `WrtThru`
- For Copy back: `CopyBack`
- Cache inhibited, serialized access: `CISer`
- Cache inhibited not-serialized access: `CINotSer`

An example cache list for the MVME167 is as follows:

```
CPUALIGN
CacheList
* NOTE these have been constructed to match the regions defined
* in the MemType entries above.
 CacheType Mem.Beg,Mem.End,CopyBack
 CacheType Max.Beg,Max.End,CopyBack

 dc.l -1 terminate list
*----------------------------------------------------
If needing to turn off caching on a particular area, another field can be added to the
cache list.  The following is an example cache list
*----------------------------------------------------
CPUALIGN
CacheList
* NOTE these have been constructed to match the regions defined
* in the MemType entries above.
 CacheType Mem.Beg,Mem.End,CopyBack
 CacheType Max.Beg,Max.End,CopyBack
 CacheType 0xf0000000,0xffffffff,CISer

 dc.l -1 terminate list
```

The above cache list turns off caching in VME standard space and VME short I/O space.

Note

The `Init` module controls a number of other features of caching. The `Init` module fields `M$Compat` and `M$Compat2` are used for this control. Features controlled are:

- Cache burst mode (68030 only).
- Cache coherency (hardware snoopiness).
- Code bank enabling (68349 only).

Custom Configuration for External Caches

The default cache operation modules supplied by Microware only control the on-chip caches of the CPUs. These caches are the only *known, guaranteed* cache mechanisms for those types of systems.

When dealing with systems equipped with external or custom hardware caches, you can easily produce a customized `SysCache` module for the individual target system. This is accomplished with the `SYSCACHE` macro included in the `syscache.a` file in the `SYSCACHE` directory.

If this macro is *undefined* to `syscache.a`, a default *no-op* macro for `SYSCACHE` allows the file to assemble without error. This is how the Microware default modules are produced.

You may provide a custom `SYSCACHE` macro in a file called `syscache.m`. You can include this file via a local defs file. This custom macro should contain the code for manipulating the system's external/custom cache hardware.

Note

The module produced with the `SYSCACHE` macro is specific for the target system, making all cache hardware operational.

Upon entry to the integrator-supplied routine, the `d0.l` register indicates which cache operations are desired. The integrator's routine does not need to check for the validity of operations. For example, a request by a user to flush the data cache when the data cache is currently disabled by another process results in no flush on the data cache. The integrator-supplied code does not see the data cache flush request for this particular call.

Control of cache functionality is implemented via the `M$Compat2` byte in the `Init` module.

M$Compat2 Bit Fields

The bit fields within `M$Compat2` are defined as follows:

Table 8-3 M$Compat2 Bit Fields

Bit	0/1	Description
0	0	External instruction cache is *not* snoopy.
	1	External instruction cache is snoopy (or absent).
1	0	External data cache is *not* snoopy.
	1	External data cache is snoopy (or absent).
2	0	On-chip instruction cache is *not* snoopy.
	1	On-chip instruction cache is snoopy (or absent).
3	0	On-chip data cache is *not* snoopy.
	1	On-chip data cache is snoopy.
4*	0	CIC bank 0 is SRAM.
	1	CIC bank 0 is cache.
5*	0	CIC bank 1 is SRAM.
	1	CIC bank 1 is cache.
6*	0	CIC bank 2 is SRAM.
	1	CIC bank 2 is cache.

Table 8-3 M$Compat2 Bit Fields (continued)

Bit	0/1	Description
`7*`	`1`	CIC bank 3 is SRAM.
	`0`	CIC bank 3 is cache.

***** Bits 4-7 are for 68349 CPU only.

The snoopy/absent flags allow the kernel to make intelligent decisions as to when to actually flush the system's caches (with `F$CCtl` calls). If the system's hardware capabilities allow the caches to maintain coherency via hardware means, you can set the appropriate flags so the kernel performs only essential cache flushes.

The 68349 CIC bank flags allow the integrator to control the mix of SRAM/cache usage for the system.

ROM Debugger and Caches

The ROMbug debugger has a limited knowledge of caching. If you use ROMbug in a system where there are no caches external to the CPU chip, link it with `flushcache.l` when the ROM is constructed. When using a 68349 CPU, you should link `flush349.l` instead of the usual `flushcache.l` routine.

For More Information

Refer to ***Using RomBug*** for more information about `ROMBug`.

If external caches are available, you should provide a separate routine that flushes any on-chip caches as well as the external caches. You can add this routine to the `sysinit.a` file or link in your own (local) version of `flushcache.l`. If you do provide a separate routine, do not link the ROM with the default `flushcache.l` library.

Note

Calls to the ROM debugger through `F$SysDbg` (for example, using the `break` utility) works correctly because the system call maintains cache integrity.

Peripheral Access Timing Violations

When caching is enabled, peripheral access timing violations sometimes occur in device drivers, especially when tight loops are written to poll device status registers. If peripheral devices begin to exhibit erratic behavior, you should take the following steps:

Step 1. Disable all caching for the system.

Step 2. Debug the driver until it is stable.

Step 3. Re-enable caching for the system.

If erratic behavior continues, timing violations are probably occurring because of cache hits. In this case, the driver can:

- Disable data and/or instruction caching during critical sections of the driver (for example, interrupt service routine).
- Re-enable caching when the critical section is completed.

Note

When a driver manipulates the cache, it should try not to access the cache hardware directly. `F$CCtl` calls should be performed instead. The driver's code is transportable and does not conflict with the system's cache control operations. Interrupt service routines can call `F$CCtl`; therefore, cache operations may occur at any time.

Timing Loops

Cache enabling may *break* routines using fixed delay timing loops. If specific time delays are required, you may have to rewrite the loops for a *worst case* loop. (Worst case is the quickest time.) Alternatively, you could disable caching for the body of the loop.

Building Instructions in the Data Space

Programs using their data space for building temporary instruction sequences need to flush the instruction cache before executing the sequences. Failure to do so may result in unpredictable program behavior.

Data Caching and DMA

Direct Memory Access (DMA) support, if available, significantly improves data transfer speed and general system performance, because the MPU does not have to explicitly transfer the data between the I/O device and memory. Enabling these hardware capabilities is generally desirable, although systems that include cache (particularly data cache) mechanisms need to be aware of DMA activity occurring in the system, so as to ensure *stale* data problems do not arise.

Note

Stale data occurs when another bus master writes to (alters) the memory of the local processor. The bus cycles executed by the other master may not be seen by the local cache/processor. Therefore, the local cache copy of the memory is inconsistent with the contents of main memory.

Device drivers performing DMA are required to ensure stale data problems do not occur. Typically, the driver needs to flush the system caches at appropriate times (for example, prior to writing data to the device; after reading data from the device) unless the caches are coherent through hardware means.

Indication of Cache Coherency

The `M$Compat2` variable also has flags indicating whether or not a particular cache is coherent. Flagging a cache as coherent (when it is) allows the kernel to ignore specific cache flush requests, using `F$CCtl`. This provides a speed improvement to the system, as unnecessary system calls are avoided and the caches are only explicitly flushed when absolutely necessary.

Note

An absent cache is inherently coherent, so you *must* indicate absent (as well as coherent) caches.

Device drivers using DMA can determine the need to flush the data caches using the kernel's system global variable, `D_SnoopD`. This variable is set to a non-zero value if BOTH the on-chip and external data caches are flagged as snoopy (or absent). Thus, a driver can inspect this variable, and determine whether a call to `F$CCtl` is required or not.

Address Translation and DMA Transfers

In some systems, the local address of memory is not the same as the address of the block as seen by other bus masters. This causes a problem for DMA I/O drivers, as the driver is passed the local address of a buffer, but the DMA device itself requires a different address.

The `Init` module's colored memory lists provide a way to set up the local/external addressing map for the system. Device drivers can determine this mapping in a generic manner using the `F$Trans` system call. Thus, you should write drivers that have to deal with DMA devices in a manner ensuring the code runs on any address mapping situation. You can do this by using the following algorithm:

- If you must pass a pointer to an external bus master, call the kernel's `F$Trans` system call.
- If `F$Trans` returns an *unknown service request* error, no address translation is in effect for the system and the driver can pass the unmodified address to the other master.
- If `F$Trans` returns any other error, something is seriously wrong. The driver should return the error to the file manager.
- If `F$Trans` returns no error, the driver should verify the size returned for the translated block is the same as the size requested. If so, the translated address can be passed to the other master. If not, the driver can adopt one of two strategies:

  1. Refuse to deal with *split blocks*, and return an error to the file manager.
  2. Break up the transfer request into multiple calls to the other master, using multiple calls to `F$Trans` until the original block has been fully translated.

  Drivers usually adopt method 1, as the current version of the kernel does not allocate memory blocks spanning address translation factors.

If drivers adopt these methods, the driver functions irrespective of the address translation issues. Boot drivers can also deal with this issue in a similar manner by using the `TransFact` global label in the bootstrap ROM.

Chapter 9: RBF Variable Sector Support

The Random Block File Manager (RBF) supports sector sizes from 256 bytes to 32768 bytes in integral binary multiples (256, 512, 1024, ... 32768). This section addresses the issues that are important for writing or modifying disk drivers to support variable logical sector sizes.

For More Information

Refer to the ***OS-9 for 68K Processors Technical I/O Manual*** for information about RBF.

Note

OS-9 for 68K Version 2.4 was the first release of RBF to support variable sector sizes. If you are modifying disk drivers that only support 256 byte logical sectors, you should read this section carefully.

This chapter includes the following topics:

RBF Device Drivers

RBF uses the `SS_VarSect` GetStat function to dynamically determine whether the driver it is calling can support logical sector sizes other than 256 bytes.

For More Information

`SS_VarSect` queries the driver to determine if support for variable logical sector sizes is available. Refer to the ***OS-9 for 68K Technical Manual*** for more information about `SS_VarSect`.

When you open a path to an RBF device, RBF calls the driver with `SS_VarSect`, and depending on the results of the call, takes the appropriate action:

Table 9-1 RBF Actions

If the Driver Returns	Description
Without error	RBF assumes the driver can handle variable logical sector sizes. It then uses the `PD_SSize` field of the path descriptor to set the media path's logical sector size, so RBF's internal buffers may be allocated.
An unknown service request error	RBF assumes it is running with a driver that presumes a logical sector size of 256-bytes. RBF allocates its buffers accordingly and does not use the `PD_SSize` field of the path descriptor.
Any other error	RBF aborts the path open operation, deallocates any resources, and returns the error to the caller.

Support for variable logical sector sizes is *optional* under the new RBF, as existing drivers operate in the same manner as they do under previous versions of RBF (such as in the second case above).

Converting Existing Drivers to Use Variable Sector Size

If you want to use the variable sector size support, use the following guidelines to convert existing drivers.

In general, device drivers written for the old RBF were written to operate under one of two situations:

- **The media logical and physical sector sizes were the same.** In this case, the driver would accept the sector count and starting LSN, convert it to the physical disk address (if required), and then perform the I/O transfer.

  To convert these drivers written to support other logical/physical sector sizes, you need to:

Step 1. Add support for the GetStat `SS_VarSect` call.

Step 2. Ensure the driver does not have any hard-wired 256-byte assumptions.

Typically, this implies the driver should:

- Use the sector size field (`PD_SSize`) in the path descriptor whenever it needs to convert sector counts to byte counts (for example when loading DMA counters).
- Maintain any disk buffers in a dynamic manner so a sector size change on the media does not cause a buffer overrun. This usually means fixed sized buffers allocated in the static storage of the driver should now be allocated and returned as required, using the `F$SRqMem` and `F$SRtMem` system calls.

For More Information

Refer to the ***OS-9 for 68K Technical Manual*** for more information about `F$SRqmem` and `F$SRtMem`.

In many cases, a correctly written driver only needs the addition of the `SS_VarSect` handler (to simply return `NO ERROR`) to work with variable sector sizes.

- **The media logical and physical sector sizes were NOT the same.** In this case, the driver would translate the logical sector count and starting LSN passed by RBF into a physical count/address, convert those values to the physical disk address (if required), and then perform the I/O transfer.

Note

These types of drivers are known as *deblocking* drivers, as they combine/split the physical sectors from the disk into the logical sectors RBF requires.

You can convert drivers written with this method to variable logical sector operation, although they may require more work than non-deblocking drivers.

Apart from adding the code to handle the GetStat `SS_VarSect` call, you should remove:

- The driver's deblocking code.
- Any hardwired assumptions about sector sizes and fixed buffers.

In effect, you are converting the driver from a deblocking driver to a non-deblocking driver.

RBF Media Conversion

Once you have updated the driver to support the new RBF, you need to decide whether or not to convert your media (specifically hard disk drives) to non-256 byte logical sector sizes.

- If you convert your media, you must reformat it.
- If you are using a 256-byte logical sector size, you can immediately use the media when the driver is ready.

If you are reformatting the media, it may only require a logical reformat (converting a deblocking 512-byte physical sector disk to 512-byte logical). In this case, you should perform the following steps:

Step 1. Backup the media to convert.

Step 2. Reformat the media. A physical format is only required if you need or wish to change the media's physical sector size. (Use the `format` utility's `-np` option if you do not wish a physical reformat).

For More Information

Refer to the ***Utilities Reference*** manual for information about using `format`.

Step 3. Re-install the data saved in step 1.

Your conversion to a non-256 byte logical sector size should now be complete.

Benefits of Non-256 Byte Logical Sectors

Using different logical sector sizes can provide the following benefits depending on your application requirements:

- **The bitmap sector count decreases.**
  This may mean you can decrease the minimum cluster size of the media on large hard disks.
- **The number of clusters in a bitmap sector increases.**
  This allows faster bitmap searches and potentially larger segments to be allocated in the file descriptor segment list.
- **The media capacity may increase.**
  Many disk drives (both floppy and hard disks) can store more data on the disk, due to the decrease in the number of sectors per track (and thus less inter-sector gaps).
- **The chances of segment list full errors decreases.**
  Expanding the sector size beyond 256 bytes allows more file segment entries in the file descriptor.

Bootstrap Drivers

Converting RBF drivers and media to non-256 byte logical sectors also implies a change to the bootstrap code if the media is to continue to provide system bootstrap support.

Note

In general, the RBF driver deals with the same issues (hard-wired assumptions about 256 byte sectors, for example) as the BootStrap driver.

If the BootStrap driver is to support booting from any logical sector size, note the following:

- The BootStrap driver must be able to read the identification sector (LSN 0) of the media. Depending on the actual hardware situation and capabilities, this may require:
    - Querying the drive for the sector size (Mode Sense command to SCSI drives).
    - Reading a fixed byte-count from the drive (partial sector read).
    - Attempting to read the sector using all possible sector sizes.
- Once LSN 0 has been successfully read, the BootStrap driver should inspect the `DD_LSNSize` field of sector zero. This field gives the media's logical sector size (if it is 0, a size of 256 is assumed), and this value combined with the known physical size allows the BootStrap driver to load the actual bootstrap file. If the logical and physical sector sizes differ, the BootStrap driver can use deblocking algorithms or return an error.

For More Information

The next section contains more information about booting concerns with variable sector sizes.

RBF Disk Utilities

Utilities needing to ascertain the media's logical sector size (such as the `dcheck` utility) can do so by:

- Opening a path to the device.
- Checking the `PD_SctSiz` field of the path options section (with the GetStat `SS_OPT` function code).

For More Information

`dcheck` checks the disk file structure. Refer to the ***Utilities Reference*** manual for information about using `dcheck`.

RBF sets the `PD_SctSiz` field to the media's logical sector size when the path is opened. If the field contains a 0, an old RBF is running in the system and the logical sector size is assumed to be 256 bytes.

Appendix A: The CBoot Technology

This chapter includes the following topics:

- **Introduction**
- **The CBOOT Common Booters**
- **CBOOT Driver Entry Points**
- **CBOOT Library Entry Points**

Introduction

This version of OS-9 for 68K is the first release to recommend the C booting technology referred to as `CBOOT`. Although `CBOOT` requires a larger amount of ROM space than the assembler boots supported in previous releases, it has several added features.

`CBOOT` allows you to create drivers in either C or assembly. In previous versions, the boot routines had to manage the device and have a knowledge of the file structure from which it was booting. The `CBOOT` system provides *front end* code for various booting methods (such as disk and tape) that make calls to the hardware level boot drivers. This greatly simplifies the writing of boot code, as the only code you need to write is generally the actual code to manage the hardware interface. You can also create a driver source that can be conditionalized such that it could be used as a boot driver as well as an OS-9 driver (see the `MWOS/OS9/SRC/IO/RBF/DRVR/SCSI/RBTEAC` directory as an example).

You can interface previous assembler booters into the `CBOOT` system relatively easily. To update existing boot drivers to use with `CBOOT`, use the `sysboot.m` macro. For example, `boot320.a` has been updated to work with `CBOOT`.

