AT&T

UNIX® SYSTEM V RELEASE 4

Device Driver Interface/ Driver-Kernel Interface (DDI/DKI) Reference Manual

UNIX Software Operation

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1. INTRODUCTION

1. INTRODUCTION

1 Introduction

About This Document

The *Device Driver Interface/Driver–Kernel Interface Reference Manual* provides reference information needed to write device drivers in the UNIX System V Release 4 environment. It describes two device driver interface specifications: the Device Driver Interface (DDI) and the Driver–Kernel Interface (DKI). Drivers written to conform to one or both of these interfaces are more likely to be portable to other environments. DDI and DKI address different aspects of the compatibility problem—their differences are summarized in Figure 1-1.

Figure 1-1: Scope of DDI and DKI

processor specific routines	DDI only (DxD)	
processor independent routines	DDI and DKI (DxDK)	DKI only (DxK)
	supported after SVR4	supported through SVR4

Each box in Figure 1-1 represents a different set of interfaces. The "DDI only" set (indicated throughout this manual with the D*x*D cross-reference code) are processor specific and are intended to be supported beyond Release 4.0. The DDI described in this manual is specific to the porting base, the 3B2 computer. The "DKI only" set (D*x*K cross-reference code) are processor independent, but are not guaranteed to be supported in the next release.

Most of the routines, functions, and structures described in this manual are part of both DDI and DKI (cross-referenced by D*x*DK). As Figure 1-1 shows, drivers written to conform to both interfaces are portable to all AT&T computers supporting UNIX System V Release 4, and they will be compatible through and beyond Release 4. To understand more completely what is meant by "portable" and "compatible" for DDI and DKI, the scope of each interface must be more thoroughly explained.

The goals of DDI and DKI overlap, and are not in any way mutually exclusive. That is, a driver may be written to conform to both interfaces, increasing the chances that driver code can be ported and can remain compatible with future releases of the operating system.

Porting

Software is usually considered portable if it can be adapted to run in a different environment more cheaply than it can be rewritten. The new environment may include a different processor, operating system, and even the language in which the program is written, if a language translator is available. More often, however, software is ported between environments that share an operating system, processor, and source language. The source code is modified to accommodate the differences in compilers or processors or releases of the operating system.

In the past, device drivers did not port easily for one or more of the following reasons:

- To enhance functionality, members had been added to kernel data structures accessed by drivers, or the sizes of existing members had been redefined.
- The calling or return syntax of kernel functions had changed.
- Driver developers did not use existing kernel functions where available, or relied on undocumented side effects that were not maintained in the next release.
- Processor-specific code had been scattered throughout the driver when it could have been isolated.

Operating systems are periodically reissued to customers as a way to improve performance, fix bugs, and add new features. This is probably the most common threat to compatibility encountered by developers responsible for maintaining software. Another common problem is upgrading hardware. As new hardware is developed, customers occasionally decide to upgrade to faster, more capable computers of the same family. Although they may run the same operating system as those being replaced, processor-specific code may prevent the software from porting.

Scope of Interfaces

Although application programs have all of the porting problems mentioned, developers attempting to port device drivers have special challenges. Before describing the differences between DDI and DKI, it is necessary to understand the position of device drivers in UNIX systems.

Device drivers are kernel modules that control data transferred to and received from peripheral devices. Although drivers are configured into a UNIX system as part of the kernel, they are developed independently from the rest of the kernel. If the goal of achieving complete freedom in modifying the kernel is to be reconciled with the goal of binary compatibility with existing drivers, the interaction between drivers and the kernel must be rigorously regulated. This driver/kernel service interface is the most important of the three distinguishable interfaces for a driver, summarized as follows:

- Driver–Kernel. I/O System calls result in calls to driver entry point routines. These make up the kernel-to-driver part of the service interface, described in Section 2 of this manual. Drivers may call any of the functions described in Section 3. These are the driver-to-kernel part of the interface.
- Driver–Hardware. All drivers (except software drivers) must include an interrupt handling entry point, and may also perform direct memory access (DMA). These, and other hardware-specific interactions make up the driver/hardware interface.
- Driver–Boot/Configuration Software. At boot time, the existence of a driver is made known to the system through information in system files, enabling the system to include the driver. The interaction between the driver and the boot and configuration software is the third interface affecting drivers.

