OS-9 for 68K Processors Technical I/O Manual

Version 3.2

www.radisys.com

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

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

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

Revision C
June 2000

Copyright and publication information

This manual reflects version 3.2 of OS-9 for 68K. Reproduction of this document, in part or whole, by any means, electrical, mechanical, magnetic, optical, chemical, manual, or otherwise is prohibited, without written permission from RadiSys Microware Communications Software Division, Inc.

Disclaimer

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

Reproduction notice

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

June 2000

Table of Contents

Chapter 1: The OS-9 Input/Output System

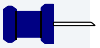
This chapter explains the relationships between IOMAN, device descriptors, path descriptors, and file managers, and how each of these components operates within OS-9. It includes the following topics:

RadiSys.
MICROWARE SOFTWARE

The OS-9 Unified Input/Output System

OS-9 features a versatile, unified, hardware-independent I/O system. The I/O system is modular; you can easily expand or customize it.

The OS-9 I/O system components (the kernel, IOMan, file managers, and device drivers) process I/O service requests at different levels. The device descriptor contains information used to assemble the elements of a particular I/O subsystem. The file manager, device driver, and device descriptor modules are standard memory modules. You can install or remove any of these modules while the system is running.



Note

The OS-9 I/O system consists of the following software components:

- The kernel and IOMan
- File managers
- Device drivers
- The device descriptor

OS-9 provides many options for the target system with respect to I/O capabilities and methodology. This manual discusses the I/O system and its usage when you use one of the standard I/O managers to control it. The OS-9 standard I/O managers are:

- `IOMan_DEV`
- `IOMan_ATOMOS-9 for 68K Processors Technical I/O Manual`

The choice of which IOMan (if any) you use in your system is controlled by the Init module's `M$IO Man` string and your target system bootfile.

Using IOMan provides the standard unified I/O system for OS-9. The main difference between the _DEV and _ATOM versions of IOMan is the lack of user parameter verification (for example, verification the user's buffer is indeed allocated to the user for I$Read calls). IOMan_DEV provides the full set of parameter verification functions; it is typically used in development-style environments. IOMan_ATOM discards this functionality to improve code-size and speed; it is typically used in embedded applications.

Note

If your system does not use IOMan or uses its own custom I/O system, the conventions discussed in this manual may not be correct. Refer to the I/O system's documentation to see which parts, if any, of this manual apply to your system.

The Kernel/IOMan

The I/O system is maintained by IOMan. The kernel performs preliminary processing of the I/O service request by:

- Determining the correct IOMan routine to call. For example, the read routine for I$Read service requests.
- Disabling system-state preemption for the process by incrementing the P$Preempt field of the process descriptor associated with the call. (System-state preemption is restored by the kernel when the IOMan call returns.)

IOMan does the following:

- Manages various data structures to maintain the I/O modules. It ensures the appropriate file manager and device driver modules process each I/O request.
- Establishes paths. These are the connections between the kernel, the application, the file manager, and the device driver.

File Managers

File managers perform the processing for a particular class of devices, such as disks or terminals. They deal with *logical* operations on the class of devices. For example, the Random Block File manager (RBF) maintains directory structures on disks; the Sequential Character File manager (SCF) edits the data stream it receives from terminals. File managers deal with the I/O requests on a generic *class* basis.

Device Drivers

Device drivers operate on a class of hardware. Operating on the actual hardware device, they send data to and from the device on behalf of the file manager. They isolate the file manager from hardware dependencies such as control register organization and data transfer modes, translating the file manager's logical requests into specific hardware operations.

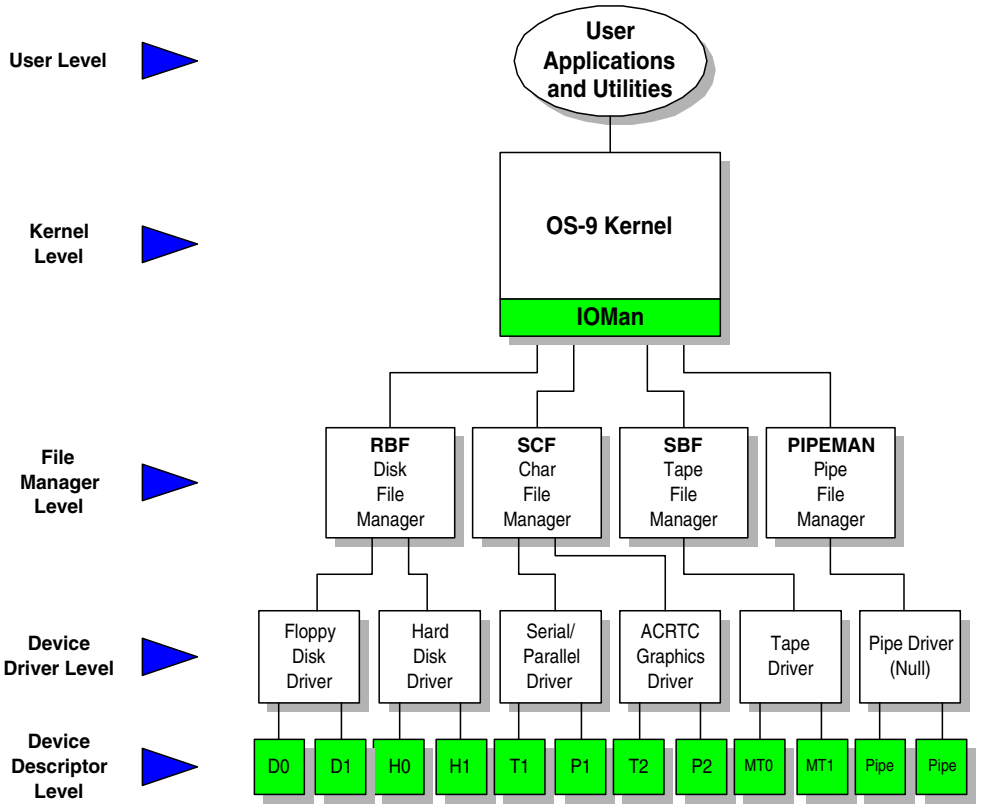
Device Descriptor

The device descriptor contains the information required to assemble the various components of an I/O subsystem (a device). It contains the names of the file manager and device driver associated with the device, as well as the device's operating parameters.

Parameters in device descriptors can be fixed, such as interrupt level and port address, or variable, such as terminal editing settings and disk physical parameters. The variable parameters in device descriptors provide the initial default values when a path is opened, but applications can change these values.

The device descriptor name is the name of a device as known by the user. For example, the device `/d0` is described by the device descriptor `d0`.

Figure 1-1 OS-9 I/O System Module Organization



IOMan and I/O

IOMan maintains the I/O system for OS-9. It provides the first level of I/O service by routing system call requests between processes and the appropriate file managers and device drivers. IOMan also allocates and initializes static storage for device drivers.

IOMan maintains two important internal data structures:

- The device table
- The path table

Device Table and Path Table

The device table is a list of all devices currently attached (loaded and initialized). The path table is a list of all I/O paths currently open. These tables reflect two other structures respectively:

- The device descriptor
- The path descriptor

When a path is opened (`I$Open`), IOMan's attach routine (`I$Attach`) is called, and it links to the device descriptor of the specified (or implied) device name in the pathlist. The device descriptor contains:

- The port address of the device
- The file manager's name
- The device driver's name

The attach routine then links to the specified file manager and device driver. After these components are located, the `I$Attach` routine inspects the current device table entries, and compares the new device specification with the current entries in the device table.

The `I$Attach` routine proceeds as follows:

1. If the device port address, file manager, device driver, and device descriptor match an existing entry in the device table, the device is known to the system. The use count for that device table entry is incremented and IOMan returns to the caller.
2. If the device port address, file manager, and device driver match an existing device table entry, but the device descriptor does not, this is a new, or synonymous device on the port. A new device table entry is created, its use count is set to one, and IOMan returns to the caller.
3. If neither of the above situations occur (no match on port address, file manager, and device driver) or this is the first time the path is opened, the device is unknown to the system. In this case, IOMan allocates static storage for the driver and calls the driver's `INIT` routine. If `INIT` does not return an error, a new device table entry is created, its use count is set to one, and IOMan returns to the caller. If `INIT` returns an error, IOMan calls the device driver's `TERM` routine before performing any necessary clean-up and returning the original error.

When a path is closed, its use count is decremented. If the use count becomes zero, IOMan attempts to detach the device (`I$Detach`) associated with the path from the I/O system. The use count in the device's device table entry is decremented. If the use count becomes zero, the following actions take place:

1. The device table is searched to determine if another device table entry is using the same static storage as the device being deleted.
2. If no other device is using the static storage, the driver's `TERM` routine is called to de-initialize the device. The driver's static storage is then returned to the system.
3. The device's entry is removed from the device table.

The file manager, device driver, and device descriptor are then unlinked.

Path Descriptors

Path descriptors maintain the status of I/O operations to devices and files. IOMan maintains pointers to these path descriptors in the path table. Each time a path is created (`I$Open`, `I$Create`), a new path descriptor is

created and an entry is added to the path table. If I$Dup is used to open a path, only the use count of an existing path descriptor is incremented. When a path is closed and its use count becomes zero, the path descriptor is de-allocated and the appropriate entry is deleted from the path table.

In user-state, each process can have up to 32 paths open at any time. In system-state, the maximum number of open paths depends on available system resources.

IOMan I/O Service Requests

File managers are not called for I$Attach, I$Detach, and I$Dup. IOMan performs the necessary system functions for these requests.

I$Attach

IOMan performs the following functions:

- Links to component modules (file manager, device driver, device descriptor)
- Determines if a device table entry matches an existing entry for the device

  If the device port address, file manager, device driver, and device descriptor match, IOMan:

  - Increments the use count for the device
  - Returns to the caller

  If the device port address, file manager, and device driver match an existing device table entry, but the device descriptor does not, this is a new (or synonymous) device on the port. I$Attach:

  - Creates a new device table entry
  - Sets the use count to one
  - IOMan returns to the caller

  If there is no match on port address, file manager, and device driver, IOMan:

- Allocates and clears the driver's static storage
- Sets V_PORT to the hardware address given in the descriptor
- Calls the driver's INIT routine to initialize the hardware

If INIT returns an error, IOMan calls the driver's TERM routine, de-allocates any resources, and returns the error.

- Sets the use count to 1
- Adds the device to the device table

I$Detach

IOMan decrements the use count for the device. If the use count becomes zero, IOMan searches the device table for other devices using the same static storage. If any are found, the original device table entry is removed from the table. Otherwise, IOMan performs the following actions:

- Calls the driver's TERM routine
- Returns the driver's static storage to the system's free memory pool
- Removes the device entry from the device table

IOMan then unlinks the file manager, device driver, and device descriptor.

I$Dup

IOMan increments the use count (PD_COUNT) of the path.

Device Descriptor Modules

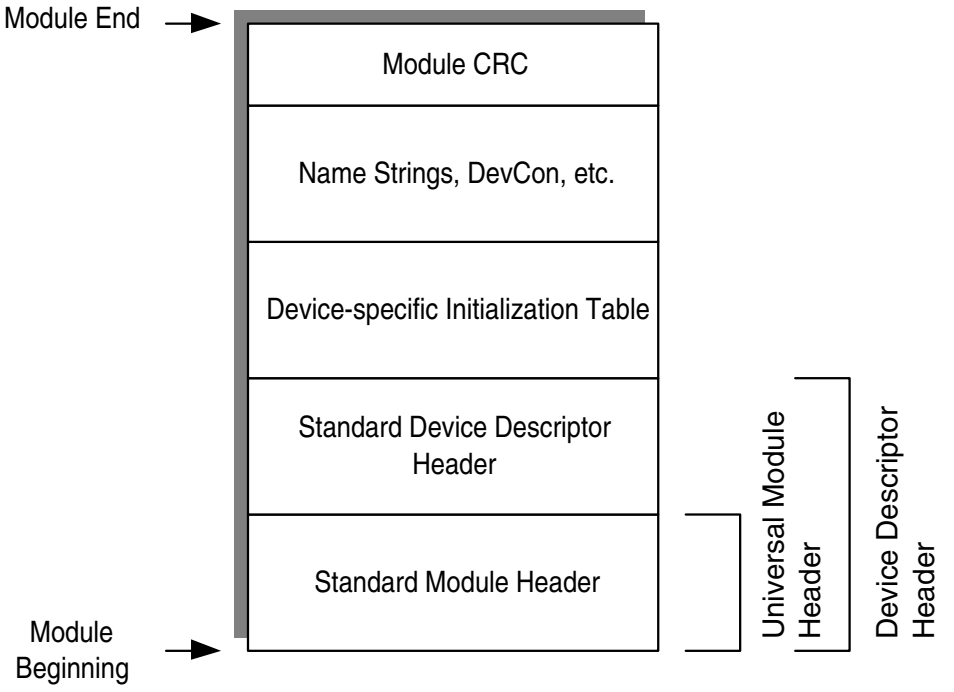
Device descriptor modules are small, non-executable modules containing information to associate a specific I/O device with its logical name, hardware controller address(es), device driver name, file manager name, and initialization parameters.

File managers operate on a class of *logical* devices. Device drivers operate on a class of *physical* devices. A device descriptor module tailors a device driver or file manager to a specific I/O port. At least one device descriptor module must exist for each I/O device in the system. An I/O device may have several device descriptors with different initialization parameters and names. For example, a serial/parallel driver could have two device descriptors, one for terminal operation (`/t1`) and one for printer operation (`/p1`).

If a suitable device driver exists, adding devices to the system consists of adding the new hardware and another device descriptor. Device descriptors can be in ROM, in the boot file, or loaded into RAM while the system is running.

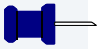
The module name is used as the logical device name by the system and user (it is the device name given in pathlists). A device descriptor module header consists of the standard module header fields with a type code of device descriptor (`DEVIC`). The standard device descriptor header is followed by a device-type specific initialization table (see **Figure 1-2**).

Figure 1-2 Device Descriptor Layout



Module Offsets

The standard device descriptor fields are listed below and described in the following pages. Refer to the appropriate chapter of this manual for the specific device-type for the device descriptor initialization table fields.



Note

In the following table, offset refers to the location of a module field, relative to the starting address of the module. Module offsets are resolved in assembly code by using the names shown here and linking with the relocatable library: `sys.l` or `usr.l`.

Table 1-1 Module Offsets

Offset	Name	Description
$30	M$Port	Port Address
$34	M$Vector	Interrupt Vector Number
$35	M$IRQLvl	Interrupt Level
$36	M$Prior	Interrupt Polling Priority
$37	M$Mode	Device Mode Capabilities
$38	M$FMgr	File Manager Name Offset
$3A	M$PDev	Device Driver Name Offset
$3C	M$DevCon	Device Configuration Offset
$3E		Reserved
$46	M$Opt	Initialization Table Size
$48	M$DTyp	Device Type (first field of initialization table)

Device Descriptors

Table 1-2 Device Descriptors

Name	Description
M$Port	***Port Address*** M$Port usually contains the absolute physical address of the hardware controller. However, it can be another address (for example, R0/R1). Before IOMan attaches a device (calls its INIT routine), this value is copied into the V_PORT field of the driver's static storage.
M$Vector	***Interrupt Vector Number*** The interrupt vector associated with the port, used to initialize hardware and for installation on the IRQ poll table: 25-31 for an auto-vectored interrupt. Levels 1 - 7. 57-63 for 68070 on-chip auto-vectored interrupts. Levels 1 - 7. 64-255 for a vectored interrupt.

Table 1-2 Device Descriptors (continued)

Name	Description
M$IRQLvl	***Interrupt Level*** The device's physical interrupt level. It is not used by the kernel, IOMan, or file manager. The device driver may use it to mask off interrupts for the device when critical hardware manipulation occurs. **NOTE**: Level 7 is a non-maskable interrupt. It should not be used by OS-9 I/O devices. A device set at this level can interrupt the kernel during critical system operations. Level 7 may be used, however, for hardware operations unknown to the system (for example, dynamic RAM refreshing).
M$Prior	***Interrupt Polling Priority*** Indicates the priority of the device on its vector in the IRQ (F$IRQ) polling system. Smaller numbers are polled first if more than one device is on the same vector. A priority of zero indicates the device requires exclusive use of the vector. **NOTE**: Devices using the fast IRQ system (F$FIRQ) do not use this field, as only one FIRQ device is permitted per vector.

Table 1-2 Device Descriptors (continued)

Name	Description
`M$Mode`	***Device Mode Capabilities*** This byte is used to validate a caller's access mode byte in `I$Create` or `I$Open` calls. It may be any combination of the following: bit 0: Set if read access bit 1: Set if write access bit 2: Set if executable access bit 4: Set if file append mode is supported bit 6: Set if single-user access (non-sharable) bit 7: Set if directory file access All other bits are reserved.
`M$FMgr`	***File Manager Name offset*** The offset to the name string of the file manager module for this device.
`M$PDev`	***Device Driver Name offset*** The offset to the name string of the device driver module for this device.

Table 1-2 Device Descriptors (continued)

Name	Description
M$DevCon	***Device Configuration*** The offset to an optional device configuration table. You can use it to specify parameters or flags the device driver needs and are not part of the normal initialization table values. This table is located after the standard initialization table. The kernel, IOMan, or file manager never references it. As the pointer to the device descriptor is passed in INIT and TERM, M$DevCon is generally available to the driver only during the driver's INIT and TERM routines. Other routines in the driver (for example, Read) must first search the device table to locate the device descriptor before they can access this field. Typically, this table is used for name string pointers, OEM global allocation pointers, or device-specific constants/flags. **NOTE**: These values, unlike the standard options, are not copied into the path descriptors options section.
M$Opt	***Table Size*** This contains the size of the device's standard initialization table. Each file manager defines a ceiling on M$Opt.
M$DTyp	***Device Type (First Field of Initialization Table)*** The device's standard initialization table is defined by the file manager associated with the device, with the exception of the first byte (M$DTyp). The first byte indicates the class of the device (RBF, SCF, etc.). See **Table 1-3** for details.

Device Types

Table 1-3 Device Types

Device Type Name	Value	Description
DT_SCF	0	Sequential Character File Manager (SCF)
DT_RBF	1	Random Block File Manager (RBF)
DT_Pipe	2	PIPE File Manager (PIPEMAN)
DT_SBF	3	Sequential Block File Manager (SBF)
DT_NFM	4	Network File Manager (NFM)
DT_CDFM	5	Compact Disc File Manager (CDFM)
DT_UCM	6	User Communications Manager (UCM)
DT_SOCK	7	Socket Communications Manager (SOCKMAN)
DT_PTTY	8	Pseudo-keyboard Manager (PKMAN)
DT_INET	9	Internet Interface Manager (IFMAN)
DT_NRF	10	Non-volatile RAM File Manager (NVRAM)
DT_GFM	11	Graphics File Manager (GFM)
DT_ISDN	12	ISDN File Manager (ISM)
DT_MPFM	13	MPEG File Manager (MPFM)

The initialization table (M$DTyp through M$DTyp + M$Opt) is copied into the option section of the path descriptor when a path to the device is opened. Typically, this table is used for the default initialization parameters such as the delete and backspace characters for a terminal. Applications may examine all of the values in this table using I$GetStt (SS_Opt). Some of the values may be changed using I$SetStt; some are protected by the file manager to prevent inappropriate changes.

The theoretical maximum initialization table size is 128 bytes. However, a file manager may restrict this to a smaller value.

Path Descriptors

Every open path is represented by a data structure called a path descriptor. It contains path-related information required by file managers and device drivers. Path descriptors are dynamically allocated and de-allocated as paths are opened and closed.

A path descriptor is 256 bytes long. It has three sections:

- The first 42 bytes are defined universally for all file managers and device drivers.
- The next 86 bytes are reserved for and defined by each type of file manager for file pointers, permanent variables, etc.
- The last 128 bytes constitute the option area used for the path's operating parameters. You can inspect or change this area. The variables are initialized at the time the path is opened by copying the initialization table contained in the device descriptor module. The file manager may also initialize certain variables at the end of the initialization table section so they may be inspected. The values in this table may be examined using `I$GetStt` or changed using `I$SetStt` by applications using the `SS_Opt` code. The file manager protects some values to prevent inappropriate changes.

The universal path descriptor fields are described below. Each file manager chapter contains definitions of the option area specific to that manager.

Table 1-4 Path Descriptor Offsets

Offset	Name	Maintained By	Description
`$00`	`PD_PD`	IOMan	Path Number
`$02`	`PD_MOD`	IOMan	Access Mode (RWESD)

Table 1-4 Path Descriptor Offsets (continued)

Offset	Name	Maintained By	Description
$04	PD_DEV	IOMan	Address of Related Device Table Entry
$08	PD_CPR	IOMan	Requester's Process ID
$0A	PD_RGS	IOMan	Address of Caller's MPU Register Stack
$0E	PD_BUF	File Manager	Address of Data Buffer
$12	PD_USER	IOMan	Group/User ID of Original Path Owner
$16	PD_PATHS	IOMan	List of Open Paths on Device
$1A	PD_COUNT	IOMan	Number of Paths using this PD
$1C	PD_LProc	IOMan	Last Active Process ID
$20	PD_ErrNo	File Manager	Global errno for C language file managers
$24	PD_SysGlob	File Manager	System global pointer for C language file managers
$2A	PD_FST	File Manager	File Manager Working Storage
$80	PD_OPT	Driver/File Man.	Option Table

Table 1-5 Path Descriptors

Name	Description
PD_PD	***Path Number*** The system path number assigned by IOMan to the open path associated with this descriptor.
PD_MOD	***Access Mode (RWESD)*** The file access mode specified by the I/O request. It may be any combination of the following: bit 0: Set if read access. bit 1: Set if write access. bit 2: Set if executable access. bit 4: Set if file append access mode. bit 6: Set if single-user access (non-sharable). bit 7: Set if directory file access. All other bits are reserved.
PD_DEV	***Address of Related Device Table Entry*** The address of the device table entry associated with this path.
PD_CPR	***Requester's Process ID*** The process ID of the process originating the I/O request.

Table 1-5 Path Descriptors (continued)

Name	Description
PD_RGS	***Address of Caller's MPU Register Stack*** The address of the originating process's MPU register stack. This pointer can be used to read or write the registers of the calling process.
PD_BUF	***Address of Data Buffer*** This is the address of the data buffer associated with the current I/O operation. It may be a buffer created by the file manager or a pointer directly to an application's buffer.
PD_USER	***Group/User ID of Original Path Owner*** The group/user ID of the process that created this path.
PD_PATHS	***List of Open Paths on Device*** This field is used to link this descriptor into a circular, singly-linked list of paths open to this device.
PD_COUNT	***Number of Paths using this PD*** The number of open paths using this path descriptor. This is set to one when the first path is opened. Using `I$Dup` to open paths increments this counter.
PD_LProc	***Last Active Process ID*** The process ID of the most recent process to perform I/O on this path.
PD_ErrNo	***Global errno for C language file managers*** This field is available for C language file managers to implement as they see fit.

Table 1-5 Path Descriptors (continued)

Name	Description
PD_SysGlob	***System global pointer for C language file managers*** This field is set by IOMan to contain the pointer to the kernel/IOMan system global data.
PD_FST	***File Manager Working Storage*** Reserved for and defined by the file manager.
PD_OPT	***Option Table*** A 128-byte option area used for the path's operating parameters that you can inspect or change. These variables are initialized at the time the path is opened by copying the initialization table contained in the device descriptor module. The file manager may also initialize certain variables at the end of the initialization table so they may be inspected. The values in this table may be examined using I$GetStt or changed using I$SetStt by applications using the SS_Opt code. The file manager protects some values to prevent inappropriate changes.

System State Time-slicing

OS-9 allows time-slicing while in system state. This requires careful design since I/O components (file managers and device drivers) often cannot tolerate this type of behavior.

To alleviate this problem and provide backwards compatibility with earlier versions of I/O system modules, the kernel disables system-state time-slicing for a process when that process makes an I/O (`I$`) service request. The kernel restores the process's time-slice capability when the I/O call completes.

File Manager Guidelines

If you want to allow time-slicing to occur within a file manager, adhere to the following guidelines.

- On entry to the file manager, enable time-slicing for the process by decrementing its `P$Preempt` field.
- On exit from the file manager, disable time-slicing for the process by incrementing its `P$Preempt` field.
- If the file manager allows preemption to occur, it may still need to disable/enable preemption when calling into the device driver. Most device drivers (refer to **Device Driver Guidelines**) cannot be preempted, so it is important to disable preemption when calling the device driver if the file manager has enabled it.
- When you re-enable the preemption, it is also important to note simply decrementing the `P$Preempt` field does not guarantee preemption occurs in a deterministic manner. If the process time-slice expires while the file manager is executing a section that cannot be preempted, the kernel ignores the process time-out and continues execution of the file manager. To ensure time-outs in these sections are not missed, the file manager should check for process time-out when it re-enables system state time-slicing. The following code example shows how to achieve this.

```
*******************************
* Preempt - allow process preemption, and check for
*           preemption pending
*
* Passed:   (a4) = current process descriptor ptr
*           (a5) = caller's register stack ptr
*           (a6) = system global data ptr
*
* Returns: nothing
*
* Destroys: nothing
*
Preempt: subq.l    #8,a7             status save & R$d0 result (if sleeping)
         move.w    sr,0(a7)          save ccr status
         subq.l    #1,P$Preempt(a4)  allow preemption
         bne.s     Pre99             ..not currently allowed, exit quickly
         btst.b    #TimOut,P$State(a4) process time-out set?
         beq.s     Pre99             ..no; keep running
         movem.l   d0-d1/a5,-(a7)    save regs
         lea.l     (3*4)+4(a7),a5    set fake frame ptr (R$d0 created above)
         moveq.l   #1,d0             give up time-slice
         OS9svc    F$Sleep
         movem.l   (a7)+,d0-d1/a5    restore regs
Pre99    move.w    0(a7),ccr         restore Carry status
         addq.l    #8,a7             toss scratch
         rts                         return
```

Device Driver Guidelines

To allow time-slicing to occur within a device driver, adhere to the following guidelines.

- In general, you cannot preempt device drivers if they perform interrupt masking during critical code sections. The interrupt-masked sections usually perform interrupt masking to the level of the device (and *not* level 7). Thus, the clock interrupt (ticker) is usually at a higher interrupt level than the device. If the file manager allows pre-emption when it calls the driver or the device driver enables pre-emption, it is possible for a clock interrupt to trigger a task switch during a driver's critical section.
- The ability of a device driver to be preemptable should be examined on a case-by-case basis. If it is feasible to preempt the driver, follow the guidelines for file managers as shown above.

System-State Threads

Some I/O systems create processes that manage parts of their I/O operations (for example, the SBF file manager creates an *SBF* process to manage its buffered I/O mode). When these processes are created, there are two ways to handle system-state time-slicing:

1. Write the process code so the `P$Preempt` field of the process is managed (according to the guidelines above) during the critical sections of the process code.
2. When the process is created, permanently disable system-state time-slicing for the process by setting a non-zero value into the process's `P$Preempt` field before inserting the process into the active process queue.

Method 1 above is preferred because it minimizes the code window where time-slicing is disabled, thus allowing maximum determinism for the system.

Status Register Considerations

OS-9 uses the Master Stack Pointer (MSP) on those processors supporting MSP/ISP usage (68020, 68030, and 68040). Previous versions of OS-9 always used the Interrupt Stack Pointer (ISP) when executing in system state.

This change means you must use care when dealing with code forming Status Register (SR) images. These images are usually created in the following situations:

- Interrupt masking
- System-state threads

Interrupt Masking

Many device drivers form SR masks so they can mask device interrupts during critical code sections. When dealing with drivers that perform this operation it is important to ensure no accidental stack switch (between MSP and ISP stacks) occurs. On those systems supporting MSP/ISP, the ISP stack is used for interrupt contexts only. The MSP stack is used for all other system-state contexts (thus, for example, a device driver is called using the MSP stack for Read).

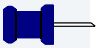
System State Threads

I/O systems that create processes to manage I/O need to ensure the correct stack is used when they create the process descriptor. When creating the process, a register image is built in the process descriptor. The image is built in the stack area of the process descriptor and consists of registers `d0-d7`, `a0-a7`, `SR`, `PC`, and `Stack Format`. This image is pointed to by the `P$sp` field of the process descriptor.

When the SR image is built in the stack frame, you must indicate the correct stack to use in the SR image. Typically, you should use the current SR as the basis of the SR image you build in the process descriptor.

File Managers

The function of a file manager is to process the raw data stream to or from device drivers for a class of similar devices. File managers make device drivers conform to the OS-9 standard I/O and file structure by removing as many unique device operational characteristics as possible from I/O operations. File managers are also responsible for mass storage allocation and directory processing, if applicable to the class of devices they service.



Note

I/O system modules must have the following module attributes:

- They must be owned by a super-user (`0.n`).
- They must have the system-state bit set in the attribute byte of the module header. OS-9 does not currently make use of this, but future revisions may require I/O system modules be system-state modules.

File managers usually buffer the data stream and issue requests to the kernel for dynamic allocation of buffer memory. They may also monitor and process the data stream. For example, they may add line-feed characters after carriage returns.

File managers are re-entrant. One file manager may be used for an entire class of devices with similar operational characteristics. OS-9 systems can have any number of file manager modules.

The following file managers are usually included in an OS-9 system:

Table 1-6 OS-9 File Managers

File Manager	Description
Random Block File Manager (RBF)	Operates random-access, block-structured devices such as disk systems.
Sequential Character File Manager (SCF)	Used with single-character-oriented devices such as CRT or hard-copy terminals, printers, and modems.
Sequential Block File Manager (SBF)	Used with sequential block-structured devices such as tape systems.
Pipe File Manager (PIPEMAN)	Supports interprocess communication through memory buffers called pipes.
PC File Manager (PCF)	Allows you to transfer files between PC-DOS and OS-9 systems.

For More Information

See the ***OS-9 for 68K PC File Manager*** manual for information on the PC File Managers.

File Manager Organization

A file manager is a collection of major subroutines accessed through an offset table. The table contains the starting address of each subroutine relative to the beginning of the table. The location of the table is specified by the execution entry point offset in the module header. A sample listing of the beginning of a file manager module is shown below.

```
* Sample File Manager
* Module Header declaration
     Type_Lang equ (FlMgr<<8)+Objct
     Attr_Revs equ ((ReEnt+Supstat)<<8)+0
     psect FileMgr,Type_Lang,Attr_Revs,Edition,0,Entry_pt
* Entry Offset Table
Entry_pt dc.w      Create-Entry_pt
         dc.w      Open-Entry_pt
         dc.w      MakDir-Entry_pt
         dc.w      ChgDir-Entry_pt
         dc.w      Delete-Entry_pt
         dc.w      Seek-Entry_pt
         dc.w      Read-Entry_pt
         dc.w      Write-Entry_pt
         dc.w      ReadLn-Entry_pt
         dc.w      WriteLn-Entry_pt
         dc.w      GetStat-Entry_pt
         dc.w      SetStat-Entry_pt
         dc.w      Close-Entry_pt
* Individual Routines Start Here
```

When IOMan calls the individual file manager routines, standard parameters are passed in the following registers:

Table 1-7 File Manager Standard Parameters

Register	Description
(a1)	Pointer to Path Descriptor.
(a4)	Pointer to current Process Descriptor.
(a5)	Pointer to User's Register Stack; user registers pass/receive parameters as shown in the system call description section.
(a6)	Pointer to system Global Data area.