`CBOOT` allows you to create menus that can be displayed on the system terminal. This allows you to use a terminal to select the device from which to boot rather than by setting switches.

For More Information

`CBOOT` is mainly written in C. Examining the code in the `CBOOT` directory can answer many questions.

The CBOOT Common Booters

The following is an overview of the common booter source files located in the `MWOS/OS9/SRC/ROM/CBOOT/SYSBOOT` directory. As a whole, you should not need to modify these sources. They are, however, valuable as documentation.

Table A-1 Common Booter Source Files

File	Booters	Description
`diskboot.c`	`diskboot()`	This is the front end code for floppy and hard disk boots. If necessary, the code performs logical to physical mapping of sectors and deblocks physical blocks. It also allocates the memory for the boot file. If the boot file is large (greater than 64K) or non-contiguous, `diskboot` performs the necessary requests to read the boot file. The requirements for the low-level boot driver are thus reduced to hardware management. This code can call either a `CBOOT` C driver or a converted assembly language driver.
`initdata.c`		This is part of the *glue* that initializes data for the `CBOOT` system when ROMbug is not being used. (ROMbug has its own `initdata.c` routine).

Table A-1 Common Booter Source Files (continued)

File	Booters	Description
`binboot.c`	`binboot()`	This is the entry point used for testing downloaded boot routines. It prompts for the bootfile size, indicates the load address to the operator, and waits for the operator to indicate the download is completed. The kernel is expected to be the first module. Once the download is completed, it jumps to the kernel entry point.
`misc.c`		This is a series of support subroutines for `CBOOT`.
`romboot.c`	`romboot()` `loadrom()`	This is the ROM boot front end. It searches the ROM list spaces for a module with the name `kernel` and verifies the module header parity. The code returns the address of the kernel to `CBOOT`. `loadrom()` differs from `romboot()` in that after finding a kernel module, it moves it and all modules contiguously following it to system RAM and begins executing the kernel there.

Table A-1 Common Booter Source Files (continued)

File	Booters	Description
`sysboot.c`		Sysboot is the *mainline* for the `CBOOT` system. It makes calls to the routine `getbootmethod()` and routes its activity accordingly.
`sysboot_glue.c`		This code provides the interface between the assembler `boot.a` code call to `sysboot.a` and the `CBOOT` boot code.
`tapeboot.c`	`tapeboot()`	This is the magnetic tape front end. It knows about the format that is expected of a boot tape and manages the memory and reading of the tape. It calls drivers that are expected to do little more than manage the hardware.

The file `syscon.c` in `PORTS/<target>` provides the routines `getbootmethod()` and `getboottype()` for the `CBOOT` system. You should review and understand this file. If the system contains hardware switches to be used to select the booting method, you should place a routine to read the switches and configure the system for booting in this file. There are also a set of variables defined in `syscon.c` that are required for proper system operation. You can create variables that are global to the drivers running under `CBOOT` by defining them in `syscon.c`.

For More Information

Examples of boot drivers are located in the `SRC/ROM/CBOOT` directory. Examining these drivers can be very instructive.

The `systype.h` file in `PORTS/<target>` performs a similar function for C code as the assembler language `systype.d` file by controlling system-wide definitions. Review this file for further information.

CBOOT Driver Entry Points

Under `CBOOT`, the boot drivers entry points are:

Table 9-2 CBOOT Driver Entry Points

Entry Point	Description
`init()`	Initialize Hardware
`read()`	Read Number of Blocks Requested into Memory
`term()`	Disable Hardware

Syntax

```
error_code init()
```

Description

`init()` initializes the hardware for use. It may install interrupt service routines if necessary.

read()

Read Number of Blocks Requested into Memory

Syntax

```
error_code read(
   u_int32    nsect,
   u_int32    lsect);
```

Description

`read()` calculates any physical sector address needed for the device (for example, head/sector) and reads the requested sectors into memory.

Note

The total byte count is guaranteed not to exceed 64K for any given read. If the device cannot read 64K, the read entry point must deblock the read.

Parameters

`nsect`	Specifies the number of sectors to read.
`lsect`	Specifies the starting logical sector.

term()

Disable Hardware

Syntax

```
error_code term()
```

Description

`term()` disables the hardware and ensures any interrupts from the device are disabled.

CBOOT Library Entry Points

Under CBOOT, the library entry points are:

Table 9-3 CBOOT Driver Entry Points

Entry Point	Description
`calldebug()`	Invoke System Level Debugger
`convhex()`	Convert Parameters to Hexadecimal Nibble
`extract()`	Allocate Memory from Boot ROM Free Memory List
`getbootmem()`	Allocate Memory for Bootfile
`gethexaddr()`	Read Hexadecimal Address
`hwprobe()`	Test for Existence of Hardware
`InChar()`	Wait to Physically Receive One Character
`InChChek()`	Perform Unblocked Read of One Character
`iniz_boot_driver()`	Initialize Boot Driver
`insert()`	Return Memory to System Memory List
`instr()`	Read String from Console Device
`inttoascii()`	Convert Parameter to ASCII

Table 9-3 CBOOT Driver Entry Points (continued)

Entry Point	Description
`makelower()`	Convert Upper Case Characters to Lower Case
`mask_irq()`	Mask Interrupts
`OutChar()`	Physically Send One Character
`OutHex()`	Convert Parameter to ASCII
`Out1Hex()`	Convert Parameter to ASCII
`Out2Hex()`	Convert Parameter to ASCII
`Out4Hex()`	Convert Parameter to ASCII
`outstr()`	Send String to Console Output Device
`powerof2()`	Convert Value to Power of Two
`setexcpt()`	Install Exception Service Routine
`streq()`	Compare Two Strings for Functional Equality
`sysreset()`	Restart System

calldebug()

Invoke System Level Debugger

Syntax

```
void calldebug();
```

Description

`calldebug()` starts the system level debugger. If no debugger is present, the system reboots when the call is made.

convhex()

Convert Parameter to Hexadecimal Nibble

Syntax

```
int convhex(char inchr);
```

Description

`convhex()` converts the hexadecimal ASCII character parameter `inchr` into a hexadecimal nibble and returns it to the caller. If `inchr` is not a hexadecimal ASCII character, `convhex()` returns -1 to the caller to indicate an error condition.

Parameters

`inchr`	Is the parameter to be converted to ASCII nibble.

extract()

Allocate Memory from Boot ROM Free Memory List

Synopsis

```
error_code extract(
   u_int32    *size,
   u_char     **mem);
```

Description

`extract()` allocates memory from the boot ROM free memory list. Memory is allocated in 16 byte increments. For example, if 248 bytes were requested, `extract()` rounds up and allocates 256 bytes.

Note

Boot devices use this routine to request memory not declared in the boot driver's `vsect` declarations. Typically, this dynamic allocation is performed by boot drivers with buffer requirements that are not known at compilation time (such as disk boot drivers supporting variable sector sizes). This method of dynamic allocation is useful for saving system memory usage as any storage declarations made at compilation time are *fixed* into the boot ROM global data area.

If the memory buffers are to be released (so they can be used by the kernel, for example), they should be returned to the boot ROM free memory list using the `insert()` call.

If an error occurs, `extract()` returns the error code. Otherwise, it returns `SUCCESS`.

Parameters

`size`	Points to a 32-bit unsigned integer that is passed in as the size of the block requested. The actual size of the block allocated is returned in this same location.
`mem`	Points to the pointer to the requested block.

getbootmem()

Allocate Memory for Bootfile

Syntax

```
error_code getbootmem(u_int32 sizereq);
```

Description

`getbootmem()` allocates memory for a bootfile via the `extract()` function. If memory for a bootfile has already been allocated by some previously called function, `getbootmem()` returns that block to the system via the `insert()` function.

The pointer to the bootfile memory allocated is returned in the global variable `bootram`.

The actual size of the memory allocated is returned in the global variable `memsize`.

If an error occurs, `getbootmem()` returns the error code to the caller. Otherwise, it returns `SUCCESS`.

Parameters

`sizereq`	Indicates the size of the requested memory block.

gethexaddr()

Read Hexadecimal Address

Syntax

```
void *gethexaddr();
```

Description

`gethexaddr()` reads the console input device for a hexadecimal address up to eight characters in length (32 bits). This address is then converted to a 32-bit integer and returned to the caller.

`gethexaddr()` ignores any character received from the console other than hexadecimal ASCII, a carriage return, or the letter `q` or `Q`. The letter `q` or `Q` returns a special abort error designation of -3 to the caller.

If a carriage return is received from the console and there was no previous input, `gethexaddr()` returns a -1 to indicate a *no address input* error.

Note

Any hexadecimal input value from `0x0` to `0xfffffffc` is returned to the caller.

hwprobe()

Test for Existence of Hardware

Syntax

```
error_code hwprobe(char *address);
```

Description

`hwprobe()` tests for the existence of hardware at `address`. `hwprobe()` installs a bus error handler and attempts to read from `address`. `hwprobe()` returns `SUCCESS` if the hardware is present or `E$BusErr` if it fails.

Parameters

`address`	Points to the address to be checked.

InChar()

Wait to Physically Receive One Character

Syntax

```
char InChar();
```

Description

`InChar()` waits for the hardware to physically receive one character, echoes the input character back to the console output device (via the `OutChar()` function), and returns the character to the caller.

InChChek()

Perform Unblocked Read of One Character

Syntax

```
int InChChek();
```

Description

`InChChek()` performs an unblocked read of one character from the console input device. If the device has not received a character, `InChChek()` does not wait, but returns an error designation of -1 to the caller. Otherwise, the character is returned.

Syntax

```
error_code iniz_boot_driver(
   void    *address,
   char    *name,
   char    *menuline,
   char    *idstring);
```

Description

`iniz_boot_driver()` initializes a boot driver by placing the parameters in the boot driver definition array.

Parameters

`address`	Points to the boot driver's execution entry point.
`name`	Points to a null-terminated character string that is the name of the boot driver. `SysBoot` uses this name for messages concerning the boot driver. For example, `An error occurred in the <name> boot driver`.
`menuline`	Points to a null terminated character string that is the message desired for the boot driver on a menu line. This entry is also used when the `AUTOSELECT` method is used to inform the user from which boot device `SysBoot` is attempting to boot. For example, `Now trying to <menuline>`.
`idstring`	Points to a null terminated character string that is the identification code to tell `SysBoot` which boot driver to call. This string appears in the menu at the end of a menu entry to indicate to the user what to

type in to select a given boot driver. `idstring` is also used to match the string returned by `getboottype()` in order to determine the boot driver selected.

Return Memory to System Memory List

Syntax

```
Dumb_mem insert(
   u_int32    size,
   u_int32    *mem);
```

Description

`insert()` returns memory to the system memory list. Memory is returned in 16 byte increments. For example, if 248 is passed as the size to return, `insert()` rounds up and returns 256 bytes.

`insert()` returns the new pointer to the head of the memory list.

Note

This pointer is also found in the global variable `freememlist`.

Parameters

`size`	Specifies the size of the returned block.
`mem`	Points to the block to return.

See Also

`extract()`

instr()

Read String from Console Device

Syntax

```
char *instr(
   char       *str,
   u_int32    size);
```

Description

`instr()` reads a string from the console device into a buffer designated by the pointer `str`. `instr()` handles the following rudimentary line editing functions:

Table A-2 Line Editing Functions

Name	Description
`<CTRL> X`	Back up the cursor to the beginning of the line.
`<CTRL> A`	Display the previous contents of the buffer.
`<BACKSPACE>`	Back up the cursor one character.

`instr()` returns to the caller when it receives a carriage return (`\n`) from the console.

Note

`instr()` ignores any character other than a carriage return if it is received when the buffer is already full.

Parameters

`*str`	Points to the beginning of the input string passed back to the caller.
`size`	is a 32-bit unsigned integer used to determine the size of the buffer to which the input string is written.

inttoascii()

Convert Parameter to ASCII

Syntax

```
u_char *inttoascii(
   u_int32    value,
   char       *bufptr);
```

Description

`inttoascii()` converts the unsigned 32-bit integer parameter `value` to a null terminated string of up to ten characters of numeric ASCII. Leading zeroes beyond the hundreds digit are ignored. At least three digits are guaranteed.

`inttoascii()` returns the buffer pointer after it is incremented to point to the first character after the ASCII string.

Parameters

`value`	Is the parameter to convert.
`bufptr`	Points to a character buffer in which to deposit the string.

Syntax

```
char makelower(char c);
```

Description

`makelower()` converts an uppercase alphabetic ASCII character to lowercase and returns it to the caller. Any other character is simply returned to the caller intact.

Parameters

`c`	Is the uppercase ASCII character to be converted to lowercase.

mask_irq()

Mask Interrupts

Syntax

```
u_int16 mask_irq(u_int16 mask);
```

Description

`mask_irq()` masks the interrupts in the 68xxx MPU status register to the level indicated by the interrupt mask bits in the parameter `mask`. `mask_irq()` returns the previous contents of the status register to the caller.

Note

`mask` is actually inserted directly into the 68xxx MPU status register. The caller must ensure the supervisor state bit is not changed. The condition codes are also affected.

`mask_irq()` does not take steps to preserve the trace flag. If soft breakpoints are enabled and ROM breakpoints are active, `mask_irq()` can disable them and the breakpoint may be missed.

Parameters

`mask`	Is the mask.

OutChar()

Physically Send One Character

Syntax

```
void OutChar(char c);
```

Description

`OutChar()` physically sends one character to the console output device.

Parameters

`c`	Is the character to send to the console output device.

OutHex()

Convert Parameter to ASCII

Syntax

```
void OutHex(char nibble);
```

Description

`OutHex()` converts the lower four bits of the parameter `nibble` to an ASCII hexadecimal character (0 - F) and sends it to the console output device via the `OutChar()` function.

Parameters

`nibble`	Is the parameter to be converted to ASCII hex.

Out1Hex()

Convert Parameter to ASCII

Syntax

```
void Out1Hex(u_char byte);
```

Description

`Out1Hex()` converts the unsigned character parameter `byte` to two ASCII hexadecimal characters (0 - F) and sends them to the console output device via the `OutChar()` function.

Parameters

`byte`	Is the parameter to be converted to ASCII hex.

Out2Hex()

Convert Parameter to ASCII

Syntax

```
void Out2Hex(u_int16 word);
```

Description

`Out2Hex()` converts the 16-bit unsigned parameter `word` to four ASCII hexadecimal characters (0 - F) and sends them to the console output device via the `OutChar()` function.

Parameters

`word`	Is the parameter to be converted to ASCII hex.

Out4Hex()

Convert Parameter to ASCII

Synopsis

```
void Out4Hex(u_int32 longword);
```

Description

`Out4Hex()` converts the 32-bit unsigned parameter `longword` to eight ASCII hexadecimal characters (0 - F) and sends them to the console output device via the `OutChar()` function.

Parameters

`longword`	Is the parameter to be converted to ASCII hex.

outstr()

Send String to Console Output Device

Syntax

```
error_code outstr(char *str);
```

Description

`outstr()` sends a null-terminated string to the console output device.

Note

`outstr()` always returns `SUCCESS`.

Parameters

`str`	Points to the first character in the string to send.

powerof2()

Convert Value to Power of Two

Syntax

```
int powerof2(u_int32 value);
```

Description

`powerof2()` converts the unsigned 32-bit integer parameter `value` into a power of two (bit position). Any remainder is discarded. If `value` is equal to `0`, `powerof2()` returns -1 to indicate an error condition.

Parameters

`value`	Is the unsigned integer parameter to be converted.

setexcpt()

Install Exception Service Routine

Syntax

```
u_int32 setexcpt(
   u_char     vector,
   u_int32    irqsvc);
```

Description

`setexcpt()` installs an exception service routine directly into the exception jump table.

`setexcpt()` returns the address of the exception service routine previously installed on the vector. You can use `setexcpt()` to set up specialized exception handlers (such as bus trap and address trap) and to install interrupt service routines.

Note

The caller must save the address of the previously installed exception handler and restore it in the exception jump table (via `setexcpt()`) once the caller is no longer using the vector.

Parameters

`vector`	Is a vector number (2 - 255).
`irqsvc`	Is the address of the exception service routine.

streq()

Compare Two Strings for Functional Equality

Syntax

```
u_int32 streq(
    char    *stg1,
    char    *stg2);
```

Description

`streq()` compares two strings for functional equality. The case is ignored on alphabetic characters, for example, 'a' = 'A'. If the two strings match, `streq()` returns TRUE (1). Otherwise, it returns FALSE (0).

Parameters

`stg1`	Points to the first string to compare.
`stg2`	Points to the second string to compare.

sysreset()

Restart System

Syntax

```
void sysreset();
```

Description

`sysreset()` restarts the system from dead start initialization. `sysreset()` does not return to the caller.