Scope of the Device Driver Interface (DDI)

The primary goal of DDI is to facilitate both source and binary portability across successive releases of UNIX System V on a particular machine. Implicit in this goal is an important fact. Although there is only one DKI, each processor product has its own DDI. Therefore, if a driver is ever to be ported to different hardware, special attention must be paid to the machine-specific routines that make up the "DDI only" part of a driver. These include but are not confined to the driver/hardware interface (as described in the previous section). Some processor-specific functionality also may belong to the driver/kernel interface, and may not be easy to locate.

To achieve the goal of source and binary compatibility, the functions, routines, and structures specified in a DDI must be used according to these rules.

- Drivers cannot access system state structure (for example, u and sysinfo) directly.
- For structures external to the driver that may be accessed directly, only the utility functions provided in Section 3 of this manual should be used. More generally, these functions should be used wherever possible.
- The header file ddi.h must be included at the end of the list of header files. This header file "undefines" several macros that are reimplemented as functions.

Scope of the Driver–Kernel Interface (DKI)

As its name implies, the DKI (Driver–Kernel Interface) is a defined service interface for the entry point routines and utility functions specified for communication between the driver and kernel. It does not encompass the driver/hardware or the driver/boot software interface.

Information is exchanged between the driver and kernel in the form of data structures. The DKI specifies the contents of these structures as well as the calling and return syntax of the entry points and utility functions.

The intent of DKI is to promote source portability across implementations of UNIX System V on different machines, and applies only to System V Release 4. Because DKI applies only to the driver/kernel interface, it must be understood that the sections of driver code affecting the hardware and boot/configuration interfaces may need to be rewritten, and should be isolated in subroutines as much as possible.

NOTE

Certain interfaces documented in the DKI are not part of the DDI. Driver writers should be aware that the use of these interfaces is not guaranteed to be supported beyond System V Release 4.

Interface Members

As noted before, most entry points (Section 2), functions (Section 3), and structures (Section 4) described in this manual belong to both DDI and DKI. Table 1-1 lists the those that are exclusive either to DDI or DKI.

Table 1-1: Exclusive Entry Points, Functions, and Structures

	DDI only	DKI only
Section 2	init, int, size, start	segmap, mmap
Section 3	dma_pageio, etoimajor, getemajor, geteminor, getvec, hdeeqd, hdelog, itoemajor, kvtophys, physiock, vtop	hat_getkpfnum
Section 4	hdedata	None

Audience

This manual is for experienced C programmers responsible for creating, modifying, or maintaining drivers that run on AT&T UNIX System V Release 4 and beyond. It assumes that the reader is familiar with UNIX system internals and the advanced capabilities of the C Programming Language. See the "Related Learning Materials" section for a list of available AT&T documents and courses.

How to Use This Document

This manual is organized into four sections and two appendixes:

- "Section 1: Introduction" introduces the DDI, DKI, and other driver interfaces, lists the notational conventions used in this document, and lists related courses and documents.
- "Section 2: Driver Entry Points" contains reference pages for all driver entry point routines.
- "Section 3: Kernel Functions" contains reference pages for all driver functions used in DDI/DKI drivers.
- "Section 4: Data Structures" contains reference pages for structures used in DDI/DKI drivers.
- "Appendix A: Error Codes" contains a list of the error codes that are appropriate for use in DDI/DKI drivers.
- "Appendix B: Migration from Release 3.2 to Release 4.0" describes the changes to DDI/DKI between Release 3.2 and Release 4.0 of System V.