These routines are called in system state.

File Manager I/O Service Requests

The general I/O responsibilities for file managers are described in the following pages. Each file manager chapter contains a description of the specific I/O functions for that manager.

Table 1-8 I/O Service Requests

Request	Description
`I$ChgDir`	On multi-file devices, `I$ChgDir` searches for a directory file. (IOMan allocates a path descriptor so `I$ChgDir` may use `I$Open` when searching for the directory.) If the directory is located, the file manager saves its address in the caller's process descriptor at `P$DIO`. `I$Open` and `I$Create` begin searching in this directory when the caller's pathlist does not begin with a slash (`/`) character. File managers that do not support directories return with the carry bit set and an error code in (`d1.w`).
`I$Close`	Ensures any output to a device is completed (writing out the last buffer if necessary), and releases any buffer space allocated when the path was opened. If required, it may do specific end-of-file processing, such as writing end-of-file records on tapes.
`I$Create`	Performs the same function as `I$Open`. If the file manager controls multi-file devices, a new file is created. File managers that do not support multi-file devices usually consider `I$Create` synonymous with `I$Open`.

Table 1-8 I/O Service Requests (continued)

Request	Description
I$Delete	Multi-file device managers usually perform a directory search similar to I$Open. Once found, the file name is removed from the directory. Any media space in use by the file is returned to the free media pool.
I$GetStt	A wild-card call designed to determine the status of various features of a device (or file manager) that are not generally device independent. The file manager may perform some specific function such as obtaining the size of a file. Status calls that are unknown to the file manager are passed to the driver to provide a further means of device independence.
I$MakDir	Creates a directory file on multi-file devices. File managers that are incapable of supporting directories return with the carry bit set and an unknown service error code in (d1.w).
I$Open	Opens a file on a particular device. This typically involves allocating required buffers, initializing path descriptor variables, and parsing the path name. If the file manager controls multi-file devices, directory searching is performed to locate the specified file.
I$Read	Returns the number of bytes requested to the user's data buffer. If no further data is available, an EOF error is returned. I$Read generally performs no editing on data. Usually, a file manager calls the device driver to read the data into a buffer. The buffer may be an internal buffer maintained by the file manager or it may be the application's buffer. The file manager chooses the appropriate buffer for the driver to use. If an internal buffer is used, the data is then copied into the user's data area.

Table 1-8 I/O Service Requests (continued)

Request	Description
I$ReadLn	I$ReadLn differs from I$Read in two respects: • I$ReadLn is expected to terminate when the first end-of-record character (carriage return) is encountered. • I$ReadLn performs any input editing appropriate for the device. Typically, I$ReadLn uses an internal buffer when calling the driver and copies the data from the buffer into the user's data area.
I$Seek	File managers supporting random access devices use I$Seek to position file pointers of the already open path to the specified byte. This is a logical movement and does not necessarily affect the physical device. If the position is beyond the current end-of-file, no error is produced at the time of the I$Seek. File managers that do not support random access usually do nothing during the I$Seek operation, and do not return an error.
I$SetStt	I$SetStt is the same as the I$GetStt function except it is generally used to set the status of various features of a device (or file manager). The file manager may perform some specific function such as setting the size of a file to a given value. Status calls that are unknown to the file manager are passed to the driver to provide a further means of device independence. For example, an I$SetStt call to format a disk track may behave differently on different types of disk controllers.

Table 1-8 I/O Service Requests (continued)

Request	Description
I$Write	The I$Write request, like I$Read, generally performs no editing on data. Usually, the I$Read and I$Write routines are nearly identical. The most notable difference is I$Write uses the device driver's output routine instead of the input routine. Writing past the end-of-file on a device expands the file with new data. RBF and similar random access devices using fixed-length records (sectors) must often pre-read a sector before writing it unless the entire sector is being written.
I$Writln	I$Writln is the counterpart of I$ReadLn. It calls the device driver to transfer data up to and including the first (if any) end-of-record (carriage return) encountered. Appropriate output editing is also performed. For example, after a carriage return, SCF usually outputs a line-feed character and nulls (if appropriate).

Device Driver Modules

Device driver modules perform basic low-level physical input/output functions. For example, a disk driver's basic function is to read or write a physical sector. The driver is not concerned about files or directories, which are handled at a higher level by the OS-9 file manager.

When written properly, a single physical driver module can support multiple identical hardware interfaces simultaneously. The specific information for each physical interface (port address, initialization constants) is provided in the device descriptor module.

Driver Module Format

All drivers must conform to the standard OS-9 memory module format. The module type code is `Drivr`. Drivers should have the system-state bit set in the attribute byte of the module header.

A sample assembly language header is shown below:

```
* Module Header
Type_Lang equ (Drivr<<8)+Objct
Attr_Revs equ ((ReEnt+Supstat)<<8)+0
psect Acia,Typ_Lang,Attr_Rev,Edition,0,AciaEnt
* Entry Point Offset Table
AciaEnt      dc.w      Init     Initialization routine offset
             dc.w      Read    Read routine offset
             dc.w      Write   Write routine offset
             dc.w      GetStat Get dev status routine offset
             dc.w      SetStat Set dev status routine offset
             dc.w      TrmNat  Terminate dev routine offset
             dc.w      Trap    Error handler routine offset
                  (0=none)
```

Note

I/O system modules must have the following module attributes:

- must be owned by a super-user (`0.n`).
- must have the system-state bit set in the attribute byte of the module header. OS-9 does not currently make use of this, but future revisions may require I/O system modules be system-state modules.

The `M$Exec` module header field is the offset to the address of an *offset table*. This table specifies the starting address of each of the seven driver subroutines relative to the base address of the module.

The `M$Mem` module header field specifies the amount of local static storage required by the driver. This is the sum of the global I/O storage, the storage required by the file manager, and any variables and tables declared in the driver.

The driver subroutines are called by the associated file manager and IOMan through the offset table, with the exception of the device driver's IRQ routine (if any) which is called directly by the kernel's IRQ polling routines. The driver routines are always executed in system state. Regardless of the device type, the standard parameters listed below are passed to the driver in the corresponding registers. Other parameters may also be passed, depending on the device type and subroutine called. These are described in individual file manager chapters.

Each subroutine is terminated by an RTS instruction. Error status is returned using the CCR carry bit with an error code returned in register `d1.w`. For the IRQ service routine, only the CCR carry status is meaningful.

Table 1-9 INIT and TERM (called by IOMan)

Register	Description
(a1)	The address of the device descriptor module.
(a2)	The address of the driver's static variable storage.
(a4)	The address of the process descriptor requesting the I/O function.
(a6)	The address of the system global variable storage area.

INIT initializes the device controller hardware and related driver variables as required. INIT also enables device interrupts and adds the device to the system's IRQ polling table, if necessary.

TERM de-initializes the device. It is assumed the device will not be used again unless re-initialized. TERM also deletes the device from the IRQ polling table and disables interrupts, if necessary.

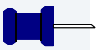
Refer to **Figure 1-3** for a diagram of the I/O system layout during the INIT and TERM routines.

Table 1-10 READ, WRITE, GETSTAT and SETSTAT (called by the file manager)

Register	Description
(a1)	The address of the path descriptor storage.
(a2)	The address of the driver's static variable storage.
(a4)	The address of the process descriptor requesting the I/O function.

Table 1-10 READ, WRITE, GETSTAT and SETSTAT (called by the file manager) (continued)

Register	Description
(a5)	The address of the caller's register stack image.
(a6)	The address of the system global variable storage area.



Note

The register conventions shown here apply to RBF and SCF.

- For SBF's READ and WRITE routines, the contents of registers a1 and a5 are undefined.
- For SBF's GETSTAT and SETSTAT routines, the contents of register a5 are undefined. Other file managers may adopt whatever register conventions are desired.

READ reads one or more standard physical units (a character or sector, depending on the device type). WRITE writes one or more standard physical units (a character or sector, depending on the device type).

GETSTAT returns a specified device status. SETSTAT sets a specified device status.

Refer to **Figure 1-4** for a diagram of the I/O system layout during the READ, WRITE, GETSTAT, and SETSTAT routines.

TRAP

Trap is also known as ERROR. This entry point is currently not used by the kernel, but in the future may be defined as the offset to error exception handling code. Because no handler mechanism is currently defined, this entry point should be set to 0 to ensure future compatibility.

IRQ

IRQ is called by the kernel's IRQ polling table handler.

There are two interrupt polling mechanisms within OS-9:

- The standard IRQ system (IRQ)
- The fast IRQ system (FIRQ).

Generally, the IRQ system is used for the majority of device drivers. The FIRQ system was designed primarily for simple I/O devices requiring a faster response than the IRQ system provides.

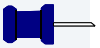
Table 1-11 IRQ

Register	Description
`d0.w`	Vector offset.
`(a2)`	The address of the driver's static variable storage.
`(a3)`	The address of the device port.
`(a6)`	The address of the system global variable storage area.

Table 1-12 FIRQ

Register	Description
`d0.w`	Vector offset.
`(a2)`	The address of the driver's static variable storage area.
`(a6)`	The address of the system global variable storage area.

The IRQ subroutine is not called by the file manager, but by the kernel's interrupt polling routine. It communicates with the driver's main section through the static storage and certain system calls.



Note

The values passed in a2 and a3 are, by convention, as described above. The values are those existing in the respective registers when the device was installed on the IRQ polling table (F$IRQ). Register a2 is usually passed to enable the IRQ service routine to access the driver's static storage. Register a3 can have any value desired, because the hardware is never accessed by the kernel's IRQ polling routine.

IRQ may only destroy values in the following registers: d0, d1, a0, a2, a3, and a6. If the interrupt was serviced, IRQ returns the carry bit clear. If not serviced, IRQ returns the carry bit set. This provides the kernel's IRQ polling routine with an indication it should call the IRQ service routine associated with the next lowest priority device on the vector.

Refer to **Figure 1-5** for a diagram of the I/O system layout during the IRQ service routine.

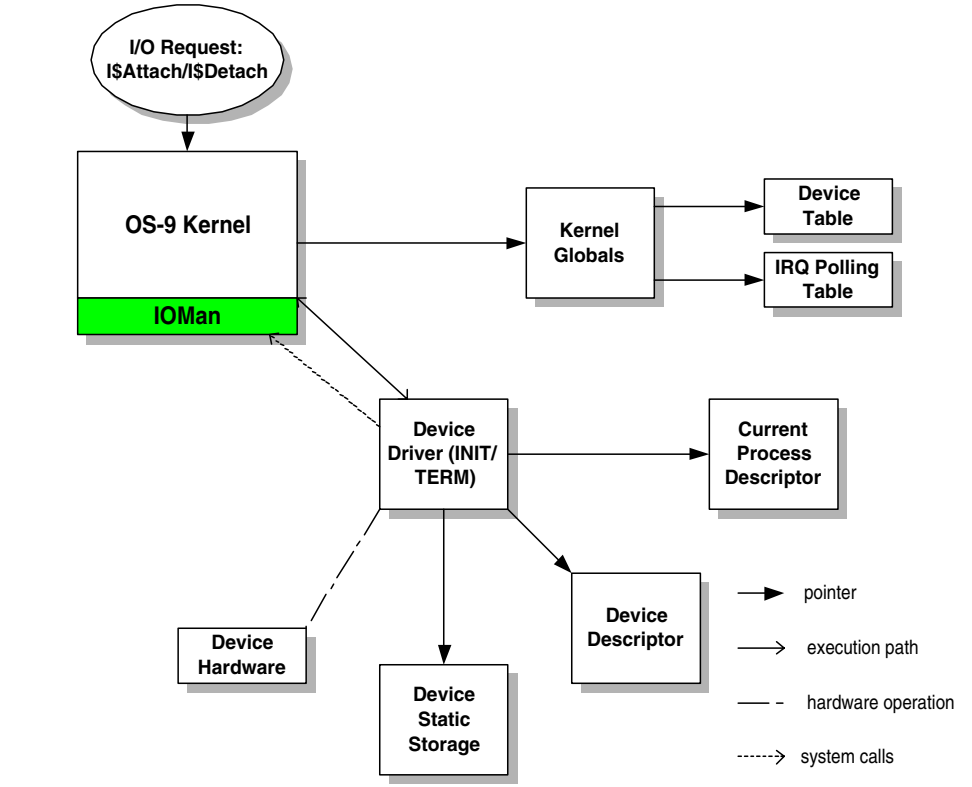
FIRQ routines may only destroy values in the d0 and a2 registers. If the interrupt was serviced, FIRQ returns carry clear. If it was not serviced or polling of the IRQ devices on the same vector is desired after servicing the FIRQ interrupt, set the carry bit when returning.

Note also if an FIRQ routine makes a system call (for example, F$Send), any registers changed by the system call must be preserved. This is especially true for the d1 register, as this register is used to indicate error status on all system calls.

Note

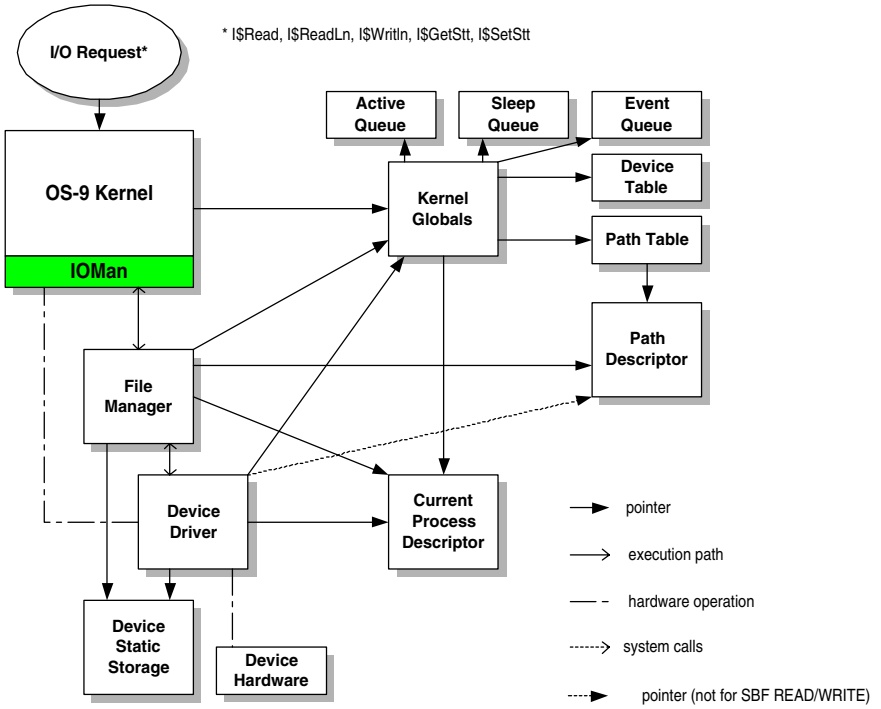
The value passed in `a2` is, by convention, as described above. It is the same as that existing when the device was installed in the Fast IRQ polling system (`F$FIRQ`). `a2` can have any value desired because the hardware is never accessed by the kernel directly.

Figure 1-3 I/O System Layout for INIT/TERM Routines



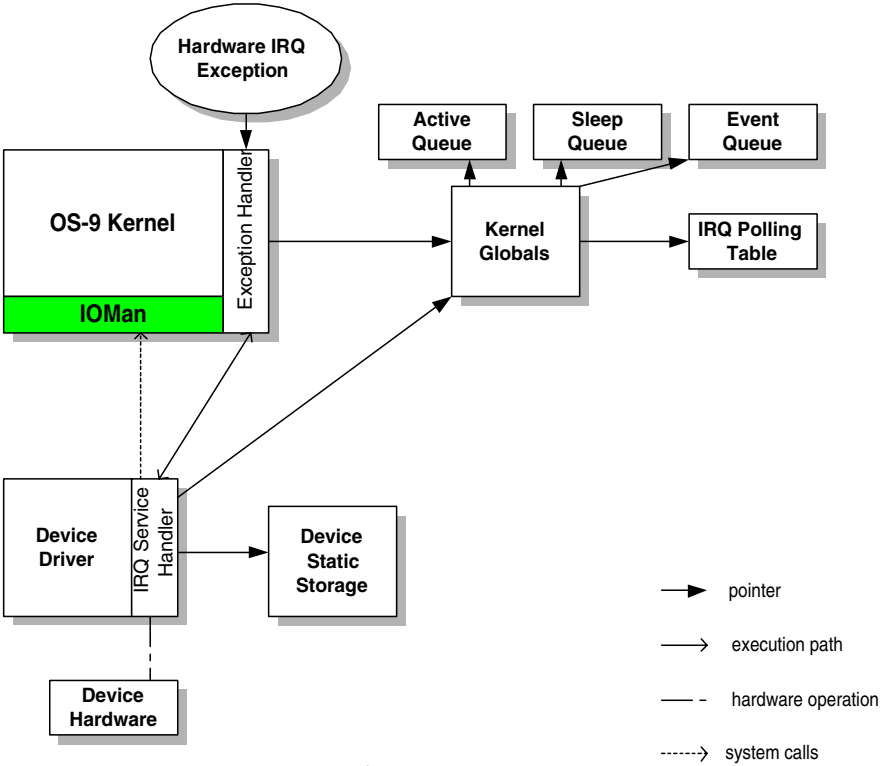
Typical system calls made by the driver include (if any):
FIRQ, FSRqMem, F$SRtMem

Figure 1-4 I/O System Layout for READ/WRITE/GETSTAT/SETSTAT Routines



Typical system calls made by the driver include (if any): F$Sleep, F$Event, F$CCtl, F$SRqMem, F$SRtMem

Figure 1-5 I/O System Layout for IRQ Service Routine



Typical system calls made by the driver include (if any): F$Send, F$Event, F$CCtl

Device Drivers That Control Multiple Devices

Properly written re-entrant device drivers can handle more than one physical hardware device. The driver is responsible for isolating the file manager from the specifics of the device interface. The device descriptor tailors the device driver to the actual physical parameters of the hardware in use (for example, port address, interrupt level). Consequently, adding hardware ports to a system is generally a matter of creating new device descriptors for the new ports.

This section highlights some of the issues arising when dealing with multi-port/multi-device hardware. It discusses three general types of hardware devices:

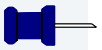
- Simple Devices
- Multi-Port Devices
- Multi-Class Devices

Simple Devices

Simple devices provide a single discrete I/O interface, such as a UART (Universal Asynchronous Receiver Transmitter) or a disk controller. If a system has a driver for a specific simple device, instances of that device can be created by building new device descriptors. This can usually be accomplished by editing an existing descriptor and installing the new hardware and descriptor on the system.

The I/O system creates a new *incarnation* of the device driver when each device is installed in the system. Each incarnation of the driver has its own static storage area; therefore, the operating parameters for each device are separated from those of similar devices.

The I/O system considers a device a *new device* when its device table entry (port address, device descriptor, driver, and file manager) differs from all existing device table entries. When this condition is detected, the new device is added to the I/O system and the device's `INIT` routine is called.



Note

If the new device differs only in that its device descriptor is different (same port address, device driver, and file manager), a new entry is made into the device table, but the `INIT` routine is not called. This is how multi-device, single-controller devices are handled.

An example of this is a disk controller supporting more than one drive. The `INIT` routine is called only once for these devices—at the first `I$Attach` to any device on this port. In this case, no new incarnation of the driver occurs. The device driver usually discriminates between the devices on the port by means of *logical* devices. For example, a RBF disk controller controlling four drives uses the `PD_DRV` field of the device descriptor to discriminate between each drive.

Most OS-9 device drivers are expected to handle only one request from a file manager at a time. The mechanism ensuring proper handling of access requests is called *I/O Blocking*. It is usually performed by the file manager associated with the device, using the `V_BUSY` variable of the driver's static storage. RBF, SCF, SBF, PCF, and PIPEMAN implement I/O blocking in this manner. Consequently, a driver written to work with one of these file managers need handle only one request at a time. For example, the disk access request to drive 0 of a controller must be completed before RBF makes an access request to drive 1.

I/O blocking *does not* affect *different* devices using the same driver. This is because the I/O blocking function is performed on a port address basis; `V_BUSY` is unique to each static storage area. Drivers written for other file managers (for example, NFM) may have to deal with more than request at a time, depending upon how the file manager operates.

Multi-Port Devices

Multi-port devices provide more than one physical I/O channel. If the hardware implementation totally separates the physical I/O channels, the device can be treated as multiple simple hardware devices. An example of this would be a DUART (Dual Universal Asynchronous Receiver Transmitter), a device providing two separate channels, each with an independent register set. Typically, the only difference between the two device descriptors is the port address. This allows separate incarnations of the driver to control each relevant part of the device.

If, however, the device contains registers that are common between the physical I/O channels, problems can arise with interaction between the incarnations of the driver running on the different ports.

A common example of this situation is the MC68681 DUART. This device contains register sets associated with each individual channel and register sets common to both channels. The common registers present a problem, in this case, because they are *write-only* registers. Each incarnation of the driver needs to manipulate these registers, but has no knowledge of the current state of the *other-side* values.

Without a mechanism for sharing these values, manipulation of the common registers can cause a driver to produce inadvertent side effects on the *other* channel. However, you can easily overcome this situation by using one of the following techniques:

- OEM global storage
- Data modules

OEM Global Storage

The OEM global storage area is a 256-byte area in the system globals of the kernel. This area is provided for system-specific, custom storage allocation. In the case of the common write-only registers, the system can be configured so memory images of these registers are stored in the OEM global area.

When an incarnation of the driver wishes to modify a common register, it must locate the appropriate image stored in RAM, modify it, store the new image back in RAM, and update the hardware. Using this scheme, multiple incarnations of the driver can operate without affecting other incarnations.

The allocation of storage within the OEM global area is system-specific and is usually defined by the individual system designer (OEM). For these types of devices, the device descriptor's DevCon section is often used to store a pointer to the area allocated for the particular device in the OEM globals.

Using the OEM global area to overcome the problems with multi-port device drivers has the following advantages:

- For the system boot-ROM's console and communications ports, it allows high-level interrupt-driven drivers to communicate current register values to low-level polled I/O routines in the boot-ROM code. Consequently, correct system operation results when switching the console port between the operating system and the boot ROMs.
- It allows multiple-function devices sharing different types of device drivers to communicate current register values between the drivers. The MC68681 DUART is a prime example of this type of device: it has two serial channels and a tick-timer device.

Data Modules

For drivers that only need to communicate between themselves (they do not need to communicate to low-level boot-ROM routines), the use of data modules to store common register values may also be an option. The driver's `INIT` routine would dynamically determine the storage area to be used by attempting to create/link the data module. Once the storage has been created/found, then the driver can manipulate the required images in the same way the OEM global storage variables are accessed.

Note

This technique often does not require DevCon values to indicate the storage to be used. Incarnations of the driver only have to agree on the naming convention to adopt when forming the data module's name. For example, you could use a common part of the port address as part of the name.

Depending upon the system's requirements, other techniques may also be appropriate for managing these situations, such as using the OS-9 event system.

Devices

Creating drivers for I/O systems supporting more than one class of I/O device (for example, disk and tape devices on a SCSI bus) presents a different set of problems. However, these problems are generally easy to solve. The most common problems for these devices involve I/O blocking and sensitivity to device class.

Because I/O blocking is usually performed at the file manager level, a common driver supporting two classes of devices (for example, RBF and SBF) may be called by one file manager while running on behalf of another file manager. Therefore, the driver must be written to handle this case or at least provide I/O blocking.

In addition, the layout of the path descriptor options and device static storage is different for each device class. Because the device driver has to be continually sensitive to the device class, the driver is somewhat cumbersome to write. The net effect is attempting to *merge* two separate drivers into a single piece of code.

To simplify these problems, the technique usually adopted is to split the driver into *high-level* and *low-level* functions. The high-level portion of the driver is the actual *device driver*, as it is the module called directly by the file manager. This module deals with all issues related to the device class (for example, static storage allocations, operational characteristics) and the

target hardware (for example, command protocols). Once the request has been prepared by the driver, it calls the low-level subroutine module, which is designed to manage the physical interface. The low-level module has no knowledge of the device class or type of operation required. Its function is to manage the I/O requests (with I/O blocking, if necessary) from multiple drivers through the physical interface.

When this technique is adopted, the DevCon section of the device descriptor is usually used as a name string for the low-level module to be used. The individual high-level device drivers can link/unlink to the module and call it, if necessary, during its `INIT/TERM` routines.

Examples of Multi-Class Devices Using SCSI System Concept

The basic premise of this system is to break the OS-9 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. Drivers deal with all controller-specific/device-class issues (for example, disk drives on an OMTI5400). They should be written so they are *portable* code (no MPU/CPU specific code). The high-level drivers prepare the command packets for the SCSI target device and then pass this packet to the low-level subroutine module.

This low-level 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 on behalf of the high-level driver. The low-level module is also responsible for coordinating 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 often 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.

Examples

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

Hardware Configuration

OMTI5400 Controller:

- 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

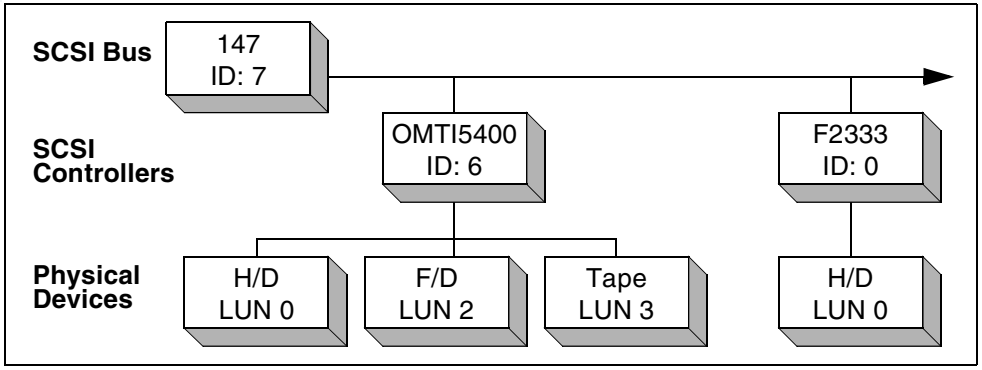
Fujitsu 2333 Hard Disk with Embedded SCSI Controller:

- Addressed as SCSI ID 0

MVME147 Host CPU:

- Uses WD33C93 SBIC Interface chip
- *Own ID* of chip is SCSI ID 7

The hardware setup would look like this:



Software Configuration

The following high-level drivers are associated with this configuration:

Table 1-13 High-level Drivers

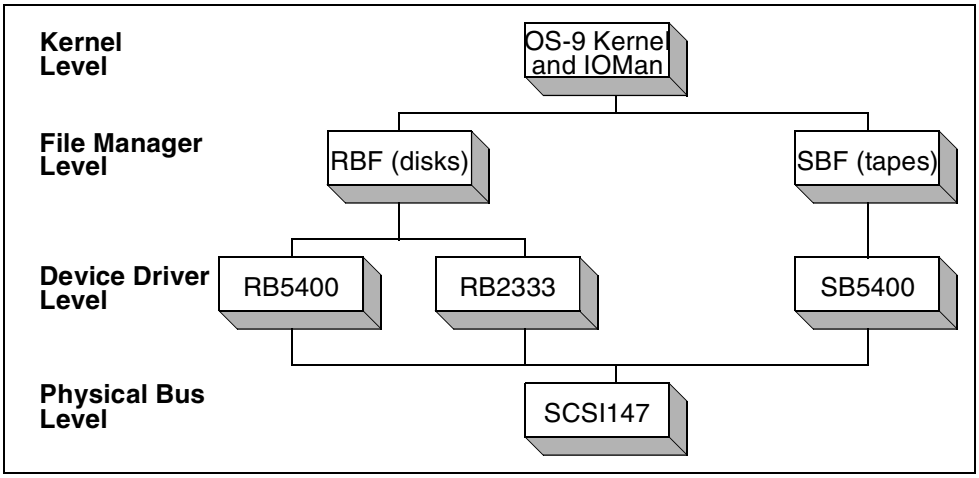
Name	Description
RB5400	Handles hard and floppy disk devices on the OMTI5400.
SB5400	Handles tape device on the OMTI5400.
RB2333	Handles hard disk device.

The following low-level module is associated with this configuration:

Table 1-14 Low-level Module

Name	Description
SCSI147	Handles WD33C93 Interface on the MVME147 CPU.

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



If the guidelines previously given are adhered to, expansion and reconfiguration of the SCSI devices (both in hardware and software) can be easily accomplished. The following three examples show how to achieve this.

Example One

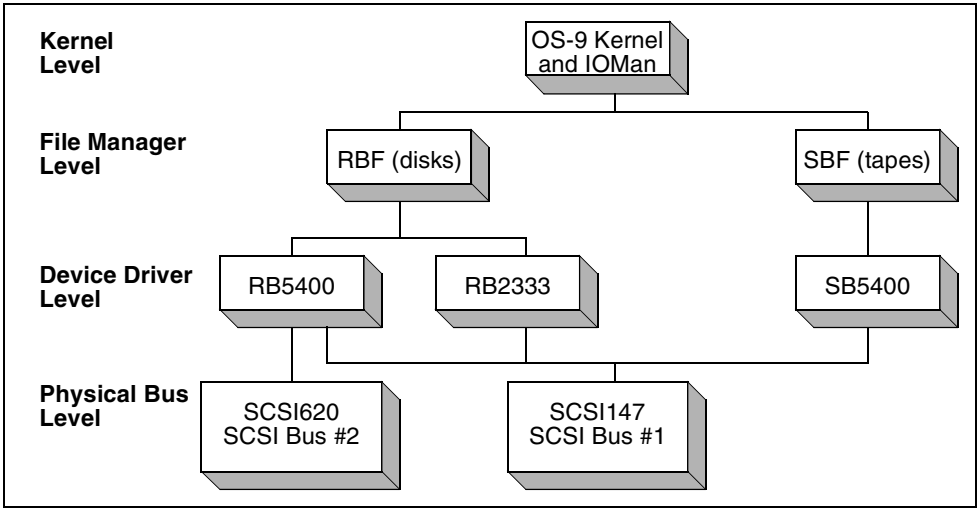
This example describes the addition of a second SCSI bus using the VME620 SCSI controller. This second bus has an OMTI5400 controller and associated hard disk.