Appendix B: Trouble Shooting

This appendix is designed to help if you run into problems while porting OS-9 for 68K. It includes the following topics:

Introduction

This appendix is designed to help if you run into problems while porting OS-9 for 68K. To use this appendix most effectively:

Step 1. Identify during which step of the booting process you are having problems.

Step 2. Go to that section in this appendix.

Step 3. Locate the description best describing your problem.

Step 4. Read and follow the directions you find there.

Step 1: Porting the Boot Code

If you encountered problems during **Chapter 3: Step One: Porting the Boot Code**, read this section carefully:

If you are getting unresolved references during linking, this error is the result of one of three conditions:

1. **A library is missing from the link line.**
   Two utilities, `rdump` and `libgen`, are available to help you find which library contains the unresolved reference. The `libgen` utility locates references for Ultra C compiler libraries, while `rdump` finds references for libraries created with the Version 3.2 compiler. To search for a reference in a library, use the following type of command:

   ```
   $ rdump -a <library.l> ! grep <reference name>
   $ libgen -le <library.l> ! grep <reference name>
   ```

   Once the library reference is found, include the library in the `LIBS` macro of the `makefile`.

2. **The ordering of the libraries is incorrect.**
   If you find the references are all in the libraries you are including, then the problem may be with the ordering of the libraries. The linker is a single pass linker. If a function references an external variable or a function defined earlier in the same library or another library and if the linker has already moved pass that point, the linker is not able to resolve the reference. For this reason, the ordering of the libraries is important.

   To determine the ordering of the OS-9 standard libraries:

Step 1. Compile a simple program in verbose mode (`-b` with Ultra C, `-bp` with the version 3.2 C compiler). The `cc` executive passes the libraries in the correct order to the linker.

Step 2. Look at the linker line generated by the `cc` executive.

Step 3. Note the ordering of the specific libraries in which you are interested. Many other libraries need to be linked in front of the standard libraries, for they often call functions out of these standard libraries.

3. **The libraries are in the wrong position in the link line.**
Sometimes, if the libraries are not included at the end of the linker line, unresolved references can occur. Try moving the libraries to the end and see if this helps.

Step 2: Porting the OS-9 for 68K Kernel and Basic I/O

If you encountered problems during **Chapter 4: Step Two: Bringing Up the Kernel and Console I/O**, look for the error message you received and read that section carefully:

- **MPU incompatible with OS-9 kernel**
  You are using the wrong kernel for that specific processor. The boot code has produced a bus error stack frame and from this, it has determined which specific processor is being run (68000, 68010, 68020, 68030, ...). There is a specific kernel for each of these processors, and the wrong kernel is being used.
- **OS-9 Boot failed; can't find init**
  The kernel could not find the `Init` module. Verify the `Init` module is in the same special memory bank as the kernel and it has a module name of `Init`. This error can also occur when `boot.a` finds an exceedingly small amount (or no RAM). Verify the amount of RAM by register `d0` and `a4` at the first boot stage.

For More Information

For additional information about `d0` and `a4`, refer to **Chapter 3: Step One: Porting the Boot Code**.

- **Can't allocate <name of> table**
  The kernel is trying to allocate room for its own table and has run out of RAM. Verify the amount of RAM by register `d0` and `a4` at the first boot stage.

Note

The error message usually reports an error number (in Hex) to indicate the reason why the failure occurred. These error numbers are standard OS-9 for 68K error codes.

- **Can’t open console terminal**
  IOMan is trying to open the console name defined in the `M$Consol` field of the `Init` module. An error has occurred preventing IOMan from booting. This error can occur for many reasons, including:

  a. The driver and descriptor modules do not have owners of 0.0. You can use the `ident` utility to verify this, and you can use the `fixmod` utility to change the owner of a module.

  b. Either the driver, descriptor, or the SCF file manager was not found during the kernel’s module search list. Review the **Searching the Module Directory** section of this chapter and verify these modules were found. If not, check the special memory areas and verify these modules are in these areas. Also, check the ROM list at the first boot stage to make sure all special memory areas were found.

  c. The driver returned an error. For some reason, the driver’s `Init` routine is returning with an error. Either the driver must be debugged using RomBug or review the source to determine the reasons why an error can be returned.

If you are using the sc68681 driver, a common problem is the proper setting of the `DevCon` descriptor field. Review the section on setting up the `DevCon` field later in this appendix.

- **Can’t open default device**
  IOMan is trying to open the default device name defined in the `M$SysDev` field of the `Init` module. The reasons for this error are similar to those for the console device given above except the file manager used is RBF.

Coldstart Errors for the Atomic Versions of the Kernel and IOMan

When running in an Atomic environment, if the Kernel or IOMan cannot complete their startup procedures correctly then an error code is printed to the system console.

These error codes are currently defined as:

Table B-1 Coldstart Errors

Module	Error	Meaning
kernel	`K-001`	the processor type and kernel are not compatible
	`K-002`	the kernel can't find the `Init` module
	`K-003`	the kernel can't allocate the process block table
	`K-004`	the kernel can't allocate its irq stack
	`K-005`	the kernel can't fork the initial process
	`K-006`	an error was returned from an extension module
	`K-007`	the kernel can't allocate its irq polling table
	`K-008`	the kernel can't allocate the event table
	`K-009`	the total size of a process descriptor is greater than 32K
ioman	`I-001`	ioman can't install its service requests

Table B-1 Coldstart Errors (continued)

Module	Error	Meaning
	`I-002`	ioman can't locate the `Init` module
	`I-003`	ioman can't allocate memory for the system path and device tables

If a problem occurs with startup using the development kernel or IOMan, a full text message is printed on the system console instead of an error code.

Errors during system startup are caused by inappropriate values in the system's `Init` module.

Setting Up the DevCon Descriptor Field for the Sc68681 Serial Driver

There is an area of 256 bytes with the kernel's system globals called *OEM Global Data*. The kernel does not use this area; OEMs may use it for whatever they like.

The MC68681 serial device has a peculiar feature—two of its registers are write only registers. These registers are the:

- Interrupt Mask Register (IMR).
- Auxiliary Control Register (ACR).

Because this device has three functions (serial port A, serial port B, and a ticker) changes to these two write only registers must be communicated to other drivers using this device. The `sc68681` driver generates a *shadow* register pair of the IMR and ACR within the OEM Global Data area. In this way, the driver running for port A can communicate changes for the driver running for port B, as well as the ticker routines.

One shadow register pair is required for each physical 68681 serial device used in the system, so the drivers for each *side* of each device can communicate with each other. The allocation of each pair is communicated to the driver via the `DevCon` section of the SCF Descriptor for each logical device. An example allocation is:

```
Device #1:  A-side port:  "TERM" - pair #1
Device #1:  B-side port:  "T1"   - pair #1
Device #2:  A-side port:  "T2"   - pair #2
Device #2:  B-side port:  "T3"   - pair #2, etc...
```

Each pair of bytes contains the current value of these registers, for each 68681 serial device in the system.

- The first byte of the pair is the Interrupt Mask Register (IMR) image.
- The second byte of the pair is the Auxiliary Control Register (ACR) image.

Allocation of each pair of bytes is done via an offset pointer located in the `DevCon` section of SCF device descriptors. The offset pointer is the address offset into this area, as follows:

```
   Byte Offset         Device Number
   -----------         -------------
       0  ----------->>  device #1
       2  ----------->>  device #2
       4  ----------->>  device #3
```

You can put the following example code into your `systype.d` file to make proper descriptors.

```
********************************
* Make Descriptors for sc68681 device
* Need to set up DevCon field correctly
 org 0 base offset starts at OEM_Glob
D_681_1 do.w 1 shadow register pair for device #1
D_681_2 do.w 1 shadow register pair for device #2
D_681_3 do.w 1 shadow register pair for device #3
D_681_4 do.w 1 shadow register pair for device #4
D_681_5 do.w 1 shadow register pair for device #5
D_681_6 do.w 1 shadow register pair for device #6
D_681_7 do.w 1 shadow register pair for device #7
********************************
* SCF device descriptor definitions
*    used only by scf device descriptor modules
*
* SCFDesc:
Port,Vector,IRQlevel,Priority,Parity,BaudRate,DriverName
*               M$Vect,M$IRQLvl,M$Prior,
*
*
*
* Descriptors term and t1 are for the 1st 68681 device
*
TERM macro
 SCFDesc TermBase,TermVect,TermLevel,1,0,14,sc68681
DevCon dc.w D_681_1 offset in OEM global storage
 endm
T1 macro
 SCFDesc T1Base,T1Vect,T1Level,2,0,14,sc68681
DevCon dc.w D_681_1 offset in OEM global storage
 endm
*
* Descriptors t2 and t3 are for the 2nd 68681 device
*
T2 macro
 SCFDesc T2Base,T2Vect,T2Level,2,0,14,sc68681
DevCon dc.w D_681_2 offset in OEM global storage
 endm
T3 macro
 SCFDesc T3Base,T3Vect,T3Level,2,0,14,sc68681
DevCon dc.w D_681_2 offset in OEM global storage
 endm
*
* Descriptors t4 and t5 are for the 3rd 68681 device
*
T4 macro
```

```
 SCFDesc T4Base,T4Vect,T4Level,2,0,14,sc68681
DevCon dc.w D_681_3 offset in OEM global storage
 endm
T5 macro
 SCFDesc T5Base,T5Vect,T5Level,2,0,14,sc68681
DevCon dc.w D_681_3 offset in OEM global storage
 endm
```

Searching the Module Directory

The gb command at the ROMBug prompt starts the boot stages for ROMBug. This tells the debugger to go in boot stages.

After the initial go, the debugger breaks out of the boot procedure just before the boot.a code jumps to the kernel. This is to check if the boot code performed like it should. The registers should be in OS-9 format as documented in the **The Boot.a File** section of **Chapter 3: Step One: Porting the Boot Code**. If all seems well, another gb in RomBug or g in debug allows the jump to the kernel and for the boot procedure to break again.

The debugger breaks in the cold part of the kernel. The code for cold has just completed the memory verification and the ROM memory module searches. It is just about ready to fork the initial process. At this point, you can manually search the module directory to see if all the modules have been found.

At this point, the memory location pointed to by the vbr register (or memory location 0 if on a 68000 processor) points to the beginning of system globals. Offset 0x3c from the system globals the address of the module directory list. Each directory entry is 16 bytes, or 10 hex bytes that can make dumping it very handy. The first long word in a directory entry is the address to the module itself.

From a debugger, the following gets to the module directory:

```
d [[.vbr]+3c]
```

The following actually gets to the first module listed in the directory, which should be kernel:

```
d [[[.vbr]+3c]]
```

Note

These examples assume a CPU with a VBR. If your CPU does not have a VBR, substitute the value of 0 in the following examples.

The next module would be obtained by:

```
d [[[.vbr]+3c]+10]
```

The modules should be listed as they were put into the ROMs or bootfile. To find the name of the module:

- Get the name offset from the header.
- Add the offset to the beginning of the header.

Note

Remember, all modules begin with the code `4afc`.

Once the system is running, you can reference the system globals with either RomBug or SysDbg to see the module directory. For example:

```
d [[[.vbr]+3c]+10]
```

The name string of the module is pointed to by a pointer stored at offset 0xc into the module. This offset is the offset of the name string from the beginning of the module. This can be referenced indirectly from the debugger and added on to the beginning of the module. Use the following debugger to find the name of the first module:

```
d [[[.vbr]+3c]]+[[[[.vbr]+3c]]+c]
```

The second and third module names can be found as follows:

```
d [[[.vbr]+3c]+10]+[[[[.vbr]+3c]+10]+c]
d [[[.vbr]+3c]+20]+[[[[.vbr]+3c]+20]+c]
```

As a shortcut to displaying the modules, the following sequences of commands can be used:

```
ROMbug:   .r1 [[.vbr]+3c]
          d [.r1]+[[.r1]+c] 10 .r1 .r1+10
```

Simply use `control-A` repeatedly after entering the second line to display the names in the module directory in sequence.

Appendix C: Low-level Driver Flags

This appendix explains the low level I/O driver flags for each driver in the Developer's Kit. These flags deal with chip addressing and other issues that are different between hardware processor boards. There are also flags determining which driver is using the Cons port and which is using the Comm port. These flags should be defined in `systype.d`. If a driver is included in the Developer's Kit and is not listed here, simply view the source to determine what each of the flags do.

This appendix contains the following topics:

Flags for io2661.a

`ConsType`	If equated to SC2661, the driver handles console I/O.
`CommType`	If equated to SC2661, the driver handles communication I/O.
`SerType`	If equated to DBC68, the registers on the chip are addressed for every byte addressing. If this label is not defined, or defined to be something else, the chip's registers are addresses for every other byte.

For example,

if `SerType = DBC68` the addressing is `base+0`, `base+1`, `base+2`, `base+3`.

if `SerType ! = DBC68` the addressing is `base+0`, `base+2`, `base+4`, `base+6`.

Flags for io6850.a

`ConsType`	If equated to MC6850, the `io6850.a` is used for console I/O.
`CommType`	If equated to MC6850, the `io6850.a` is used for communication I/O.
`IOType`	This flag must be equated to either 0 or 1. This driver accesses the 6850's status register with an offset of zero from the `Cons_Addr` (or `Comm_Adr`), and the data register is accessed either by an offset of 1 or 2 depending on whether `IOType` is equated to 0 or 1 respectively.
`Ser Type`	If equated to H68K, an onboard chip accessible baud rate generator is available. A flag, `TimPort`, needs to be equated to address of this baud rate generator. Codes within this conditionalized code needs to be modified to set the baud rate generator correctly. If there is no chip accessible baud rate generator, `SerType` should not be defined at all.

Flags for io68560.a

ConsType	If equated to R68560, io68560 is used for console I/O.
CommType	If equated to R68560, io68560 is used for communication I/O.
CPUType	If equated to CPU29, another flag, BusWidth, needs to be defined.

BusWidth label determines the addressing for the registers on the 68560. If CPUType is not defined at all, the default addressing or bus width is 2, registers are accessed on every other byte.

By default, the driver accesses registers starting at the base address. If you wish to start accessing the registers at base address +1, equate label IOBdType to 2.

Flags for io68562.a

`ConsType`	If equated to S68562, `io68562` driver handles console I/O.
`CommType`	If equated to S68562, `io68562` handles communication I/O.
`CPUType`	This label can be defined to CPU30. If not defined, or defined to be something else, the registers of the 68562 start at the `Cons_Addr` (or `Comm_Adr`) and are addressed by every byte. If this label is set to CPU30, another label, `BusWidth` needs to be defined. Also, the registers start at `Cons_Addr+1` (or `Comm_Adr+1`). `BusWidth` label is set to the number of bytes between each register.

Flags for io68564.a

There are no flag or label definitions for this driver. All of the register labels for the 68564 start at `Cons_Addr` or `Comm_Adr` and is addressed for every byte. If the addressing for your hardware is different, these labels need to be changed to fit your hardware.

Flags for io68681.a

The standard version of this code assumes the Console device is the A side chip port, and the communications device is the B side port of the same chip. When this situation does not apply, you need to implement system specific conditionals via `ifdef` statement (refer to `PACERMOS` for example coding).

For all versions, the IMR shadow images for the CONS port is assumed to be held in the first *pair* of bytes, starting at the OEM global area, `D_Start`.

For the PACER system, the IMR shadow image for the COMM is expected to reside in the second *pair* of OEM Globals.

For More Information

For further information about OEM Globals and shadow registers, please refer to the section **Setting Up the DevCon Descriptor Field for the Sc68681 Serial Driver** in **Appendix B: Trouble Shooting**.

There are three label definitions that need to be defined for this driver: `FASTCONS`, `PACERMOS`, and `CPUType`.

`FASTCONS`	If this label is defined, the CONS port and COMM port runs at 19.2K Baud. If not defined, the default is 9600 Baud.
`PACERMOS`	If this label is defined, the CONS port is on the A side of chip one, and the COMM port is on the B side of chip two. This also sets the port to be even parity and seven bits/character.
`CPUType`	This label has several different definitions. Its main purpose is to define the registers on the 68681 are addressed.

VME165 addressing is every fourth byte.

VME135,VME140,VME141, SYS360. MC68340 addressing is every other byte.

In addition to the above, the following `CPUType` labels have affects:

`MC68340`	There is a separate mode register 2 and this allows coding for it.
`SYS360`	Sets up RTS on the CONS port.

Flags for io68901.a

`ConsType`	If set to MOS68901, the `io68901.a` is used as the console drivers.
`CommType`	If set to MOS68901 the `io68901.a` is used on the communications driver.
`BC_68901`	This label should be equated to the bus width of the ship's register addressing. If not defined, the default bus width is two for addressing the registers on every other byte.