Organization of Driver Reference Manuals

Driver reference manual pages are similar to those in the *Programmer's Reference Manual*, with the page name followed by a section number in parentheses. All driver reference manual entries begin with a "D" to distinguish them as driver reference pages.

Currently, the reference pages for the different interfaces are published in separate volumes. Each manual contains three sections:

D2	driver entry points
D3	kernel functions used by drivers
D4	system data structures accessed by drivers

Each section number is suffixed with a letter indicating the interfaces covered. The suffixes used are:

D	Device Driver Interface (DDI)
K	Driver–Kernel Interface (DKI)
DK	DDI and DKI
I	SCSI Device Interface (SDI)
P	Portable Device Interface (PDI)
X	Block and Character Interface (BCI)

For example, open(D2DK) refers to the open entry point routine for a driver, not to the open(2) system call documented in the *Programmer's Reference Manual*.

Conventions Used in This Document

Table 1-2 lists the textual conventions used in this book.

Table 1-2: Textual Conventions Used in This Book

Item	Style	Example
C Reserved Words	`Constant Width`	`typedef`
C `typedef` Declarations	`Constant Width`	`caddr_t`
Driver Routines	`Constant Width`	open routine
Error Values	`Constant Width`	`EINTR`
File Names	`Constant Width`	`sys/conf.h`
Flag Names	`Constant Width`	`B_WRITE`
Kernel Macros	`Constant Width`	`minor`
Kernel Functions	`Constant Width`	`ttopen`
Kernel Function Arguments	*Italics*	*bp*
Structure Members	`Constant Width`	`b_addr`
Structure Names	`Constant Width`	`buf` structure
Symbolic Constants	`Constant Width`	`NULL`
System Calls	`Constant Width`	`ioctl`(2)
C Library Calls	`Constant Width`	`printf`(3S)
Shell Commands	`Constant Width`	`layers`(1)
User-Defined Variable	*Italics*	*prefix*`close`

Related Learning Materials

AT&T provides a number of documents and courses to support users of our systems. For a listing see:

AT&T Computer Systems Documentation Catalog (300-000)
AT&T Computer Systems Education Catalog (300-002)

Documentation

Most documents listed here are available from the AT&T Customer Information Center. Refer to the six-digit select code (in parentheses, following the document title) when ordering.

If ordering by telephone, use the following numbers:

1-800-432-6600 (toll free within the continental United States)
1-317-352-8557 (outside the continental United States)

In addition to AT&T documents, the following list includes some commercially available documents that are relevant.

Driver Development

The *UNIX System V and V/386, Release 3, Block and Character Interface (BCI) Development Guide*(307-191) discusses driver development concepts, debugging, performance, installation, and other related driver topics for UNIX System V Release 3.

The *UNIX System V and V/386, Release 3, Block and Character Interface (BCI) Driver Reference Manual* (307-192) includes UNIX System V Rlease 3 reference material to be used in conjunction with the above manual. It describes driver entry point routines (Section D2X), kernel-level functions used in BCI drivers (Section D3X), and data structures accessed by BCI drivers (Section D4X).

The *UNIX System V PDI Driver Design Reference Manual* (305-014) defines the kernel functions and data structures used for Portable Driver Interface (PDI) drivers.

The *UNIX System V SCSI Driver Interface (SDI), Driver Design Reference Manual* (305-009) defines the kernel functions and data structures used for SDI drivers.

STREAMS

The *Programmer's Guide: STREAMS* tells how to write drivers and access devices that use the STREAMS driver interface for character access.

C Programming Language and General Programming

Bentley, Jon Louis, *Writing Efficient Programs* (320-004), Englewood Cliffs, New Jersey: Prentice-Hall, 1982, gives hints for coding practices that improve process performance. Many of these ideas can be applied to driver code.

Kernighan, B. and D. Ritchie, *C Programming Language, Second Edition* (307-136), Englewood Cliffs, New Jersey: Prentice-Hall, 1988, defines the functions, structures, and interfaces of the C Programming Language. A short tutorial is included.