The VME620 module uses the WD33C93 chip as the SCSI interface controller, but it uses a NEC DMA controller chip. Thus, a new low-level module needs to be created for the VME620 (call the module `SCSI620`). You can create this module by editing the existing files in the `SCSI33C93` directory to add the VME620 specific code. This new code would typically be *conditionalized*. A new makefile (such as `make.vme620`) could then be created to allow production of 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 modules for the system would now look like this:

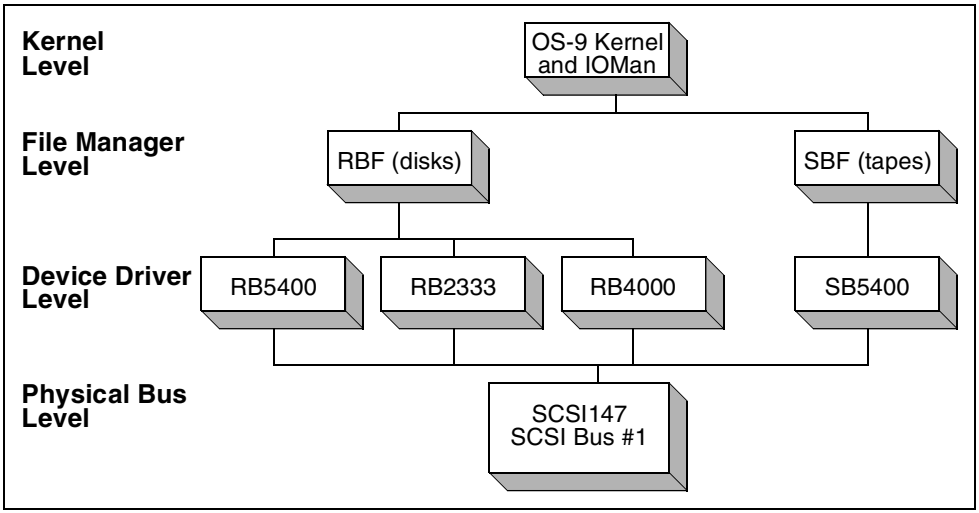


Example Two

This example describes the addition of 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. Create a new directory (such as `RB4000`) and write the high-level driver based upon an existing example (such as `RB5400`). You do not need to write a low-level module, as this already exists. Then, 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 modules for the system would now look like this:



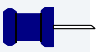
Example Three

Perhaps the most common reconfiguration occurs when adding devices of the same type as the existing device. For example, an additional Fujitsu 2333 disk to the SCSI bus on the MVME147. To add a similar controller to the bus, just create a new device descriptor. There are no drivers to write or modify, as these already exist (`RB2333` and `SCSI147`). The only modifications required would be to take the existing descriptor for the `RB2333` device and modify it to reflect the second devices physical parameters (for example, SCSI ID) and change the actual name of the descriptor itself.

Interrupt Driven I/O

OS-9 is a multi-tasking, real-time operating system. To support these capabilities, I/O devices should be, whenever possible, set up to provide fully interrupt-driven operation. Non-interrupt-driven operation (polled I/O) should only be used for I/O devices that are always ready to read/write data (for example, output to a memory-mapped video RAM). If a driver has to wait for the device to read/write data, then real-time system operation may be affected.

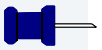
For character-oriented devices (for example, SCF), the controller should be set up to generate an interrupt upon the receipt of an incoming character and at the completion of transmission of an outgoing character. Both the input data and the output data should be buffered in the driver. In the case of block-type devices (for example, RBF and SBF), the controller should be set up to generate an interrupt upon the completion of a block read or write operation. It is usually not necessary for the driver to buffer data because the driver is passed the address of a complete buffer.



Note

The maximum number of devices (device table entries) and interrupting devices (polling table entries) are defined in the initialization module (`init`). These fields (`M$DevCnt` and `M$PollSz`) are user adjustable.

Devices are usually added to the system's IRQ polling tables when the device is attached (`INIT` routine) and removed from the IRQ polling tables when the device is detached (`TERM` routine). The device is added and deleted by the driver using the `F$IRQ/F$FIRQ` service requests. Device drivers for devices generating multiple vectors (for example, separate receive and transmit interrupts) or hardware ports having multiple devices (for example, disk controllers with associated DMA device) may have to make multiple `F$IRQ/F$FIRQ` calls to add and delete each device in the polling table.



Note

OS-9 provides two interrupt polling systems:

- Fast (`F$FIRQ`)
- Normal (`F$IRQ`)

Generally, `F$IRQ` is used for most device drivers. The `F$FIRQ` system was designed primarily for simple hardware devices requiring faster response time than provided by the `F$IRQ` system.

The kernel does not place any restrictions on which vectors (`M$Vector` of the device descriptor) may be used by devices or how many devices may share a vector. If devices share a vector, the priority of the device on the vector is determined by the IRQ polling priority (`M$Prior`) specified for the device. As a general rule, the system integrator should attempt to allocate one device per vector so the kernel's IRQ polling table *vectors* to the correct device immediately.

Interrupt-driven drivers generally consist of two separate execution threads:

- driver mainline
- interrupt service routine

A typical I/O operation by the driver consists of the following:

1. Driver mainline (called by file manager) initiates I/O operation and suspends itself.
2. Device interrupt occurs and IRQ service routine initiates wake-up of driver mainline.
3. Driver mainline is reactivated and returns to caller.

The synchronization of the driver mainline and IRQ service routine is usually accomplished by one of the following mechanisms:

SIGNALS	The driver suspends itself by sleeping (`F$Sleep`) and is reactivated when the IRQ service routine sends the driver a signal

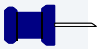
	(`F$Send`, signal `S$Wake`). This is the most common method used by interrupt-driven drivers. The interlock between the execution threads is usually done using the static storage variable `V_WAKE`.
EVENTS	The driver suspends itself by waiting on an event (`F$Event`), and is reactivated when the IRQ service routine signals the event. The interlock between the execution threads is done via the event values.

The decision whether to use signals or events for interrupt operation should be based on the complexity of the driver. If the driver is simple (only needs to communicate interrupt occurrences), either method is suitable. If the driver is complicated (needs to communicate more than one state), the event system is usually preferred. For example, the event system would be more suitable for a SCSI driver supporting multiple devices that can disconnect.

The assignment of a device's physical interrupt level(s) can have a significant impact on system operation. Generally, the smarter the device, the lower its interrupt level can be set. For example, a disk controller that buffers sectors can wait longer for service than a single-character buffered serial port. Usually, the interrupt levels can be assigned according to the system's requirements, but it is recommended you assign the clock tick device the highest possible level to keep interference with system time-keeping at a minimum.

The following table shows how interrupt levels can be assigned in a typical system:

```
level 6:     clock ticker
      5:     "dumb" (non-buffering) disk controller
      4:     terminal ports
      3:     printer port
      2:     "smart" (sector-buffering) disk controller
```



Note

Level 7 is a non-maskable interrupt. It should not be used by OS-9 I/O devices. A device set at this level can interrupt the kernel during critical system operations. However, level 7 can be used for hardware operations *unknown* to the system (for example, dynamic RAM refreshing).

Exception conditions (such as a Bus Error) should be avoided when IRQ service routines are executing. Under the current version of the kernel, an exception in an IRQ service routine crashes the system.

DMA I/O and System Caches

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 a desirable goal, 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.

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 and may lead to data corruption or *locked* drivers.

The system's caching characteristics are controlled by two OS-9 components:

- **Syscache Module**
- **Init Module**

Syscache Module

The `Syscache` module is the global mechanism to invoke caching. If this module is present in the bootstrap file, caching occurs in the system. If the module is not found during system startup, all cache functions are disabled.

Default `Syscache` modules are provided for each class of MPU (for example, the 68020 provides instruction caching, while the 68030 provides instruction and data caching) so as to support the on-chip cache capabilities of the system.

You can integrate off-chip (system specific) caches into the system by having the OEM customize the `Syscache` module for the CPU module in use.

Init Module

The Init module's Compat variables also play a role in the cache control for the system. You can set flags in these variables to fine-tune the kernel's cache control.

The following flags are available in the Init module.

Table 1-15 Flags

Variable	Bit	Function
M$Compat	3	0=enable burst mode (68030 systems only) 1=disable burst mode
M$Compat2	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 or absent
	4	0=68349: cache/SRAM bank 0 is SRAM 1=68349: cache/SRAM bank 0 is Cache

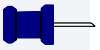
Table 1-15 Flags (continued)

Variable	Bit	Function
	5	0=68349: cache/SRAM bank 1 is SRAM 1=68349: cache/SRAM bank 1 is Cache
	6	0=68349: cache/SRAM bank 2 is SRAM 1=68349: cache/SRAM bank 2 is Cache
	7	0=68349: cache/SRAM bank 3 is SRAM 1=68349: cache/SRAM bank 3 is Cache

Avoiding Stale Data Problems

To ensure stale data problems do not arise, use the following set of guidelines when writing system code (file managers and device drivers) and setting up the `Init` module cache flags.

The `M$Compat2` variable has flags indicating whether or not a particular cache is coherent. Flagging a cache as coherent (when it is) allows the kernel to ignore specific cache flush requests, using `F$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 it is important to 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 means to setup the local/external addressing map for the system. This mapping can be determined by device drivers 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 using the following algorithm:

If a pointer must be passed to an external bus master, make a call to 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$Trans` returns no error, the driver should verify the size returned for the translated block is the same as the size requested. If so, the address can be passed to the other master. If not, the driver can adopt one of two strategies:
  - Refuse to deal with split blocks, and return an error to the file manager.
  - Break up the transfer request into multiple calls to the other master, using multiple calls to `F$Trans` until the original block has been fully translated.

The first method (refuse split blocks) is the usual method adopted by drivers, as the current version of the kernel does 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 2: Random Block File Manager (RBF)

This chapter explains how to use the RBF manager to process I/O service requests to random access devices and the parameters driving it. It includes the following topics:

RadiSys.
MICROWARE SOFTWARE

RBF General Description

The Random Block File Manager (RBF) is a re-entrant subroutine package for I/O service requests to random-access devices. RBF can handle any number or type of such devices simultaneously (for example, large hard disk systems, small floppy systems, and RAM disk systems) and is responsible for maintaining the logical file structure.

Because RBF is designed to support a wide range of devices with different performance and storage capacities, it is highly parameter-driven.

Some of the physical parameters RBF uses are stored on the media itself. On disk systems, this information is written on the first few sectors of track number zero. The device drivers also use this information, particularly the media format parameters stored on sector 0. These parameters are written by the format program when it initializes and tests the media. Storage systems that initialize themselves without using format are responsible for establishing the initial file structure of the media themselves (for example, RAM disk systems).

RBF handles the following I/O service requests:

Table 2-1 RBF I/O Service Requests

I$ChgDir	I$Close	I$Create	I$Delete	I$GetStt
I$MakDir	I$Open	I$Read	I$ReadLn	I$Seek
I$SetStt	I$Write	I$Writln		

The following I/O service requests do not call RBF:

Table 2-2 Non-RBF I/O Service Requests

I$Attach	I$Detach	I$Dup

RBF I/O Service Requests

When a process makes one of the following system calls to an RBF device, RBF executes the file manager functions described for that call.

I$ChgDir

RBF performs the following functions:

- Sets the directory bit in the access mode.
- Calls RBF's `Open` routine to search the specified pathlist.
- If accessible, updates the appropriate default `P$DIO` pointer in the process descriptor.
- Closes the path opened by the `Open` routine.

I$Close

RBF performs the following functions:

- Flushes any data not yet written to the disk (any partial block of data left from a previous write call).
- Checks the use count in the path descriptor. If the use count is non-zero, no further action is taken. Otherwise, RBF:
  - Updates the file descriptor, if necessary.
  - Trims the file size, if necessary.
  - Calls the device driver with the `SS_Close SetStat` (ignores any returned errors).

I$Create

RBF performs the following functions:

- Initializes the path descriptor to the default option values.
- Searches directories specified or implied by the pathlist.

  - If the user does not have permission to access a directory element, an error is returned.
  - If the file is found, RBF returns an error.
- Creates a directory entry for the new file. If there is no free space in the directory, it is expanded to make room for the new entry.
- Creates and initializes a file descriptor for the file. If an initial size allocation has been specified, RBF attempts to allocate the specified amount of disk space for the file. If not specified, the first `I$Write` expands the file.
- Calls the device driver with an `SS_Open SetStat`. RBF ignores `E$UnkSvc` errors, but aborts `I$Create` on any other error.

I$Delete

RBF performs the following functions:

- Initializes the path descriptor to the default option values.
- Searches any directories specified or implied by the pathlist. If the user does not have permission to access a directory element, an error is returned.
- Checks the permission attributes of the file. The file's directory bit (`dirbit`) must be turned off using the `SS_Attr SetStat` call before `I$Delete` is called. To delete the file, you must have permission to write to the file and there cannot be other open paths to the file. An error is returned if these conditions are not met.
- Decrements link count in file descriptor. If the link count becomes zero, all disk space associated with the file is returned. This includes the file's file descriptor block. If the link count is non-zero, no disk space is returned.
- Removes directory entry for the file.

I$GetStt

Refer to the I$GetStt description in the ***OS-9 for 68K Technical Manual*** for a detailed explanation of the RBF supported I$GetStt functions:

Table 2-3 I$GetStt Functions

Function	Description
SS_EOF	Check for end-of-file condition.
SS_FD	Get a copy of the file descriptor.
SS_FDInf	Get a copy of a specified file descriptor.
SS_Opt	Read path descriptor options.
SS_Pos	Determine file position.
SS_Ready	Test for data ready.
SS_Size	Determine file's size.

All other GetStat calls are passed to the driver.

I$MakDir

RBF performs a Create operation with the directory bit set for the file access mode. If the Create succeeds, RBF creates directory entries for "." and ". ." in the new directory file and then closes the path opened by Create.

I$Open

RBF performs the following functions:

- Initializes the path descriptor with the default option values.
- Searches any directories specified or implied by the pathlist. If the user does not have permission to access a directory element, an error is returned.
- Checks the permission attributes of the file. If the user does not have permission to open the file in the access mode requested, an error is returned.
- Updates the last modified date in the file descriptor, if open for writing.
- Calls the device driver with the `SS_Open SetStat`. RBF ignores `E$UnkSvc` errors, but aborts the `I$Open` on any other error.

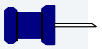
I$Read

RBF performs the following functions:

- Attempts to acquire a record lock of the section of the file. If the record is in use, RBF waits for the time specified by the `SS_Ticks SetStat` call. This value defaults to zero, resulting in an indefinite sleep until the record becomes available.
- Determines if there is data left to read in the file. If there is none, an end-of-file error (`E$EOF`) is returned.
- Calls the driver to read the data, as needed by RBF. Complete blocks of data are transferred directly into the process's buffer. Partial blocks are read into a buffer maintained by RBF after which the portion of data requested from those blocks are copied into the calling process's buffer.
  - If the requested data was found in a buffer from a previous read, RBF copies the data to the calling process's buffer without calling the driver.
  - If the file is open only for reading, the record lock on the requested section is released immediately.
  - If the file is open for update, the record remains locked.
  - A read of 0 bytes, a read of a different section, or an `I$Write` releases the current section's record lock.

I$ReadLn

`I$ReadLn` is similar to `I$Read`, except RBF maintains a buffer to read data into using single sector reads. It searches the data until it locates the first end-of-record character (carriage return), or reads the number of bytes requested, whichever comes first. It copies the read buffer into the process's buffer as necessary.



Note

The portion of the file that is record locked begins at the file position from where the `I$ReadLn` call was made and continues through the number of bytes requested, regardless of whether the EOR is found earlier.

If the file is open only for reading, the record lock on the requested section is released immediately. If the file is open for update, the record remains locked. A read of 0 bytes, a read of a different section, or an `I$Write` releases the current section's record lock.

I$Seek

RBF sets the current position in the path descriptor to the specified position. If RBF's internal buffer has a sector containing modified data, and the new position is not in that sector, the driver is called to write that sector before the current position in the path descriptor is updated.

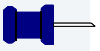
I$SetStt

Refer to the `I$SetStt` description in the ***OS-9 for 68K Technical Manual*** for a detailed explanation of the RBF supported `I$SetStt` functions:

Table 2-4 I$SetStt Functions

Function	Description
SS_Attr	Set file's permission attributes.
SS_FD	Write some file descriptor information.
SS_Lock	Record lock a portion of the file.
SS_Opt	Write the path descriptor options.
SS_RsBit	Reserve bitmap sector.
SS_Size	Set the file's size.
SS_Ticks	Set the record locking time-out value.

All other SetStat calls are passed to the driver.



Note

SS_Opt is passed to the driver after processing by RBF. If an unknown service request error (E$UnkSvc) is returned by the driver, it is ignored.

I$Write

RBF performs the following functions:

- Attempts to acquire a record lock of the section of the file. If the record is in use, RBF waits for the time specified by the SS_Ticks SetStat call. This value defaults to 0 which results in an indefinite sleep until the record becomes available.

- Expands the file, if necessary.
- Calls the driver to write the data, as needed. Complete blocks of data are transferred directly from the process's buffer. Partial blocks are copied into a buffer maintained by RBF. This data is written after a subsequent write fills the buffer, or a seek, read, or write is done to another portion of the file, or when the file is closed.

  Although the data is written in the cases described above, the file descriptor is only guaranteed to be written when the file is closed, or when the file descriptor is written using the GetStat `SS_FD/SetStat SS_FD` sequence. Writing the file descriptor will also result in the writing of the current data sector.

Any active record lock is released once the section has been written. A write of zero bytes also releases the record lock.

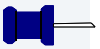
I$WritIn

`I$Writln` is similar to `I$Write`, except RBF searches the calling process's data buffer for an end-of-record character (carriage return). If one is found, only the data up to that end-of-record character is written. If no end-of-record character is found, RBF writes the number of bytes specified by the caller.

Any active record lock is released once the section has been written. A write of 0 bytes also releases the record lock.

RBF Device Descriptor Modules

This section describes the definitions of the initialization table contained in device descriptor modules for RBF devices. The table immediately follows the standard device descriptor module header fields. The size of the table is defined in the `M$Opt` field.



Note

In this table the offset values are the device descriptor offsets, while the labels are the path descriptor offsets. To correctly access these offsets in a device descriptor using the path descriptor labels, you must make the following adjustment: (`M$DTyp - PD_OPT`)

For example, to access the drive number in a device descriptor, use `PD_DRV` + (`M$DTyp - PD_OPT`). To access the drive number in the path descriptor, use `PD_DRV`. Module offsets are resolved in assembly code by using the names shown here and linking with the relocatable library: `sys.l` or `usr.l`.

Table 2-5 Device Descriptor Offset and Path Descriptor Label

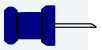
Device Descriptor Offset	Path Descriptor Label	Description
`$48`	`PD_DTP`	Device Class
`$49`	`PD_DRV`	Drive Number
`$4A`	`PD_STP`	Step Rate

Table 2-5 Device Descriptor Offset and Path Descriptor Label (continued)

Device Descriptor Offset	Path Descriptor Label	Description
$4B	PD_TYP	Device Type
$4C	PD_DNS	Density
$4D		Reserved
$4E	PD_CYL	Number of Cylinders
$50	PD_SID	Number of Heads/Sides
$51	PD_VFY	Disk Write Verification
$52	PD_SCT	Default Sectors/Track
$54	PD_T0S	Default Sectors/Track 0
$56	PD_SAS	Segment Allocation Size
$58	PD_ILV	Sector Interleave Factor
$59	PD_TFM	DMA Transfer Mode
$5A	PD_TOffs	Track Base Offset
$5B	PD_SOffs	Sector Base Offset
$5C	PD_SSize	Sector Size (in bytes)
$5E	PD_Cntl	Control Word
$60	PD_Trys	Number of Tries

Table 2-5 Device Descriptor Offset and Path Descriptor Label (continued)

Device Descriptor Offset	Path Descriptor Label	Description
$61	PD_LUN	SCSI Unit Number of Drive
$62	PD_WPC	Cylinder to Begin Write Precompensation
$64	PD_RWR	Cylinder to Begin Reduced Write Current
$66	PD_Park	Cylinder to Park Disk Head
$68	PD_LSNOffs	Logical Sector Offset
$6C	PD_TotCyls	Number of Cylinders On Device
$6E	PD_CtrlrID	SCSI Controller ID
$6F	PD_Rate	Data transfer/Disk Rotation Rates
$70	PD_ScsiOpt	SCSI Driver Options Flags
$74	PD_MaxCnt	Maximum Transfer Count



Note

In the following table, parameters marked with an asterisk (*) are format specific.

Table 2-6 Path Descriptor Labels and Descriptions

Name	Description
PD_DTP	***Device Type*** This field is set to one for RBF devices.
PD_DRV	***Drive number*** This field is used to associate a one-byte logical integer with each drive a driver/controller handles. Each controller's drives should be numbered 0 to n-1 (n is the maximum number of drives the controller can handle and is set into V_NDRV by the driver's INIT routine). This number defines which drive table the driver and RBF access for this device. RBF uses this number to set up the drive table pointer (PD_DTB). Prior to initializing PD_DTB, RBF verifies PD_DRV is valid for the driver by checking for a value less than V_NDRV in the driver's static storage. If not, RBF aborts the path open and returns an error. On simple hardware, this logical drive number is often the same as the physical drive number.

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_STP	***Step rate*** This field contains a code that sets the drive's head-stepping rate. To reduce access time, the step rate should be set to the fastest value of which the drive is capable. For floppy disks, the following codes are commonly used: ***Step Code*** ***5" Disks*** ***8" Disks*** 0 30ms 15ms 1 20ms 10ms 2 12ms 6ms 3 6ms 3ms For hard disks, the value in this field is usually driver dependent.

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_TYP	***Disk Type*** Defines the physical type of the disk, and indicates the revision level of the descriptor. If bit 7 = 0, floppy disk parameters are described in bits 0-6: bit 0: 0 = 5 1/4" floppy disk (pre-Version 2.4 of OS-9 for 68K) 1 = 8" floppy disk (pre-Version 2.4 of OS-9 for 68K) bits 1-3: 0 = (pre-Version 2.4 of OS-9 for 68K descriptor) Bit 0 describes type/rates. 1 = 8" physical size 2 = 5 1/4" physical size 3 = 3 1/2" physical size 4-7: Reserved bit 4: Reserved bit 5: 0 = Track 0, side 0, single density 1 = Track 0, side 0, double density bit 6: Reserved If bit 7 = 1, hard disk parameters are described in bits 0-6: bits 0-5: Reserved bit 6: 0 = Fixed hard disk 1 = Removable hard disk

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_DNS	***Disk Density **** Indicates the hardware density capabilities of a floppy disk drive: bit 0: 0 = Single bit density (FM) 1 = Double bit density (MFM) bit 1: 1 = Double track density 96 TPI/135 TPI) bit 2: 1 = Quad track density (192 TPI) bit 3: 1 = Octal track density (384 TPI)
PD_CYL	***Number of cylinders (tracks) **** Indicates the logical number of cylinders per disk. format uses this value, PD_SID, and PD_SCT to determine the size of the drive. PD_CYL is often the same as the physical cylinder count (PD_TotCyls), but can be smaller if using partitioned drives (PD_LSNOffs) or track offsetting (PD_TOffs). If the drive is an autosize drive (PD_Cntl), format ignores this field.
PD_SID	***Heads or Sides **** This field indicates the number of heads for a hard disk (Heads) or the number of surfaces for a floppy disk (Sides). If the drive is an autosize drive (PD_Cntl), format ignores this field.

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_VFY	***Verify Flag*** This field indicates whether or not to verify write operations. 0 = verify disk write 1 = no verification **NOTE:** Write verify operations are generally performed on floppy disks. They are not usually performed on hard disks because of the lower soft error rate of hard disks.
PD_SCT	***Default sectors/track**** This field indicates the number of sectors per track. If the drive is an autosize drive (PD_Cntl), format ignores this field.
PD_T0S	***Default Sectors/Track (Track 0) **** This field indicates the number of sectors per track for track 0. This may be different than PD_SCT (depending on specific disk format). If the drive is an autosize drive (PD_Cntl), format ignores this field.
PD_SAS	***Segment allocation size*** Indicates the default minimum number of sectors allocated when a file is expanded. Typically, this is set to the number of sectors on the media track (for example, 8 for floppy disks, 32 for hard disks), but can be adjusted to suit the requirements of the system.

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_ILV	***Sector interleave factor **** Indicates the sequential arrangement of sectors on a disk (for example, 1, 2, 3... or 1, 3, 5...). For example, if the interleave factor is 2, the sectors are arranged by 2's (1, 3, 5...) starting at the base sector (see PD_SOffs). **NOTE:** Optimized interleaving can drastically improve I/O throughput. **NOTE:** PD_ILV is typically only used when the media is formatted, as format uses this field to determine the default interleave. However, when the media format occurs (I$SetStat, SS_WTrk call), the desired interleave is passed in the parameters of the call.
PD_TFM	***DMA (Direct Memory Access) transfer mode*** Indicates the mode of transfer for DMA access, if the driver is capable of handling different DMA modes. Use of this field is driver dependent.
PD_TOffs	***Track base offset **** This field is the offset to the first accessible physical track number. Track 0 is not always used as the base track because it is often a different density.
PD_SOffs	***Sector base offset **** This field is the offset to the first accessible physical sector number on a track. Sector 0 is not always the base sector.

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_SSize	***Sector Size*** Indicates the physical sector size in bytes. The default sector size is 256. Depending upon whether the driver supports non-256 byte logical sector sizes (a variable sector size driver), the field is used as follows: ***Variable Sector Size Driver*** If the driver supports variable logical sector sizes, RBF inspects this value during a path open (specifically, after the driver returns "no error" on the SS_VarSect GetStat call) and uses this value as the logical sector size of the media. This value is then copied into PD_SctSiz of the path descriptor options section, so applications programs can know the logical sector size of the media, if required. RBF supports logical sector sizes from 256 bytes to 32,768 bytes, in integral binary multiples (256, 512, 1024, etc.). During the SS_VarSect call, the driver can validate or update this field (or the media itself) according to the driver's conventions. These typically are: 1. If the driver can dynamically determine the media's sector size, and PD_SSize is passed in as 0, the driver updates this field according to the current media setting. 2. If the driver can dynamically set the media's sector size, and PD_SSize is passed in as a non-zero value, the driver sets the media to the value in PD_SSize (this is typical when re-formatting the media). 3. If the driver cannot dynamically determine or set the media sector size, it usually validates PD_SSize against the supported sector sizes, and returns an error (E$SectSiz) if PD_SSize contains an invalid value. **Non-Variable Sector Size Driver** If the driver does not support variable logical sector sizes (logical sector size is fixed at 256 bytes), RBF ignores PD_SSize. In this case, PD_SSize can be used to support deblocking drivers that support various physical sector sizes. **NOTE:** A non-variable sector sized driver is defined as a driver which returns the E$UnkSvc error for GetStat (SS_VarSect).

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_Cntl	***Device Control Word*** Indicates options reflecting the capabilities of the device. These options may be set by the user, as follows: bit 0: 0 = Format enable 1 = Format inhibit bit 1: 0 = Single-Sector I/O 1 = Multi-Sector I/O capable bit 2: 0 = Device has non-stable ID 1 = Device has stable ID bit 3: 0 = Device size determined from descriptor values 1 = Device size obtained by SS_DSize GetStat call bit 4: 0 = Device cannot format a single track 1 = Device can format a single track bit 5: 0 = Media is writable by RBF 1 = Media is write protected by RBF bit 6-15: Reserved

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_Trys	***Number of Tries*** Indicates whether a driver should try to access the disk again before returning an error. Depending upon the driver in use, this field may be implemented as a flag or a retry counter: **Value** / **Flag** / **Counter** 0 / retry ON / default number of retries 1 / retry OFF / no retries other / retry ON / specified number of retries Drivers working with controllers having error correcting functions (for example, E.C.C. on hard disks) should treat this field as a flag so they can set the controller's error correction/retry functions accordingly. When formatting media, especially hard disks, the format-enabled descriptor should set this field to one (retry OFF) to ensure marginal media sections are marked out of the media free space.
PD_LUN	***Logical Unit Number of SCSI Drive*** Used in the SCSI command block to identify the logical unit on the SCSI controller. To eliminate allocation of unused drive tables in the driver static storage, this number may be different from PD_DRV. PD_DRV indicates the logical number of the drive to the driver, that is, the drive table to use. PD_LUN is the physical drive number on the controller.

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_WPC	***First Cylinder to Use Write Precompensation*** Indicates the cylinder to begin write precompensation.
PD_RWR	***First Cylinder to Use Reduced Write Current*** Indicates the cylinder to begin reduced write current.
PD_Park	***Cylinder Used to Park Head*** Indicates the cylinder at which to park the hard disk's head when the drive is shut down. Parking is usually done on hard disks when they are shipped or moved and is implemented by the SS_SQD SetStat to the driver.
PD_LSNOffs	***Logical Sector Offset*** The offset to use when accessing a partitioned drive. The driver adds this value to the logical block address passed by RBF prior to determining the physical block address on the media. Typically, using PD_LSNOffs is mutually exclusive to using PD_TOffs.
PD_TotCyls	***Total Cylinders on Device*** Indicates the actual number of physical cylinders on a drive. It is used by the driver to correctly initialize the controller/drive. PD_TotCyls is typically used for physical initialization of a drive that is partitioned or has PD_TOffs set to a non-zero value. In this case, PD_CYL denotes the *logical* number of cylinders of the drive. If PD_TotCyls is zero, the driver should determine the physical cylinder count by using the sum of PD_CYL and PD_TOffs.

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_CtrlrID	***SCSI Controller ID*** The ID number of the SCSI controller attached to the drive. The driver uses this number to communicate with the controller.
PD_ScsiOpt	***SCSI Driver Options Flags*** Indicate the SCSI device options and operation modes. It is the driver's responsibility to use or reject these values, as applicable. bit 0: 0 = ATN not asserted (no disconnect allowed) 1 = ATN asserted (disconnect allowed) bit 1: 0 = Device cannot operate as a target 1 = Device can operate as a target bit 2: 0 = Asynchronous data transfer 1 = Synchronous data transfer bit 3: 0 = Parity off 1 = Parity on All other bits are reserved.

Table 2-6 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_Rate	***Data Transfer/Rotational Rate*** Contains the data transfer rate and rotational speed of the floppy media. Note this field is normally used only when the physical size field (PD_TYP, bits 1-3) is non-zero. bits 0-3: Rotational speed 0 = 300 RPM 1 = 360 RPM 2 = 600 RPM All other values are reserved. bits 4-7: Data transfer rate 0 = 125K bits/sec 1 = 250K bits/sec 2 = 300K bits/sec 3 = 500K bits/sec 4 = 1M bits/sec 5 = 2M bits/sec 6 = 5M bits/sec All other values are reserved.
PD_MaxCnt	***Maximum Transfer Count*** Contains the maximum byte count the driver can transfer in one call. If this field is 0, RBF defaults to the value of $ffff (65,535).

RBF Path Descriptor Definitions

The first 26 fields of the path options section (PD_OPT) of the RBF path descriptor are copied directly from the device descriptor standard initialization table. All of the values in this table may be examined using I$GetStt by applications using the SS_Opt code. Some of the values may be changed using I$SetStt; some are protected by the file manager to prevent inappropriate changes.