Flags for ioz8530.a

`ConsType`	If equated to ZA, the A side of the chip is the console port. If equated to ZB, the B side is the console port.
`CommType`	If equated to ZA, the A side of the chip is the communications port. If equated to ZB, the B side is the communications port.
`CPUType`	This determines the addressing of 8530. If set to VME117, VME107, or VME162, the addressing starts at `Cons_Addr+1` (or `Comm_Adr+1`) and is accessed on every byte.
`ConsBaud`	Setting this sets the console device baud rate. If this is not defined, the label WR12Std needs to be set. This label is set to the value to be put into write register 12 to set the baud rate.
`CommBaud`	Same as `ConsBaud`, except it sets the baud rate for the communications port.
`WR14Std`	This label needs to be set up for write register 14 of the 8530.

Appendix D: SCSI-System Notes

This appendix contains information about the **OS-9 for 68K SCSI-System Drivers**.

RadiSys.

MICROWARE SOFTWARE

OS-9 for 68K SCSI-System Drivers

Hardware Configuration

The basic premise of this system is to break the OS-9 for 68K driver into separate *high-level* and *low-level* areas of functionality. This allows 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 controller-specific/device-class issues (for example, disk drives on an OMTI5400).

For More Information

When you write a device driver, do not include MPU/CPU specific code. This makes the device driver *portable*. Refer to the ***OS-9 for 68K Technical Manual*** for more information about device drivers.

The high-level drivers:

- Prepare the command packets for the SCSI target device.
- 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 simply 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, and thus 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 via the *DevCon* offset in the device descriptor. This offset pointer points to a string containing the name of the low-level module.

Example One

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

OMTI5400 Controller

Attributes include:

- Addressed as SCSI ID 6.
- Hard disk addressed as controller’s LUN 0.
- Floppy disk addressed as controller’s LUN 2.
- Tape drive addressed as controller’s LUN 3.

Fujitsu 2333 Hard Disk with Embedded SCSI Controller

Addressed as SCSI ID 0.

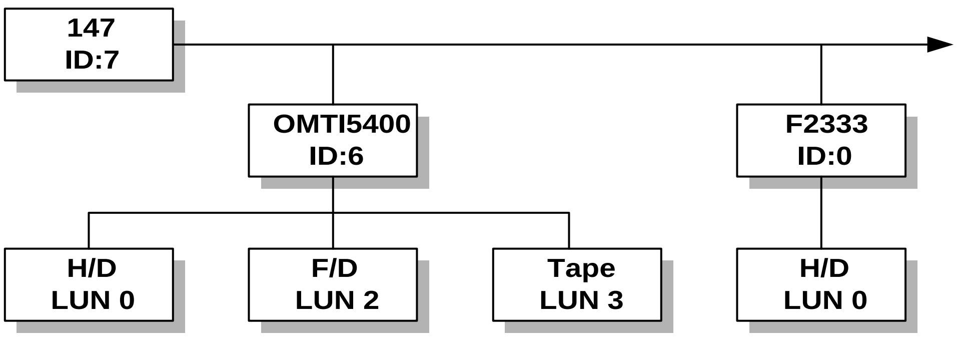
Host CPU: MVME147

Attributes include:

- Uses WD33C93 SBIC Interface chip.
- *Own ID* of chip is SCSI ID 7.

The hardware setup looks like this:

Figure D-1 Hardware Setup



Software Configuration

The high-level drivers associated with this configuration are:

Table D-1 High-level Drivers

Name	Handles
`RB5400`	Hard and floppy disk devices on the OMTI5400.
`SB5400`	Tape device on the OMTI5400.
`RB2333`	Hard disk device.

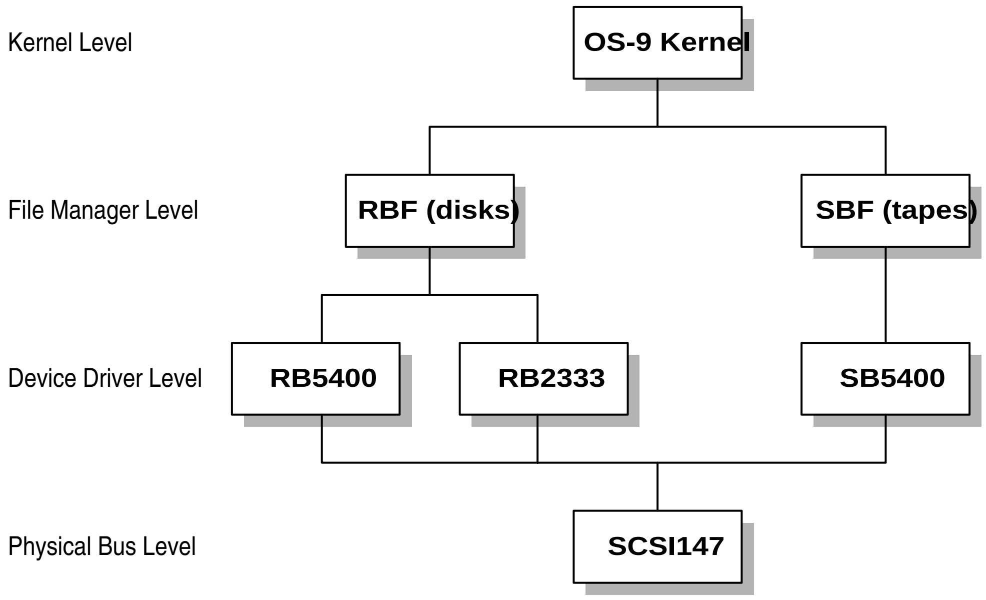
The low-level module associated with this configuration is:

Table D-2 Low-level Modules

Name	Handles
`SCSI147`	WD33C93 Interface on the MVME147 CPU.

A conceptual map of the OS-9 for 68K modules for this system looks like this:

Figure D-2 Example 1 Conceptual Map of OS-9 for 68K Modules



If you have followed the previous guidelines, you can easily expand and reconfigure the SCSI devices (both in hardware and software). Three examples show how this could be achieved.

Example Two

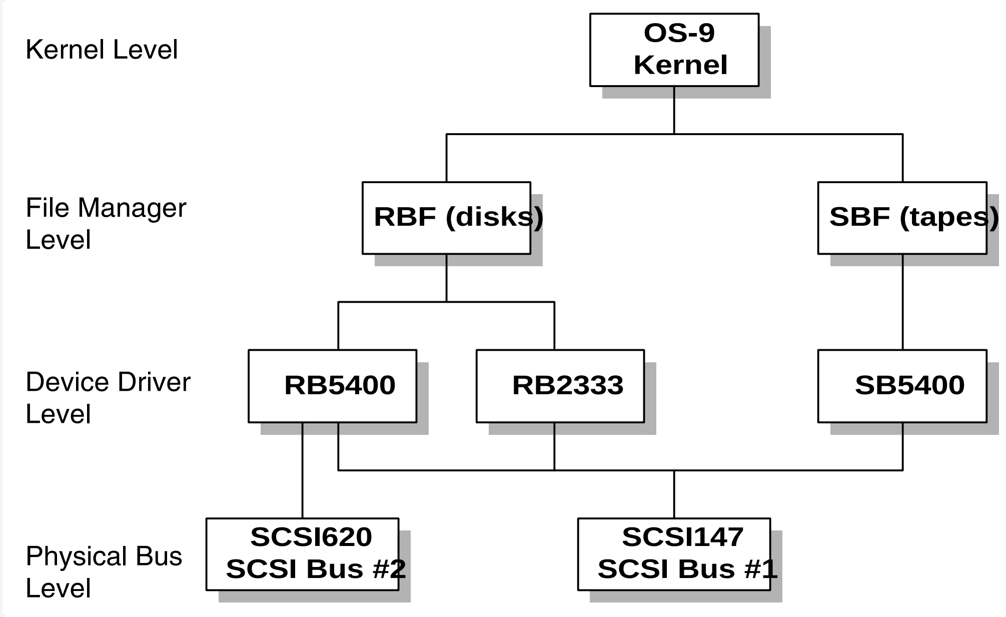
This example adds a second SCSI bus using the VME620 SCSI controller. This second bus has an OMTI5400 controller and associated hard disk.

The VME620 module uses the WD33C93 chip as the SCSI interface controller, but it uses a NEC DMA controller chip. Thus, you need to create a new low-level module for the VME620 (we call the module `SCSI620`). To create this module, edit the existing files in the `SCSI33C93` directory to add the VME620 specific code. This new code would typically be *conditionalized*. You could then create a new makefile (such as `make.vme620`) to produce the final `SCSI620` low-level module.

The high-level driver for the new OMTI5400 is already written (`RB5400`), so you only have to create a new device descriptor for the new hard disk. Apart from any disk parameter changes pertaining to the actual hard disk itself (such as the number of cylinders), you could take one of the existing `RB5400` descriptors and modify it so the `DevCon` offset pointer points to a string containing `SCSI620` (the new low-level module).

The conceptual map of the OS-9 for 68K modules for the system now looks like this:

Figure D-3 Example 2 Conceptual Map of OS-9 for 68K Modules



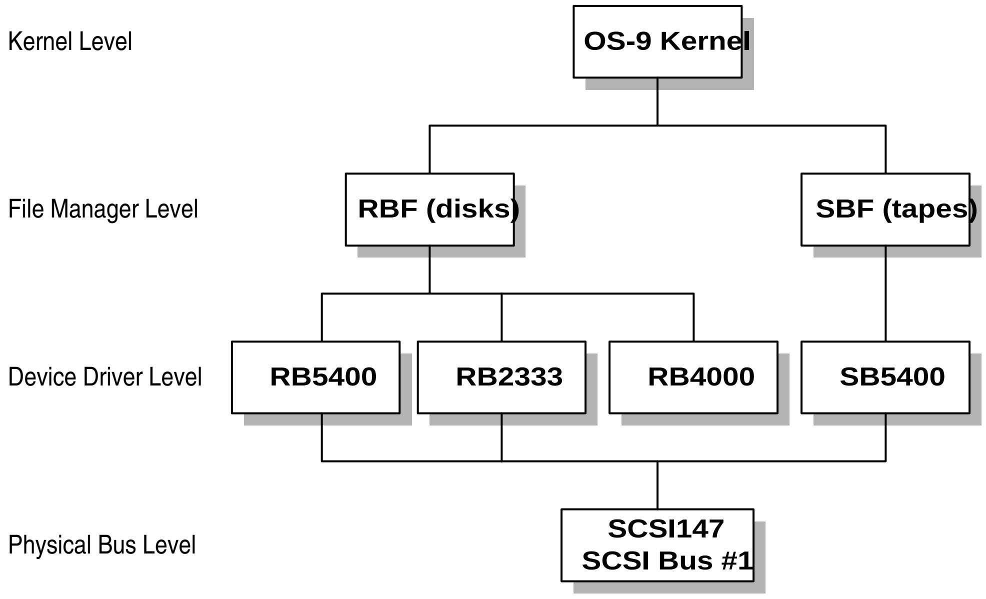
Example Three

This example adds an Adaptec ACB4000 Disk Controller to the SCSI bus on the MVME147 CPU.

To add a new, different controller to an existing bus, you need to write a new high-level device driver. You would create a new directory (such as `RB4000`) and write the high-level driver based on an existing example (such as `RB5400`). You do not need to write a low-level module, as this already exists. You then need to create your device descriptors for the new devices, with the module name being `rb4000` and the low-level module name being `scsi147`.

The conceptual map of the OS-9 for 68K modules for the system now looks like this:

Figure D-4 Example 3 Conceptual Map of OS-9 for 68K 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 Fujitsu 2333 disk to the SCSI bus on the MVME147. To add a similar controller to the bus, you only need to create a new device descriptor. There are no drivers to write or modify, as these already exist (`RB2333` and `SCSI147`). You need to modify the existing descriptor for the `RB2333` device to reflect the second device’s physical parameters (SCSI ID) and change the actual name of the descriptor itself.

Appendix E: Using the OS-9 for 68K System Security Module

This appendix includes the following topics:

- **Memory Management Units**
- **Hardware/Software Requirements**
- **Configuring SSM for MC68451 Systems**
- **Adding SSM to the OS-9 Bootfile**
- **Creating a System Security Module**
- **SSM Module Structure**
- **Hardware Considerations**
- **Complete Source Listing**

Memory Management Units

This section describes the level of support for the various memory management units (MMU) provided by Microware. Included are:

- Motorola 68451 (typically for 68010 systems)
- Motorola 68851 (typically for 68020 systems)
- Embedded MMUs found on the 68030 and 68040 microprocessors.

The 68451 requires only minor modification before use while the others are implementation independent.

Instructions and an example are also included for instances where OEMs may wish to design their own MMU.

Hardware/Software Requirements

The following hardware and software is required for use with the OS-9 System Security Module (SSM):

- OS-9, Version 2.4 or greater.
- A Memory Management Unit must be installed on the system:

  •as a discrete chip,

  •embedded on the microprocessor, or

  •as a separate card.

Versions of SSM040

There are two versions of SSM040. The difference between the two is the cache mode for supervisor state:

- `ssm040` is write-thru.
- `ssm040_cbsup` is copy-back.

In both cases the user-state cache mode defaults to write-thru. Select the appropriate SSM module for the supervisor state cache mode desired, and then set up cache overrides in the `Init` module cache list entries to turn on copy-back/etc regions for user-state.

Configuring SSM for MC68451 Systems

You may need to modify the code for the MC68451 SSM module for your particular hardware. A short source file, `ssmdefs.a`, is included with the OS-9 for 68K Developers Kit distribution to allow you to specify the base address of the MC68451 chip and the offsets into the Address Space Table used by the SSM code.

In most cases, you only need to change the device base address. Some hardware implementations of the MC68451 (specifically the Heurikon M10/V10 CPU's) use the DMA portion of the Address Space Table (AST) instead of the MPU section which is normally used. You should change the offsets for the AST registers to match your hardware. The `ssmdefs.a` file has conditional directives to accommodate either the standard or Heurikon style implementations.

For More Information

Refer to pages 3-4 of the ***Motorola MC68451*** manual, April 1983 for a complete description of the Address Space Table.

For example, the Eltec VEX CPU has two MC68451 chips located at `$00fa8000` and `$00fa8200`. The SSM code supplied by Microware supports only one MMU, so the `MMU_Addr` in the `ssmdefs.a` file should be changed to either `$00fa8000` or `$00fa8200`. You must also remove the conditional code for the Motorola MVME121 for the Eltec VEX CPU.

Before: `nam ssmdefs`

`ttl` definitions for system security module

```
 ***********************
*   This file contains definitions which may need to be
* changed for different applications of the MC68451. These
* include the base address of the MMU chip and the Address
* space table registers used for the various types of memory
* accesses.

 opt -l
 use <oskdefs.d>
 use <systype.d>
 opt l

 psect ssmdefs,0,0,0,0,0

 ifndef VME121
VME121 equ 121
 endc

 ifndef CPUType
CPUType set 0
 endc

CPUType set VME121

 *******************
* Define the address of the MMU chip
*
 ifne CPUType-VME121
MMU_Addr: equ $FE7000 assume heurikon
 else
MMU_Addr: equ $F60000 base address of the mmu for VME121
 endc

 ifeq CPUType-VME121
* AST register definitions for non-Heurikon
*
MMU_UserData: equ $02 offset to user data entry in ast
MMU_UserCode: equ $04 to user's code
MMU_SysData: equ $0A to system data
MMU_SysCode: equ $0C to system code

 else

* AST register definitions for Heurikon
*
MMU_UserData: equ $12 offset to user data entry in ast
MMU_UserCode: equ $14 for user's code area
MMU_SysData: equ $1A for system data
MMU_SysCode: equ $1C for system code
 endc

 ends
```

After: nam ssmdefs

ttl definitions for system security module

```
***********************
*
*   This file contains definitions which may need to be
* changed for different applications of the MC68451. These
* include the base address of the MMU chip and the Address
* space table registers used for the various types of memory
* accesses.

 opt -l
 use <oskdefs.d>
 use <systype.d>
 opt l

 psect ssmdefs,0,0,0,0,0

*******************
* Define the address of the MMU chip
*

MMU_Addr: equ $FA8000 assume heurikon

* AST register definitions for Eltec VEX CPU
* Eltec uses the normal layout as described in
* the Motorola MC68451 manual.
*
MMU_UserData: equ $02 offset to user data entry in ast
MMU_UserCode: equ $04 to user's code
MMU_SysData: equ $0A to system data
MMU_SysCode: equ $0C to system code

 ends
```

Once the `ssmdefs.a` file has been modified to match your hardware, you can assemble `ssmdefs.a` and link it to the `ssm.r` file (the relocatable code for the MC68451 SSM module) to create the ssm object code. A makefile is included on the distribution disk for this purpose.