Lapin, J. E., *Portable C and UNIX System Programming*, Englewood Cliffs, New Jersey: Prentice-Hall, 1987, discusses how to maximize the portability of C language programs.

The *Programmer's Guide: Networking Interfaces* provides detailed information, with examples, on the Section 3N library that comprises the UNIX system Transport Level Interface (TLI).

The *Programmer's Guide: ANSI C and Programming Support Tools* includes instructions on using a number of UNIX utilities, including make and SCCS.

Assembly Language

The *AT&T 3B2/3B5/3B15 Computers Assembly Language Programming Manual* (305-000) describes the Assembly Language instructions used by AT&T 3B2, 3B15 and 3B4000 computers.

WE 32100 Microprocessor Information Manual, Maxicomputing in Microspace (307-730) introduces the WE 32100 microprocessor and summarizes its available support products.

Operating System

Bach, Maurice J., *Design of the UNIX Operating System* (320-044), Englewood Cliffs, New Jersey: Prentice-Hall, 1986, discusses the internals of the UNIX operating system, and includes an explanation of how drivers relate to the rest of the kernel.

The UNIX System V reference manuals are the standard reference materials for the UNIX operating system. This information is organized into three books, published separately for each system:

- The *System Administrator's Reference Manual* includes information on administrative commands (Section 1M), special device files (Section 7), and system-specific maintenance commands (Section 8).
- The *Programmer's Reference Manual* includes information on programming commands (Section 1), system calls (Section 2), library routines (Section 3), file formats (Section 4), and miscellaneous topics (Section 5).
- The *User's Reference Manual* includes information on UNIX system user-level commands (Section 1).

Software Packaging

The *Programmer's Guide: System Services and Application Packaging Tools* describes how to write the scripts necessary to install a driver (or other software) under the System Administration utility.

Training

The following courses are of particular interest to driver writers. To register for a class:

- Within the continental United States, call 1-800-TRAINER.
- Within Canada, call 1-800-221-1647.
- Outside the continental United States, call 1-201-953-7554.

C Language for Experienced Programmers (UC1001) is a thorough, formal introduction to the C Programming Language.

Internal UNIX System Calls and Libraries Using C Language (UC1011) is an introduction to UNIX application programming in C. Topics include the execution environment, memory management, input/output, record and file locking, process generation, and interprocess communication (IPC).

UNIX System V Release 4 Device Drivers(UC1056) explores device driver mechanisms, operating system supplied functions, device driver source code examples, installation procedures and debugging techniques. Character, STREAMS, and block devices are covered as well as the entire I/O subsystem.

UNIX System V Release 4 Internals (UC1057) presents an in-depth look at UNIX System V, Release 4, including the process, file and I/O subsystems. New UNIX System V Release 4 concepts such as Network File Sharing (NFS), fast file system, and virtual file systems (VFS) are also reviewed.

Internal System Calls and Libraries (Part 1) (UC1058) presents the C language programmer's interface to UNIX System V Release 4. This course covers those system calls and library functions not pertaining to interprocess communication. Interprocess communication system calls and library functions are covered in Part 2 of this course.

Internal System Calls and Libraries (Part 2) (UC1059) presents UNIX System V Release 4 system calls and library functions pertaining to interprocess communication.

2. DRIVER ENTRY POINTS (D2)

2. DRIVER ENTRY POINTS (D2)

2 Driver Entry Points (D2)

Introduction

This chapter describes the DDI/DKI, DDI-only, and DKI-only entry-point routines a developer may include in a device driver. These are called entry-point routines because they provide the calling and return syntax from the kernel into the driver. For all driver types, these routines are called in response to system calls, when the computer is started, when a device generates an interrupt, or for STREAMS drivers, in response to STREAMS events.

All driver routines common to both DDI and DKI are identified with the (D2DK) cross reference code. All DDI-only or DKI-only routines are identified with the (D2D) or (D2K) reference codes respectively.

Functions provided to allow the driver to communicate with the kernel are described in section 3, and use the (D3DK), (D3D), and (D3K) cross reference codes.