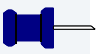
Refer to the previous section on RBF device descriptors for descriptions of the first 26 fields. The last five fields contain information provided by RBF

Table 2-7 RBF Path Descriptors and Descriptions

Name	Description
PD_ATT	***File Attributes*** The file's attributes are defined as follows: bit 0: Set if owner read. bit 1: Set if owner write. bit 2: Set if owner execute. bit 3: Set if public read. bit 4: Set if public write. bit 5: Set if public execute. bit 6: Set if only one user at a time can open the file. bit 7: Set if directory file.
PD_FD	***File Descriptor*** The LSN (Logical Sector Number) of the file's file descriptor is written here.

Table 2-7 RBF Path Descriptors and Descriptions (continued)

Name	Description
PD_DFD	***Directory File Descriptor*** The LSN of the file's directory's file descriptor is written here.
PD_DCP	***File's Directory Entry Pointer*** The current position of the file's entry in its directory.
PD_DVT	***Device Table Pointer (copy)*** The address of the device table entry associated with the path.
PD_SctSiz	***Logical Sector Size*** The logical sector size of the device associated with the path. If this is 0, assume a size of 256 bytes.
PD_NAME	***File Name***



Note

In the following chart, the *offset* refers to the location of a path descriptor field relative to the starting address of the path descriptor. Path descriptor offsets are resolved in assembly code by using the names shown here and linking with the relocatable library: `sys.l` or `usr.l`.

Table 2-8 Path Descriptor Offsets, Names, and Descriptions

Offset	Name	Description
$80	PD_DTP	Device Class
$81	PD_DRV	Drive Number
$82	PD_STP	Step Rate
$83	PD_TYP	Device Type
$84	PD_DNS	Density
$85		Reserved
$86	PD_CYL	Number of Cylinders
$88	PD_SID	Number of Heads/Sides
$89	PD_VFY	Disk Write Verification
$8A	PD_SCT	Default Sectors/Track
$8C	PD_TOS	Default Sectors/Track 0
$8E	PD_SAS	Segment Allocation Size
$90	PD_ILV	Sector Interleave Factor
$91	PD_TFM	DMA Transfer Mode
$92	PD_TOffs	Track Base Offset
$93	PD_SOffs	Sector Base Offset

Table 2-8 Path Descriptor Offsets, Names, and Descriptions (continued)

Offset	Name	Description
$94	PD_SSize	Sector Size (in bytes)
$96	PD_Cntl	Control Word
$98	PD_Trys	Number of Tries
$99	PD_LUN	SCSI Unit Number of Drive
$9A	PD_WPC	Cylinder to Begin Write Precompensation
$9C	PD_RWR	Cylinder to Begin Reduced Write Current
$9E	PD_Park	Cylinder to Park Disk Head
$A0	PD_LSNOffs	Logical Sector Offset
$A4	PD_TotCyls	Number of Cylinders On Device
$A6	PD_CtrlrID	SCSI Controller ID
$A7	PD_Rate	Data Transfer/Rotational Rates
$A8	PD_ScsiOpt	SCSI Driver Option Flag
$AC	PD_MaxCnt	Maximum Transfer Count
$B0		Reserved
$B5	PD_ATT	File Attributes
$B6	PD_FD	File Descriptor

Table 2-8 Path Descriptor Offsets, Names, and Descriptions (continued)

Offset	Name	Description
$BA	PD_DFD	Directory File Descriptor
$BE	PD_DCP	File's Directory Entry Pointer
$C2	PD_DVT	Device Table Pointer (copy)
$C6		Reserved
$C8	PD_SctSiz	Logical Sector Size
$CC		Reserved
$E0	PD_NAME	File Name

Floppy Disk Formats

Floppy disk controllers and drives can support a multitude of disk formats. When writing disk drivers, it is important to ensure all of the disk formats you may want to support are easily implemented via changes to the device descriptor parameters. This allows one driver to control multiple *devices* with one device descriptor per format.

There are two aspects of disk formats that must be considered:

- **Physical Format**
- **Logical Format**

Physical Format

The physical format refers to the actual encoding of track and sector information on the media. It describes certain physical characteristics of the media. It is independent of the operating system, and is typically defined by the hardware (the disk controller and disk drive(s)).

In general, the following device descriptor fields describe the media physical format:

Table 2-9 Fields Describing Media Physical Formats

Field	Description
PD_DNS	Disk density
PD_SID	Number of sides
PD_SCT	Sectors per track
PD_T0S	Sectors per track, track 0, side 0.

Table 2-9 Fields Describing Media Physical Formats (continued)

Field	Description
PD_ILV	Sector interleave
PD_Rate	Data transfer rate and disk rotational speed

In addition, the following fields describe the physical format and, depending upon the driver, may also affect the media format (for example, whether or not the media is OS-9 Universal Format):

Table 2-10 Fields Describing Media Formats and Physical Formats

Field	Description
PD_SSize	Sector size
PD_SOffs	Sector base offset
PD_TOffs	Track Base Offset
PD_CYL	Number of cylinders
PD_TotCyl	Total number of cylinders on drive

For More Information

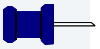
See **Universal Format** in this chapter for more information about the universal format.

Logical Format

The logical format refers to the file system the operating system expects to find on the media. For RBF, this structure consists of sector 0, the media bitmap, and directory/file information.

For More Information

Refer to the ***OS-9 for 68K Technical Manual***, ***Appendix B: Path Descriptors and Device Descriptors***, for further information on the RBF disk structure.



Note

A disk logical format can exist on a number of physical formats. The device driver (using the device descriptor parameters) isolates the physical layout of the media from the logical structure expected by the File Manager (RBF). Generally, the impact of the physical format only affects the media's total capacity. For example, single-sided media versus double-sided media.

Supported Media Formats

The supported media formats are described by the device descriptor parameters. An RBF device descriptor is usually created with the following:

- A macro (for example, `DiskD0`) in the `systype.d` file
- An assembler source file (for example, `d0.a`)
- The generic descriptor making file for RBF devices (`rbfdesc.a`)

While you can use the disk macro to describe all characteristics of the media format, there are a number of standard media format codes you can use to set the basic parameters for these formats. The `RBFDesc` macro (refer to the `rbfdesc.a` source file) parameter number 6 is used to set these standard parameters.

The following tables describe the standard formats supported by `rbfdesc.a`.

Table 2-11 Macro `ramdisk`--Volatile RAM disk

Label	Value	Comment
DiskKind	0	
Cylnders	0	
BitDns	Single	
TrkDns	Single	
SectTrk0	0	
Heads	0	
StepRate	0	
Intrleav	0	
NoVerify	ON	
SegAlloc	4	
Trys	0	
DevCon	0	Not used by ram-disk driver

Table 2-11 Macro `ramdisk`--Volatile RAM disk

Label	Value	Comment
`Control`	`MultEnabl`	Format enabled, m/s capable
`MaxCount`	`$ffffffff`	

Table 2-12 Macro `nvramdisk` -- Non-volatile RAM disk

Label	Value	Comment
`DiskKind`	`0`	
`Cylnders`	`0`	
`BitDns`	`Single`	
`TrkDns`	`Single`	
`SectTrk0`	`0`	
`Heads`	`0`	
`StepRate`	`0`	
`Intrleav`	`0`	
`NoVerify`	`ON`	
`SegAlloc`	`4`	
`Trys`	`0`	

Table 2-12 Macro `nvramdisk` -- Non-volatile RAM disk

Label	Value	Comment
DevCon	0	Not used by RAM disk driver
Control	FmtDsabl+MultEnabl	nvramdisks are format disabled, m/s capable
MaxCount	$ffffffff	

Table 2-13 Macro `dd380` -- 3 1/2", 80 track drive

Label	Value	Comment
DiskKind	Size3	
Cylnders	80	
BitDns	Double	
Rates	xfr250K+rpm300	
TrkDns	Double	135 tpi
SectTrk	16	
SectTrk0	10	
TotalCyls	Cylnders	Number of actual cylinders on disk

Table 2-14 Macro `uv380` -- universal 3 1/2" 80 track

Label	Value	Comment
`DiskKind`	`Size3`	
`Cylnders`	`80`	Number of (physical) tracks
`BitDns`	`Double`	MFM recording
`Rates`	`xfr250K+rpm300`	
`DnsTrk0`	`Double`	MFM track 0
`TrkDns`	`Double`	135 tpi
`SectTrk`	`16`	Sectors/track (except track 0, side 0)
`SectTrk0`	`16`	Sectors/track, track 0, side 0
`SectOffs`	`1`	Physical sector start = 1
`TrkOffs`	`1`	Track 0 not used
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-15 Macro `ed380` -- 3 1/2" 80 track EXTRA density (4M unformatted)

Label	Value	Comment
`DiskKind`	`Size3`	
`Cylnders`	`80`	Number of (physical) cylinders
`BitDns`	`Double`	MFM recording
`Rates`	`xfr1M+rpm300`	
`DnsTrk0`	`Double`	MFM track 0
`TrkDns`	`Double`	135 tpi
`SectTrk`	`61`	Sectors/track (except track 0, side 0)
`SectTrk0`	`61`	Sectors/track, track 0, side 0
`SectOffs`	`1`	Physical sector start = 1
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-16 Macro `hd380` -- 3 1/2" 80 track (2M unformatted, 1.4M formatted)

Label	Value	Comment
`DiskKind`	`Eight+Size3`	(Eight for compatibility)
`Cylnders`	`80`	Number of (physical) tracks
`BitDns`	`Double`	MFM recording
`Rates`	`xfr500K+rpm300`	
`TrkDns`	`Double`	96 tpi
`SectSize`	`512`	Physical sector size
`SectTrk`	`18`	Sectors/track (except track0, side 0)
`SectTrk0`	`18`	Sectors/track, track 0, side 0
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-17 Macro `d540` -- 5 1/4", 40 track drive, single density

Label	Value	Comment
`DiskKind`	`Size5`	
`Cylnders`	`40`	

Table 2-17 Macro `d540` -- 5 1/4", 40 track drive, single density (continued)

Label	Value	Comment
BitDns	Single	FM encoding
Rates	xfr125K+rpm300	
TrkDns	Single 48 tpi	
SectTrk	10	
SectTrk0	10	
TotalCyls	Cylnders	Number of actual cylinders on disk

Table 2-18 Macro `dd540` -- 5 1/4", 40 track, double density drive

Label	Value	Comment
DiskKind	Size5	
Cylnders	40	
BitDns	Double	MFM encoding
Rates	xfr250K+rpm300	
TrkDns	Single	48 tpi
SectTrk	16	

Table 2-18 Macro `dd540` -- 5 1/4", 40 track, double density drive (continued)

Label	Value	Comment
`SectTrk0`	`10`	
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-19 Macro `d580` -- 5 1/4", 80 track, single density drive

Label	Value	Comment
`DiskKind`	`Size5`	
`Cylnders`	`80`	
`BitDns`	`Single`	FM encoding
`Rates`	`xfr125K+rpm300`	
`TrkDns`	`Double`	96 tpi
`SectTrk`	`10`	
`SectTrk0`	`10`	
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-20 Macro `dd580` -- 5 1/4", 80 track drive, double density

Label	Value	Comment
`DiskKind`	`Size5`	
`Cylnders`	`80`	
`BitDns`	`Double`	MFM encoding
`Rates`	`xfr250K+rpm300`	
`TrkDns`	`Double`	96 tpi
`SectTrk`	`16`	
`SectTrk0`	`10`	
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-21 Macro `uv580` -- universal 5 1/4" 80 track

Label	Value	Comment
`DiskKind`	`Size5`	Five inch disk
`Cylnders`	`80`	Number of (physical) tracks
`BitDns`	`Double`	MFM recording
`Rates`	`xfr250K+rpm300`	

Table 2-21 Macro `uv580` -- universal 5 1/4" 80 track (continued)

Label	Value	Comment
`DnsTrk0`	`Double`	MFM track 0
`TrkDns`	`Double`	96 tpi
`SectTrk`	`16`	Sectors/track (except track 0, side 0)
`SectTrk0`	`16`	Sectors/track, track 0, side 0
`SectOffs`	`1`	Physical sector start = 1
`TrkOffs`	`1`	Track 0 not used
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-22 Macro `hd580` -- 5 1/4" 80 track '8" image

Label	Value	Comment
`DiskKind`	`Eight+Size5`	(Eight for compatibility)
`Cylnders`	`80`	Number of (physical) tracks
`BitDns`	`Double`	MFM recording
`Rates`	`xfr500K+rpm360`	
`TrkDns`	`Double`	96 tpi

Table 2-22 Macro `hd580` -- 5 1/4" 80 track '8" image (continued)

Label	Value	Comment
`SectTrk`	`28`	Sectors/track (except track0, side 0)
`SectTrk0`	`16`	Sectors/track, track 0, side 0
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-23 Macro `hd577` -- 5 1/4" 77 track '8" image'

Label	Value	Comments
`DiskKind`	`Eight+Size5`	(Eight for compatibility)
`Cylnders`	`77`	Number of (physical) tracks
`BitDns`	`Double`	MFM recording
`Rates`	`xfr500K+rpm360`	
`TrkDns`	`Double`	96 tpi
`SectTrk`	`28`	Sectors/track (except track0, side 0)
`SectTrk0`	`16`	Sectors/track, track 0, side 0
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-24 Macro `uv577` -- universal 5 1/4" 77 track '8" image'

Label	Value	Comment
`DiskKind`	`Eight+Size5`	(Eight for compatibility)
`Cylnders`	`77`	Number of (physical) tracks
`BitDns`	`Double`	MFM recording
`Rates`	`xfr500K+rpm360`	
`DnsTrk0`	`Double`	MFM track 0
`TrkDns`	`Double`	96 tpi
`SectTrk`	`28`	Sectors/track (except track0, side 0)
`SectTrk0`	`28`	Sectors/track, track 0, side 0
`SectOffs`	`1`	Physical sector start = 1
`TrkOffs`	`1`	Track 0 not used
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-25 Macro `d877` -- 8", 77 track drive, single density

Label	Value	Comment
`DiskKind`	`Eight+Size8`	(Eight for compatibility)
`Cylnders`	`77`	
`BitDns`	`Single`	FM encoding
`Rates`	`xfr250K+rpm360`	
`TrkDns`	`Single`	48 tpi
`SectTrk`	`16`	
`SectTrk0`	`16`	
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-26 Macro `dd877` -- 8", 77 track, double density

Label	Value	Comment
`DiskKind`	`Eight+Size8`	(Eight for compatibility)
`Cylnders`	`77`	
`BitDns`	`Double`	MFM encoding
`Rates`	`xfr500K+rpm360`	

Table 2-26 Macro `dd877` -- 8", 77 track, double density (continued)

Label	Value	Comment
`TrkDns`	`Single`	48 tpi
`SectTrk`	`28`	
`SectTrk0`	`16`	
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-27 Macro `uv877` -- universal 8" 77 track

Label	Value	Comment
`DiskKind`	`Eight+Size8`	(Eight for compatibility)
`Cylnders`	`77`	Number of (physical) tracks
`BitDns`	`Double`	MFM recording
`Rates`	`xfr500K+rpm360`	
`DnsTrk0`	`Double`	MFM track 0
`TrkDns`	`Single`	48 tpi
`SectTrk`	`28`	Sectors/track (except track0, side 0)
`SectTrk0`	`28`	Sectors/track, track 0, side 0
`SectOffs`	`1`	Physical sector start = 1

Table 2-27 Macro `uv877` -- universal 8" 77 track (continued)

Label	Value	Comment
`TrkOffs`	`1`	Track 0 not used
`TotalCyls`	`Cylnders`	Number of actual cylinders on disk

Table 2-28 Autosizes and Autosize Devices

autosize	`autosize` device (`SS_DSize` tells capacity)
`SectTrk`	0 sectors/track (except track 0, side 0)
`SectTrk0`	0 sectors/track, track 0, side 0
`Cylnders`	0 total cylinders
`Heads`	0 total heads

Universal Format

The definitions above provide for a variety of floppy disk formats (for example, extra-high density for backups, other operating system support). However, you should not ignore the issue of system media interchange. It is possible, for example, that high-density on one system *may not* be physically compatible with another system's high-density format.

The universal format definitions given above for 5 1/4" (uv580) and 3 1/2" (uv380) describe Microware's standard shipping format for floppy-based media. Thus, to ensure the greatest possibility for media interchange

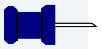
between software suppliers and/or different OEM systems, ensure your device driver supports the universal format if at all possible. A universal format disk has the following characteristics:

Table 2-29 Universal Format Characteristics

Characteristic	Value	Field
Disk Physical Size	5 1/4" or 3 1/2"	(PD_TYP)
Number of Physical Cylinders	80	(PD_TotCyl)
Number of Logical Cylinders	79	(PD_CYL)
Number of Sides	2	(PD_SID)
Track Density (TPI)	96/135	(PD_DNS)
Recording Format	MFM	(PD_DNS)
Sectors Per Track	16	(PD_SCT)
Sector Size (Logical & Physical)	256	(PD_SSize)
Sector Base Offset	1	(PD_SOffs)
First Accessible Track	1	(PD_TOffs)
Disk Rotational Rate (rpm)	300	(PD_Rate)
Data Transfer Rate (Kbits/sec)	250	(PD_Rate)

Summary of Common Physical Formats

The following tables detail some of the physical formats commonly supported by floppy disk controllers and drives. This information should provide you with an overall view of the possible formats you may want to support in your drivers.



Note

Do not confuse the format codes listed in this section with the disk format codes given earlier in the discussion on `rbfdesc.a` formats.

Table 2-30 Format Codes Supported by Floppy Disk Controllers and Drivers

Format Codes	Description
`D`	35/40 track, normal density
`DD`	80 track, normal density
`AT`	PC/AT-style, 80 track, high density
`ED`	80 track, extra high density
`HD`	80 track, high density, 8" image style
`XX`	80 track, normal density, high rotational speed

Physical Disk Format

Table 2-31 Physical Disk Formats Supported by Floppy Disk Controllers and Drivers

Format	Sides	Cylinders	RPM	Data Transfer Rate	TPI	Physical Size	Unformatted Capability
D	2	35/40	300	250K	48/62.5	5/3	500K
DD	2	80	300	250K	96/135	5/3	1M
AT	2	80	300	500K	96/135	5/3	2M
ED	2	80	300	1M	135	3	4M
HD	2	77/80	360	500K	96	5	1.6M
XX	2	80	360	300K	96	5	1M

Logical Disk Format

Table 2-32 Logical Disk Formats Supported by Floppy Disk Controllers and Drivers

	256-byte/sector		512-byte/sector		1024-byte/sector	
Format	Sect/ Trk	Fmt Cap.	Sect/ Trk	Fmt Cap.	Sect/ Trk	Fmt Cap.
D	16	327K	9	368K	5	409K
DD	16	655K	9	737K	5	819K

Table 2-32 Logical Disk Formats Supported by Floppy Disk Controllers and Drivers (continued)

	256-byte/sector		512-byte/sector		1024-byte/sector	
Format	Sect/ Trk	Fmt Cap.	Sect/ Trk	Fmt Cap.	Sect/ Trk	Fmt Cap.
AT	32	1.31M	18	1.47M	10	1.64M
ED	61	2.49M	36	2.95M	20	3.27M
HD	26	1.02M/1.06M	15	1.18M/1.23M	8	1.26M/1.31M
XX	16	655K	9	737K	5	819K

Example Hardware Support

Table 2-33 Example Hardware Support

Format	Drive Model/Mode
D	Any 35/40 track version of DD; DD drive in double-step mode.
DD	Teac 235-JS (1M mode); Teac 235-HF (1M mode); Teac 55GFR (300 rpm normal density).
AT	Teac 235-JS (2M mode); Teac 235-HF (2M mode).
ED	Teac 235-JS (4M mode).

Table 2-33 Example Hardware Support (continued)

Format	Drive Model/Mode
HD	Teac 55GFR (360 rpm high density).
XX	Teac 55GFR (300 rpm normal density, single-speed model).

Example Device Descriptor Fields

Table 2-34 Example Device Descriptor Fields

Size/Format	PD_TYP	PD_DNS	PD_Rate
	7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0	7 - 4 3 - 0
5D	0 0 x 0 0 1 0 0	0 0 0 0 0 0 0 1	0 0
3D	0 0 x 0 0 1 1 0	0 0 0 0 0 0 0 1	0 0
5DD	0 0 x 0 0 1 0 0	0 0 0 0 0 0 1 1	0 0
3DD	0 0 x 0 0 1 1 0	0 0 0 0 0 0 1 1	0 0
5AT	0 0 1 0 0 1 0 0	0 0 0 0 0 0 1 1	2 0
3AT	0 0 1 0 0 1 1 0	0 0 0 0 0 0 1 1	2 0
3ED	0 0 1 0 0 1 1 0	0 0 0 0 0 0 1 1	3 0
5HD	0 0 x 0 0 0 1 1	0 0 0 0 0 0 1 1	2 1

Table 2-34 Example Device Descriptor Fields

Size/Format	PD_TYP	PD_DNS	PD_Rate
	7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0	7 - 4 3 - 0
3XX	0 0 1 0 0 1 1 0	0 0 0 0 0 0 1 1	3 0
8DD	0 0 x 0 0 0 1 1	0 0 0 0 0 0 0 1	2 1

RBF Device Drivers

RBF reads and writes in logical blocks, called sectors. A logical sector can be any integral binary power from 256 to 32768. The file manager takes care of all file system processing and passes the driver a starting logical sector number (LSN), a sector count, and the address of the data buffer for each read or write operation.

The logical sector size of the media is determined by RBF when a path is opened to the device. RBF queries the driver to determine whether the driver can support variable sector sizes or not, using the `SS_VarSect GetStat` call.

If the driver supports variable sector size, RBF assumes the logical and physical sector sizes are the same, with the size specified in `PD_SSize`.

If the driver does not support variable sector sizes, RBF assumes a logical sector size of 256 bytes, and ignores the value in `PD_SSize`. If the media physical sector size is not 256 bytes, it is the driver's responsibility to translate and deblock RBF LSNs into the media's LSNs. For example, if `PD_SSize` is set to 512, and a read request of eight sectors at LSN four is made, the driver should translate the operation into a read of four sectors at LSN two.

Read and write calls to the driver initiate the sector read/write operations and, if required, a prior seek operation.

If the controller cannot be interrupt-driven, it must wait until the media is ready, and then transfer the data by polling. If possible, avoid disk controllers that cannot be interrupt-driven. They cause the driver to dominate the system CPU while disk I/O is in progress.

For interrupt-driven systems, the driver initiates the I/O operation and suspends itself (`F$Sleep` or `F$Event`) until the interrupt arrives. The interrupt service routine then services the interrupt and **wakes up** the driver.

Note

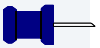
If the driver is awakened by a signal (for example, a keyboard abort) while waiting for the I/O interrupt to occur, it should suspend itself again until the I/O interrupt has occurred. This is because many read/write calls to a driver are made by RBF on behalf of itself, such as in directory searching or bitmap updating. If a signal causes a process to terminate, RBF determines the appropriate time to return to the kernel. Failure to enforce the I/O interrupt completion may result in “locked” disks or corrupted media.

If Direct Memory Access (DMA) hardware support is available, I/O performance increases dramatically because the driver does not have to move the data between memory and the controller.

When the driver reads sector zero, it should copy the first 21 bytes of the sector into the drive table (`PD_DTB`) associated with the logical unit. Sector zero of the disk media has format information recorded by the `format` utility. This information allows the driver to determine the actual format of the media and to compare the device physical capabilities specified in the path descriptor options with the media format. This allows the driver to adapt its operation for reading and writing multiple formats in one physical drive. For example, a floppy drive that can read/write double-sided, double-density disks can be made to operate with single-sided or single-density media.

RBF always reads sector zero of the media when a file is opened. Many RBF drivers provide caching of sector zero to improve the performance of `I$Open` calls by RBF. This function is generally associated with non-removable media (for example, fixed hard disks). When a hard disk driver reads sector zero, it updates the drive table and copies the full sector zero into a local buffer. The state of the buffered sector for the unit is recorded in the logical unit drive table variables `V_ZeroRd` and `V_ScZero`. This enables the driver to return sector zero data on subsequent calls by RBF without accessing the disk. Removable media should not have sector zero buffered unless the driver is capable of automatically detecting the media removal (by an interrupt) and marking sector 0 unbuffered.

RBF generally processes GetStat calls to RBF devices; they are not normally seen by the driver. The main exception is the SS_VarSect call, which RBF uses to inquire about the driver's ability to support non-256-byte logical sectors.



Note

The INIT routine generally does not perform initialization of the logical units attached to the controller, for example, disk parameter definitions for SCSI drives. This type of initialization should normally be done when the first Read/Write/GetStat/SetStat call is made to the unit.

The INIT and TERM routines of RBF drivers are called directly by IOMan when the device is attached and detached. Typically, the INIT routine only performs controller-specific initialization such as adding the controller to the IRQ polling table, setting default values in the drive tables, and initializing the controller hardware interface.

The TERM routine typically disables the device's interrupts, if required, and removes the controller from the IRQ polling table.

Main Driver Types

The complexity of RBF drivers depends on the capabilities of the hardware involved. Simple hardware controllers require more effort by the driver than do intelligent controllers. Generally, RBF drivers fall into three levels of complexity:

Simple Floppy Interfaces

These drivers perform all physical drive movement operations explicitly: seek head, wait for head settle delay, etc. They translate the RBF LSN into a track/head/sector, select the drive, move the disk head to the required

position, and then issue the I/O command. If multiple drives are connected to the controller, the driver often has to maintain a record of the current head position of each drive.

Combined Hard/Floppy Interfaces

These drivers deal with *medium* intelligence controllers. Typically, the physical drive selection and automatic seeking are handled by the controller. The driver becomes somewhat simpler because it must only translate the RBF LSN into a track/head/sector value. Adding hard disk operation to the driver adds some minor complexity to the driver due to the differences in floppy vs. hard disk operation.

Intelligent Controllers

These drivers are typically used with SCSI or similar style controllers. These controllers usually accept only a command *packet* indicating the operation required and the address of the operation. They are similar to *medium* intelligence controllers, except the RBF LSN is usually accepted directly by the controller as the physical sector number.

RBF Device Driver Storage Definitions

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

`IOMan` allocates a static storage area for each device (which may control several drives). The size of the storage area is specified in the device driver module header (`M$Mem`). Some of this storage area is required by `IOMan` and RBF; the device driver may use the remainder in any manner. Information on device driver static storage required by the operating system can be found in the `rbfstat.a` and `drvstat.a` `DEFS` files. The following table shows how static storage is used:

Table 2-35 Device Driver Storage Definitions

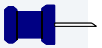
Name	Description
V_PORT	***Device base port address*** The device's physical port address. It is copied from M$Port in the device descriptor when the device is attached by IOMan.
V_LPRC	***Last active process ID*** The process ID of the most recent process to use the device. This field is required by IOMan for all device driver static storage, but is not used by RBF.
V_BUSY	***Current active process*** The process ID of the process currently using the device. It is used to implement I/O blocking by RBF. This field is also used by the interrupt drivers when they wish to suspend themselves, by copying V_BUSY to V_WAKE (prior to suspending themselves). A value of zero indicates the device is not busy.
V_WAKE	***Process ID to awaken*** The process ID of any process waiting for the device to complete I/O. A value of 0 indicates no process is waiting. V_WAKE is set by the driver from V_BUSY and provides the interlock between the driver and the driver's interrupt service routine.
V_PATHS	***Linked List of Open Paths*** This is a singly-linked list of all paths currently open on this device.

Table 2-35 Device Driver Storage Definitions (continued)

Name	Description
V_NDRV	***Number of drives*** This field is set by the driver's INIT routine to indicate the maximum number of logical drives the driver can use. RBF validates the logical drive number of the drive (PD_DRV) against this number prior to setting the drive table pointer (PD_DTB). PD_DRV must be less than V_NDRV.
V_DRVBEG	***Drive Tables*** This section contains one table for each drive the controller handles. The drive table associated with the drive is indicated by the drive table pointer (PD_DTB) in the path descriptor.

Device Driver Tables

After the driver's INIT routine has been called, RBF requests the driver to read the identification sector (LSN 0) from the drive. After reading sector 0, the driver must initialize the corresponding drive table. It does this by copying the number of bytes specified by DD_SIZ (21) from the beginning of sector 0 into the appropriate table (PD_DTB). The following is the format of each drive table:



Note

There must be as many tables as are specified in V_NDRV. All references to Sector 0 in the Maintained By column mean this field is initialized by the driver with information obtained from Sector 0 when it is first read.

Table 2-36 Formats of Drive Tables

Offset	Name	Maintained By	Description
$00	DD_TOT	Sector 0	Total Number of Sectors
$03	DD_TKS	Sector 0	Track Size (in sectors)
$04	DD_MAP	Sector 0	Number of Bytes in Allocation Map
$06	DD_BIT	Sector 0	Number of Sectors/Bit (cluster size)
$08	DD_DIR	Sector 0	LSN of Root Directory FD
$0B	DD_OWN	Sector 0	Owner ID
$0D	DD_ATT	Sector 0	Attributes
$0E	DD_DSK	Sector 0	Disk ID
$10	DD_FMT	Sector 0	Disk Format: Density/Sides
$11	DD_SPT	Sector 0	Sectors/Track
$13	DD_RES		Reserved
$16	V_TRAK	Driver	Current Track Number
$18	V_FileHd	File Manager	Open File List for Disk
$1C	V_DiskID	File Manager	Disk ID
$1E	V_BMapSz	File Manager	Bitmap Size

Table 2-36 Formats of Drive Tables (continued)

Offset	Name	Maintained By	Description
$20	V_MapSct	File Manager	Lowest Bitmap Sector to Search
$22	V_BMB	File Manager	Bitmap In Use Flag
$24	V_ScZero	Driver	Pointer to Sector 0
$28	V_ZeroRd	Driver	Sector 0 Read Flag
$29	V_Init	Driver	Drive Initialized Flag
$2A	V_Resbit	File Manager	Reserved Bitmap Sector Number
$2C	V_SoftEr	Driver	Number of Recoverable Errors
$30	V_HardEr	Driver	Number of Non-Recoverable Errors
$34	V_Cache	Cache Utility	Drive Cache Queue Head
$38	V_DText	Driver	Drive Table Extension pointer
$3C	V_MapMax	File Manager	Maximum Bitmap Sector Number
$3e	V_MapOffs	File Manager	Bitmap Sector Offset
$40			Reserved (20 bytes)

Table 2-37 Drive Tables and Descriptions

Name	Description
DD_TOT	***Total Number of Sectors*** Contains the size of the media in sectors. RBF uses this field to set the size of the *raw* device file (@ file opens). The driver can also use this value to verify the LSN passed by RBF is in range for the media. Driver INIT routines typically initialize this field in the drive table to a non-zero value, so sector 0 may be read initially.
DD_TKS	***Track Size (in sectors)*** Contains the number of sectors per track, as a byte value.
DD_MAP	***Number of Bytes in Allocation Map*** Contains the size of the media bitmap.
DD_BIT	**Number of Sectors/Bit (cluster size)** Contains the size of a cluster of sectors on the disk. This value is always an integral power of two.
DD_DIR	***LSN of Root Directory FD*** Contains a pointer to the file descriptor of the media's root directory.
DD_OWN	***Owner ID*** The user ID of the disk owner.
DD_ATT	***Attributes*** Defines the access attributes of the media.