To accomplish this, follow these two steps:

- Change to the SSM451 directory.
- Enter `make ssm451`.

For example:

```
$ chd /h0/MWOS/OS9/SRC/SYSMODS/SSM/SSM451
$ make ssm451
```

You can now install the SSM module on your system.

Adding SSM to the OS-9 Bootfile

Three steps are required to add SSM to the OS-9 for 68K Bootfile:

Step 1. Create a new `init` module.

Step 2. Create a new bootfile.

Step 3. Test SSM operation.

Each step is detailed below.

Step One: Create a New Init Module

To create a new `init` module, change your working directory to `/h0/MWOS/OS9/680X0/PORTS/<your CPU>`.

Edit the system's `systype.d` file `CONFIG` macro so the string `ssm` appears in the Init Module Extension list.

Note

Most systems do not define `Extens` in this macro because the default extension module (`os9p2`) is defined in `init.a` if no extension module list is given in `CONFIG`:

Before: `CONFIG` macro

```
Mainfram dc.b "Motorola VME 110",0
SysStart dc.b "sysgo",0 name of initial module to execute
SysParam dc.b C$CR,0 parameter to SysStart
SysDev dc.b "/D0",0 initial system disk pathlist
ConsolNm dc.b "/Term",0 console terminal pathlist
ClockNm dc.b "mc6840",0 clock module name
  endm
* (Other default values may be set here)
```

After: `CONFIG` macro

```
Mainfram dc.b "Motorola VME 110",0
SysStart dc.b "sysgo",0 name of initial module to execute
SysParam dc.b C$CR,0 parameter to SysStart
SysDev dc.b "/D0",0 initial system disk pathlist
ConsolNm dc.b "/Term",0 console terminal pathlist
ClockNm dc.b "mc6840",0 clock module name
Extens dc.b "os9p2 ssm",0
  endm
* (Other default values may be set here)
```

Remake the `Init` module by using the makefile located in the `OS9/SRC/SYSMODS/INIT` directory.

```
    $ make init  ;* Make new init module.
```

Step Two: Create a New Bootfile

Edit the bootlist file so the SSM you use appears in that list. For example, `ssm851` for systems using an MC68851.

```
    $ chd MWOS/OS9/680X0/PORTS/<your CPU>
    $ os9gen /h0fmt -z=bootlist;* Create the bootfile.
```

Step Three: Test SSM Operation

After making the new bootfile, reboot the system and test the basic functions of SSM operation. To verify the SSM was found and initialized correctly, attempt to access a protected area of memory.

One memory area that is protected from all user state accesses is the `Mem.Beg` address in the system's `systype.d` file. Most systems have `Mem.Beg` set to $400.

```
$ debug ;* Call user state debugger.
dbg: d 400 Access Mem.Beg.
0x00000400 - bus error
```

Access prevented: bus error results.

For More Information

For more information on the `maps` utility, refer to the ***Utilities Reference***.

To test the SSM functionality more thoroughly, use the supplied `maps` utility. Run `maps` on all processes in the system and exercise all options of `maps`.

```
 $ maps -l  ;* Loop through all processes.
```

Installation of SSM is now complete.

Creating a System Security Module

This section explains how to write a System Security Module (SSM) for an OS-9 system with memory protection hardware that Microware currently does not support. The code for individual systems varies considerably, according to the design of the hardware. Source code for a customized system security module is provided in a later section to illustrate the memory management principles discussed. The module you write must accomplish the same tasks, but may accomplish these tasks in whatever way you deem most effective.

The System Security Module (SSM) protects system memory by preventing processes from accessing memory not assigned to the process. Each time a process accesses memory, the memory address is passed through memory protection hardware which checks the address to see if the process has access to it. If the address is protected, a bus error exception is generated. The purpose of the SSM is to install a group of system service requests which the kernel invokes when it gives a process access to specific memory blocks.

Note

The SSM does not provide address translation of any kind, even if the memory management hardware is capable of this. The OS-9 for 68K kernel's memory management routines are designed to make the implementation of an SSM as easy as possible. To accomplish this, the kernel must make two assumptions about how the protection hardware works.

- The kernel assumes the memory protection hardware is disabled during supervisor state accesses.
- The kernel assumes the user state address space may be divided into equal-sized blocks protected independently of each other.

SSM determines the size of the memory blocks based on the amount of addressable system memory and the protection hardware being used. The blocks are usually 4, 8, or 16K bytes each. Smaller blocks are preferred when possible. A process can access memory in two ways:

- It may be part of a module to which the process links (the process' primary module is implicitly linked).
- It may be part of the process' data area.

Linked modules are not considered to be owned by a process; they are owned by the system, and the process has been granted permission to access them. A process' data area is considered owned by the process, and must not be accessible to other processes. For each process, the protection module must keep track of the following:

- The memory blocks the process may access.
- The read/write permissions for these blocks.
- The number of times each block has been made accessible to the process.

In the example code, each process has associated with its process descriptor a map of the system memory blocks it may access. This map is a copy of the memory protection hardware's task image and contains read/write permissions for each block in the address space. Two of the protection module's subroutines, `F$Permit` and `F$Protect`, update this map rather than the hardware. Another map, containing the number of times specific memory blocks have been made accessible to the program, is also kept for each process.

SSM Module Structure

The System Security Module must conform to the basic structure of all OS-9 for 68K modules. It must be a system object module with the supervisor state attribute. The example code illustrates how the module's psect header establishes this. At a minimum, you must include seven subroutines in the module body:

- `Init`
- `F$Permit`
- `F$Protect`
- `F$AllTsk`
- `F$DelTsk`
- `F$ChkMem`
- `F$GSPUMp`

For More Information

For more specific information about memory modules, refer to the ***OS-9 for 68K Technical Manual***.

Except for `Init`, these subroutines are installed as system calls the OS-9 for 68K kernel calls at appropriate times. The subroutines are not large or difficult; the challenge in writing a protection module is deciding how to make the memory protection hardware conform to OS-9's memory protection model. Aside from this, the structure of the module depends entirely on the system's specific hardware and the whim of the programmer.

Input

```
a3) = SSM global static storage
a6) = system global pointer
```

Error

```
cc = carry bit set
```

Output

```
d1.w = error code if error
```

Destroys

The `Init` routine may destroy the values of (`d0`) and (`d1`).

Description

`Init` is called by OS-9 during coldstart and serves as the protection module's initialization entry point.

`Init` initializes the following:

- Any system global variables.
- The protection hardware.
- SSM service requests.

The name of the memory protection module, usually `ssm`, must be included in a list of extension module names found in the system configuration module, `init`. This informs the kernel to link to the protection module during coldstart, and if found, to execute its `init` entry point. The `init` entry point is run in system state before any user state processes have begun. If necessary, the protection module may declare its own static global (`vsect`) variables. If a vsect is included, the vsect data is allocated and cleared at coldstart and a pointer to these variables is passed to the `init` routine in the (`a3`) register.

Note

Initialized variables are not allowed in the vsect. The kernel never deallocates or reuses the vsect memory. If the SSM service requests are installed with (`a3`) intact, the kernel also passes this vsect pointer to each service routine when it is called. This enables the service routines to share some private global variables.

Two system global variables are of particular interest to the protection module:

`D_AddrLim`	Is the highest RAM/ROM address found by the kernel's coldstart routine. `Init` can use `D_AddrLim` to determine the physical block size most appropriate for the memory protection hardware.
`D_BlkSiz`	Is the system's minimum memory allocation size in bytes. The `init` routine should reset `D_BlkSiz` to the minimum blocksize the memory protection hardware can accept. The value must be an integral power of two and has a default value of sixteen bytes.

Both `D_AddrLim` and `D_BlkSiz` are of type long. In the example code, the protection module allocates global storage to contain a task allocation table. This table contains one entry for each hardware task number available to be assigned to a process. Each four-byte entry contains a pointer to the process assigned to the task number. If the task number has not been assigned to a process, the entry is `NULL`.

Note

If `init` returns the carry bit set, cold start aborts and the system does not come up.

The remaining subroutines, implemented as system calls, are documented in the ***OS-9 for 68K Technical Manual***. For reference, these are:

`F$Permit`	Allow Process Access to Specified Memory
`F$Protect`	Remove Process' Permission to Memory Block
`F$AllTsk`	Ensure Protection Hardware Is Ready
`F$DelTsk`	Release Protection Structures
`F$ChkMem`	Check Access Permissions
`F$GSPUMp`	Check Access Permissions

Hardware Considerations

The protection module code provided with this manual was designed for use with a custom designed board providing memory protection without address translation. The hardware is automatically disabled during system state processes. The hardware supports up to 64 independent tasks. It may be configured in one of four ways, depending on the amount of memory in the system:

Table E-1 System Memory Size

Maximum Address Space	Block Size	Number of Blocks
2 Meg	8K	256
4 Meg	8K	512
8 Meg	16K	512
16 Meg	32K	512

A task number (0-63) is stored in the protection unit's hardware task register to select one of the 64 available tasks. The selected task's hardware protection image appears as RAM on the bus at the `SPU_RAM` address. The protection image for a task consists of either 256 or 512 contiguous data bytes depending on how the hardware has been configured.

Each byte in the protection image contains a two-bit protection mask for every four blocks of main memory. The protection blocks are arranged in descending order within each byte. For example:

Table E-2 Protection Image

Byte offset in image	**Byte 0**	**Byte 1**	**Byte 2**	**Byte 3**	**. . . etc**
Address block #	`3 2 1 0`	`7 6 5 4`	`B A 9 8`	`F D E C`	. . . etc.
Protection bits	`wrwrwrwr`	`wrwrwrwr`	`wrwrwrwr`	`wrwrwrwr`	

The software protection image is an exact copy of the protection map used by the hardware.

Complete Source Listing

Note

Previous versions of the System Security Module were called the System Protection Unit (SPU). As a result, the source code used in this manual refers to SPU rather than SSM.

Customized 68020 protection module

```
Task Allocation routines -
                     nam      Task           Allocation routines
 00000010 Edition    equ      16             current edition number
 00000c01 Typ_Lang   equ      (Systm<<8)+Objct
 0000a000 Attr_Rev   equ      ((ReEnt+SupStat)<<8)+0
                     psect    spu,Typ_Lang,Attr_Rev,Edition,0,Init
                     use      <oskdefs.d>
                     opt      -l
********************************
* System Protection Unit (SPU) hardware definitions
 00000040 MAXTASK    equ      64             total number of SPU tasks available
 01e00000 SPU_RAM    equ      $1e00000       SPU map image RAM area (uses odd addr)
 01e80000 SPU_Stat   equ      $1e80000       address of SPU status register
 01d00000 SPU_Ctl    equ      $1d00000       address of SPU control register
 01d80000 SPU_Task   equ      $1d80000       address of SPU task register
* SPU task RAM protection bits (in map image)
 00000001 ReadProt   equ      %00000001      enable read protect
 00000002 WritProt   equ      %00000010      enable write protect
* SPU status register (currently unimplemented)
 00000001 E_SPU      equ      %00000001      SPU error
 00000002 E_IO       equ      %00000010      I/O bus error
 00000004 E_TimeO    equ      %00000100      time out error
 00000008 E_Parity   equ      %00001000      parity error
* SPU control register bits
 00000000 Mem2MB     equ      %00000000      two megabyte address space
 00000001 Mem4MB     equ      %00000001      four megabyte address space
 00000002 Mem8MB     equ      %00000010      eight megabyte address space
 00000003 Mem16MB    equ      %00000011      sixteen megabyte address space (max)
 00000008 EnabSPU    equ      %00001000      enable SPU when set
 00000010 EnCache    equ      %00010000      enable 68020 inst cache (hardware)
0000 0020 SPUSizes   dc.l     $200000,$400000,$800000,$1000000
0010 0d0d BlkSizes   dc.b     13,13,14,15    corresponding block sizes (2^n)
0014 0100 SPUBlks    dc.w     256,512,512,512 corresponding number of SPU blocks
```

```
********************************
* SPU global variable definitions
* NOTE: this memory is allocated and cleared, but NOT initialized by OS-9
                     vsect
 00000000            ds.b     1              reserved
 00000001 S_BlkBit   ds.b     1              system block size as a power of 2
 00000002 S_SPUBlks  ds.w     1              # of blocks the addr space is div into
 00000004 S_TskTbl   ds.l     MAXTASK        SPU task allocation table
 00000000 S_MemSiz   equ      .              size of global storage
 00000000            ends
********************************
* SPU process variable definitions
 00000000            org      0
 00000000 P_Task     do.w     1              task number assigned to process
 00000002 P_BlkCnt   do.l     1              ptr to block count map
 00000006 P_SPUImg   equ      .              beginning of SPU image map
*   .--------------------.
*   |       task number    |
*   |--------------------|
*   | ptr to blk counts +---.
*   |--------------------|   |
*   |        SPU image     |   |
*   | (64 or 128 bytes) |   |
*   |--------------------|<--"
*   |  block count map  |
*   | (256 or 512 bytes)|
*   "--------------------"
********************************
* Subroutine Init
*   Called by OS-9 coldstart to initialize SPU hardware
* and related global variables.
* Passed: (a3)=SPU global data ptr
*         (a6)=system global ptr
* Returns: none
* Destroys: d1
* Data: D_AddrLim, D_BlkSiz
          Init:
001c 48e7            movem.l  d0/d2-d3/a0-a1,-(a7) save regs
0020=226e            movea.l  D_AddrLim(a6),a1 get highest accessable address
0024 41fa            lea      SPUSizes(pc),a0 table of possible SPU block sizes
0028 7003            moveq    #3,d0
002a b3d8 InitSP10   cmpa.l   (a0)+,a1       would this spu size be large enough?
002c 53c8            dbls     d0,InitSP10    keep searching if not
0030 625c            bhi.s    InitErr        abort if address space too large
0032 0a00            eori.b   #%0011,d0      convert to SPU ctl word size
0036 0000            ori.b    #EnabSPU!EnCache,d0 add SPU (& cache) enable bit(s)
003a 13c0            move.b   d0,SPU_Ctl     enable SPU
0040 0240            andi.w   #%0011,d0      strip out SPU blocksize index
0044 7600            moveq    #0,d3
0046 163b            move.b   BlkSizes(pc,d0.w),d3 get size of spu block power of 2
004a 1743            move.b   d3,S_BlkBit(a3) set it
004e 07c3            bset     d3,d3          convert to number
0050 4203            clr.b    d3             clear extraneous bits
0052=2d43            move.l   d3,D_BlkSiz(a6) reset system block size
0056 d040            add.w    d0,d0          times two bytes per entry
```

```
0058 363b            move.w   SPUBlks(pc,d0.w),d3 get number of spu blocks
005c 3743            move.w   d3,S_SPUBlks(a3) save number of SPU blocks
0060 7400            moveq    #0,d2clear SPU mapping RAM
0062 723f            moveq    #MAXTASK-1,d1  start with highest task number
0064 e44b            lsr.w    #2,d3          divide SPU blocks by 4 blocks per word
0066 5343            subq.w   #1,d3          minus one for dbra
0068 33c1 InitSP20   move.w   d1,SPU_Task    select task
006e 207c            movea.l  #SPU_RAM,a0    get SPU mapping RAM ptr
0074 3003            move.w   d3,d0          number of words per task
0076 10c2 InitSP30   move.b   d2,(a0)+       clear mapping RAM for task
0078 51c8            dbra     d0,InitSP30    repeat for all pages of task
007c 51c9            dbra     d1,InitSP20    repeat for all tasks
0080 43fa            lea      SvcTbl(pc),a1
0084=4e40            os9      F$SSvc         install SPU system calls
0088 4cdf Init99     movem.l  (a7)+,d0/d2-d3/a0-a1 restore regs
008c 4e75            rts                     return carry clear
008e=003c InitErr    ori      #Carry,ccr     return carry set
0092=323c            move.w   #E$NoTask,d1   return (sic) error
0096 60f0            bra.s    Init99
          SvcTbl
0098=0000            dc.w     F$DelTsk+SysTrap,DelTsk-*-4
009c=0000            dc.w     F$AllTsk+SysTrap,AllTsk-*-4
00a0=0000            dc.w     F$Permit+SysTrap,Permit-*-4
00a4=0000            dc.w     F$Protect+SysTrap,Protect-*-4
00a8=0000            dc.w     F$ChkMem+SysTrap,ChkMem-*-4
00ac=0000            dc.w     F$GSPUMp,GSPUMp-*-4
00b0 ffff            dc.w     -1             end of table
********************************
* Subroutine Permit
*   Update SPU image in user process to allow access to a
* specified memory area.
* Passed: d0.l=size of area
*         d1.b=permission requested (Read_/Write_/Exec_)
*         (a2)=address of area requested
*         (a3)=SPU global data ptr
*         (a4)=process descriptor requesting access
*         (a6)=system global ptr
* Returns: cc=carry bit set, d1.w=error code if error
* Destroys: none
* Data: S_BlkBit
* Calls: none
          Permit:
00b2 48e7            movem.l  d0-d3/a0-a2,-(a7) save regs
00b6 4a80            tst.l    d0             zero size requested?
00b8 6700            beq      Permit90       exit if so
00bc 74ff            moveq    #-1,d2         sweep reg
00be=0801            btst     #WriteBit,d1   write permission requested?
00c2 6706            beq.s    Permit10       continue if not
00c4 0202            andi.b   #^(ReadProt+WritProt),d2 allow reads and writes
00c8 600a            bra.s    Permit20       continue
00ca 0201 Permit10   andi.b   #Read_+Exec_,d1 read or exec permission request?
00ce 6772            beq.s    Permit90       exit if not
00d0 0202            andi.b   #^ReadProt,d2  allow reads
00d4=4aac Permit20   tst.l    P$SPUMem(a4)   is SPU process memory allocated?
00d8 6604            bne.s    Permit25       continue if so
```

```
00da 616c           bsr.s    AllSPU         allocate SPU image & block counts
00dc 6564           bcs.s    Permit90       abort if error
00de 7600 Permit25   moveq    #0,d3          sweep register
00e0 162b           move.b   S_BlkBit(a3),d3 get SPU block size power (2^n)
00e4 220a           move.l   a2,d1          copy beginning block address
00e6 d081           add.l    d1,d0          form end of requested area (+1) ptr
00e8 5380           subq.l   #1,d0          end of requested area
00ea e6a8           lsr.l    d3,d0          convert end addr to last block num
00ec e6a9           lsr.l    d3,d1          convert address to block number
00ee 9041           sub.w    d1,d0          convert to number of blocks (-1)
00f0 1601           move.b   d1,d3          copy beginning block number
00f2 0203           andi.b   #%0011,d3      strip off lower two bits
00f6 d603           add.b    d3,d3          make SPU bit offset of first block
00f8 e73a           rol.b    d3,d2shift perm bits into initial position
00fa=262c           move.l   P$DbgPar(a4),d3 is this program being debugged?
00fe 6714           beq.s    Permit30       continue if not
0100 c78c           exg      d3,a4          switch to par's debugger's process desc
0102 48e7           movem.l  d0-d1,-(a7)    save regs
0106 4cef           movem.l  8(a7),d0-d1    restore original size of area, perm
010c 61a4           bsr.s    Permit         update parent (debugger) SPU image
010e c78c           exg      a4,d3          restore process descriptor ptr
0110 4cdf           movem.l  (a7)+,d0-d1    restore regs
0114=08ec Permit30   bset     #ImgChg,P$State(a4) mark SPU image change
011a=246c           movea.l  P$SPUMem(a4),a2 get SPU process memory ptr
011e 226a           movea.l  P_BlkCnt(a2),a1 ptr to SPU map block count
0122 41ea           lea      P_SPUImg(a2),a0 ptr to SPU image
0126 3601 Permit40   move.w   d1,d3          copy block number
0128 e44b           lsr.w    #2,d3          convert block number to byte offset
012a c530           and.b    d2,(a0,d3.w)   unprotect block in SPU image
012e 5231           addq.b   #1,(a1,d1.w)   increment SPU block count
0132 6404           bcc.s    Permit50       continue if no overflow
0134 5331           subq.b   #1,(a1,d1.w)   reset to max count (255) <<?? glitch>>
0138 e51a Permit50   rol.b    #2,d2          shift mask for next block
013a 5241           addq.w   #1,d1          move to next block
013c 51c8           dbra     d0,Permit40    repeat until end of area requested
0140 7000           moveq    #0,d0          return carry clear
0142 4cdf Permit90   movem.l  (a7)+,d0-d3/a0-a2 restore regs
0146 4e75           rts
********************************
* Subroutine AllSPU
*   Allocate and initialize SPU structures for new process.
* The data size per process is either 640 or 320 bytes.
* Passed: (a4)=process descriptor ptr
* Returns: cc=carry set, d1.w=error code if error
* Destroys: d1
0148 48e7 AllSPU     movem.l  d0/d2/a1-a2,-(a7) save regs
014c 7000           moveq    #0,d0          sweep register
014e 302b           move.w   S_SPUBlks(a3),d0 get number of SPU blocks per map
0152 2200           move.l   d0,d1          save size of block counts
0154 e480           asr.l    #2,d0          divided by 4 entries per map byte
0156 2400           move.l   d0,d2          save size of image map
0158 d081           add.l    d1,d0          get combined size
015a d0bc           add.l    #P_SPUImg,d0   add size of non-map variables
0160=4e40           os9      F$SRqMem       request system memory
0164 6530           bcs.s    AllSPU90       abort if error
```

```
0166=294a            move.l   a2,P$SPUMem(a4) save ptr to SPU memory
016a 426a            clr.w    P_Task(a2)     initialize task number
016e 43f2            lea      P_SPUImg(a2,d2.l),a1 get ptr to block count map
0172 2549            move.l   a1,P_BlkCnt(a2) save ptr to block counts
0176 45ea            lea      P_SPUImg(a2),a2 get ptr to image map
017a e44a            lsr.w    #2,d2          div size of image map by 4 bytes/long
017c 5382            subq.l   #1,d2          minus one for dbra
017e 72ff            moveq    #-1,d1
0180 24c1 AllSPU10   move.l   d1,(a2)+       initialize SPU image
0182 51ca            dbra     d2,AllSPU10
0186 302b            move.w   S_SPUBlks(a3),d0 get size of block count map
018a e448            lsr.w    #2,d0          divide by 4 bytes per long
018c 5380            subq.l   #1,d0          minus one for dbra
018e 7200            moveq    #0,d1
0190 24c1 AllSPU20   move.l   d1,(a2)+       initialize block counts
0192 51c8            dbra     d0,AllSPU20
0196 4cdf AllSPU90   movem.l  (a7)+,d0/d2/a1-a2 restore regs
019a 4e75            rts
********************************
* Subroutine Protect
*   Update SPU image in user process to disallow access to a
* specified memory area.
* Passed: d0.l=size of area
*          (a2)=address of area returned
*          (a3)=SPU global data ptr
*          (a4)=process descriptor removing access
*          (a6)=system global ptr
* Returns: cc=carry bit set, d1.w=error code if error
* Destroys: none
* Data: S_BlkBit
          Protect:
019c 48e7            movem.l  d0-d3/a0-a2,-(a7) save regs
01a0 4a80            tst.l    d0             zero size returned?
01a2 676c            beq.s    Protec90       exit if so
01a4=4aac            tst.l    P$SPUMem(a4)   SPU image allocated?
01a8 6766            beq.s    Protec90       exit if not (strange)
01aa 7600            moveq    #0,d3          sweep register
01ac 162b            move.b   S_BlkBit(a3),d3 get SPU block size power (2^n)
01b0 220a            move.l   a2,d1          copy beginning block address
01b2 d081            add.l    d1,d0          form end of requested area (+1) ptr
01b4 5380            subq.l   #1,d0          end of requested area
01b6 e6a9            lsr.l    d3,d1          convert address to beginning block num
01b8 e6a8            lsr.l    d3,d0          convert end addr to last block number
01ba 9041            sub.w    d1,d0          convert to number of blocks (-1)
01bc 1601            move.b   d1,d3          copy beginning block number
01be 0203            andi.b   #%0011,d3      strip off lower two bits
01c2 d603            add.b    d3,d3          make SPU bit offset of first block
01c4 7403            moveq    #ReadProt+WritProt,d2 protection mask
01c6 e73a            rol.b    d3,d2          shift mask into initial position
01c8=262c            move.l   P$DbgPar(a4),d3 is this program being debugged?
01cc 670e            beq.s    Protec20       continue if not
01ce c78c            exg      d3,a4          switch to parent debugger's proc desc
01d0 2f00            move.l   d0,-(a7)       save reg
01d2 202f            move.l   4(a7),d0       restore original size of area
01d6 61c4            bsr.s    Protect        update parent (debugger) SPU image
```

```
01d8 c78c          exg      a4,d3          restore process descriptor ptr
01da 201f          move.l   (a7)+,d0       restore reg
01dc=08ec Protec20 bset     #ImgChg,P$State(a4) mark SPU image change
01e2=246c          movea.l  P$SPUMem(a4),a2 get ptr to SPU process memory
01e6 226a          movea.l  P_BlkCnt(a2),a1 ptr to SPU map block count
01ea 41ea          lea      P_SPUImg(a2),a0 ptr to SPU image
01ee 2608          move.l   a0,d3          any allocated?
01f0 671e          beq.s    Protec90       exit if not
01f2 5331 Protec40 subq.b   #1,(a1,d1.w)   decrement SPU block count
01f6 6706          beq.s    Protec50       protect block if zero
01f8 640c          bcc.s    Protec60       skip if no underflow
01fa 4231          clr.b    (a1,d1.w)      reset block count <<possible glitch>>
01fe 3601 Protec50 move.w   d1,d3          copy block number
0200 e44b          lsr.w    #2,d3          convert block number to byte offset
0202 8530          or.b     d2,(a0,d3.w)   protect block in SPU image
0206 5241 Protec60 addq.w   #1,d1          move to next block
0208 e51a          rol.b    #2,d2          shift mask for next block
020a 51c8          dbra     d0,Protec40    repeat until end of area requested
020e 7000          moveq    #0,d0          clear carry
0210 4cdf Protec90 movem.l  (a7)+,d0-d3/a0-a2 restore regs
0214 4e75          rts
********************************
* Subroutine AllTsk
*   Allocate task number to current process; update SPU image if
* necessary. The SPU task register is set to the allocated number.
* Passed: (a3)=SPU global data ptr
*         (a4)=current process descriptor ptr (to allocate)
*         (a6)=system global ptr
* Returns: cc=carry set, d1.w=error code if error
* Destroys: d1
* Data: S_TskTbl, S_SPUBlks
* Calls: FindTsk
* Note: the task table is an array of pointers to
*    the process descriptor each task is using.
          AllTsk:
0216 48e7          movem.l  d0/a1-a2,-(a7) save regs
021a=246c          movea.l  P$SPUMem(a4),a2 get SPU process memory
021e 302a          move.w   P_Task(a2),d0  task already assigned to process?
0222 6712          beq.s    AllTsk05       continue if not
0224=08ac          bclr     #ImgChg,P$State(a4) test/clear image change flag
022a 663c          bne.s    AllTsk50       update SPU image if changed
022c 33c0          move.w   d0,SPU_Task    select task
0232 6000          bra      AllTsk99       exit
0236 43eb AllTsk05 lea   S_TskTbl+(MAXTASK*4)(a3),a1  end task table (+1) ptr
023a 303c          move.w   #MAXTASK-2,d0# of tasks (-1 avoid task #0, -1 dbra)
023e 4aa1 AllTsk10 tst.l    -(a1)          unused task?
0240 57c8          dbeq     d0,AllTsk10    keep searching if not
0244 6714          beq.s    AllTsk20       continue if unused task number found
0246 6100          bsr      FindTsk        find an appropriate task to use
024a 6500          bcs      AllTsk99       abort if error
024e 3200          move.w   d0,d1          copy task number
0250 e541          asl.w    #2,d1          times four bytes per long
0252 43eb          lea      S_TskTbl(a3),a1 get task table ptr
0256 d2c1          adda.w   d1,a1          form ptr to task table entry
0258 5340          subq.w   #1,d0
```

```
025a 228c AllTsk20   move.l   a4,(a1)        mark task number in use by this process
025c=08ac            bclr     #ImgChg,P$State(a4) clear image change flag
0262 5240            addq.w   #1,d0
0264 3540            move.w   d0,P_Task(a2)  set process task number
* Update SPU mapping RAM from process SPU image.
0268 48e7 AllTsk50   movem.l  d1-d7/a0,-(a7) save regs
026c 33c0            move.w   d0,SPU_Task    set SPU task register
0272 41ea            lea      P_SPUImg(a2),a0 get process SPU image ptr
0276 2008            move.l   a0,d0          none allocated? (should be impossible)
0278 673a            beq.s    AllTsk90       exit if so
027a 227c            movea.l  #SPU_RAM,a1    get base of SPU image RAM
0280 0c6b            cmpi.w   #256,S_SPUBlks(a3) 256 blocks?
0286 6718            beq.s    AllTsk60       move only 64 longs if so
0288 4cd8            movem.l  (a0)+,d0-d7    update SPU image
028c 48e9            movem.l  d0-d7,0*4(a1)  (128 pages)
0292 4cd8            movem.l  (a0)+,d0-d7
0296 48e9            movem.l  d0-d7,8*4(a1)  (128 pages)
029c 43e9            lea      16*4(a1),a1    move to second half of SPU image
02a0 4cd8 AllTsk60   movem.l  (a0)+,d0-d7
02a4 48e9            movem.l  d0-d7,0*4(a1)  (128 pages)
02aa 4cd8            movem.l  (a0)+,d0-d7
02ae 48e9            movem.l  d0-d7,8*4(a1)  (128 pages)
02b4 4cdf AllTsk90   movem.l  (a7)+,d1-d7/a0 restore regs
02b8 4cdf AllTsk99   movem.l  (a7)+,d0/a1-a2 restore regs
02bc 4e75            rts                     exit
********************************
* Subroutine FindTsk
*   Find a task number to assign to a process.  Process currently
* assigned a task number are examined to find the least active.
* Its task number is then deallocated for use by the new process.
* Passed: (a1)=Task Table ptr
*         (a6)=system global data ptr
* Returns: d0.w=task number found
*          cc=carry set, d1.w=error code if error
* Destroys: d1
* Queue preference (high to low)
02be=  00 QPref      dc.b     Q_Wait         8 wait queue - use immediately if found
02bf=  00            dc.b     Q_Dead         7 dead process - use immediately
02c0=  00            dc.b     Q_Sleep        6 timed sleep queue
02c1=  00            dc.b     Q_Sleep        5 untimed sleep queue
02c2=  00            dc.b     Q_Debug        4 inactively debugging
02c3=  00            dc.b     Q_Event        3 event queue
02c4=  00            dc.b     Q_Active       2 active queue, lowest priority
02c5=  00            dc.b     Q_Currnt       1 currently running
 00000008 QTypes     equ      *-QPref        number of entries in table
* Register use:
* d0=task loop counter       a0=temp proc desc ptr
* d1=temp queue type         a1=task table entry ptr
* d2=task priority pref      a2=preference tbl ptr
* d3=best preference found   a3=best process found
02c6 48e7 FindTsk    movem.l  d2-d3/a0-a3,-(a7) save regs
02ca 7600            moveq    #0,d3          clear 'best' queue type found
02cc 303c            move.w   #MAXTASK-1,d0  number of tasks available (-1 for dbra)
02d0 2059 FindTsk10  movea.l  (a1)+,a0       get (next) task's proc desc ptr
02d2=1228            move.b   P$QueuID(a0),d1 get the process' queue ID
```

```
02d6 45fa            lea      QPref(pc),a2   get queue type preference tbl ptr
02da 7407            moveq    #QTypes-1,d2   number of table entries (-1 for dbra)
02dc b21a FindTsk20  cmp.b    (a2)+,d1       find preference of queue type
02de 57ca            dbeq     d2,FindTsk20   repeat until found
02e2 5242            addq.w   #1,d2          adjust preference
02e4=b23c            cmp.b    #Q_Sleep,d1    is process in sleep queue?
02e8 660a            bne.s    FindTsk30      continue if not
02ea=082a            btst     #TimSleep,P$State(a2) timed sleep?
02f0 6602            bne.s    FindTsk30      continue if so
02f2 5342            subq.w   #1,d2          make sleep(0) lower than timed sleep
02f4 b403 FindTsk30  cmp.b    d3,d2          is this least active so far?
02f6 651c            blo.s    FindTsk50      keep searching if not
02f8 6210            bhi.s    FindTsk40      update best task found if so
02fa b43c            cmp.b    #2,d2          is process current or active?
02fe 6214            bhi.s    FindTsk50      skip it if not
0300=3228            move.w   P$Prior(a0),d1 get task's priority
0304=b26b            cmp.w    P$Prior(a3),d1 is its priority lowest so far?
0308 640a            bhs.s    FindTsk50      skip it if not
030a 1602 FindTsk40  move.b   d2,d3          save best queue type found
030c 2648            movea.l  a0,a3          save ptr to best process (task) found
030e b63c            cmp.b    #7,d3          inert process found?
0312 6408            bhs.s    FindTsk60      use it if so
0314 51c8 FindTsk50  dbra     d0,FindTsk10   search for most inactive process
0318 4a03            tst.b    d3             ANY available tasks found (surely)
031a 6718            beq.s    FindTskER      abort if not
031c 7000 FindTsk60  moveq    #0,d0          sweep register
031e=206b            movea.l  P$SPUMem(a3),a0 get chosen process' SPU memory
0322 2008            move.l   a0,d0          any?
0324 670e            beq.s    FindTskER      abort if not (should be impossible)
0326 3028            move.w   P_Task(a0),d0  get task number chosen
032a 4268            clr.w    P_Task(a0)     mark it stolen
032e 4cdf FindTsk90  movem.l  (a7)+,d2-d3/a0-a3 restore regs
0332 4e75            rts
0334=323c FindTskER  move.w   #E$NoTask,d1   error: no available tasks
0338=003c            ori      #Carry,ccr     return carry set
033c 60f0            bra.s    FindTsk90      abort
********************************
* Subroutine DelTsk
*   Called when a process terminates (TermProc) to release
* the SPU structures structures used by the process.
* Passed: (a3)=SPU global data ptr
*         (a4)=process descriptor ptr to clear
*         (a6)=system global ptr
* Returns: cc=carry set, d1.w=error code if error
* Destroys: d1
* Data: S_TskTbl, S_SPUBlks
          DelTsk:
033e 48e7            movem.l  d0/a0/a2,-(a7) save regs
0342=246c            movea.l  P$SPUMem(a4),a2
0346 200a            move.l   a2,d0          is SPU memory allocated?
0348 672e            beq.s    DelTsk90       exit if not
034a 302a            move.w   P_Task(a2),d0  get process task number
034e 6710            beq.s    DelTsk10       continue if none (or task #0)
0350 426a            clr.w    P_Task(a2)     clear process task
0354 b07c            cmp.w    #MAXTASK,d0    is task number in range?
```

```
0358 6406            bhs.s    DelTsk10       continue if not
035a e540            asl.w    #2,d0          task number times 4 bytes per entry
035c 42b3            clr.l    S_TskTbl(a3,d0.w) release task number
0360 7000 DelTsk10   moveq    #0,d0          sweep register
0362 302b            move.w   S_SPUBlks(a3),d0 get number of SPU blocks per map
0366 e480            asr.l    #2,d0          divided by 4 entries per map byte
0368 d06b            add.w    S_SPUBlks(a3),d0 add sz of SPU blk ct map
036c d07c            add.w    #P_SPUImg,d0   add size of pre-image variables
0370=42ac            clr.l    P$SPUMem(a4)
0374=4e40            os9      F$SRtMem       return system memory
0378 4cdf DelTsk90   movem.l  (a7)+,d0/a0/a2 restore regs
037c 4e75            rts
********************************
* Subroutine ChkMem
*   Check SPU image in user process to determine if access
* to a specified memory area is allowed.
* Passed: d0.l=size of area
*         d1.b=permission requested (Read_/Write_/Exec_)
*         (a2)=address of area requested
*         (a3)=SPU global data ptr
*         (a4)=process descriptor requesting access
*         (a6)=system global ptr
* Returns: cc=carry bit set, d1.w=error code if error
* Destroys: none
* Data: S_BlkBit
* Calls: none
          ChkMem:
037e 48e7            movem.l  d0-d3/a0,-(a7) save regs
0382 4a80            tst.l    d0             zero size requested?
0384 675a            beq.s    ChkMem90       exit if so
0386 7400            moveq    #0,d2          sweep reg
0388=0801            btst     #WriteBit,d1   write request?
038c 6704            beq.s    ChkMem10       continue if not
038e 843c            or.b     #WritProt,d2   check for writes
0392 0201 ChkMem10   andi.b   #Read_+Exec_,d1 read (or exec) request?
0396 6704            beq.s    ChkMem20       continue if not
0398 843c            or.b     #ReadProt,d2   check reads
039c 4a02 ChkMem20   tst.b    d2             read and/or write request?
039e 6740            beq.s    ChkMem90       exit if not
03a0=4aac            tst.l    P$SPUMem(a4)   is SPU memory allocated?
03a4 6742            beq.s    ChkMemEr       abort if not (very strange)
03a6 7600            moveq    #0,d3          sweep register
03a8 162b            move.b   S_BlkBit(a3),d3 get SPU block size power (2^n)
03ac 220a            move.l   a2,d1          copy beginning block address
03ae d081            add.l    d1,d0          form end of requested area (+1) ptr
03b0 6536            bcs.s    ChkMemEr       abort if address wraparound
03b2 5380            subq.l   #1,d0          end of requested area
03b4 e6a8            lsr.l    d3,d0          convert end address to last block num
03b6 e6a9            lsr.l    d3,d1          convert address to block number
03b8 9041            sub.w    d1,d0          convert to number of blocks (-1)
03ba 1601            move.b   d1,d3          copy beginning block number
03bc 0203            andi.b   #%0011,d3      strip off lower two bits
03c0 d603            add.b    d3,d3          make SPU bit offset of first block
03c2 e73a            rol.b    d3,d2          shift request bits into init position
03c4=206c            movea.l  P$SPUMem(a4),a0 get ptr to SPU process memory
```

```
03c8 41e8           lea      P_SPUImg(a0),a0 ptr to SPU image
03cc 3601 ChkMem40  move.w   d1,d3          copy block number
03ce e44b           lsr.w    #2,d3          convert block number to byte offset
03d0 1630           move.b   (a0,d3.w),d3   get SPU image byte
03d4 c602           and.b    d2,d3          match request with SPU image
03d6 6610           bne.s    ChkMemEr       abort if illegal request
03d8 e51a           rol.b    #2,d2          shift mask for next block
03da 5241           addq.w   #1,d1          move to next block
03dc 51c8           dbra     d0,ChkMem40    repeat until end of area requested
03e0 7000 ChkMem90  moveq    #0,d0          return carry clear
03e2 4cdf ChkMem95  movem.l  (a7)+,d0-d3/a0 restore regs
03e6 4e75           rts
03e8=3f7c ChkMemEr  move.w   #E$BPAddr,6(a7) return Illegal block addr error
03ee=003c           ori      #Carry,ccr     return carry set
03f2 60ee           bra.s    ChkMem95       exit
********************************
* Subroutine GSPUMp
*   Return data about specified process' memory map.
* Passed: d0.w=process id whose information is returned
*         d2.l=size of information buffer
*         (a0)=information buffer ptr
*         (a3)=SPU global data ptr
*         (a4)=process descriptor requesting access
*         (a5)=caller's register image ptr
*         (a6)=system global ptr
* Returns: R$d0(a5)=system minimum block size
*          R$d2(a5)=size of information buffer used
* Returns: cc=carry bit set, d1.w=error code if error
03f4 48e7 GSPUMp:   movem.l  d0/d2-d3/a0-a2,-(a7) save regs
03f8 2002           move.l   d2,d0          copy block size
03fa 2448           move.l   a0,a2          copy address
03fc 7203           moveq    #Write_+Read_,d1 request read+write permission
03fe 6100           bsr      ChkMem         is memory accessible?
0402 6554           bcs.s    GSPUMp99       abort if not
0404 2017           move.l   (a7),d0        restore process id
0406=4e40           os9      F$GProcP       get process descriptor ptr
040a 654c           bcs.s    GSPUMp99       abort if error
040c=42ad           clr.l    R$d2(a5)       default no bytes in buffer
0410=2269           move.l   P$SPUMem(a1),a1 get address of process spu info
0414 2009           move.l   a1,d0          is process spu buffer allocated?
0416 673a           beq.s    GSPUMp90       exit if not
0418 45e9           lea      P_SPUImg(a1),a2 get address of protection info
041c 2269           move.l   P_BlkCnt(a1),a1 get address of spu block count map
0420 7000           moveq    #0,d0          sweep register
0422 302b           move.w   S_SPUBlks(a3),d0 get the number of SPU blocks
0426 e28a           lsr.l    #1,d2          convert user buffer size to num of blks
0428 b480           cmp.l    d0,d2          enough room for entire map?
042a 6302           bls.s    GSPUMp20       skip if not
042c 2400           move.l   d0,d2          copy the entire map
042e 2002 GSPUMp20  move.l   d2,d0          copy number of blocks to move
0430 d080           add.l    d0,d0          convert to bytecount
0432=2b40           move.l   d0,R$d2(a5)    return the amount of buffer used
0436 671a           beq.s    GSPUMp90       exit if no bytes to copy
0438 5342           subq.w   #1,d2          blockcount-1 for dbra(s)
043a 121a GSPUMp50  move.b   (a2)+,d1       get the (next) permission byte
```

```
043c 7604            moveq    #4,d3          number of permission blocks per byte
043e 7003 GSPUMp60   moveq    #ReadProt+WritProt,d0
0440 c001            and.b    d1,d0          strip out bits for current block
0442 10c0            move.b   d0,(a0)+       copy block permissions to buffer
0444 10d9            move.b   (a1)+,(a0)+    copy block count to buffer
0446 e409            lsr.b    #2,d1          shift permission bits for next block
0448 5343            subq.w   #1,d3          dec num of blocks in current perm byte
044a 57ca            dbeq     d2,GSPUMp60    repeat until end of byte or end of buf
044e 56ca GSPUMp70   dbne     d2,GSPUMp50    repeat if more blocks
0452=2b6e GSPUMp90   move.l   D_BlkSiz(a6),R$d0(a5) the blk size used (clear carry)
0458 4cdf GSPUMp99   movem.l  (a7)+,d0/d2-d3/a0-a2 restore regs
045c 4e75            rts
 0000045e            ends
```