Table 2-37 Drive Tables and Descriptions (continued)

Name	Description
DD_DSK	***Disk ID*** Contains a pseudo-random number identifying the media volume. This number is put here by the `format` utility.
DD_FMT	***Disk Format: Density/Sides*** Defines the format of the media volume, to enable drivers to adapt to different formats: bit 0: `0` = Single-sided `1` = Double-sided bit 1: `0` = Single-density (FM) `1` = Double-density (MFM) bit 2: `1` = Double-track density (96 TPI/135 TPI) bit 3: `1` = Quad track density (192 TPI) bit 4: `1` = Octal track density (384 TPI)
DD_SPT	***Sectors/Track*** A two byte value of `DD_TKS`.
V_TRAK	***Current Track Number*** This value is used to record the current track number of a logical unit for those drivers needing to perform seek functions explicitly. Typically, driver `INIT` routines initialize this field to an unknown track number (for example, `$FF`), so the first access to the drive results in a restore operation.
V_FileHd	***Open File List for Disk*** A pointer to the list of all files open on the logical unit.

Table 2-37 Drive Tables and Descriptions (continued)

Name	Description
V_DiskID	***Disk ID*** A copy of DD_DSK.
V_BMapSz	***Bitmap Size*** The size of the media's bitmap.
V_MapSct	***Lowest Bitmap Sector to Search*** The starting sector number to begin bitmap allocation functions.
V_BMB	***Bitmap In Use Flag*** Indicates whether or not the bitmap is in use.
V_ScZero	***Pointer to Sector 0*** A pointer to a buffered sector 0 for the unit. This is only used by drivers performing this function.
V_ZeroRd	***Sector 0 Read Flag*** Used by the driver to indicate whether or not the buffered sector 0 is valid. If the data is valid, this flag should be non-zero.
V_Init	***Drive Initialized Flag*** Used by the driver to indicate whether or not the logical unit has been initialized. If the unit has been initialized, this field should be non-zero.

Table 2-37 Drive Tables and Descriptions (continued)

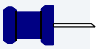
Name	Description
V_Resbit	***Reserved Bitmap Sector Number*** Indicates the bitmap sector number to ignore during RBF bitmap allocation functions. It is set by the SS_RsBit SetStat call.
V_SoftEr	***Number of Recoverable Errors*** Allows the driver to keep a count of *soft* errors during I/O operations. The value is typically returned by a SS_ELog GetStat call. After reading this value, it is typically reset to zero.
V_HardEr	***Number of Non-Recoverable Errors*** Allows the driver to keep a count of *hard* errors during I/O operations. The value would typically be returned by a SS_ELog GetStat call. After reading this value, it is typically reset to zero.
V_Cache	***Drive Cache Queue Head*** A pointer to the cache queue for the drive.
V_DTExt	***Drive Table Extension Pointer*** A pointer to an extension of the drive table. Drivers requiring storage of additional drive table variables can use this field as a pointer to the extra information.
V_MapMax	***Maximum Bitmap Sector Number*** The sector number of the last sector of the bitmap.
V_MapOffs	***Offset into current bitmap sector*** The bit offset into the current bitmap sector to begin the search for a free sector.

Linking RBF Drivers

After an RBF driver has been assembled into its relocatable object file (ROF), the driver needs to be linked to produce the final driver module. Linking resolves all code references in drivers comprised of several ROF files. It also resolves the external data and static storage references by the driver.

The most important part of linking is to correctly resolve the static storage references. Generally, the static storage area is composed of three sections in this order (see **Figure 2-1**):

1. I/O globals
2. Drive tables (one per logical drive)
3. Driver-declared variables



Note

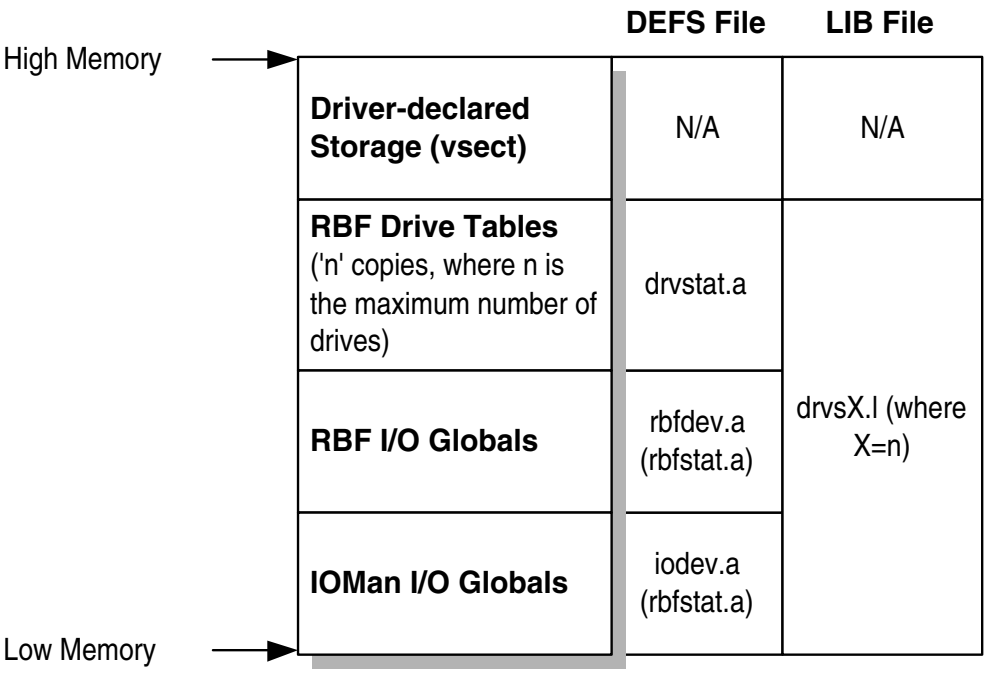
Specifying the `drvsX.l` file first causes the vsect variables declared by the file to be allocated before the vsect variables in the ROF file.

Failure to correctly allocate the I/O system and drive table variables first, or failure to link the correct number of drive tables at all, results in erratic driver operation.

The driver-declared variables are declared in vsect areas of the driver, but they must be allocated after the drive table storage areas. The method you must use to allocate all of the storage, in the correct order, is to link one of the `drvsX.l` library files before the user written ROF files. The `drvsX.l` files are usually found in the system's LIB directory. Each `drvsX.l` file contains vsect declarations allocating the I/O system variables and the appropriate number of drive tables. For example, `drvs1.l` allocates the I/O system-defined section and one drive table, while `drvs4.l` allocates the I/O system-defined section and four drive tables. The following is a typical linker command line for an RBF driver:

```
168 /dd/LIB/drvs4.l REL/rb320.r -O=OBJS/rb320
```

Figure 2-1 RBF Static Storage Layout



RBF Device Driver Subroutines

As with all device drivers, RBF device drivers use a standard executable memory module format with a module type of Drivr (code $E0). RBF drivers are called in system state.

Note

I/O system modules must have the following module attributes:

- They must be owned by a super-user (0.n).
- They must have the system-state bit set in the attribute byte of the module header. OS-9 does not currently make use of this, but future revisions may require I/O system modules be system-state modules.

The execution offset address in the module header points to a branch table with seven entries. Each entry is the offset of a corresponding subroutine. The branch table appears as follows:

```
ENTRY     dc.w          INIT          initialize device
          dc.w          READ          read character
          dc.w          WRITE         write character
          dc.w          GETSTAT       get device status
          dc.w          SETSTAT       set device status
          dc.w          TERM          terminate device
          dc.w          TRAP          handle illegal exception
                                      (0 = none)
```

Each subroutine should exit with the carry bit of the condition code register cleared, if no error occurred. Otherwise, the carry bit should be set and an appropriate error code returned in the least significant word of register d1.w.

The TRAP entry point is currently not used by the kernel, but in the future will be defined as the offset to error exception handling code. Because no handler mechanism is currently defined, this entry point should be set to zero to ensure future compatibility.

The following pages describe each subroutine.

Table 2-38 RBF Device Driver Subroutines

Subroutine	Description
GETSTAT/SETSTAT	Get/Set Device Status
INIT	Initialize Device and its Static Storage Area
IRQ Service Routine	Service Device Interrupts
READ	Read Sector(s)
TERM	Terminate Device
WRITE	Write Sectors

Input

```
d0.w = status code
(a1) = address of the path descriptor
(a2) = address of the device static storage area
(a4) = process descriptor pointer
(a5) = caller's register stack pointer
(a6) = system global data storage pointer
```

Output

Depends on the function code

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

These routines are wild-card calls used to get/set the device's operating parameters as specified for the `I$GetStt` and `I$SetStt` service requests.

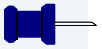
Calls involving parameter passing require the driver to examine or change the register stack variables. These variables contain the contents of the MPU registers at the time of the `I$Getstt/I$SetStt` request was made. Parameters passed to the driver are set up by the caller prior to using the service call. Parameters passed back to the caller are available when the service call completes.

Typical RBF drivers handle the following `I$GetStt/I$SetStt` calls:

Table 2-39

`I$GetStt:`	`SS_DSize, SS_VarSect`
`I$Setstt:`	`SS_Reset, SS_SQD, SS_WTrk`

Any unsupported I$GetStt/I$SetStt calls to the driver should return an unknown service error (E$UnkSvc).



Note

A minimal RBF driver should support SS_Reset and SS_WTrk, so that media may be formatted.

The following pages describe the driver implementation of the above I$GetStt/I$SetStt calls.

GetStat Calls

The following GetStat calls are available to RBF:

SS_DSize — This routine is used to return the media size for autosize devices (PD_Cntl, bit three set). The routine must perform the following steps:

Step 1. Locate the associated drive table (PD_DTB) and check whether the unit is initialized (V_Init). If not, perform any drive initialization required and mark the drive initialized in the drive table.

Step 2. Prepare the hardware for the request and start the I/O operation.

Step 3. Wait for the I/O operation to complete (with interrupts, if possible).

Step 4. Return the media size (in terms of its logical sector size) to the caller's d2 register (R$d2 offset from passed a5). Note if the driver supports *deblocking* (logical and physical sizes are not the same), the returned sector count should be a *logical* sector count.

Step 5. Return status to RBF.

`SS_VarSect`

This routine is called by RBF whenever a path is opened to the device, so RBF can determine the logical sector size of the media. The driver should indicate its support for variable logical sector sizes as follows:

- If variable logical sector sizes are supported, the driver should return a *no error* status. Upon return to RBF, RBF uses the value in `PD_SSize` as the media's logical sector size. It is permissible for the driver to query the drive for its current sector size setting and update `PD_SSize` during this call.

WARNING

Querying the drive *does not* mean issuing a physical read of the disk's sector 0 (to read `DD_LSNSize`) as RBF has not yet set up the buffer pointers for the path (`PD_BUF = 0`). Unless you take special care, attempting to perform physical data I/O at this point will probably crash the system. The only type of I/O operations valid at this point are generally internal driver operations (for example, Mode Sense command to a SCSI drive). Drivers dealing with media that cannot return *current sector size* generally require `PD_SSize` be set correctly in the device descriptor. The driver returns *no error* to indicate RBF can use `PD_SSize` as the logical media size.

- If the driver does not support variable logical sector sizes, it should return an *unknown service request* (`E$UnkSvc`) error, to indicate to RBF the logical sector size of the media is 256 bytes and `PD_SSize` should be ignored.
- If the driver returns any error other than *unknown service request*, RBF aborts the path open operation and returns the error to the caller.

SetStat Calls

`SS_Reset` — Recalibrate (restore) the media head to the outer track. This is mainly used by format to ensure the media is at a known position.

The restore routine must perform the following functions:

Step 1. Locate the associated drive table (`PD_DTB`) and check whether the unit is initialized (`V_Init`). If not, perform any drive initialization required and mark the drive initialized in the drive table.

Step 2. Prepare the hardware for the request and start the I/O operation.

Step 3. Wait for the I/O operation to complete (with interrupts, if possible).

Step 4. Return the status of the restore to RBF.

`SS_SQD` — This is mainly used to move (park) the heads of hard disk drives to a safe area. The park routine must perform the following:

Step 1. Check if the device is a floppy disk. If so, return an `E$UnkSvc` error.

Step 2. Check the `PD_Park` value. If it is zero or within the range of the RBF media area, return an `E$UnkSvc` error.

Step 3. Locate the associated drive table (`PD_DTB`) and initialize the drive according to the parking function. This typically involves setting the drive's cylinder count to the `PD_Park` value. After initialization, do not mark the drive initialized (`V_Init` should be clear). This ensures any subsequent accesses to the drive causes the drive to be re-initialized correctly (`PD_CYL` or `PD_TotCyls` count instead of `PD_Park`).

Step 4. Prepare the hardware for the park request and start the I/O operation.

Step 5. Wait for the I/O operation to complete (with interrupts, if possible).

Step 6. Return the status of the park to RBF.

Step 7. Issue a seek or read command and specifying a sector address on the desired cylinder. On some drives/controllers, this may fail because the parking cylinder is not formatted and the controller attempts to verify the seek/read. In these situations, it is typical for the driver to perform a write track operation on the desired track.

`SS_WTrk` This is used by format to perform physical initialization of the media. The write track routine must perform the following steps:

Step 1. Check whether the media may be formatted (`PD_Cntl`, bit 0 clear). If not, the media is format protected and the driver should return an `E$Format` error.

Step 2. Locate the associated drive table (`PD_DTB`) and check whether the unit is initialized (`V_Init`). If not, perform the required drive initialization and mark the drive initialized in the drive table. If the driver supports buffering sector 0 for the unit, and the track being formatted is the first track of the media (`PD_TOffs`), the driver should clear `V_ZeroRd` to mark sector 0 is unbuffered.

Step 3. If the driver supports any buffering of physical sectors (non `VarSect` driver with physical sectors not equal to 256 bytes), it should mark any active buffers as invalid.

Step 4. For drivers performing explicit seeking, seek to the desired track. If the seek involves the selection of a drive different from the last one selected, this may also require the current track position to be saved in the last selected drive's drive table (`V_TRAK`).

Step 5. Prepare the hardware for the write track request and start the I/O operation.

Step 6. Wait for the I/O operation to complete (with interrupts, if possible).

Step 7. Return the status of the write track to RBF.

The method of formatting disk drives varies with the hardware in use. However, note the following points:

- The parameters passed are physical parameters, with one exception: the sector interleave table. If the driver must pass the interleave table to the hardware (or prepare its own table), it must add the `PD_SOffs` value to each interleave table entry so a physical interleave table is passed to the hardware.
- The driver typically only initializes the drive when the track number passed is equal to the `PD_TOffs` value (at the beginning of the format operation).

`SS_WTrk`

calls to the driver issued by format are dependent on the autosize flag in `PD_Cntl` (bit three) in the following manner:

- If the media is autosize capable (bit three set), format makes only one `SS_WTrk` call to the driver with the passed track number being equal to `PD_TOffs`. The driver is expected to format the entire media from this call.
- If the media is non-autosize capable (bit three clear), format issues a `SS_WTrk` call for each track on the media (`PD_CYLS x PD_SID`). The driver is expected to format the media one track at a time. If the hardware cannot handle individual tracks, the driver must perform a format all media operation on the first `SS_WTrk` call (`PD_TOffs` equal to the passed track number and side number zero) and simply ignore all other `SS_WTrk` calls without returning an error.

Input

```
(a1) = address of the device descriptor module
(a2) = address of device static storage
(a4) = process descriptor pointer
(a5) = caller's register stack pointer
(a6) = system global data pointer
```

Output

None

Error Output

```
cc = carry bit
setd1.w = error code
```

Description

The INIT routine must:

Step 1. Initialize the device's permanent storage. Minimally, this consists of:

- Initializing V_NDRV to the number of drives with which the controller works.
- Initializing DD_TOT in each drive table to a non-zero value so sector 0 may be read or written to.
- If the driver must perform explicit seeks, initializing V_TRAK to $FF so the first seek finds track 0.

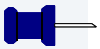
Step 2. Place the IRQ service routine on the IRQ polling list by using the FIRQ/FFIRQ system call.

Step 3. Initialize device control registers (enable interrupts if necessary).

Prior to being called, the device static storage is cleared (set to 0), except for V_PORT which contains the device address. The driver should initialize each drive table entry appropriately for the type of disk the driver expects to be used on the corresponding drive.

If INIT returns an error, it does not have to clean up its operation, for example, remove device from polling table or disable hardware. IOMan calls TERM to allow the driver to clean up INIT's operation before returning to the calling process.

Usually, the INIT routine should only perform controller-specific initialization, as opposed to drive-specific initialization. This is because the controller may have more than one type of drive connected to it.



Note

If the INIT routine causes an interrupt to occur, you can handle the interrupt in one of the following ways:

- Process the interrupt directly by masking interrupts to the level of the device, polling/servicing the device hardware, and then restoring the previous interrupt level. This is the preferred technique unless the interrupt is time-consuming.
- Allow the interrupt service routine to service the hardware. In this case, the process descriptor contains the process ID (P$ID) to which V_WAKE should be set. V_BUSY cannot be used because it is zero when INIT is called.

Input

```
d0.w = vector offset
(a2) = static storage address
(a3) = port address
(a6) = system global static storage
```

Output

None

Error Output

```
cc = carry set
(interrupt not serviced)
```

Description

This routine is called directly by the kernel's IRQ polling table routines. Its function is to:

Step 1. Check the device for a valid interrupt. If the device does not have an interrupt pending, the carry bit must be set and the routine exited with an RTS instruction as quickly as possible. Setting the carry bit signals the kernel the next device on the vector should have its IRQ service routine called.

Step 2. Service device interrupts.

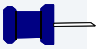
Step 3. Wake up the driver mainline, using the synchronization method of the driver:

Signals	Send a wake-up signal to the process whose process ID is in `V_WAKE`, when the I/O is complete. Also, clear `V_WAKE` as a flag to the mainline program that the IRQ has occurred.

Events	Signal the event that the IRQ has occurred, using the event system's signal function.

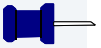
Step 4. Clear the carry bit and exit with an RTS instruction after servicing an interrupt.

Avoid exception conditions (for example, a Bus Error) when IRQ service routines are executing. Under the current version of the kernel, an exception in an IRQ service routine crashes the system.



Note

`F$IRQ` service routines may destroy the contents of the following registers only: `d0`, `d1`, `a0`, `a2`, `a3`, and `a6`. You must preserve the contents of all other registers or unpredictable system errors (system crashes) occur.



Note

The description above assumes you are using the `F$IRQ` system for interrupt servicing. If you are using the Fast Interrupt System (`F$FIRQ`), note the following:

- INPUT:

```
d0.w = vector offset

(a2) = static storage

(a6) = system global pointer
```

- Only `d0` and (`a2`) can be destroyed.

- Returning carry set causes polling of `F$IRQ` installed devices for the same vector.

Input

```
d0.l = number of contiguous sectors to read
d2.l = disk logical sector number to read
(a1) = address of path descriptor
(a2) = address of device static storage
(a4) = process descriptor pointer
(a5) = caller's register stack pointer
(a6) = system global data storage pointer
```

Output

Sector(s) returned in the sector buffer

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

The READ routine must perform the following operations:

Step 1. Locate the associated drive table (PD_DTB) and determine if it is initialized. If not, perform any drive initialization required and mark the drive initialized in the drive table. If the driver performs sector zero buffering for the unit, allocate a sector zero buffer.

Step 2. Verify the starting LSN and ending LSN (if a multi-sector read) against the size of the media (DD_TOT).

Step 3. Compute the physical disk address (track/head/sector) from the LSN, if required.

Step 4. If the driver supports sector 0 buffering, and the read request is for sector 0, return the sector 0 data to the buffer specified. If no further sectors are requested, return to RBF. Otherwise, proceed to read the remaining sectors into the remainder of the buffer.

Step 5. For drivers performing explicit seeking, seek to the desired track. If the seek involves the selection of a drive different from the last one selected, this may also require you save the current track position in the last selected drive's drive table (`V_TRAK`).

Step 6. Prepare the hardware for the read request and start the I/O operation. The data should be read into the buffer specified by `PD_BUF`.

Step 7. Wait for the I/O operation to complete (with interrupts, if possible).

Step 8. If the starting LSN of the read was not LSN 0, return to RBF. Otherwise:

a. Update the unit's drive table by copying the number of bytes specified by `DD_SIZ (21)` from the beginning of sector 0 into the appropriate table.

b. If the driver supports buffering sector zero for the unit, copy sector zero into the driver's local buffer (`V_ScZero`) and mark the buffer valid (`V_ZeroRd`).

Step 9. If the logical unit and driver support multiple disk formats, the driver should validate the media is readable by the drive. If not, the driver should return a Bad Type error (`E$BTyp`). If it can, the driver should ready itself for the new format by either:

- Marking the logical unit as uninitialized (`V_Init` cleared), so the next access causes the unit to be re-initialized by the driver.
- Re-initializing the unit hardware for the new format.

Step 10. Return the status of the read to RBF.

Sector/Transfer Count

The number of sectors to transfer is passed by RBF. If bit number one in PD_Cntl is clear, RBF always requests only one sector. If the bit is set, RBF requests a maximum count, based on the value in PD_MaxCnt. The value in PD_MaxCnt is truncated to an exact sector count, so the device always sees requests in terms of an integral number of sectors.

Sector Zero Reads

Whenever logical sector zero is read from the media, the first part of it must be copied into the drive table for the logical unit. PD_DTB contains the pointer to the drive table. The number of bytes to copy is DD_SIZ.

Drivers that buffer sector zero also update their local copy when sector zero is read from the media. The drive table variables V_ScZero (pointer to sector zero) and V_ZeroRd (sector zero valid flag) allow the driver to maintain this buffer. When the driver receives a read request for LSN zero, it can check these flags. If the buffer is valid, it can simply return the buffered data to RBF without performing any disk I/O.

Sector zero buffering should normally be performed only on fixed media (fixed hard disks). This ensures media volume changes are noticed by RBF. Failure to detect media changes correctly can result in corruption of the new volume.

If the driver can detect media removal (for example, via an interrupt when the door is opened), it is permissible for the driver to buffer sector 0 while the media is installed.

Sector Size Support

If the driver supports variable sector sizes, RBF assumes the size of a sector is specified by PD_SSize, and the logical and physical sector sizes are the same. Drivers operating under this mode simply process the RBF transfer count and LSN address according to the disk's requirements.

If the driver does not support variable sector sizes (logical sector size is 256 bytes) and the physical sector size of the media (PD_SSize) is not 256 bytes, the driver must deblock the media sectors. Typically, this involves the following steps:

Step 1. Determine if RBF's starting LSN falls at the start of a media physical sector. If not, check if the physical sector is currently buffered by the driver. If the physical sector is currently buffered by the driver, copy the appropriate part of the buffer to RBF's buffer. If not, read the physical sector into the driver's buffer and return the appropriate part to RBF's buffer.

Step 2. If any sectors remain to be read, convert the remaining start address and count into the physical start address and count. Then, read (and count) those sectors into the RBF buffer.

Step 3. If any partial sector remains to be read, read that physical sector into the driver's physical buffer. Then, return the appropriate part of the buffer to the end of the RBF buffer.

Interrupt-driven Operation

If the hardware uses interrupts to perform I/O, the driver should perform the following:

Synchronization using Signals

Step 1. Issue the I/O command to the hardware.

Step 2. Copy `V_BUSY` to `V_WAKE` in the static storage.

Step 3. The driver should then suspend itself (`F$Sleep`).

Step 4. The IRQ service routine is called when the interrupt occurs. The IRQ service routine verifies the interrupt occurred for its hardware, services the interrupt, and sends a wake-up signal (`S$Wake`) to the driver. The driver's process ID is in `V_WAKE`. After sending the signal, the IRQ service routine should clear `V_WAKE` to signify the interrupt occurred.

Step 5. When the driver awakens, it should check `V_WAKE`. If zero, the interrupt has occurred and the driver can continue to check status. If non-zero, the driver should suspend itself again.

Synchronization using Events

Step 1. Issue the I/O command to the hardware.

Step 2. The driver should suspend itself using the event system's *wait* function.

Step 3. The IRQ service routine is called when the interrupt occurs. The IRQ service routine verifies the interrupt occurred for its hardware, services the interrupt, and then uses the event system's *signal* function to awaken the driver.

Step 4. When the driver awakens, it should determine if the event value is within range. If so, the interrupt was serviced and the driver can check the status. If not, the driver should suspend itself again.

Input

```
(a1) = address of the device descriptor module
(a2) = address of device static storage area
(a4) = process descriptor
(a6) = system global static storage pointer
```

Output

None

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

This routine is called when a device is no longer in use in the system (see `I$Detach`).

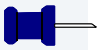
The `TERM` routine must:

Step 1. Wait until any pending I/O has completed.

Step 2. Disable the device interrupts.

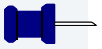
Step 3. Remove the device from the IRQ polling list.

Step 4. Return any buffers the driver has requested on behalf of itself, for example, sector zero buffers or physical sector deblocking buffers.



Note

The driver should not attempt to return buffers within its defined static storage area. IOMan releases this memory when the `TERM` routine completes.



Note

If an error occurs during the device's `INIT` routine, IOMan calls the `TERM` routine to allow the driver to clean up. If the `TERM` routine uses static storage variables (for example, interrupt mask values, dynamic buffer pointers), it should validate these variables prior to using them. The `INIT` routine may not have set up all the variables prior to exiting with the error.

Input

```
d0.l = number of contiguous sectors to write
d2.l = disk logical sector number
(a1) = address of the path descriptor
(a2) = address of the device static storage area
(a4) = process descriptor pointer
(a5) = caller's register stack pointer
(a6) = system global data storage pointer
```

Output

The sector buffer is written to disk.

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

The `WRITE` routine must perform the following operations:

Step 1. Determine the starting LSN. If zero, the driver should check the format control flag for format protection (`PD_Cntl`, bit 0). If bit 0 is clear, the media can be formatted and sector 0 may be written. If bit 0 is set, the media is format protected and the driver should return an `E$Format` error.

Step 2. Locate the associated drive table (`PD_DTB`) and check if the unit is initialized (`V_Init`). If not, perform any drive initialization required and mark the drive initialized in the drive table.

Step 3. If the driver supports buffering of sector 0 for the unit, and sector 0 is being written, the driver should clear `V_ZeroRd` to mark sector 0 is unbuffered.

Step 4. Verify the starting LSN (and ending LSN, if a multi-sector write) against the size of the media (DD_TOT).

Step 5. Compute the physical disk address (track/head/sector) from the LSN, if required.

Step 6. For drivers performing explicit seeking, seek to the desired track. If the seek involves the selection of a drive different from the last one selected, this may also require you to save the current track position in the last selected drive's drive table (V_TRAK).

Step 7. Prepare the hardware for the write request and start the I/O operation. The data should be written from the buffer specified by PD_BUF.

Step 8. Wait for the I/O operation to complete (with interrupts, if possible).

Step 9. Return the status of the write to RBF.

Sector/Transfer Count

The number of sectors to transfer is passed by RBF. If bit number one in PD_Cntl is clear, RBF always requests only one sector. If the bit is set, RBF requests a maximum count, based on the value in PD_MaxCnt. The value in PD_MaxCnt is truncated to an exact sector count, so the device always sees requests in terms of an integral number of sectors.

Sector Zero Writes

Whenever the starting LSN is zero, the driver should check whether the media may be formatted (PD_Cntl, bit 0). If bit 0 is set, the media is format protected and sector zero may not be written. The driver should return a E$Format (format protected) error in this case.

If the driver buffers sector zero of the media, it should clear V_ZeroRd to mark the buffer invalid. This ensures the next read of sector zero accesses the media.

Sector Size Support

If the driver supports variable sector sizes, RBF assumes the size of a sector is specified by `PD_SSize`, and the logical and physical sector sizes are the same. Drivers operating under this mode simply process the RBF transfer count and LSN address according to the disk's requirements.

If the driver does not support variable sector sizes (logical sector size is 256 bytes) and the physical sector size of the media (`PD_SSize`) is not 256 bytes, the driver must deblock the media sectors. Typically, this involves the following steps:

Step 1. Determine if RBF's starting LSN falls at the start of a media physical sector. If not, and the physical sector is not currently cached, read the physical sector into the driver's local buffer. Update the appropriate part of the buffer with RBF's data and write the local buffer to the media.

Step 2. If any sectors remain to be written, convert the remaining start address and count into the physical start address and count. Then, write (and count) those sectors from the RBF buffer.

Step 3. If any partial sector remains to be written, read that physical sector into the driver's local buffer. Next, update the appropriate part of the buffer with RBF's data and write the local buffer to the media.

Interrupt Operation

If the hardware uses interrupts to perform I/O, the driver should perform the following:

Synchronization using Signals

Step 1. Issue the I/O command to the hardware.

Step 2. Copy `V_BUSY` to `V_WAKE` in the static storage.

Step 3. The driver should suspend itself (`F$Sleep`).

Step 4. The IRQ service routine is called when the interrupt occurs. The IRQ service routine verifies the interrupt occurred for its hardware, services the interrupt, and sends a wake-up signal (`S$Wake`) to the driver. The driver's process ID is in `V_WAKE`. After sending the signal, the IRQ service routine should clear `V_WAKE` to signify the interrupt occurred.

Step 5. When the driver awakens, it should check `V_WAKE`. If zero, the interrupt has occurred and the driver can continue to check status. If non-zero, the driver should suspend itself again.

Synchronization using Events

Step 1. Issue the I/O command to the hardware.

Step 2. The driver should suspend itself using the event system's *wait* function.

Step 3. The IRQ service routine is called when the interrupt occurs. The IRQ service routine verifies the interrupt occurred for its hardware, services the interrupt, and then uses the event system's *signal* function to awaken the driver.

Step 4. When the driver awakens, it should verify the event value is within range. If so, the interrupt was serviced and the driver can check the status. If not, the driver should suspend itself again.

Chapter 3: Sequential Character File Manager (SCF)

This chapter explains how to use the SCF manager to process I/O service requests to devices operating on a character by character basis, and the I/O editing functions available for line-oriented operations. It includes the following topics:

RadiSys.
MICROWARE SOFTWARE

SCF General Description

The Sequential Character File Manager (SCF) is a re-entrant subroutine package for I/O service requests to devices operating on a character-by-character basis, such as terminals, printers, and modems. SCF can handle any number or type of character-oriented devices. It includes some input and output editing functions for line-oriented operations such as backspace, line delete, repeat line, auto line feed, screen pause, and return delay padding.

The following I/O service requests are handled by SCF:

Table 3-1 SCF I/O Service Requests

I$Close	I$Create	I$GetStt	I$Open
I$Read	I$ReadLn	I$SetStt	I$Write
I$Writln			

The following I/O service requests are not valid for SCF:

Table 3-2 Invalid-SCF I/O Service Requests

I$ChgDir	I$Delete	I$MakDir	I$Seek

When an I$ChgDir, I$Delete, or I$MakDir is made to SCF, an appropriate error code is returned. I$Seek does not return an error.

The following I/O service requests do not call SCF:

Table 3-3 Non-SCF I/O Service Requests

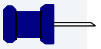
I$Attach	I$Detach	I$Dup

SCF device drivers are responsible for the actual transfer of data between their own internal buffers and the device hardware.

SCF transfers data to/from the driver in register `d0`. The driver typically operates as follows, depending upon whether or not the driver uses interrupts.

Polled Mode

The `WRITE` routine writes the data to the hardware and the driver returns immediately. The `READ` routine checks for available data, waits if there is no data, and returns the data when ready. Polled-mode drivers usually do not buffer the data internally.



Note

Polled I/O operation can have a harmful effect on real-time system operation. Polled I/O is acceptable if the device is always ready to send or receive data (for example, output to a memory-mapped video display). Polled I/O is not acceptable if the driver has to wait for the device to send or receive data.

Interrupt Mode

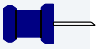
Interrupt-driven drivers typically use input FIFO and output FIFO buffers for the data being read and written. The `WRITE` routine deposits the data in the output FIFO buffer, arms the output interrupts (if necessary), and allows the device's output interrupt service routine to empty the output FIFO. When the output FIFO is empty, output interrupts are usually disabled. The `READ` routine checks the input FIFO buffer. If data is available, `READ` takes the next character from the buffer and returns. If no data is available, `READ` suspends itself until data is available. The device's input interrupt service routine is responsible for filling the input FIFO and waking any waiting process. Input interrupts are usually enabled for the time the device is attached to the system.

SCF Line Editing

The I$Read and I$Write service requests to SCF devices pass data to/from the device without modification; SCF does not add line feeds or NULLs after writing a carriage return.

The I$ReadLn and I$Writln service requests to SCF devices perform all line editing functions enabled for the particular device.

Line editing functions are initialized when a path is first opened by copying the option table from the device descriptor associated with that device into the path descriptor. They may be altered later by programs using the I$GetStt and I$SetStt (SS_Opt) service requests. You can use the xmode utility to modify the option table of SCF device descriptors in writable memory, so changes can be applied prior to opening a path to the device. You can also use the tmode utility to modify the options from the keyboard. Line editing functions are disabled when the option table field is set to zero.



Note

If software handshaking (X-ON/X-OFF) is enabled, these characters are intercepted by the device driver and not processed by SCF.

SCF I/O Service Requests

When a process makes one of the following system calls to a SCF device, SCF executes the file manager functions described for that call.

I$Close

SCF performs the following functions:

- Checks for additional paths open to the device by the calling process. If no additional paths are open, a `SS_Relea` SetStat is performed to release the device signal conditions and disassociate the device signals from the process.
- Checks for any other users of the path. If there are none, SBF:

Step 1. Performs an `SS_Close` SetStat to the driver.

Step 2. Performs an `I$Detach` if the device has an output (echo) device.

Step 3. Returns buffers allocated by the original `I$Open` call.

I$Create

SCF considers this system call synonymous with `I$Open`.

I$GetStt

The `SS_Opt` GetStat function is supported by SCF. It is passed to the driver to enable the driver to update hardware specific parameters such as the baud rate. If the driver returns an `E$UnkSvc` error, it is ignored. All other GetStat calls are passed directly to the driver.

Refer to the `I$GetStt` system call description in the ***OS-9 for 68K Technical Manual*** for specific information on the various SCF-oriented `I$GetStt` functions.

I$Open

SCF performs the following functions:

- Validates the pathname.
- Allocates memory for the *path buffer*.

- Initializes the path descriptor with the default options section.
- Performs an I$Attach if the device has an output (echo) device.
- Calls the driver with an SS_Open SetStat. If the driver returns an E$UnkSvc error, SCF ignores it.

I$Read

I$Read requests read input from the device without modifying the data. The read terminates under any of these circumstances:

- The requested number of bytes has been read.
- An end-of-record character is detected (PD_EOR).
- An end-of-file (PD_EOF) is detected as the first character of the read.
- An error occurs.

You can control the method of transfer in the following ways:

- De-select (set to zero) the end-of-record (PD_EOR) character using I$GetStt and I$SetStt. This prevents the read from terminating early due to PD_EOR detection. The read continues until the requested number of characters has been read.
- De-select (set to zero) the end-of-file (PD_EOF) character using I$GetStt and I$SetStt. This prevents the read from terminating when receiving an end-of-file character as the first character of the read.

If the requested data is not immediately available, the driver waits (F$Sleep) for the data. This *busies* the driver (other processes I/O block) until the data READ request has completed. If you do not wish a process to wait for data, use the SS_Ready GetStat or SS_SSig SetStat calls to detect when an I$Read can be issued.

I$ReadLn

I$ReadLn requests read input from the device and may edit the data. The read terminates under any of these circumstances:

- An end-of-record character is detected (PD_EOR).

- An end-of-file (PD_EOF) is detected as the first character of the read.
- An error occurs.

If the end-of record character is not encountered before the requested number of bytes has been read, SCF echoes the line overflow character (PD_OVF) for each subsequent character read. This indicates the characters are being ignored. This condition is maintained until the end-of-record character is read. You have control over how the data stream is edited by setting the path descriptor options using I$GetStt and I$SetStt.

Note

Never use I$ReadLn on a path that has its end-of-record (PD_EOR) function disabled, as I$ReadLn can then only terminate on an error or end-of-file condition.

I$SetStt

The SS_Opt SetStat function is supported by SCF. After SCF updates the path descriptor option section, it is passed to the driver to enable the driver to update hardware specific parameters such as the baud rate. If the driver returns an E$UnkSvc error, SCF ignores it. All other SetStat calls are passed directly to the driver.

For More Information

Refer to the I$SetStt system call description in the ***OS-9 for 68K Technical Manual*** for specific information on the various SCF-oriented I$SetStt functions.

I$Write

I$Write requests output data to the device without modifying the data being passed. The write terminates only when all characters have been sent or an error occurs.

I$WritLn

I$Writln is similar to I$Write except I$Writln writes data until an end-of-record character (PD_EOR) is written or until the specified number of bytes has been sent. The line editing I$Writln performs for SCF devices consists of auto line feed, null byte padding at end-of-record, tabulation, and auto page pause.

SCF Device Descriptor Modules

This section describes the definitions of the initialization table contained in device descriptor modules for SCF devices. The initialization table immediately follows the standard device descriptor module header fields and defines initial values for the I/O editing features. The size of the table is defined in the `M$Opt` field.

Table 3-4 Initialization Table Definitions

Device Descriptor Offset	Path Descriptor Label	Description
$48	PD_DTP	Device Type
$49	PD_UPC	Upper Case Lock
$4A	PD_BSO	Backspace Option
$4B	PD_DLO	Delete Line Character
$4C	PD_EKO	Echo
$4D	PD_ALF	Automatic Line Feed
$4E	PD_NUL	End Of Line Null Count
$4F	PD_PAU	End Of Page Pause
$50	PD_PAG	Page Length
$51	PD_BSP	Backspace Input Character
$52	PD_DEL	Delete Line Character
$53	PD_EOR	End Of Record Character

Table 3-4 Initialization Table Definitions (continued)

Device Descriptor Offset	Path Descriptor Label	Description
$54	PD_EOF	End Of File Character
$55	PD_RPR	Reprint Line Character
$56	PD_DUP	Duplicate Line Character
$57	PD_PSC	Pause Character
$58	PD_INT	Keyboard Interrupt Character
$59	PD_QUT	Keyboard Abort Character
$5A	PD_BSE	Backspace Output
$5B	PD_OVF	Line Overflow Character (bell)
$5C	PD_PAR	Parity Code, # of Stop Bits, and # of Bits/Character
$5D	PD_BAU	Adjustable Baud Rate
$5E	PD_D2P	Offset To Output Device Name
$60	PD_XON	X-ON Character
$61	PD_XOFF	X-OFF Character
$62	PD_TAB	Tab Character
$63	PD_TABS	Tab Column Width

Note

In this table the offset values are the device descriptor offsets, while the labels are the path descriptor offsets. To correctly access these offsets in a device descriptor using the path descriptor labels, you must make the following adjustment: (`M$DTyp - PD_OPT`).

For example, to access the letter case in a device descriptor, use `PD_UPC + (M$DTyp - PD_OPT)`. To access the letter case in the path descriptor, use `PD_UPC`. Module offsets are resolved in assembly code by using the names shown here and linking with the relocatable library: `sys.l` or `usr.l`.

Note

You can change or disable most of these special editing functions by changing the corresponding control character in the path descriptor. Do this with the `I$SetStt` service request, the `tmode` utility, or the `xmode` utility.

Table 3-5 Path Descriptor Labels and Descriptions

Name	Description
PD_DTP	***Device Type*** Set to 0 for SCF devices.
PD_UPC	***Letter Case*** If PD_UPC is not equal to 0, input or output characters in the range a-z are made A-Z.
PD_BSO	***Destructive Backspace*** If PD_BSO is 0 when a backspace character is input, SCF echoes PD_BSE (backspace echo character). If PD_BSO is non-zero, SCF echoes PD_BSE, space, PD_BSE.
PD_DLO	***Delete*** If PD_DLO is 0, SCF deletes by backspace-erasing over the line. If PD_DLO is not 0, SCF deletes by echoing a carriage return/line-feed.
PD_EKO	***Echo*** If PD_EKO is not 0, then all input bytes are echoed, except undefined control characters printed as periods. If PD_EKO is 0, input characters are not echoed.
PD_ALF	***Automatic Line Feed*** If PD_ALF is not 0, carriage returns are automatically followed by line-feeds.

Table 3-5 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_NUL	***End of Line Null Count*** Indicates the number of NULL padding bytes to be sent after a carriage return/line-feed character.
PD_PAU	***End of Page Pause*** If PD_PAU is not 0, an auto page pause occurs upon reaching a full screen of output. See PD_PAG for setting page length.
PD_PAG	***Page Length*** Contains the number of lines per screen (or page).
PD_BSP	***Backspace "Input" Character*** Indicates the input character recognized as backspace. See PD_BSE and PD_BSO.
PD_DEL	***Delete Line Character*** This field indicates the input character recognized as the delete line function. See PD_DLO.
PD_EOR	***End of Record Character*** This field defines the last character on each line entered (I$Read, I$ReadLn). An output line is terminated (I$Writln) when this character is sent. Normally PD_EOR should be set to $0D. **WARNING:** If PD_EOR is set to 0, SCF's I$ReadLn never terminates, unless an EOF or error occurs.

Table 3-5 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_EOF	***End of File Character*** This field defines the end-of-file character. SCF returns an end-of-file error on I$Read or I$ReadLn if this is the first (and only) character input.
PD_RPR	***Reprint Line Character*** If this character is input, SCF (I$ReadLn) reprints the current input line. A carriage return is also inserted in the input buffer for PD_DUP (see below) to make correcting typing errors more convenient.
PD_DUP	***Duplicate Last Line Character*** If this character is input, SCF (I$ReadLn) duplicates whatever is in the input buffer through the first PD_EOR character. Normally, this is the previous line typed.
PD_PSC	***Pause Character*** If this character is typed during output, output is suspended before the next end-of-line. This also deletes any *type ahead* input for I$ReadLn.
PD_INT	*Keyboard Interrupt Character* If this character is input, SCF sends a keyboard interrupt signal to the last user of this path. It terminates the current I/O request (if any) with an error identical to the keyboard interrupt signal code. PD_INT is normally set to a control-C character.

Table 3-5 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_QUT	***Keyboard Abort Character*** If this character is input, SCF sends a keyboard abort signal to the last user of this path. It terminates the current I/O request (if any) with an error code identical to the keyboard abort signal code. PD_QUT is normally set to a control-E character.
PD_BSE	***Backspace "Output" Character (Echo Character)*** This field indicates the backspace character to echo when PD_BSP is input. See PD_BSP and PD_BSO.
PD_OVF	***Line Overflow Character*** If I$ReadLn has satisfied its input byte count, SCF ignores any further input characters until an end-of-record character (PD_EOR) is received. It echoes the PD_OVF character for each byte ignored. PD_OVF is usually set to the terminal's bell character.

Table 3-5 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_PAR	***Parity Code, Number of Stop Bits, and Bits/Character*** Bits zero and one indicate the parity as follows: 0 = no parity 1 = odd parity 3 = even parity Bits two and three indicate the number of bits per character as follows: 0 = 8 bits/character 1 = 7 bits/character 2 = 6 bits/character 3 = 5 bits/character Bits four and five indicate the number of stop bits as follows: 0 = 1 stop bit 1 = 1 1/2 stop bits 2 = 2 stop bits Bits six and seven are reserved.

Table 3-5 Path Descriptor Labels and Descriptions (continued)

Name	Description
PD_BAU	***Software Adjustable Baud Rate*** This one-byte field indicates the baud rate as follows: ***Baud*** ***Value*** 50 0 75 1 110 2 134.5 3 150 4 300 5 600 6 1200 7 1800 8 2000 9 2400 A 3600 B 4800 C 7200 D 9600 E 19200 F 38400 10 External FF
PD_D2P	***Offset to Output Device Descriptor Name String*** SCF sends output to the device named in this string. Input comes from the device named by the M$PDev field. This permits two separate devices (a keyboard and video display) to be one logical device. Usually PD_D2P refers to the name of the same device descriptor in which it appears.
PD_XON	***X-ON Character*** See PD_XOFF below.

Table 3-5 Path Descriptor Labels and Descriptions (continued)

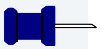
Name	Description
PD_XOFF	***X-OFF Character*** The X-ON and X-OFF characters are used to support software handshaking. Output from an SCF device is halted immediately when PD_XOFF is received and is not resumed until PD_XON is received. This allows the distant end to control its incoming data stream. Input to an SCF device is controlled by the driver. If the input FIFO is nearly full, the driver sends PD_XOFF to the distant end to halt input. When the FIFO has been emptied sufficiently, the driver resumes input by sending the PD_XON character. This allows the driver to control its incoming data stream. **NOTE:** When software handshaking is enabled, the driver consumes the PD_XON and PD_XOFF characters itself.
PD_Tab	***Tab Character*** In I$WritLn calls, SCF expands this character into spaces to make tab stops at the column intervals specified by PD_Tabs. **NOTE:** SCF does not know the effect of tab characters on particular terminals. Tab characters may expand incorrectly if they are sent directly to the terminal.
PD_Tabs	***Tab Field Size*** See PD_Tab.

SCF Path Descriptor Definitions

The first 27 fields of the path options section (PD_OPT) of the SCF path descriptor are copied directly from the SCF device descriptor initialization table. See **Table 3-6**.

The fields can be examined or changed using the I$GetStt and I$SetStt service requests or the tmode and xmode utilities.

You may disable the SCF editing functions by setting the corresponding control character value to zero. For example, if you set PD_INT to 0, there is no *keyboard interrupt* character.



Note

Full definitions for the fields copied from the device descriptor are available in the previous section. The additional path descriptor fields are defined below:

Table 3-6 SCF Path Descriptors

Name	Description
PD_TBL	***Device Table Entry*** A user-visible copy of the device table entry for the device.
PD_COL	***Current Column*** The current column position of the cursor.
PD_ERR	***Most Recent Error Status*** The most recent I/O error status.

Note

Offset refers to the location of a path descriptor field relative to the starting address of the path descriptor. Path descriptor offsets are resolved in assembly code by using the names shown here and linking the module with the relocatable library: `sys.l` or `usr.l`.

Table 3-7 Path Descriptors Offsets

Offset	Name	Description
$80	PD_DTP	Device Type
$81	PD_UPC	Upper Case Lock
$82	PD_BSO	Backspace Option
$83	PD_DLO	Delete Line Character
$84	PD_EKO	Echo
$85	PD_ALF	Automatic Line Feed
$86	PD_NUL	End Of Line Null Count
$87	PD_PAU	End Of Page Pause
$88	PD_PAG	Page Length
$89	PD_BSP	Backspace Input Character
$8A	PD_DEL	Delete Line Character

Table 3-7 Path Descriptors Offsets (continued)

Offset	Name	Description
$8B	PD_EOR	End Of Record Character
$8C	PD_EOF	End Of File Character
$8D	PD_RPR	Reprint Line Character
$8E	PD_DUP	Duplicate Line Character
$8F	PD_PSC	Pause Character
$90	PD_INT	Keyboard Interrupt Character
$91	PD_QUT	Keyboard Abort Character
$92	PD_BSE	Backspace Output
$93	PD_OVF	Line Overflow Character (bell)
$94	PD_PAR	Parity Code, # of Stop Bits, and # of Bits/Character
$95	PD_BAU	Adjustable Baud Rate
$96	PD_D2P	Offset To Output Device Name
$98	PD_XON	X-ON Character
$99	PD_XOFF	X-OFF Character
$9A	PD_TAB	Tab Character
$9B	PD_TABS	Tab Column Width
$9C	PD_TBL	Device Table Entry

Table 3-7 Path Descriptors Offsets (continued)

Offset	Name	Description
$A0	PD_Col	Current Column
$A2	PD_Err	Most Recent Error Status
$A3		Reserved

SCF Device Drivers

SCF device drivers support I/O devices reading and writing data one character at a time, such as serial devices.

The input data (usually from a keyboard) is buffered by the driver's interrupt service routine. Each read request returns one character at a time from the driver's circular input FIFO buffer. If the buffer is empty when the request occurs, the driver must suspend the calling process until an input character is received. Input interrupts are usually enabled throughout the time the device is attached to the system. If the device is incapable of interrupt-driven operation, the driver must poll the device until the data becomes available. This situation has a harmful effect on real-time system performance.

The output data may or may not be buffered, depending on the physical characteristics of the output device. If the device is a memory-mapped video display driven by the main CPU, buffering and interrupts are not usually needed. If the device is a serial interface, use buffering and interrupts. Each write request passes a single output character to the driver which is placed in a circular FIFO output buffer. The output interrupt routine takes output characters from this buffer. If the buffer is full when a write request is made, the driver should suspend the calling process until the buffer empties sufficiently.

The `I$GetStt` system call (`SS_Ready`) and `I$SetStt` system call (`SS_SSig`) permit an application program to determine if the input buffer contains any data. By checking first, the program is not suspended if data is not available.

The driver may optionally handle full input buffer conditions using X-ON/X-OFF or similar protocols. The input routine must also handle the special pause, abort, and quit control characters. All other control characters (such as backspace and line delete) are handled at the file manager level.

Special Characters and NULLs

Line-editing functions (if any) are generally dealt with at the file manager level by SCF. Device drivers are, however, required to deal with the following special characters in their input character routine:

NULL character	The driver's input routine should first determine if the received character is a NULL. If so, it should skip all special character tests, because the disabled state of these special characters is indicated by a NULL in the appropriate path option field. Failure to check for a received NULL results in erratic terminal and/or line-editing operation.
Abort and interrupt characters	The abort and interrupt characters should cause the appropriate signal to be sent to the last process using the device. The received character should then be buffered.
Page pause	The page pause character should cause a page pause request to be set in the echo device's static storage. The received character should then be buffered.
Software flow control	The start and stop transmission characters should cause the resumption/suspension of output data transmission. When this protocol is used, these characters are consumed by the driver's input character routine.

Parity Stripping

SCF device drivers do not usually modify the raw data stream when receiving and transmitting data. The drivers are expected to pass eight-bit data characters *as is*. When parity is enabled, however, the driver may have to be sensitive to the issue of *parity stripping*.

For eight-bit data characters, parity is not normally an issue (except for error checking), because the character parity status is signalled *out-of-band* from the character itself (there is a parity-error status flag). For smaller sized data characters (for example, seven-bit characters), the hardware sometimes passes the value of the parity bit in the high-bit of the received character. If a driver supports parity checking and non-eight-bit character formats, then the driver's input character routine must be sensitive to the current communications mode and strip the parity flag from the data prior to processing and buffering the character. Failure to strip this parity value from the received character may cause erratic terminal operation (for example, the software flow control characters may not be recognized correctly).

Data Flow Control

Data flow control is the process used to control the transfer of data over the physical interface. It ensures each end of the connection only transmits data when the other end is capable of receiving data. The data flow may be controlled by either hardware and/or software.

Hardware Flow Control

Hardware flow control uses physical signal lines to indicate the state of the interface. The Ready To Send (RTS) and Clear To Send (CTS) signals on the RS-232 Standard Interface are examples of these physical lines.

The level of implementation of hardware handshaking in a SCF driver is determined by the capabilities of the serial interface itself, which include the capabilities of the interface-chip and the board-level implementation of the interface.

A driver implementing fully functional hardware flow control performs the following functions:

- Configures the transmitter to only send data when the distant end's *ready-to-receive* is active.
- Controls the distant end's *ready-to-transmit* line so input buffer over-runs do not occur.

- Supports the SS_EnRTS, SS_DsRTS, SS_DCDOn, and SS_DCDOff SetStat calls, to allow a user application to directly control/monitor the serial connection.

A driver providing minimal (or no) support for hardware flow control usually configures the hardware control lines so the interface is *ready* whenever the device is attached. Drivers providing this level of operation usually implement software flow control.

Software Flow Control

Software flow control uses a software protocol to indicate the *ready* state of the two ends of the interface.

Support for software flow control is provided via the PD_XON (start transmission) and PD_XOFF (stop transmission) fields of the device descriptor. When these fields are enabled (both non-zero), then the driver implements the protocol as follows:

- If the driver receives the stop transmission character, it should immediately suspend data transmission. The driver can resume transmission when a start transmission character is received. Thus, the distant end is allowed to control its incoming data stream.
- If the driver's input routine detects its input buffer is about to fill, then it causes a stop transmission character to be sent to the distant end. When the buffer has been sufficiently emptied, the driver can cause transmission of a start transmission character. Thus, the driver is capable of controlling its incoming data stream.

When implementing software flow control, note the following points:

- The start transmission and stop transmission characters are *consumed* by the driver's input routine. If pure binary transfers are desired (the character values for flow control are actually part of the data stream), then software flow control must be disabled and hardware flow control enabled.
- Software flow control only works reliably with interrupt-driven drivers, because the detection of the incoming stop transmission character must take place immediately.

- The characters involved with the protocol must be *agreed upon* by both ends of the connection. Most systems default to the ASCII control characters X-ON and X-OFF. However, any other pair of characters may be used if both ends concur.
- When controlling the input data, the driver's input routine and read routine cooperate in the protocol as follows:
  - The input routine detects a *high-water* mark; a point at which the input buffer is almost full. When this mark is reached (ten characters remaining in buffer), the input routine causes the stop transmission character to be sent. The *head room* provided by the high-water mark should be set so the distant end has time to suspend transmission before the buffer actually fills.
  - The read routine simply takes characters from the input buffer until the buffer count reaches the *low-water* mark. Then, the read routine causes the start transmission character to be sent to resume input. The low-water mark is usually set to a low value to keep the total overhead in the software flow control to a minimum.

SCF Device Driver Storage Definitions

SCF device driver modules contain a package of subroutines performing raw I/O transfers to or from a specific hardware controller. Because these modules are re-entrant, one copy of the module can simultaneously run several identical I/O controllers.

IOMAN allocates a static storage area for each device (which may control several drives). The size of the storage area is given in the device driver module header (`M$Mem`). Some of this storage area is required by IOMAN and SCF; the device driver may use the remainder in any manner. Information on device driver static storage required by the operating system can be found in the `scfstat.a` DEFS file. **Table 3-8** shows how static storage is used.

Note

Offset refers to the location of a static storage field, relative to the starting address of the static storage area. Offsets are resolved in assembly code by using the names shown here and linking the module with the relocatable library: `sys.l`.

Table 3-8 SCF Device Driver Storage Offsets

Offset	Name	Maintained By	Description
$00	V_PORT	IOMAN	Device base address
$04	V_LPRC	File Manager	Last active process ID
$06	V_BUSY	File Manager	Active process ID
$08	V_WAKE	Driver	Process ID to awaken
$0A	V_Paths	IOMAN	Linked list of open paths
$0E			Reserved
$2E	V_DEV2	IOMAN	Address of attached device static storage
$32	V_TYPE	File Manager	Device type or parity
$33	V_LINE	File Manager	Lines left until end of page
$34	V_PAUS	Driver/File Manager	Pause request

Table 3-8 SCF Device Driver Storage Offsets (continued)

Offset	Name	Maintained By	Description
$35	V_INTR	File Manager	Keyboard interrupt character
$36	V_QUIT	File Manager	Keyboard abort character
$37	V_PCHR	File Manager	Pause character
$38	V_ERR	Driver	Error accumulator
$39	V_XON	File Manager	X-ON character
$3A	V_XOFF	File Manager	X-OFF character
$3B			Reserved
$46	V_Hangup	Driver/File Manager	Path lost flag
$54			Device Driver Variables begin here

Table 3-9 SCF Device Drivers

Name	Description
V_PORT	*Device Base Address* The device's physical port address. It is copied from M$Port in the device descriptor when the device is attached by IOMAN.
V_LPRC	***Last Active Process ID*** The process ID of the last process to use the device. The IRQ service routine sends this process the proper signal when an interrupt or quit character is received.
V_BUSY	*Current Active Process* The process ID of the process currently using the device. It is used to implement I/O blocking by SCF. This field is also used by the interrupt drivers when they wish to suspend themselves, by copying V_BUSY to V_WAKE (prior to suspending themselves). A value of 0 indicates the device is not busy.
V_WAKE	*Process ID to Awaken* The process ID of any process waiting for the device to complete I/O. A value of zero indicates no process is waiting. V_WAKE is set by the driver from V_BUSY and provides the interlock between the driver and the driver's interrupt service routine.
V_PATHS	*Linked List of Open Paths* A singly-linked list of all paths currently open on this device.

Table 3-9 SCF Device Drivers (continued)

Name	Description
V_DEV2	*Attached Device Static Storage* The address of the echo (output) device's static storage area. A device is typically its own echo device, but may not be, as in the case of a keyboard and a memory mapped video display. The interrupt service routine uses this pointer to set an output pause request (see V_PAUS and V_PCHR). If the value in V_DEV2 is 0, there is no echo device.
V_TYPE	*Device Type or Parity* This value is copied from PD_PAR in the path descriptor by SCF, so it may be used by interrupt service routines, if required.
V_LINE	*Lines Left Until End of Page* The number of lines left until the end of the page. Paging is handled by SCF.
V_PAUS	*Pause Request* A flag used to signal SCF that a pause character has been received. Setting its value to anything other than 0 causes SCF to stop transmitting characters at the end of the next line. Device driver input routines must set V_PAUS in the echo device's static storage area. SCF checks this value in the echo device's static storage when output is sent. Once paused, SCF clears any type-ahead (I$ReadLn), waits for and consumes the next input character, clears V_PAUS, and resumes output (see V_DEV2 and V_PCHR).

Table 3-9 SCF Device Drivers (continued)

Name	Description
V_INTR	*Keyboard Interrupt Characters* This value is copied from PD_INT in the path descriptor by SCF so it may be used by the driver's input routine. Receipt of this character should cause a signal (S$Intrp) to be sent to the last user of the device (V_LPRC).
V_QUIT	*Quit Character* This value is copied from PD_QUT in the path descriptor by SCF so it may be used by the driver's input routine. Receipt of this character should cause a signal (S$Quit) to be sent to the last user of the device (V_LPRC).
V_PCHR	*Pause Character* This value is copied from PD_PSC in the path descriptor by SCF, so it may be used by the driver's input routine. When the input routine receives this character, it should set the output pause request flag (V_PAUS) in the echo device's static storage (V_DEV2). (See V_DEV2 and V_PAUS.)
V_ERR	*Error Accumulator* This location is used to accumulate I/O errors. Typically, the IRQ service routine uses it to record input errors so they may be reported later when SCF calls the device driver read routine.
V_XON	*X-ON Character* This character is copied from PD_XON of the path descriptor by SCF, so it may be used for software handshaking by interrupt service routines, if required.

Table 3-9 SCF Device Drivers (continued)

Name	Description
V_XOFF	*X-OFF Character* This character is copied from PD_XOFF of the path descriptor by SCF, so it may be used for software handshaking by interrupt service routines, if required.
V_Hangup	*Path Lost Flag* This flag should be set to a non-zero value when the driver detects the path has been lost (for example, carrier lost on a modem).

Linking SCF Drivers

After an SCF driver has been assembled into its relocatable object file (ROF), the driver needs to be linked to produce the final driver module. Linking resolves all code references in drivers that are comprised of several ROF files. It also resolves the external data and static storage references by the driver.

The most important part of linking is to correctly resolve the static storage references. Generally, the static storage area is composed of two sections, in this order (see **Figure 3-1**):

1. I/O globals
2. Driver-declared variables

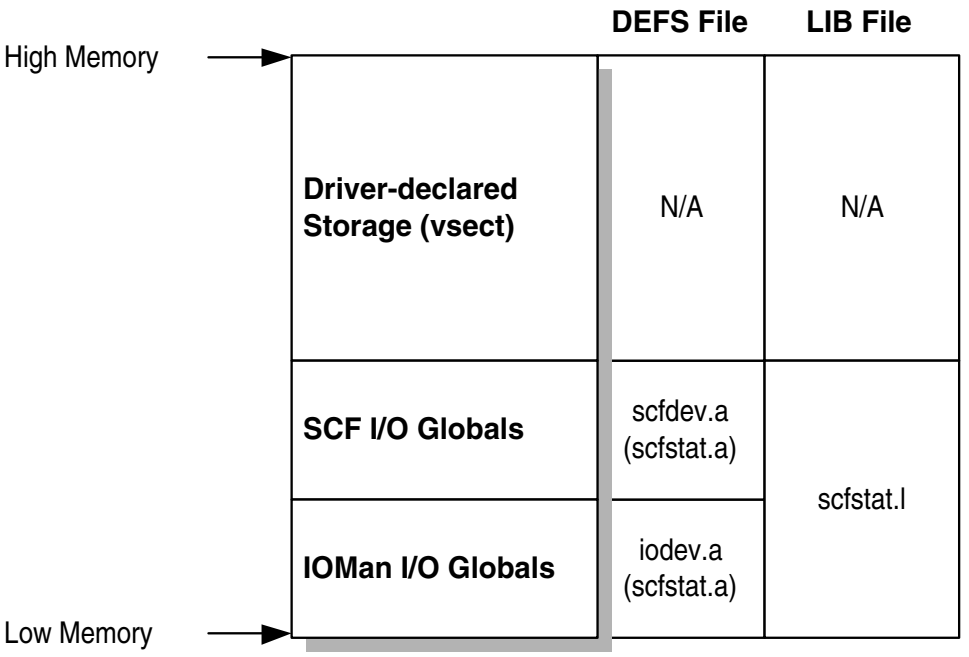
The driver-declared variables are declared in vsect areas of the driver, but they *must* be allocated after the I/O globals. To allocate all of the storage, *in the correct order*, the scfstat.l *must* be the first module specified. The scfstat.l file is usually found in the system's LIB directory. The following is a typical linker command line for an SCF driver:

```
168 /dd/LIB/scfstat.l REL/sc335.r -O=OBJS/sc335
```

Note

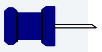
Failure to link the I/O global storage first, or not at all, results in erratic driver operation.

Figure 3-1 SCF Static Storage Layout



SCF Device Driver Subroutines

As with all device drivers, SCF device drivers use a standard executable memory module format with a module type of `Drivr` (code `$E0`). SCF drivers are called in system state.