Appendix F: Example ROM Source and Makefiles

This appendix includes the following topics:

defsfile

```
opt f issue form feeds
use <oskdefs.d>
use systype.d
```

systype.d

```
*
* System Definitions for OEM example.
*
 opt -l
 pag
********************************
* Edition History
*   date    comments                                                 by
* -------- ---------------------------------------------------- ---
* 93/05/21 genesis                                                   XYZ
* 93/10/28 updated for OS-9 V3.0       XYZ
*

*
* test example on MVME162
*
VME162          equ 162
CPUType         set VME162

*******************************
* System Memory Definitions
*
* These are used by the MemDefs (for rom) and MemList (for init module)
* macros to describe the system ram structure.
*
VBRBase         equ 0 base address of vectors
RAMVects        equ  included exception vectors are RAM

 ifndef TRANS
TRANS           equ $0 no address translation
 endc
TRANSLATE       equ TRANS
ProbeSize       equ $1000 block probe size = 4K

DRAMBeg         equ 0 physical start of system memory
DRAMSize        equ $100000 assume 1MB total system memory

LoadSize        equ $20000 make available 64K for downloaded rombug

 ifdef RAMLOAD
CPUSize         equ DRAMSize-LoadSize
 else NOT RAMLOAD
CPUSize         equ DRAMSize entire DRAM available for system memory
 endc

MapOut          equ $400 vector table space at beginning of DRAM
* These are the ROM definitions for the on-board ROM sockets
Rom.Size        equ $40000say we have 256K for ROM

Rom.Beg         equ $FF800000 ROM starting address
Rom.End         equ Rom.Beg+Rom.Size
```

```
*

Mem.Beg         equ DRAMBeg+MapOut
Mem.End         equ DRAMBeg+CPUSize
Spc1.Beg        equ Rom.Beg
Spc1.End        equ Rom.End

 ifdef RAMLOAD
Spc2.Beg        equ Mem.End
Spc2.End        equ Mem.End+LoadSize
 else
Spc2.Beg        equ 0
Spc2.End        equ 0
 endc

********************************
* Hardware type definitions
*
MPUChip         equ 68000 define the microprocessor in use
CPUTyp          set MPUChip (pay the old label)

 ifeq           (CPUType-VME162)

IOBase          equ $FFF00000
TERMBase        equ IOBase+$45000 Zilog 85230 SCC

TermBase        equ TERMBase+4 SCC port A (console port)
ConsType        equ ZA
Cons_Adr        equ TermBase console device address

T1Base          equ TermBase-4 SCC port B (communication port for download)
CommType        equ ZB
Comm_Adr        equ T1Base auxilliary device address
 endc

*********************************
* Configuration module constants
*  used only by init module
*
CONFIG macro
MainFram dc.b "OEM example target",0
SysStart dc.b "sysgo",0 name of initial module to execute
SysParam dc.b 0 parameters to pass to initial module
SysDev set 0 ROM based system has no disk

ConsolNm dc.b "/term",0 console terminal pathlist
ClockNm  dc.b "tk_oem",0 clock module name
Extens dc.b "os9p2 syscache ssm sysbuserr fpu",0
 endc

*
* Colored memory list definitions for init module (user adjustable)
*
 align
```

```
MemList
* MemType  type, priority, attributes, blksiz, addr limits, name, DMA-offset
*
* on-board ram covered by "boot rom memory list" - doesn't need parity iniz
*
 MemType SYSRAM,250,B_USER,ProbeSize,Mem.Beg,Mem.End,OnBoard,CPUBeg+TRANS

 dc.l 0  terminate this list

OnBoard dc.b "on-board ram",0

 endm


************************************************
* SCF device descriptor definitions
* (used only by SCF device descriptor modules)
*
* SCFDesc: Port,Vector,IRQlevel,Priority,Parity,BaudRate,DriverName
*
*TERM macro
* SCFDesc Port,Vector,IRQlevel,Priority,Parity,BaudRate,DriverName
** default descriptor values can be changed here
*DevCon set 0
* endm

*
* These two labels are obsolete under "SysBoot" but are
* still required to link in "boot.a"
*
SysDisk set 0
FDsk_Vct set 0

***************************
* Memory list definitions
*

MemDefs macro
 dc.l Mem.Beg,Mem.End the normal memory search list
 dc.l 0
 dc.l Spc1.Beg,Spc1.End PROM
 dc.l Spc2.Beg,Spc2.EndSpecial RAM load area
 dc.l 0
 dc.l 0,0,0,0,0,0,0,0,0,0,0,0 free bytes for patching

 endm

 opt l
```

sysinit.a

```
* SysInit: perform system specific initialization (part 1)
*
SysInit:
 reset reset all system hardware that can be

 movea.l VBRPatch(pc),a0 get (patchable) vbr address
 movec a0,vbr set vbr

 ifdef  RAMVects
*
* copy reset vectors from the rom into ram (rom appears at $0 for
* first 4 cycles after a reset, then it's the ram)
*
 move.l VectTbl(pc),0(a0) copy reset vectors across
 move.l VectTbl+4(pc),4(a0)
 endc

SIExit:
 ROMPAK1

 bra SysRetrn return to boot.a


************************************************************
* SInitTwo:  perform system specific initialization (part 2)
*
SInitTwo:

 ROMPAK2

 rts


*****************
*
* UseDebug:  return status of system debugger (enabled/not enabled)
*
UseDebug:
 btst.b #0,CallDBug(pc) test the debug flag
 eori.b #Zero,ccr flip the zero bit
 rts

*************************
* entry points for
 ifndef     CBOOT
_stklimit:      dc.l        $80000
_stkhandler: rts
 endc

 ends
```

```
* end of file
```

syscon.c

```
/*--------------------------------------------------------------------------!
! syscon.c: Boot configuration routines for the OEM example target.    !
+--------------------------------------------------------------------------+
!   Edition History:                      !
!   #   Date     Comments             By  !
!   -- -------- ---------------------------------------------------- --- !
!   01 93/10/28 Genesis.              ats !
!--------------------------------------------------------------------------*/

#include                    <sysboot.h>

#ifdef NOBUG
int     errno;
u_char                      trapflag;
#endif


#ifdef _UCC
u_int32 _stklimit = 0x80000;/* big to limit _stkhandler calls
                            from clib.l calls */
#endif

/*
 * Declarations for real functions
 */
extern error_code           sysreset(),
            binboot();

char*nulstr = "";           /* only need one of these */

#ifdef _UCC
/*
 * Dummy _stkhandler routine for clib.l calls
 */
_stkhandler()
{
}
#endif


/*
 * getbootmethod: This function allows the developer to select
 * the booting method algorithm best suited for the system.
 */
int getbootmethod()
{
    /*
     * Initialize the boot drivers.
     *
    *  NOTE: The order of initialization determines the order of
    *  priority when using the "AUTOSELECT" booting method.
    */
    iniz_boot_driver(binboot, nulstr,
        "Boot Manually Loaded Bootfile Image", "ml");
    iniz_boot_driver(romboot, "ROM", "Boot from ROM", "ro");
    iniz_boot_driver(loadrom, "ROM", "Load from ROM", "lr");
    iniz_boot_driver(sysreset, nulstr, "Restart the system", "q");

/*  vflag = TRUE; */
    return USERSELECT;
}

/*
 * getboottype: When the boot method (determined by the above function)
 * is set to SWITCHSELECT, this function allows the developer to select
 * the actual booting type (device, ROM, etc...) according to hardware
 * switches, non-volatile RAM or hard-code a single boot device type
 * NOTE: for this devpak, this is a dummy function.
 */
Bdrivdef getboottype()
{
    return NULL;
}
```