Note

I/O system modules must have the following module attributes:

- They must be owned by a super-user (`0.n`).

- They must have the system-state bit set in the attribute byte of the module header. (OS-9 does not currently make use of this, but future revisions may require I/O system modules be system-state modules.)

The execution offset address in the module header points to a branch table with seven entries. Each entry is the offset of the corresponding subroutine. The branch table appears as follows:

```
ENTRY dc.w INIT    initialize device
      dc.w READ    read character
      dc.w WRITE   write character
      dc.w GETSTAT get device status
      dc.w SETSTAT set device status
      dc.w TERM    terminate device
      dc.w TRAP    handle illegal exception
                   (0 = none)
```

Each subroutine should exit with the carry bit of the condition code register cleared, if no error occurred. Otherwise, set the carry bit and return an appropriate error code in the least significant word of register `d1.w`.

The `TRAP` entry point is currently not used by the kernel, but in the future will be defined as the offset to error exception handling code. Because no handler mechanism is currently defined, this entry point should be set to zero to ensure future compatibility.

The following pages describe each subroutine.

Table 3-10 SCF Device Driver Subroutines

Subroutine	Description
`GETSTAT/SETSTAT`	Get/Set Device Status
`INIT`	Initialize Device and its Static Storage Area

Table 3-10 SCF Device Driver Subroutines

Subroutine	Description
IRQ Service Routine	Service Device Interrupts
READ	Get Next Character
TERM	Terminate Device
WRITE	Output a Character

Input

```
d0.w = function code
(a1) = address of path descriptor
(a2) = address of device static storage
(a4) = process descriptor pointer
(a5) = caller's register stack pointer
(a6) = system global data pointer
```

Output

Depends upon function code

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

These routines are wild-card calls used to get/set the device's operating parameters as specified for the `I$GetStt` and `I$SetStt` service requests.

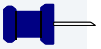
Calls involving parameter passing require the driver to examine or change the register stack variables. These variables contain the contents of the MPU registers at the time the `I$GetStt/I$SetStt` request was made. Parameters passed to the driver are set up by the caller prior to using the service call. Parameters passed back to the caller are available when the service call completes.

Typical SCF drivers handle the following `I$GetStt/I$SetStt` calls:

- `I$Getstt: SS_EOF, SS_Opt, SS_Ready`
- `I$SetStt: SS_Break, SS_DCOff*, SS_DCOn*, SS_DsRTS, SS_EnRTS, SS_Open, SS_Opt, SS_Relea*, SS_SSig*`

* only for interrupt-driven drivers

Any unsupported I$GetStt/I$SetStt calls to the driver should return an unknown service error (E$UnkSvc).



Note

A minimal SCF driver should support SS_Ready and SS_EOF, and if interrupt-driven, SS_SSig.

The following pages describe the driver's role in the implementation of the above I$GetStt/I$SetStt calls.

GetStat Calls

GetStat calls include:

SS_EOF	This routine should exit without an error.
SS_Opt	This routine is called when SCF is asked to return the current path options. SCF calls the driver so the driver can update the path descriptor's baud rate (PD_BAU) and communications mode (PD_PAR) to the current hardware values. This function is usually done by drivers supporting dynamic changes to baud rate. Drivers not supporting these changes typically return an unknown service request error (E$UnkSvc).
SS_Ready	This routine returns the current count of data available in the input FIFO buffer. If data is available, the count should be returned in the caller's d1 register (R$d1 offset from passed a5) and the driver should return to SCF without an error. If no data is available, then a "not ready" error (E$NotRdy) should be returned to SCF.

SetStat Calls

SetStat calls include:

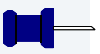
`SS_Break`

This routine is called when an application wishes to assert a *break* condition on the outgoing serial line.

`SS_DCOff/SS_DCOn`

These routines are called when you wish to notify an application the Data Carrier has been asserted (`SS_DCOn`) or negated (`SS_DCOff`). Typically, this routine saves the process ID (`PD_CPR`), path number (`PD_PD`), and signal code (user's `d2` register) in static storage and then returns without error. The IRQ service routine detects the presence or loss of the Data Carrier, sends the signal, and clears down the signal condition.

Drivers having hardware detection of a change-of-state only on the Data Carrier line typically have to track the current state (asserted or negated) of the line and signal a change of state accordingly.



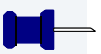
Note

Only interrupt-driven drivers should implement these calls.

`SS_DsRTS, SS_EnRTS`

These routines are called by applications wishing to explicitly assert (`SS_EnRTS`) or negate (`SS_DsRTS`) the RTS handshake line. Typically, the driver performs the hardware action and returns without an error.

SS_Open	This routine is called by SCF whenever a new path to the device is opened. Typically, drivers handle this call in the same way as a SetStat (SS_Opt) call, (check for baud-rate, configuration mode changes).
SS_Opt	This routine is called when SCF is asked to change the current path options. SCF passes the call to the driver so it may implement baud-rate and configuration mode changes to the hardware. Typically, the driver checks PD_BAU and PD_PAR to determine if they have changed. If not, the driver simply returns without an error. If one or both of these have changed, the driver validates the requested change and if correct, implements the change in hardware (for example, new baud rate). If the request is for an unsupported or illegal I/O mode (for example, invalid stop-bit count), then the driver typically returns a *bad I/O mode* error (E$BMode) and refuses the change.
SS_Relea	This routine is called when either SCF or an application wishes to clear down device signalling. This routine should erase any pending signal conditions (due to SS_SSig, SS_DCOn, SS_DCOff) and return without an error.



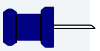
Note

When clearing down the signal condition(s), the driver should only clear the signal if the process ID (PD_CPR) and path number (PD_PD) of the caller match the process ID and path number of the original set-up call.

`SS_SSig`

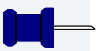
This routine is called when applications wish to have a signal sent to them when input data is available. Typically, the routine operates as follows:

1. It determines if another process has set up a `SS_SSig` condition. If so, a *not ready* error (`E$NotRdy`) is returned.
2. It determines if data is available in the input FIFO buffer. If so, the specified signal (user's `d2` register value) is sent to the process (`PD_CPR`) and the routine returns.
3. If no data is available, the process ID, path number (`PD_PD`), and signal are saved in static storage and the routine simply returns. When the data arrives, the input IRQ service routine sends the signal and releases the send-signal condition.



Note

Setting up a *send signal on data ready* condition *busies* the driver for read requests (see `READ` description), but allow writes to proceed as normal.



Note

Only interrupt-driven drivers should implement this call.

Input

```
(a1) = address of device descriptor module
(a2) = address of device static storage
(a4) = process descriptor pointer
(a5) = caller's register stack pointer
(a6) = system global data pointer
```

Output

None

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

The INIT routine must:

Step 1. Initialize the device static storage.

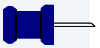
Step 2. Initialize the device control registers.

Step 3. Place the driver IRQ service routine on the IRQ polling list by using the FIRQ/FFIRQ service requests, if required.

Step 4. Enable interrupts if necessary.

Prior to being called, the device static storage is cleared (set to 0) except for V_PORT which contains the device port address. Do not initialize the portion of static storage used by SCF.

If INIT returns an error, it does not have to clean up its operation, for example, remove device from polling table or disable hardware. IOMAN calls TERM to allow the driver to clean up INIT's operation before returning to the calling process.



Note

If the INIT routine causes an interrupt to occur, the interrupt can be handled in one of the following ways:

- Process the interrupt directly by masking interrupts to the level of the device, polling/servicing the device hardware, and then restoring the previous interrupt level. This is the preferred technique unless the interrupt is time-consuming.
- Allow the interrupt service routine to service the hardware. In this case, the process descriptor contains the process ID (P$ID) to which V_WAKE should be set. V_BUSY cannot be used because it is zero when INIT is called.

Input

```
do.w = vector offset
(a2) = static storage
(a3) = port address
(a6) = system global static storage
```

Output

None

Error Output

```
cc = carry bit set (interrupt not serviced)
```

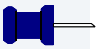
Description

This routine is called directly by the kernel's IRQ polling table routines. Its function is to:

1. Check the device for a valid interrupt. If the device does not have an interrupt pending, the carry bit must be set and the routine exited with an RTS instruction as quickly as possible. Setting the carry bit signals the kernel that the next device on the vector should have its IRQ service routine called.
2. Service device interrupts. There are three categories of interrupts: control interrupts, input interrupts, and output interrupts. Usually, input interrupts are checked first, because most serial hardware devices have minimal (or no) hardware data buffering. After the interrupt is serviced, many drivers check for another pending interrupt prior to exiting to the kernel. This technique (for example, service input interrupt, service pending output interrupt, service next input interrupt) provides efficient interrupt servicing because it allows the driver to service multiple interrupts with one call to the IRQ service routine.
3. Clear the carry bit and exit with a RTS instruction after servicing an interrupt.

Avoid exception conditions (for example, a Bus Error) when IRQ service routines are executing. Under the current version of the kernel, an exception in an IRQ service routine crashes the system.

IRQ service routines may destroy the contents of the following registers only: `d0`, `d1`, `a0`, `a2`, `a3`, and `a6`. You must preserve the contents of all other registers or unpredictable system errors (system crashes) occur.



Note

The description above assumes you are using the `F$IRQ` system for interrupt servicing. If you are using the Fast Interrupt System (`F$FIRQ`), note the following:

- Input:

```
d0.w = vector offset
(a2) = static storage
(a6) = system global pointer
```

- Only `d0` and (`a2`) can be destroyed.
- Returning carry set causes polling of `F$IRQ` installed devices for the same vector.

The interrupt categories (control, input, and output) are described in the following pages.

Control Interrupts

These interrupts are usually associated with non-data type information on the serial port, such as the receipt of a break character or a change in the Data Carrier line. Control interrupts may also signal error conditions on the data stream (for example, parity error).

When signaling is set up for Data Carrier transactions (see SetStat, SS_DCOn, SS_DCOff), the routine should send the specified signal to the specified process, clear down the signal condition, mark the path as *lost* (V_HangUp set to non-zero), and then exit (carry bit clear) or service more interrupts.

Input Interrupts

The input interrupt routine typically performs the following:

Step 1. Read the character from the hardware, clear down the interrupt, and strip parity (if required).

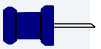
Step 2. Check character error status. If in error, update V_ERR to indicate the error.

Step 3. If the character is not a NULL character, determine whether or not the character requires special handling.

a. If the character is the output pause character (V_PCHR), set a pause request (V_PAUS) in the echo device's static storage (V_DEV2).

b. If the character is a keyboard interrupt (V_INTR) or quit character (V_QUIT), send the appropriate signal to the last process to use the device (V_LPRC).

c. If the character is a software handshake character (V_XON or V_XOFF), service the handshake request. For an *output resume* case (V_XON), this typically involves clearing the *output halted due to X-OFF* flag, checking for data in the output FIFO, and enabling output interrupts, if so. For an *output halt* case (V_XOFF), this typically involves setting the *output halted due to X-OFF* flag and disabling output interrupts on the hardware.



Note

The software handshake characters are consumed by this routine. After processing these characters, the IRQ service routine exits to the kernel (carry bit clear) or services the next pending device interrupt.

Put the character into the input FIFO buffer. If there is no room in the buffer, the character is lost and the driver should indicate *input buffer overrun* in the accumulated error status (`V_ERR`). In this case, the driver often returns to the kernel at this point, after waking the driver process (`V_WAKE`).

Step 4. Determine if any process has set up a *send signal on data ready* condition (`SS_SSig`). If so, signal the process, clear down the signaling condition, and exit (carry bit clear) or service the next pending interrupt.

Step 5. Examine the number of characters in the input FIFO, if the driver supports handshaking.

- For software handshaking, if the buffer is nearly full (reached the *high-water mark*), the driver should send a suspend transmission character (`V_XOFF`) to the distant end and flag that input has been halted. This function allows the driver to prevent input FIFO overrun errors when the data is being received at a faster rate than it is being read from the FIFO. Typically, the `READ` routine re-enables input data flow when it has emptied the input FIFO to a suitable low value (*low-water mark*) by causing the `V_XON` character to be sent.
- For hardware handshaking, the input interrupt routine should signal its desire to suspend input by negating its *ready to receive* line.

Step 6. If desired, the input IRQ service routine can now service more interrupts. Once fully completed, it should exit to the kernel with the carry bit clear. Prior to exiting, it should send a wake-up signal (`S$Wake`) to any waiting driver process. You can find the process ID in `V_WAKE`, which you should clear.

Output Interrupts

The output interrupt routine typically performs the following:

Step 1. Determine if V_XON or V_XOFF is pending, due to input buffer software handshaking. If so, send the required character, flag it sent, and mark the current state of input (halted or resumed). The driver should then determine if output is currently halted (buffer empty or software handshake). If so, it should disable output interrupts and return to the kernel (carry bit clear). If not, further interrupts may be processed or an exit may be made to the kernel (carry bit clear).

Step 2. Determine if output is halted due to software handshaking. If so, disable output device interrupts and return to the kernel (carry bit clear).

Step 3. Determine if any data is waiting in the output FIFO for transmission. If so, write the data to the hardware.

Step 4. Determine the remaining data count in the output FIFO.

a. If zero, flag the buffer empty, disable output device interrupts, wake any waiting process (V_WAKE) and exit to the kernel (carry bit clear).

b. If not zero, check if current count is below the output buffer's *low-water mark*. If not, exit to the kernel (carry bit clear) *without* waking the driver process. If so, wake the driver process before exiting.

This technique minimizes contention between the driver's WRITE routine (filling the output buffer) and the output IRQ service routine (emptying the output buffer), as the buffer is allowed to empty significantly before the WRITE process is re-activated.

Input

```
(a1) = address of path descriptor
(a2) = address of device static storage
(a4) = process descriptor pointer
(a5) = caller's register stack pointer
(a6) = system global data pointer
```

Output

```
d0.b = input character
```

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

This routine returns the next character available. Depending upon whether or not the routine is interrupt-driven, READ typically operates as follows:

Polled I/O Mode

A polled I/O read routine checks the hardware for available data. If there is none, the routine must wait until data is available. When data is available, READ should strip parity (if required) and then determine whether or not the character requires special handling:

1. If the character is the output pause character (V_PCHR), READ sets a pause request (V_PAUS) in the echo device's static storage (V_DEV2).
2. If the character is a keyboard interrupt (V_INTR) or quit (V_QUIT) character, READ sends the appropriate signal to the last process to use the device (V_LPRC).

If the received character is a NULL character, then special character tests should be ignored.

Note

Software handshaking, as specified by V_XON/V_XOFF is not usually implemented for polled-mode I/O, as the lack of interrupt-driven operation makes this handshake feature unreliable. Polled I/O drivers can usually only perform hardware handshaking.

The character read is returned to SCF in register d0.

Interrupt I/O Mode

For interrupt-driven drivers, READ gets data from the driver's input FIFO buffer. This buffer is filled by the input interrupt service routine. The following describes how READ operates.

Step 1. Determine if another process has set up a *send signal on data ready* condition. If so, READ returns a *not ready* (E$NotRdy) error (the device is busy for reading, but not for writing).

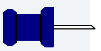
Step 2. Determine if data is available in the input FIFO buffer. If not, the driver should suspend itself by copying its process ID from V_BUSY to V_WAKE and then performing an F$Sleep service request to put itself to sleep indefinitely.

When the driver awakens, either data is available in the FIFO or a signal occurred. If a signal occurred, either the signal value is in P$Signal (process descriptor) or the process is condemned (condemn bit set in P$State). If the process is condemned or the signal value is deadly to I/O (less than S$Deadly), then the driver should return immediately to SCF with the carry bit set and the signal code (if any) as the error code.

Step 3. Get the next character from the input FIFO.

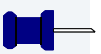
Step 4. If software handshaking is implemented, determine if input has been halted (V_XOFF sent to distant end). If so, and reading this character causes the FIFO count to go below the *low-water mark* of the FIFO, then resume input by sending a V_XON character to the distant end and flagging input resumed.

Step 5. Determine if any errors have been logged by the input interrupt service routine (V_ERR). If so, return an error (E$Read) to SCF and clear V_ERR. Otherwise, return the character read to SCF in register d0.



Note

Data buffers for queueing data between the main driver and the IRQ service routine are *not* automatically allocated by SCF. They should be defined in the device driver's static storage area (vsect) or allocated dynamically by the driver (for example, at INIT call).



Note

Normally, READ should not have to enable the device's *data-buffer-full* interrupt. The device should normally be configured so any input while the device is attached causes an interrupt. This is usually done during INIT. Input interrupts are typically disabled only when the device is detached (TERM routine).

Input

```
(a1) = device descriptor pointer
(a2) = pointer to device static storage
(a4) = process descriptor pointer
(a6) = system global data pointer
```

Output

None

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

This routine is called when a device is no longer in use in the system (see `I$Detach`).

The `TERM` routine must:

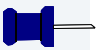
Step 1. Copy the process ID from the process descriptor (`P$ID`) into `V_BUSY` and `V_LPRC`.

Step 2. Determine if the output FIFO buffer contains any data waiting to be written. If so, the driver should suspend itself by copying its process ID from `V_BUSY` to `V_WAKE` and performing an `F$Sleep` service request to put itself to sleep indefinitely.

If the driver awakens before the output FIFO has emptied (due to a signal), the driver should suspend itself again until the buffer is empty.

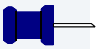
Step 3. After the pending output data has been written, the driver should disable hardware handshake protocols and then disable all device interrupts, if the driver is interrupt-driven. The device should then be removed from the system's IRQ polling table (`F$IRQ` or `F$FIRQ`), if applicable.

Step 4. Return any buffers the driver has requested on behalf of itself.



Note

The driver should not attempt to return buffers within its defined static storage area. IOMAN releases this memory when the `TERM` routine completes.



Note

If an error occurs during the device's `INIT` routine, IOMAN calls the `TERM` routine to allow the driver to clean up. If the `TERM` routine uses static storage variables (for example, interrupt mask values, dynamic buffer pointers), it should validate these variables prior to using them. The `INIT` routine may not have set up all the variables prior to exiting with the error.

Input

```
d0.b = character to write
(a1) = address of the path descriptor
(a2) = address of device static storage
(a4) = process descriptor pointer
(a5) = caller's register stack pointer
(a6) = system global data pointer
```

Output

None

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

The `WRITE` routine writes a character. Depending upon whether or not the routine is interrupt-driven, `WRITE` typically operates as follows:

Polled I/O Mode

A polled I/O driver checks the hardware for *ready-to-transmit*. When ready, the character is written to the hardware and the driver returns to SCF without an error.

Interrupt I/O Mode

For interrupt-driven drivers, `WRITE` attempts to put the character into the driver's output FIFO buffer and then ensures output interrupts are enabled. The driver's output interrupt service routine empties the output FIFO. `WRITE` operates as follows:

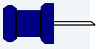
Step 1. Determine if space is available in the output FIFO buffer. If not, the device driver should suspend itself by copying its process ID from `V_BUSY` to `V_WAKE` and then performing a `F$Sleep` service request to put itself to sleep indefinitely.

When the driver awakens, either space is available in the output FIFO or a signal occurred. If a signal occurred, either the signal value is in `P$Signal` (process descriptor) or the process is condemned (condemn bit set in `P$State`). If the process is condemned or the signal value is deadly to I/O (less than `S$Deadly`), the driver should return immediately to `SCF` with the carry bit set and the signal code (if any) as the error code.

Step 2. Put the character into the output FIFO buffer.

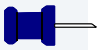
Step 3. Determine if output interrupts are currently enabled. If so, this implies output is currently active (using the output IRQ service routine) and the driver can simply return to SCF without an error.

Step 4. If output interrupts are disabled, then output is halted due to software handshaking (`V_XOFF` received from distant end) or a previously empty output FIFO. If output is halted due to software handshaking, the driver should return to SCF without an error. Otherwise, the driver should enable output interrupts on the device (allowing the output interrupt service routine to empty the output FIFO) and return to SCF without an error.



Note

Data buffers for queueing data between the main driver and the IRQ service routine are *not* automatically allocated by SCF. They should be defined in the device driver's static storage area (`vsect`) or allocated dynamically by the driver (for example, at `INIT` call).



Note

Typically, this routine should ensure output interrupts are enabled only when necessary. After an output interrupt is generated, the IRQ service routine continues to transmit data until the output FIFO is empty and then it typically disables the device's *ready-to-transmit* interrupts.

This dynamic enabling/disabling of the device's transmit interrupts is essential to some serial devices, as the *transmit ready* interrupt is generated every *character period* (at the device's baud rate), regardless of whether a character is actually transmitted. Avoid this type of situation, because it leads to excessive and unnecessary overhead to the system.

Chapter 4: Sequential Block File Manager (SBF)

This chapter explains how to use the SBF manager to process I/O service requests to sequential block-oriented mass storage devices. It includes the following topics:

- **SBF General Description**
- **SBF Device Descriptor Modules**
- **SBF Path Descriptor Definitions**
- **SBF Device Drivers**

RadiSys.

MICROWARE SOFTWARE

SBF General Description

The Sequential Block File Manager (SBF) is a re-entrant subroutine package for I/O service requests to sequential block-oriented mass storage devices, such as tape systems. SBF can handle any number or type of such systems simultaneously.

The following I/O service requests are handled by SBF:

Table 4-1 SBF I/O Service Requests

I$Close	I$Create	I$GetStt	I$Open
I$Read	I$ReadLn	I$SetStt	I$Write
I$Writln			

The following I/O service requests are not valid for SBF:

Table 4-2 Invalid-SBF I/O Service Requests

I$ChgDir	I$Delete	I$MakDir	I$Seek

When one of these service requests is made to SBF, an appropriate error code is returned.

The following I/O service requests do not call SBF:

Table 4-3 Non-SBF I/O Service Requests

I$Attach	I$Detach	I$Dup

SBF is designed to support both buffered and unbuffered I/O. It is capable of handling variable logical block sizes. SBF has no knowledge of the media's physical block size, and the driver is responsible for translating the

logical block requests by SBF into the media's physical block requests. The logical block size for an SBF device is defined in the PD_BlkSiz field of the path descriptor.

Unbuffered I/O

Unbuffered I/O is used when the PD_NumBlk field of the path descriptor is set to 0.

When operating in unbuffered mode, SBF uses a single buffer for I$ReadLn and I$Writln calls. I$Read and I$Write calls do not use an intermediate buffer, and the data is transferred directly between the caller's data buffer and the driver.

Unbuffered I/O operates synchronously with the requesting process. The process makes a read or write request and SBF returns to the caller when the I/O operation has completed.

Buffered I/O

Buffered I/O is used when the PD_NumBlk field of the path descriptor is set to a positive number. All buffered I/O is initiated asynchronously by an auxiliary process created by SBF. SBF uses a *pool* of buffers to accomplish this. The maximum number of buffers to use is specified by the PD_NumBlk field of the path descriptor. The size of each buffer is specified by the PD_BlkSiz field of the path descriptor.

I$Read requests cause SBF to copy data from the buffer pool. If a full buffer is not yet available, SBF allocates a new buffer and passes it to the auxiliary process. SBF then waits for the auxiliary process to return the buffer containing the next block. Multiple buffers (up to the number specified by PD_NumBlk) may be allocated, thus allowing SBF to copy data from one buffer while the auxiliary process reads data into others.

I$Write requests cause SBF to copy data into a buffer and return to the user immediately. When a buffer fills, SBF passes it to the auxiliary process for writing. If another buffer is required before the auxiliary process has had

time to write the previous buffer, SBF allocates a new buffer and copies data to it. This allows SBF to copy data into one buffer while the auxiliary process writes from others.

Considerations When Writing to Tapes

When an SBF path is opened, any I/O operations may be done on the path. However, after an `I$Write` call is made, SBF flags the path as *in write mode* and does not allow any `I$Read` calls until an `I$SetStt` call is made. Typically, when writing a tape, an `I$Close` call follows an `I$Write` call and SBF performs its normal close processing. When an `I$SetStt` call follows an `I$Write` call, SBF waits for any pending writes to complete, clears the write mode flag, and performs the `I$SetStt`. It is recommended `I$SetStt` writes one or more filemarks, to ensure a filemark follows the data written.

End-Of-Tape Processing

There is no *end-of-tape* error on `Read` requests. Consequently, SBF requires an end-of-file mark to be present or the user process to handle the situation (to know the size of the file or use an end-of-data record).

`I$Write` requests return a media full error (`E$Full`) when end-of-tape is reached. All prior writes have completed; no other data may be written other than filemarks after the end-of-tape has been reached.

SBF I/O Service Requests

When a process makes one of the following system calls to an SBF device, SBF executes the file manager functions described for that call.

I$Close

SBF performs the following functions:

- If the use count for the path is:
  - non-zero (other processes are still using this path), SBF does not return an error.
  - zero, SBF determines if the path is in write mode. If so, SBF calls the device driver to write two filemarks to the tape.
- If the path is in write mode and the `f_eras_b` flag is set in the `PD_Flags` field of the path descriptor, SBF calls the device driver to erase to the end of the tape.
- If the `f_rest_b` flag is set in `PD_Flags`, SBF calls the device driver to rewind the tape. If the path is in write mode and `f_rest_b` is not set, SBF calls the device driver to skip back one filemark. This positions the tape between the two filemarks just written.
- If the `f_offl_b` flag is set in `PD_Flags`, SBF calls the device driver to take the tape drive off-line.
- Any buffers associated with the path are returned to the system.

I$Create

SBF considers `I$Create` to be synonymous with `I$Open`.

I$GetStt

Refer to the `I$GetStt` description in the ***OS-9 for 68K Technical Manual*** for a detailed explanation of the SBF-supported `I$GetStt` functions:

`SS_Ready`	Test for data ready.
`SS_EOF`	Check for end of file condition.

All other `GetStat` calls are passed to the driver.

I$Open

SBF performs the following functions:

- Validates the pathname.
- Verifies the drive number (`PD_TDrv`) is legal for the device driver (`SBF_NDRV`).
- Initializes path descriptor variables.
- Creates the auxiliary process for the driver (`SBF_DPrc`), if required.

I$Read

SBF calls the driver as needed to read the data. Complete blocks of data are transferred directly to the user's buffer while incomplete blocks are transferred into SBF's buffer. The portion of the data requested by the calling process is copied into the calling process' buffer. If buffers are required for the read (for example, buffered I/O mode), these are allocated as required.

I$ReadLn

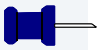
`I$ReadLn` is similar to `I$Read`, except SBF stops the read if an end-of-record character (carriage return) is found. `I$ReadLn` requests always transfer the data through an intermediate SBF buffer.

I$SetStt

Refer to the `I$SetStt` description in the ***OS-9 for 68K Technical Manual*** for a detailed explanation of the SBF-supported `I$SetStt` functions.

`SS_Opt`	Write the path descriptor options.

All other `SetStat` calls are passed to the driver. If the block size (`PD_BlkSiz`) has changed, SBF ensures all current buffers are flushed prior to calling the device driver.



Note

Only SS_Opt is passed to the driver after processing by SBF. If an unknown service request error (E$UnkSvc) is returned by the driver, it is ignored.

I$Write

SBF calls the driver as needed to transfer the data as follows:

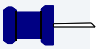
Buffered I/O	SBF copies the user's data into the next free buffer in the SBF buffer pool. The user process is reactivated immediately. As each buffer fills (PD_BlkSiz), SBF calls the driver to write the data when the driver is available.
Unbuffered I/O	SBF calls the driver with the data pointer pointing to the user's data buffer. The driver writes the data to tape; the user process is reactivated when the driver completes the write operation.

I$WritIn

I$Writln is similar to I$Write, except SBF only writes data up to and including the first end-of-record character (carriage return), if there is one in the calling process's buffer. If no end-of-record character is found, SBF writes the amount of data specified by the calling process. I$Writln requests always transfer the data through an intermediate SBF buffer.

SBF Device Descriptor Modules

This section describes the definitions of the initialization table contained in device descriptor modules for SBF devices. The initialization table immediately follows the standard device descriptor module header fields. The size of the table is defined in the `M$Opt` field.



Note

In this table the offset values are the device descriptor offsets, while the labels are the path descriptor offsets. To correctly access these offsets in a device descriptor using the path descriptor labels, make the following adjustment:

```
(M$DTyp - PD_OPT)
```

For example, to access the tape drive number in a device descriptor, use the following value:

```
PD_TDrv + (M$DTyp - PD_OPT)
```

To access the tape drive number in the path descriptor, use `PD_TDrv`. Module offsets are resolved in assembly code by using the names shown here and linking with the relocatable library: `sys.l` or `usr.l`.

Table 4-4 Device Descriptor Offset and Path Descriptor Label

Device Descriptor Offset	Path Descriptor Label	Description
$48	PD_DTP	Device Type
$49	PD_TDrv	Tape Drive Number
$4A	PD_SBF	Reserved
$4B	PD_NumBlk	Maximum Number of Blocks to Allocate
$4C	PD_BlkSiz	Logical Block Size
$50	PD_Prior	Driver Process Priority
$52	PD_SBFFlags	SBF Path Flags
$53	PD_DrivFlag	Driver Flags
$54	PD_DMAMode	Direct Memory Access Mode
$56	PD_ScsiID	SCSI Controller ID
$57	PD_ScsiLUN	LUN on SCSI Controller
$58	PD_ScsiOpts	SCSI Options Flags

Table 4-5 Path Descriptors and Descriptions

Name	Description
PD_DTP	*Device class* This field is set to three for SBF devices.
PD_TDrv	*Tape Drive number* Used to associate a one-byte integer with each drive a controller handles. If using dedicated (for example, non-SCSI bus) controllers, this field usually defines both the logical and physical drive number of the tape drive. If using tape drives connected to SCSI controllers, this number defines the logical number of the tape drive to the device driver. The physical controller ID and LUN are specified by the PD_ScsiID and PD_ScsiLUN fields. Each controller's drives should be numbered 0 to n-1 (n is the maximum number of drives the controller can handle). This number also defines how many drive tables are required by the driver and SBF. SBF verifies this number against SBF_NDRV prior to calling the driver.
PD_NumBlk	*Number of Buffers/Blocks Used For Buffering* Specifies the maximum number of buffers allocated by SBF for use by the auxiliary process in buffered I/O. If this field is set to 0, unbuffered I/O is specified.

Table 4-5 Path Descriptors and Descriptions (continued)

Name	Description
PD_BlkSiz	*Logical Block Size Used For I/O* Specifies the size of the buffer allocated by SBF. This buffer size is used when allocating multiple buffers used in buffered I/O. Unless the driver manages partial physical blocks, this size should be an integer multiple of the physical tape block size.
PD_Prior	*Driver Process Priority* The priority at which SBF's auxiliary process run. This value is used during initialization. Changing this value after initialization has no effect.
PD_SBFFlags	*SBF Path Flags* Specifies the actions SBF takes when the path is closed. A user can update this field using GetStat/SetStat (SS_Opt). SBF supports the following flag definitions: bit 0: (f_rest_b) 0 = No rewind on close. 1 = Rewind on close. bit 1: (f_offl_b) 0 = Do not put drive off-line on close. 1 = Put drive off-line on close. bit 2: (f_eras_b) 0 = Do not erase to end-of-tape on close. 1 = Erase to end-of-tape on close.