rombug.make

```
# Makefile for OEM example ROM with ROMBUG

-b

TYPE        = ROMBUG
RELSDIR     = RELS/$(TYPE)
OBJDIR      = CMDS/BOOTOBJS/$(TYPE)

# ROMBUG customization flags

RBUG        = "RBUG=-aROMBUG"
CBUG        =
TDIR        = "TYPE=$(TYPE)"

TARGET      =
ROMDBG      =

# Testing options

MBUGTRC     = #"MBUGTRC=-aMBUGTRC"
RAMLOAD     = #"RAMLOAD=-aRAMLOAD"

MAKERS      = rom_common.make \
                rom_serial.make \
                rom_port.make \
                rom_image.make \
                rom_initext.make

MAKEOPTS    = $(RBUG) $(CBUG) $(TDIR) \
            $(TARGET) $(ROMDBG) $(MBUGTRC) $(RAMLOAD)

MAKER       = ./rombug.make # this file

INITEXT     = $(OBJDIR)/initext
RBGSTB      = #$(OBJDIR)/STB/rombug.stb
FILES       = $(OBJDIR)/rombug $(INITEXT) $(RBGSTB)

OFILE       = $(OBJDIR)/rombugger

MAKE        = make                 # make utility
CFP         = cfp                  # command file processor

CFPOPTS     = "-s=$(MAKE) -f=* $(MAKEOPTS)"

MERGE       = merge
REDIR       = >-
CHD         = chd
DEL         = del
ALLFILES    = *
TOUCH       = touch
```

```
-x

rombug.date: $(MAKER)
    $(CFP) $(CFPOPTS) $(MAKERS)
    $(MERGE) $(FILES) $(REDIR)$(OFILE)

clean: $(MAKER)
    $(CHD) $(RELSDIR); $(DEL) $(ALLFILES)

# end of file
```

rom.make

```
# Makefile for OEM example ROM without ROMBUG

-b

TYPE          = NOBUG
RELSDIR       = RELS/$(TYPE)
OBJDIR        = CMDS/BOOTOBJS/$(TYPE)

# ROM customization flags

RBUG          = "RBUG="
CBUG          = "CBUG=-dNOBUG"
TDIR          = "TYPE=$(TYPE)"

TARGET        = "TARGET=rom"
ROMDBG        = "ROMDBG="

# Testing options

MBUGTRC       = #"MBUGTRC=-aMBUGTRC"
RAMLOAD       = #"RAMLOAD=-aRAMLOAD"

MAKERS        = rom_common.make \
                  rom_serial.make \
                  rom_port.make \
                  rom_image.make \
                  rom_initext.make

MAKEOPTS      = $(RBUG) $(CBUG) $(TDIR) \
              $(TARGET) $(ROMDBG) $(MBUGTRC) $(RAMLOAD)

MAKER    = ./rom.make    # this file

INITEXT       = $(OBJDIR)/initext
RBGSTB        = #$(OBJDIR)/STB/rom.stb
FILES         = $(OBJDIR)/rom $(INITEXT) $(RBGSTB)

OFILE         = $(OBJDIR)/rommer

MAKE          = make                   # make utility
CFP           = cfp                    # command file processor

CFPOPTS       = "-s=$(MAKE) -f=* $(MAKEOPTS)"

MERGE         = merge
REDIR         = >-
CHD           = chd
DEL           = del
ALLFILES      = *
TOUCH         = touch
```

```
-x

rom.date: $(MAKER)
    $(CFP) $(CFPOPTS) $(MAKERS)
    $(MERGE) $(FILES) $(REDIR)$(OFILE)

clean: $(MAKER)
    $(CHD) $(RELSDIR); $(DEL) $(ALLFILES)

# end of file
```

rom_common.make

```
# Makefile for the common boot modules in the OEM example ROM

ROOT        = ../../..      # base of dir system
BASEROOT    = $(ROOT)/68000 # dir system for LIB, etc
CPUROOT     = $(ROOT)/68000 # dir system for output
SRCROOT     = $(ROOT)/SRC   # dir system for source

SDIR        = $(SRCROOT)/ROM/COMMON# specific source dir

TYPE        = ROMBUG
RDIR        = RELS/$(TYPE)
RDUP        = ../..
LIBROOT     = $(RDIR)

SYSDEFS     = $(SRCROOT)/DEFS# std OS defs

TMPDIR      = /dd

MAKER       = rom_common.make

SYSBOOT     = #sysboot.r            # use sysboot.a instead of CBOOT
OBJECTS     = vectors.r boot.r $(SYSBOOT)

OLIB        = rom_common.l

COMDEFS     = $(SYSDEFS)/oskdefs.d
DEFS        = systype.d $(COMDEFS)

RBUG        = -aROMBUG
MBUGTRC     = #-aMBUGTRC # enables MBUG tracing and breakpoints for testing
RAMLOAD     = #-aRAMLOAD # support rombug load directly for porting

SPEC_RFLAGS = $(MBUGTRC) $(RAMLOAD) #-aFASTCONS

-mode=compat
RC          = r68
SRCHDIRS    = -u=. -u=$(SYSDEFS)
RFLAGS      = -q $(RBUG) -aCBOOT $(SPEC_RFLAGS) $(SRCHDIRS)

TOUCH       = touch
CHD         = chd
MERGE       = merge
REDIR       = >-

-x

rom_common.date : $(LIBROOT)/$(OLIB)
    $(TOUCH) $@

$(LIBROOT)/$(OLIB) : $(OBJECTS)
```

```
     $(CHD) $(RDIR); $(MERGE) $(OBJECTS) $(REDIR)$(RDUP)/$@

$(OBJECTS) : $(DEFS) $(MAKER)
```

rom_serial.make

```
# Makefile for the I/O driver in the OEM example ROM

ROOT        = ../../..      # base of dir system
BASEROOT    = $(ROOT)/68000 # dir system for LIB, etc
CPUROOT     = $(ROOT)/68000 # dir system for output
SRCROOT     = $(ROOT)/SRC   # dir system for source

SDIR        = $(SRCROOT)/ROM/SERIAL# specific source dir

TYPE        = ROMBUG
RDIR        = RELS/$(TYPE)
RDUP        = ../..
LIBROOT     = $(RDIR)

SYSDEFS     = $(SRCROOT)/DEFS# std OS defs
SYSMACS     = $(SRCROOT)/MACROS

TMPDIR      = /dd

MAKER       = rom_serial.make

OBJECTS     = ioz8530.r

OLIB        = rom_serial.l

COMDEFS     = $(SYSDEFS)/oskdefs.d
DEFS        = systype.d $(COMDEFS)

RBUG        = -aROMBUG
MBUGTRC     = #-aMBUGTRC # enables MBUG tracing and breakpoints for testing
RAMLOAD     = #-aRAMLOAD # support rombug load directly for porting

SPEC_RFLAGS = $(MBUGTRC) $(RAMLOAD) #-aFASTCONS

-mode=compat
RC          = r68
SRCHDIRS    = -u=. -u=$(SYSDEFS) -u=$(SYSMACS)
RFLAGS      = -q $(RBUG) -aCBOOT $(SPEC_RFLAGS) $(SRCHDIRS)

TOUCH       = touch
CHD         = chd
MERGE       = merge
REDIR       = >-

-x

rom_serial.date : $(LIBROOT)/$(OLIB)
    $(TOUCH) $@

$(LIBROOT)/$(OLIB) : $(OBJECTS)
```

```
     $(CHD) $(RDIR); $(MERGE) $(OBJECTS) $(REDIR)$(RDUP)/$@

$(OBJECTS) : $(DEFS) $(MAKER)
```

rom_port.make

```
# Makefile for port modules in the OEM example ROM

ROOT        = ../../..      # base of dir system
BASEROOT    = $(ROOT)/68000 # dir system for LIB, etc
CPUROOT     = $(ROOT)/68000 # dir system for output
SRCROOT     = $(ROOT)/SRC   # dir system for source

SDIR        = .             # specific source dir

TYPE        = ROMBUG
RDIR        = RELS/$(TYPE)
RDUP        = ../..
LIBROOT     = $(RDIR)

BOOTDEFS    = $(SRCROOT)/ROM/CBOOT/DEFS
SCSIDEFS    = $(SRCROOT)/IO/SCSI/DEFS
SYSDEFS     = $(SRCROOT)/DEFS# std OS defs
SYSMACS     = $(SRCROOT)/MACROS
CDEFS       = $(ROOT)/../SRC/DEFS# std C defs

TMPDIR      = /dd

MAKER       = rom_port.make

SYSINIT     = sysinit.r
SYSCON      = bootio.r syscon.r
OBJECTS     = $(SYSINIT) $(SYSCON)

OLIB        = rom_port.l

COMDEFS     = $(SYSDEFS)/oskdefs.d
DEFS        = systype.d $(COMDEFS)

RBUG        = -aROMBUG
MBUGTRC     = #-aMBUGTRC # enables MBUG tracing and breakpoints for testing
RAMLOAD     = #-aRAMLOAD # support rombug load directly for porting

SPEC_RFLAGS = $(MBUGTRC) $(RAMLOAD) #-aFASTCONS

CBUG        = #-dNOBUG

SPEC_CFLAGS = $(CBUG)

-mode=compat
CC          = cc
CSRCHDIRS   = -v=. -v=$(BOOTDEFS) -v=$(SCSIDEFS) -v=$(SYSDEFS) -v=$(CDEFS)
CFLAGS      = -qst=$(TMPDIR) -O=0 -dCBOOT $(SPEC_CFLAGS) $(CSRCHDIRS)

RC          = r68
RSRCHDIRS   = -u=. -u=$(SYSDEFS) -u=$(SYSMACS)
```

```
RFLAGS      = -q $(RBUG) -aCBOOT $(SPEC_RFLAGS) $(RSRCHDIRS)

TOUCH       = touch
CHD         = chd
MERGE       = merge
REDIR       = >-

-x

rom_port.date : $(LIBROOT)/$(OLIB)
    $(TOUCH) $@

$(LIBROOT)/$(OLIB) : $(OBJECTS)
    $(CHD) $(RDIR); $(MERGE) $(OBJECTS) $(REDIR)$(RDUP)/$@

$(SYSINIT) : $(DEFS) $(MAKER)

$(SYSCON) : $(MAKER)
```

rom_image.make

```
# Makefile for linked rom image in the OEM example ROM

-b

ROOT    = ../../..      # base of dir system
BASEROOT    = $(ROOT)/68000 # dir system for LIB, etc
CPUROOT     = $(ROOT)/68000 # dir system for output
SRCROOT     = $(ROOT)/SRC   # dir system for source
BOOTROOT    = $(SRCROOT)/ROM/LIB
SYSROOT     = $(BASEROOT)/LIB

TYPE        = ROMBUG
RDIR        = RELS/$(TYPE)
RDUP        = ../..
LIBROOT     = $(RDIR)

TMPDIR      = /dd

MAKER       = rom_image.make

ODIR        = CMDS/BOOTOBJS/$(TYPE)

TARGET      = rombug

ROMDBG      = $(BOOTROOT)/rombug.l
ROMIO       = $(BOOTROOT)/romio.l

FILES       = $(LIBROOT)/rom_common.l \
            $(LIBROOT)/rom_port.l \
            $(LIBROOT)/rom_serial.l \
            $(ROMDBG) $(ROMIO)


CLIB        = $(SYSROOT)/clib.l
LCLIB       = -l=$(CLIB)
SYS_CLIB    = $(SYSROOT)/sys_clib.l
LSYS_CLIB   = -l=$(SYS_CLIB)
MLIB        = $(SYSROOT)/os_lib.l
LMLIB       = -l=$(MLIB)
SYSL        = $(SYSROOT)/sys.l
LSYSL       = -l=$(SYSL)

SYSBOOT     = $(BOOTROOT)/sysboot.l
LSYSBOOT    = -l=$(SYSBOOT)
CACHEFL     = $(BOOTROOT)/flushcache.l
LCACHEFL    = -l=$(CACHEFL)


LIBS        = $(LSYSBOOT) $(LCACHEFL) \
            $(LCLIB) $(LSYS_CLIB) $(LMLIB) $(LSYSL)
```

```
LIBDEPS     = $(SYSBOOT) $(CACHEFL) \
              $(CLIB) $(SYS_CLIB) $(MLIB) $(SYSL)

-mode=compat
LC          = l68
LFLAGS      = -r=FF800000 -swam -M=3k -g -b=4

TOUCH       = touch
CHD         = chd
MERGE       = merge
REDIR       = >-

-x

rom_image.date : $(ODIR)/$(TARGET)
    $(TOUCH) $@

$(ODIR)/$(TARGET) : $(FILES) $(LIBDEPS) $(MAKER)
    $(LC) $(LFLAGS) $(FILES) $(LIBS) -O=$@ $(REDIR)$@.map
```

bootio.c

```
/*
 * Copyright 1993 by Microware Systems Corporation
 * Copyright 2001 by RadiSys Corporation
 * Reproduced Under License
 *
 * This source code is the proprietary confidential property of
 * Microware Systems Corporation, and is provided to licensee
 * solely for documentation and educational purposes. Reproduction,
 * publication, or distribution in any form to any party other than
 * the licensee is strictly prohibited.
 */

#include <sysboot.h>

/* my favorite loop function */
#define LOOPfor(;;)

/* utility routines */

#define     ESC 0x1b
#define     CR  0x0d
#define     TAB 0x09
#define     BS  0x08
#define     BEL 0x07

char getinchar()
{
    char inchar;

    inchar = InChar();
    if ((inchar>= 'A') && (inchar <= 'Z'))
        inchar |= CASEBIT;

    return(inchar);
}

int outhex(h)
u_int32 h;
{
    u_int32 t, l=0;
    char    d;

    OutChar('0');
    OutChar('x');
    if (!h) {
        OutChar('0');
        return(1);
    }

    for (t=0x10000000; t>=1; t/=0x10)
```

```
        if (h >= t) break;/* skip leading zeros */

    for (; t>=1; t/=0x10) {
        d = h / t;
        if (d <= 9)
            OutChar(d + '0');
        else
            OutChar(d - 10 + 'a');
        l++;
        h = h - d * t;
    }
    return(l);
}

int outint(i)
u_int32 i;
{
    u_int32 t, l=0;

    if (!i) {
        OutChar('0');
        return(1);
    }

    for (t=1000000000; t>=1; t/=10)
        if (i >= t) break;/* skip leading zeros */

    for (; t>=1; t/=10) {
        OutChar( (i / t) | 0x30 );
        i = i - (i / t) * t;
        l++;
    }
    return(l);
}

void outsome(s)
u_char *s;
{
    if (!(*s))
        outstr("<none>");
    else
        outstr(s);
}

void outerase(n)
u_int32 n;
{
    int     i;

    OutChar(' ');
    OutChar(BS);

    for (i=n-1; i>0; i--) {
        OutChar(BS);
        OutChar(' ');
        OutChar(BS);
    }
}

u_char ask_ynq(quit)
u_int32 quit;
{
    char    inchar, newval, newprmpt, valspec;
    u_int32 n;

    valspec = FALSE;
    newprmpt = TRUE;

    LOOP {
        if (newprmpt) {
            outstr("\n\(<yes>/<no>");
            if (quit)
                outstr("/<quit>");
            outstr("\)? ");
            if (valspec){
                if (newval == 'y')outstr("yes");
                else if (newval == 'n')outstr("no");
                else        outstr("quit");
            }
            newprmpt = FALSE;
        }

        inchar = getinchar();

        if (inchar == CR) {
            if (!valspec) {
                newprmpt = TRUE;
                OutChar(BEL);
                continue;
            }
            break;
        }
        if (inchar == BS) {
            if (!valspec) {
                newprmpt = TRUE;
                OutChar(BEL);
                continue;
            }
            if (newval == 'y')n = 3;
            else if (newval == 'n')n = 2;
            else            n = 4;
            outerase(n);
            valspec = FALSE;
            continue;
        }
        if (!valspec) {
            newval = inchar;
            if (inchar == 'y') {
                outstr("es");
                valspec = TRUE;
                continue;
            }
            if (inchar == 'n') {
                OutChar('o');
                valspec = TRUE;
                continue;
            }
            if (quit && (inchar == 'q')) {
                outstr("uit");
                valspec = TRUE;
                continue;
            }
        }
        newprmpt = TRUE;
        OutChar(BEL);
    }
    return(newval);
}

/* Dummy entry points to satisfy linker
 * until this is put into sysboot.l */

void    checknvram()    {}
void    outendis()      {}

error_code  rc_btlist() {}
error_code  rc_endis()  {}
error_code  rc_int()    {}
error_code  rc_vmeints(){}
error_code  reconfig()  {}
```

Index