Table 4-5 Path Descriptors and Descriptions (continued)

Name	Description
PD_DrivFlag	***SBF Driver Flag*** This field is available for use by the driver. **NOTE:** References to these flags are often made using the PD_Flags offset (defined in sys.l and usr.l). This reference is equivalent to PD_SBFFlags. References to PD_DrivFlag should use a value of PD_Flags + 1.
PD_DMAMode	*Direct Memory Access Mode* This field is hardware specific. If available, you can use this word to specify the DMA Mode of the driver.
PD_ScsiID	*SCSI Controller ID* This is the ID number of the SCSI controller attached to the device. The driver uses this number when communicating with the controller.

Table 4-5 Path Descriptors and Descriptions (continued)

Name	Description
PD_ScsiLUN	*Logical Unit Number of SCSI Device* This number is the value to use in the SCSI command block to identify the logical unit on the SCSI controller. This number may be different from PD_TDrv to eliminate allocation of unused drive table storage. PD_TDrv indicates the logical number of the drive to the driver and SBF (drive table to use). PD_ScsiLUN is the physical drive number on the controller.
PD_ScsiOpts	*SCSI Driver Options Flags* This field allows SCSI device options and operation modes to be specified. It is the driver's responsibility to use or reject these if applicable: bit 0: 0 = ATN not asserted (no disconnects allowed). 1 = ATN asserted (disconnects allowed). bit 1: 0 = Device cannot operate as a target. 1 = Device can operate as a target. bit 2: 0 = asynchronous data transfers. 1 = synchronous data transfers. bit 3: 0 = parity off. 1 = parity on. All other bits are reserved.

SBF Path Descriptor Definitions

The reserved section (PD_OPT) of the path descriptor used by SBF is copied directly from the initialization table of the device descriptor. The following table is provided to show the offsets used in the path descriptor. For a full explanation of the path descriptor fields, refer to the previous pages.

Table 4-6 SBF Path Descriptors and Descriptions

Offset	Name	Description
$80	PD_DTP	Device Type
$81	PD_TDrv	Tape Drive Number
$82	PD_SBF	Reserved
$83	PD_NumBlk	Maximum Number of Blocks to Allocate
$84	PD_BlkSiz	Logical Block Size
$88	PD_Prior	Driver Process Priority
$8A	PD_SBFFlags*	SBF Path Flags
$8B	PD_DrivFlag*	Driver Flags
$8C	PD_DMAMode	Direct Memory Access Mode
$8E	PD_ScsiID	SCSI Controller ID
$8F	PD_ScsiLUN	LUN on SCSI controller
$90	PD_ScsiOpts	SCSI Options Flags

* References to these flags are often made using the `PD_Flags` offset (defined in `sys.l` and `usr.l`). This reference is equivalent to `PD_SBFFlags`. References to `PD_DrivFlag` should use a value of `PD_Flags + 1`.

Offset refers to the location of a path descriptor field relative to the starting address of the path descriptor. Path descriptor offsets are resolved in assembly code by using the names shown here and linking the module with the relocatable library: `sys.l` or `usr.l`.

SBF Device Drivers

SBF device drivers are designed to support any sequential storage device that reads and writes data in fixed or variable size blocks (tapes).

Because SBF is intended for sequentially accessed files, it does not support a directory structure or provide a byte-oriented file positioning mechanism. Consequently, `I$Makdir`, `I$ChgDir`, `I$Delete`, and `I$Seek` return the error `E$UnkSvc`.

Read and write calls to the driver are made by SBF in terms of logical blocks. The logical block size is specified in the `PD_BlkSiz` field of the path descriptor. The driver is responsible for translating the block request into the appropriate number of physical media blocks. If a *partial* physical block results from this translation, drivers must either buffer the partial block or return an error.

`GetStat` calls are passed straight to the driver, with the exception of `SS_EOF` and `SS_Ready`, which are handled by SBF. Typical drivers ignore all GetStat calls and return an unknown service request error (`E$UnkSvc`).

`SetStat` calls are passed straight to the driver, with the exception of `SS_Opt`. SBF determines if the buffer size has changed, and if so, flushes any pending buffers to tape prior to calling the driver. SetStat calls to the driver are used for control and positioning operations (for example, write filemark, rewind tape) on the media. These calls can originate from the user or from SBF internal operations (for example, write filemark when file closed).

Sensing the End-of-Tape

All tape drives can sense the physical end-of-tape (EOT). Many drives also provide an *early* EOT warning. The type of warning(s) provided by the drive determines whether or not buffered I/O (`PD_NumBlk`) is usable, as follows:

- **Early EOT Warning**
- **Physical EOT Warning**

Early EOT Warning

Drives providing an early EOT capability notify the driver of the EOT condition prior to reaching the end of the physical tape. The amount of tape between the early EOT mark and physical tape end varies among drive models; however, typical drives allow about 1000 physical blocks to be written after the early EOT warning.

When a driver that is writing blocks encounters the early EOT warning, it should write the blocks to the tape and return a media full error (`E$Full`). If the device is using buffered I/O, subsequent write calls may still be made by SBF to the driver to flush all currently buffered blocks to the tape. The driver should not refuse these write requests: it should continue to write the data to tape and continue returning `E$Full`.

The driver should maintain this mode of operation until a *control* operation occurs (for example, write filemark or rewind), at which time the driver can clear its EOT status. This technique of writing all currently buffered blocks to tape ensures the application knows which blocks are on which tape.

When setting up the device descriptors block size (`PD_BlkSiz`) and buffer count (`PD_NumBlk`), you should ensure there is enough room on the tape after the early EOT mark to accommodate the total amount of data that could be buffered (`PD_NumBlk * PD_BlkSiz`).

Drives providing early EOT warning can operate in buffered or unbuffered I/O mode.

Physical EOT Warning

Drives that only provide a physical EOT warning notify the driver when the actual end-of-tape is about to be reached. There is sufficient tape remaining to allow the last write to complete and a filemark to be written. No additional blocks can be written to the tape.

You can only operate physical EOT devices in unbuffered I/O mode, because there is no guarantee you can write SBF-buffered blocks to tape after the physical EOT is detected. When the driver detects EOT, it should ensure the last write has completed and return a media full error (`E$Full`). The next access to the driver is typically a write filemark operation and rewind.

Tape Positioning Operations

`SetStat` functions are available to allow tape positioning operations. These calls allow the driver to skip forward or backward on the tape, using a specified block or filemark count.

Depending upon the capabilities of the tape drive in use, reverse tape movement may require driver assistance. If the tape drive supports reverse movement, the driver simply hands the count to the drive. If the tape drive only supports forward movement, the driver has to maintain counters for the current filemark and block position on the tape. The driver must use movement commands supported by the tape drive to simulate reverse movement. For example, if the tape's current position is filemark #2, block #20, then a request to move back five blocks would (typically) be simulated by:

1. Rewind tape
2. Skip forward two filemarks
3. Skip forward 15 blocks

When this situation is in effect, drivers maintain these tape position counters in an external module (for example, data module), so the counters are not erased when the device is attached and detached. The `INIT` routine attempts to create and link to the module, while the `TERM` routine unlinks the module.

Some tape motion commands (for example, rewind, skip blocks, retension) may take a long time. When using SCSI tape drives, these types of functions can busy the SCSI bus to other users for excessive lengths of time. To improve this situation, drivers should follow these guidelines:

- If possible, set the *immediate return* flag in the SCSI command packet, to enable the tape drive to return status without waiting for motion to complete.
- If possible, implement disconnect/reconnect, to enable the tape drive to release the bus during long motion functions, allowing other SCSI activity (such as disk accesses) to occur.

Tape Streaming

Tape *streaming* is achieved when the process and driver are able to send/receive data to/from the tape device at a rate equal to or faster than the tape drive's data I/O rate. The tape drive can keep the tape in motion continuously, thus achieving the minimum data transfer time. If the data rate falls below this threshold, the tape drive has to perform stop-motion/reverse/start-motion functions whenever it has to wait for the process/driver to issue the next I/O request. This stop/start motion can significantly increase the time it takes for the overall tape operations.

To achieve maximum streaming on tapes, drivers should follow these guidelines:

- Use buffered I/O (`PD_NumBlk`) on tape drives supporting early EOT detection.
- Set the logical block size (`PD_BlkSiz`) to the size of the tape drive's internal buffer (typical tape drives have an internal buffer to assist streaming).
- If the tape drive supports *immediate returns* on writes, turn this function on. Immediate returns allow the tape drive's controller to indicate *command complete* to the driver when the data is in the controller's internal buffer, but prior to writing the data to physical tape. The controller then begins writing to tape while SBF is preparing for the next write.
- On SCSI-based systems, implement disconnect/reconnect if possible, so tape operations minimize SCSI bus occupancy. This allows situations such as SCSI-disk to SCSI-tape backups to achieve maximum overlaps of disk/tape activity.

SBF Device Driver Storage Definitions

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

IOMan allocates a static storage area for each device (which may control several drives). The size of the storage area is given in the device driver module header (M$Mem). Some of this storage area is required by IOMan and SBF; the device driver may use the remainder in any manner. Information on device driver static storage required by the operating system can be found in the sbfdev.d DEFS files. Static storage is used as follows.

Note

Offset refers to the location of a static storage field relative to the starting address of the static storage. Offsets are resolved in assembly code by using the names shown here and linking the module with the relocatable library: sys.l.

Table 4-7 SBF Device Drivers and Static Storage

Offset	Name	Maintained By	Description
$00	V_PORT	IOMan	Device base address
$04	V_LPRC	IOMan	Last active process ID
$06	V_BUSY	File Manager	Active process ID
$08	V_WAKE	Driver	Process ID to awaken
$0A	V_Paths	IOMan	Linked list of open paths
$0E			Reserved
$30	SBF_NDRV	Driver	Number of drives
$32	SBF_Flag	File Manager	Driver flags

Table 4-7 SBF Device Drivers and Static Storage (continued)

Offset	Name	Maintained By	Description
$34	SBF_Drvr	File Manager	Driver module pointer
$38	SBF_DPrc	File Manager	Driver process pointer
$3C	SBF_IPrc	Driver	Interrupt process pointer
$40			Reserved
$80			Drive tables begin

Table 4-8 SBF Device Drivers and Descriptions

Name	Description
V_PORT	*Device Port Address* Contains the device's physical port address. It is copied from M$Port in the device descriptor when the device is attached by IOMan.
V_LPRC	*Last Active Process ID* Contains the process ID of the last process to use the device. While this field is required for all static storage by IOMan, it is not used by SBF.

Table 4-8 SBF Device Drivers and Descriptions (continued)

Name	Description
V_BUSY	*Current Active Process* The process ID of the process currently using the device. It is used to implement I/O blocking by SBF. This field is also used by interrupt drivers when they wish to suspend themselves, by copying V_BUSY to V_WAKE (prior to suspending themselves). A value of 0 indicates the device is not busy.
V_WAKE	*Process ID to Awaken* The process ID of any process waiting for the device to complete I/O. A value of 0 indicates no process is waiting. The driver sets V_WAKE from V_BUSY. V_WAKE provides the interlock between the driver and the driver's interrupt service routine.
V_PATHS	*Linked List of Open Paths* A singly-linked list of all paths currently open on this device.
SBF_NDRV	*Number of Drives* Contains the number of drives the controller can use. It is defined by the device driver as the maximum number of logical drives with which the controller can work. SBF assumes there is a drive table for each drive. SBF validates the tape drive number (PD_TDrv) against this value to ensure the logical drive number is valid for the driver.
SBF_Flag	*Driver Flags* Contains flags used by SBF to indicate the current state of the path.

Table 4-8 SBF Device Drivers and Descriptions (continued)

Name	Description
SBF_Drvr	*Driver Module Pointer* Contains the pointer to the device driver.
SBF_DPrc	*Driver Process Pointer* Contains the pointer to the process associated with the driver. SBF initializes this when a path is opened to the device. The driver's TERM routine should check this field, and if non-zero, delete the process (F$DelPrc).
SBF_IPrc	*Interrupt Process Pointer (obsolete)* This field is available for the driver to use when the driver wishes to create its own process (for example, interrupt handler process). **NOTE:** Do not confuse this process with the SBF process created for buffered I/O. (See SBF_DPrc.) *Drive Tables* Contains one table per drive the controller handles. SBF assumes there are as many tables as specified in SBF_NDRV.

Device Driver Tables

There must be as many drive tables as specified in SBF_NDRV. The format of each drive table is given below:

Table 4-9 Drive Table Formats

Offset	Name	Maintained By	Description
$00	SBF_DFlg	File Manager	Drive Flag
$02	SBF_NBuf	File Manager	Buffer Count
$04	SBF_IBH	File Manager	Pointer to Head of Input Buffer List
$08	SBF_IBT	File Manager	Pointer to Tail of Input Buffer List
$0C	SBF_OBH	File Manager	Pointer to Head of Output Buffer List
$10	SBF_OBT	File Manager	Pointer to Tail of Output Buffer List
$14	SBF_Wait	File Manager	Pointer to Waiting Process
$18	SBF_SErr	Driver	Number of Recoverable Errors
$1C	SBF_HErr	Driver	Number of Non-Recoverable Errors
$20			Reserved

Table 4-10 Device Driver Tables and Descriptions

Name	Description
SBF_DFlg	*Drive Flag* The high byte of this field contains the current status of the logical drive. The flags are maintained by SBF, and are defined as follows: bit 1: Set if write mode. bit 2: Set if driver servicing this drive. bit 3: Set if EOF (end of file). All other bits and the low byte bits are reserved.
SBF_NBuf	*Buffer Count* Contains the number of buffers currently allocated to the drive.
SBF_IBH	*Pointer to Head of Input Buffer List*
SBF_IBT	*Pointer to Tail of Input Buffer List* These fields contain the head and tail pointers, respectively, of the buffers being returned to SBF by the driver.
SBF_OBH	*Pointer to Head of Output Buffer List*
SBF_OBT	*Pointer to Tail of Output Buffer List* These fields contain the head and tail pointers, respectively, of the buffers being sent to the driver by SBF.

Table 4-10 Device Driver Tables and Descriptions (continued)

Name	Description
SBF_Wait	*User Process' Process Descriptor Pointer* This pointer is set when the user process is suspended, waiting for driver I/O to complete.
SBF_SErr	*Number of Recoverable Errors* This field allows the driver to keep a count of *soft* errors during I/O operations. The value would typically be returned by a SS_ELog GetStat call. After reading this value, it is typically reset to 0.
SBF_HErr	*Number of Non-Recoverable Errors* This field allows the driver to keep a count of *hard* errors during I/O operations. The value would typically be returned by a SS_ELog GetStat call. After reading this value, it is typically reset to 0.

Linking SBF Drivers

After a SBF driver has been assembled into its relocatable object file (ROF), the driver needs to be linked to produce the final driver module. Linking resolves all code references in drivers comprised of several ROF files. It also resolves the external data and static storage references by the driver.

The most important part of linking is to correctly resolve the static storage references. Generally, the static storage area is composed of three sections in this order (see **Figure 4-1**):

1. I/O globals
2. Drive tables (one per logical drive)
3. Driver-declared variables

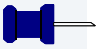
The driver-declared variables are declared in vsect areas of the driver, but they must be allocated after the drive table storage areas. The method used to allocate all of the storage, in the correct order, is to link the `sbfstat.r` library file, ‘n’ instances of `sbfdrvtb.r`, and then the driver vsect. The `sbfstat.r` and `sbfdrvtb.r` files are located in the system’s `LIB` directory.

The following examples show how a driver should be linked. The first link line creates a driver supporting one logical drive, as only one drive table vsect is allocated.

```
l68 /dd/LIB/sbfstat.r /dd/LIB/sbfdrvtb.r
RELS/sbviper.r -O=OBJS/sbviper
```

The second link line creates a driver supporting two logical drives, as two drive table vsects are allocated:

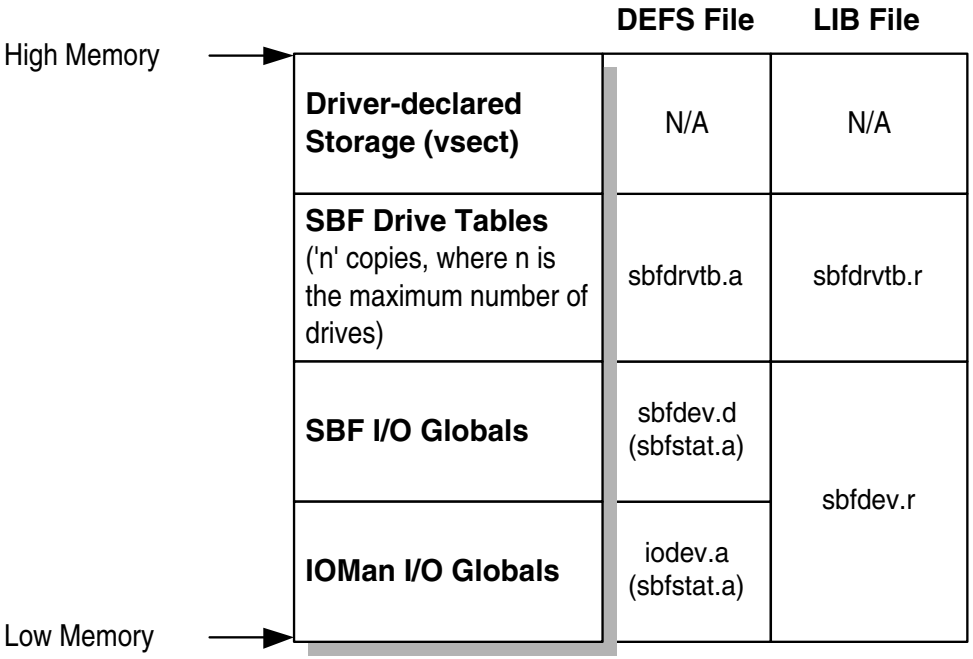
```
l68 /dd/LIB/sbfstat.r /dd/LIB/sbfdrvtb.r
/dd/LIB/sbfdrvtb.r RELS/sbtape.r
     -O=OBJS/sbtape
```



Note

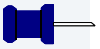
Failure to link the I/O system globals and the correct number of drive tables, and in the correct order, results in erratic driver operation.

Figure 4-1 SBF Static Storage Layout



SBF Device Driver Subroutines

As with all device drivers, SBF device drivers use a standard executable memory module format with a module type of `Drivr` (code `$E0`). SBF drivers are called in system state.



Note

I/O system modules must have the following module attributes:

- They must be owned by a super-user (`0.n`).

- They must have the system-state bit set in the attribute byte of the module header. OS-9 does not currently make use of this, but future revisions may require I/O system modules be system-state modules.

The execution offset address in the module header points to a branch table with seven entries. Each entry is the offset of the corresponding subroutine. The branch table appears as follows:

Table 4-11 Branch Table

Offset Address	Entry	Description
`dc.w`	`INIT`	initialize device
`dc.w`	`READ`	read character
`dc.w`	`WRITE`	write character
`dc.w`	`GETSTAT`	get device status
`dc.w`	`SETSTAT`	set device status
`dc.w`	`TERM`	terminate device
`dc.w`	`TRAP`	handle illegal exception (0 = none)

Each subroutine should exit with the carry bit of the condition code register cleared, if no error occurred. Otherwise, the carry bit should be set and an appropriate error code returned in the least significant word of register `d1.w`.

The `TRAP` entry point is currently not used by the kernel, but in the future will be defined as the offset to error exception handling code. Because no handler mechanism is currently defined, this entry point should be set to `0` to ensure future compatibility.

The following pages describe each subroutine.

Table 4-12 SBF Device Driver Subroutines

Subroutine	Description
GETSTAT/SETSTAT	Get/Set Device Status
INIT	Initialize Device and its Static Storage
IRQ Service Routine	Service Device Interrupts
READ	Read Block(s)
TERM	Terminate Device
WRITE	Write Block(s)

Input

```
d0.w = status code
d2.l = argument count
(a1) = address of the path descriptor
(a2) = address of the device static storage area
(a3) = drive table
(a4) = process descriptor pointer
(a6) = system global data storage pointer
```

Output

Depends on the function code

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

Calls involving parameter passing require the driver to examine or change the register stack variables. These variables contain the contents of the MPU registers at the time the `I$GetStt/I$SetStt` request was made. Parameters passed to the driver are set up by the caller prior to using the service call. Parameters passed back to the caller are available when the service call completes. The register stack image pointer is stored in the path descriptor (`PD_RGS`).

Typical SBF drivers have routines to handle the following I$SetStt codes:

Table 4-13 I$SetStt Codes

Code	Description
SS_Feed	Erase tape
SS_Opt	Write path options section
SS_Reset	Rewind tape
SS_Reten	Retension tape
SS_RFM	Skip past tape mark(s)
SS_Skip	Skip block(s)
SS_SQD	Place drive off-line
SS_WFM	Write tape mark(s)

Usually all I$GetStt codes and other I$SetStt codes return with an unknown service request error (E$UnkSvc).

The following pages describe the driver's role in the implementation of the above I$SetStt calls.

SS_Feed — erases all or part of the tape. The number of blocks to be erased is passed in register d2. If the count is -1, the entire tape is to be erased from the current position to end-of-tape (EOT), otherwise, the specified count of blocks should be written, starting at the current tape position.

The erase routine should:

Step 1. Initialize the drive, if required.

Step 2. Issue the appropriate command to achieve the desired erase function. Many tape devices support a direct *erase* command. If the tape device does not support this feature, the driver should perform *writes* to simulate the desired effect. Once the command is issued, the driver should wait for I/O to complete (with interrupts if possible).

Step 3. Check the status of the I/O command and return any error to SBF.

Step 4. If the driver maintains flags pertaining to current tape position, these should be updated.

Step 5. Return status to SBF.

`SS_Opt` is called when the path descriptor options are changed by the user. Typically, the driver ignores this call.

`SS_Reset` rewinds the tape to beginning-of-tape (BOT). The rewind routine should:

Step 1. Initialize the drive, if required.

Step 2. Issue the appropriate command to the device and wait for I/O to complete (with interrupts, if possible).

Step 3. Check the status of the I/O command and return any error to SBF.

Step 4. If the driver maintains internal flags pertaining to current tape position, they should be reset. Typical flags would be end-of-file and end-of-tape. For drivers counting current filemark/block positions, these counters should also be cleared.

Step 5. Return status to SBF.

SS_Reten	performs a retension pass on the tape. Typically, the tape moves to BOT, moves to EOT, then rewinds to BOT. The sequence of actions for SS_Reten is the same as that for SS_Reset. Retensioning tape media is highly recommended for new media, shipped media, or any media stored for a long period.
SS_RFM	is called when the tape position is to be moved forward or backwards by the specified number of filemarks. (This number is passed in register d2.) If the tape device is incapable of directly skipping backward, the driver has to simulate the reverse movement using rewind and skip forward commands. The sequence of actions for SS_RFM is the same as that for SS_SQD.
SS_Skip	is called when the tape position is to be moved forward or backward the specified number of tape blocks. The number of blocks to skip is passed as a logical block count (PD_BlkSz) in register d2. The driver must translate this count into the media's physical block count. If the tape is incapable of directly skipping backward, it has to simulate the reverse movement using rewind and skip forward commands. The sequence of actions for SS_Skip is the same as that for SS_SQD.
SS_SQD	is called to unload the tape (put the tape device off-line). Depending upon the capabilities of the tape device, this action may turn off the drive-select LED, or unload and eject the media. The unload routine should:

Step 1. Initialize the drive, if required.

Step 2. Issue the appropriate command to the device and wait for I/O to complete (with interrupts, if possible).

Step 3. Check the status of the I/O command and return any error to SBF.

Step 4. If the driver maintains flags pertaining to current tape position, these should be updated.

Step 5. Return status to SBF.

`SS_WFM` is called to write the specified number of filemarks to the tape. (This number is passed in register `d2`.) Applications may place filemarks on the tape as they see fit. The sequence of actions for `SS_WFM` is the same as that for `SS_SQD`.

Input

```
(a1) = address of the device descriptor module
(a2) = address of device static storage
(a4) = process descriptor pointer
(a5) = register's stack pointer
(a6) = system global data pointer
```

Output

None

Error Output

```
cc = carry bit set
d1.w = error code
```

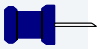
Description

`INIT` does the following:

- Initializes the device's permanent storage. Minimally, this consists of initializing `SBF_NDRV` to the number of drives with which the controller works.
- If the driver maintains flags/variables that must *span* detach/attach sequences (for example, for reverse movement simulation), then the `INIT` routine should create/link to an external module (for example, a data module). The module pointer should then be saved. If the module was created, its storage area should then be initialized.
- Places the IRQ service routine on the IRQ polling list by using the `F$IRQ/F$FIRQ` service requests, if required.
- Initializes device control registers (enable interrupts if necessary).

Prior to being called, the device permanent storage is cleared (set to `0`) except for `V_PORT`, which contains the device address.

If INIT returns an error, it does not have to clean up its operation (for example, remove device from polling table or disable hardware). IOMan calls TERM to allow the driver to clean up INIT's operation before returning to the calling process.



Note

If the INIT routine causes an interrupt to occur, handle the interrupt in one of two ways:

- Process the interrupt directly by masking interrupts to the level of the device, polling/servicing the device hardware, then restoring the previous interrupt level. This is the preferred technique unless the interrupt is time-consuming.
- Allow the interrupt service routine to service the hardware. In this case, the process descriptor contains the process ID (P$ID) to which V_WAKE should be set. You cannot use V_BUSY because it is zero when INIT is called.

Input

```
d0.w = vector offset
(a2) = static storage address
(a3) = port address
(a6) = system global static storage
```

Output

None

Error Output

```
cc = carry set (interrupt not serviced)
```

Description

The IRQ Service Routine does the following:

Step 1. Check the device for a valid interrupt. If the device does not have an interrupt pending, the carry bit must be set and the routine exited with an RTS instruction as quickly as possible. Setting the carry bit signals the kernel that the next device on the vector should have its IRQ service routine called.

Step 2. Service device interrupts.

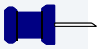
Step 3. Wake up the driver mainline, using the synchronization method of the driver:

Signals	Send a wake-up signal to the process whose process ID is in `V_WAKE`, when the I/O is complete. Also, clear `V_WAKE` as a flag to the mainline program that the IRQ has occurred.
Events	Signal the event that the IRQ has occurred, using the event system's signal function.

Step 4. Clear the carry bit and exit with an RTS instruction after servicing an interrupt.

Avoid exception conditions (for example, a Bus Error) when IRQ service routines are executing. Under the current version of the kernel, an exception in an IRQ service routine crashes the system.

IRQ service routines may destroy the contents of following registers only: `d0`, `d1`, `a0`, `a2`, `a3`, and `a6`. The contents of all other registers must be preserved or unpredictable system errors (system crashes) occur.



Note

The description above assumes you are using the `F$IRQ` system for interrupt servicing. If you are using the Fast Interrupt System (`F$FIRQ`), note the following:

- Input:

```
d0.w = vector offset
(a2) = static storage
(a6) = system global pointer
```

- Only `d0` and (`a2`) can be destroyed.
- Returning carry set causes polling of `F$IRQ` installed devices for the same vector.

Input

```
d0.l = buffer size
(a0) = address of buffer
(a2) = address of device static storage
(a3) = drive table
(a4) = process descriptor pointer
(a6) = system global data storage pointer
```

Output

```
d1.l = block size read
```

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

`READ` does the following:

- Initialize the drive, if required.
- Convert the requested byte-count into the block-count for the media. If the requested count does not specify an integral number of media blocks, the driver returns an error (typical case) or takes steps to buffer the partial block.
- Issue the `READ` command to the device and wait for I/O to complete (using interrupts if possible).
- When the I/O operation is complete, check the status of the `READ`. If a fatal error occurred, return it to SBF.
- If no error, or a non-fatal error occurred, check the amount of data actually read and return that count to SBF.

- Most tape devices terminate a `READ` request when a filemark is encountered. The tape device returns the data from the current position up to the filemark. Thus, the byte-count returned may be less than the requested amount. This is a typical non-fatal error on tape devices.

Input

```
(a1) = address of the device descriptor module
(a2) = address of device static storage area
(a4) = process descriptor pointer
(a6) = system global static storage
```

Output

None

Error Output

```
cc = carry set
d1.w = error code
```

Description

The TERM routine must:

- Wait until any pending I/O has completed.
- Disable the device interrupts.
- Remove the device from the IRQ polling list.
- Kill the driver process created by SBF. If SBF_DPrc is non-zero, this is a pointer to the driver's process descriptor. This process is returned by making a F$DelPrc system call with the process ID from P$ID.
- If the driver maintains flags/variables that must *span* detach/attach sequence, then the TERM routine should unlink any external modules linked to during INIT.

Note

If an error occurs during the device's `INIT` routine, IOMan calls the `TERM` routine to allow the driver to clean up. If the `TERM` routine uses static storage variables (for example, interrupt mask values, dynamic buffer pointers), it should validate these variables prior to using them. The `INIT` routine may not have set up all the variables prior to exiting with the error.

Input

```
d0.l = buffer size
(a0) = address of buffer
(a2) = address of the device static storage area
(a3) = drive table
(a4) = process descriptor pointer
(a6) = system global data storage pointer
```

Output

The buffer is written to tape.

Error Output

```
cc = carry bit set
d1.w = error code
```

Description

`WRITE` does the following:

- Initialize the drive, if required.
- Convert the requested byte-count into the block-count for the media. If the requested count does not specify an integral number of media blocks, then the driver should return an error (typical case) or take steps to buffer the partial block.
- Issue the `WRITE` command to the device and wait for I/O to complete (using interrupts if possible).
- When the I/O operation has completed, check the status of the `WRITE`. If a fatal error occurred, return it to SBF.
- If no error, or a non-fatal error occurred, check the amount of data actually written.

Many tape devices terminate a write request when an early end-of-tape (EOT) is detected. For these types of devices, the data can still be written to tape because the EOT state is a warning there is a small amount of tape remaining. The driver should ensure this write is fully completed, and return a media full error (`E$Full`).

Subsequent write calls should not be refused at this point, as SBF may need to flush its current buffers (if in buffered I/O mode) to the tape. The application is notified of the media full condition on its next write, so it may close the file. When the file closes, SBF issues appropriate `SetStats` (for example, `write filemark`) to finalize tape operation.

If the tape device is one that only detects a physical EOT condition, then the driver should only be operated in unbuffered I/O mode. In this case, the driver should ensure the write invoking the physical EOT condition is written to tape and a media full error (`E$Full`) returned to SBF. No further writes should be presented to the driver, as the application is notified immediately of the media full condition. The application can then close the path, allowing SBF to write the final filemark and finalize tape operation.

Index

Symbols

Numerics

A

B

C

D

E

F

G

H

I

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Product Discrepancy Report

To: Microware Customer Support

FAX: 515-224-1352

From:_____

Company:_____

Phone:_____

Fax:_____Email:_____

Product Name:

Description of Problem:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Host Platform_____

Target Platform_____

RadiSys.

MICROWARE SOFTWARE