In this section, reference pages contain the following headings:

- NAME describes the routine's purpose.
- SYNOPSIS summarizes the routine's calling and return syntax.
- ARGUMENTS describes each of the routine's arguments.
- DESCRIPTION provides general information about the routine.
- DEPENDENCIES lists possible dependent routine conditions.
- SEE ALSO gives sources for further information.

Overview of Driver Entry-Point Routines and Naming Conventions

Each driver is organized into two parts: the base level and the interrupt level. The base level interacts with the kernel and the user program; the interrupt level interacts with the device.

To uniquely identify a driver, a prefix string is added to the driver routine names. The prefix is defined in the driver's master file. For a driver with the *pre* prefix, the driver code may contain routines named *pre*_open, *pre*_close, *pre*_init, *pre*_int, and so forth. All global variables associated with the driver should also use the same prefix.

System routines can call subroutines that are assigned names by the driver writer. Subroutines should be declared as static, and should also use the driver prefix to increase code readability.

Table 2-1 summarizes the STREAMS driver entry points described in this section. These entry points may be used in either DDI or DKI.

Table 2-1: STREAMS Driver Entry Point Summary

Routine	Description
put	receive messages from the preceding queue
srv	service queued messages

Table 2-2 summarizes the block I/O driver entry points described in this section. These entry points may be used in either DDI or DKI, except as noted.

Table 2-2: Driver Entry Points not Specific to STREAMS

Routine	Description	Type
`chpoll`	poll entry point for a non-STREAMS character driver	
`close`	relinquish access to a device	
`init`	initialize a device	DDI only
`int`	process a device interrupt	DDI only
`ioctl`	control a character device	
`mmap`	return page frame number	DKI only
`open`	gain access to a device	
`print`	display a driver message on system console	
`read`	read data from a device	
`segmap`	map device memory into user space	DKI only
`size`	return size of logical device	DDI only
`start`	start access to a device	DDI only
`strategy`	perform block I/O	
`write`	write data to a device	

NAME

chpoll – poll entry point for a non-STREAMS character driver

SYNOPSIS

```
#include <sys/poll.h>

chpoll(dev_t dev, short events, int anyyet, short *reventsp,
     struct pollhead **phpp);
```

ARGUMENTS

dev The device number for the device to be polled.

events The events that may occur. Valid events are:

POLLIN	Data are available to be read.
POLLOUT	Data may be written without blocking.
POLLPRI	High priority data may be read.
POLLHUP	A device hangup.
POLLERR	A device error.

anyyet A flag that is non-zero if any other file descriptors in the pollfd array have events pending. The poll(2) system call takes a pointer to an array of pollfd structures as one of its arguments. See the poll(2) reference page for more details.

reventsp A pointer to a bitmask of the returned events satisfied.

phpp A pointer to a pointer to a pollhead structure. The pollhead structure is defined in sys/poll.h.

DESCRIPTION

The chpoll entry point routine is used by non-STREAMS character device drivers that wish to support polling. The driver must implement the polling discipline itself. The following rules must be followed when implementing the polling discipline:

1. Implement the following algorithm when the chpoll entry point is called:

```
if (events_are_satisfied_now) {
      *reventsp = mask_of_satisfied_events;
} else {
      *reventsp = 0;
      if (!anyyet)
            *phpp = &my_local_pollhead_structure;
}
return (0);
```

2. Allocate an instance of the pollhead structure. This instance may be tied to the per-minor data structure defined by the driver. The pollhead structure should be treated as a "black box" by the driver. None of its fields should be referenced. However, the size of this structure is guaranteed to remain the same across releases.

3. Call the pollwakeup(D3DK) function whenever an event of type events listed above occur. This function should only be called with one event at a time.

RETURN

A `chpoll` routine should return 0 for success, or the appropriate error number.

SEE ALSO

`pollwakeup`(D3DK), `poll`(2)

NAME

close – relinquish access to a device

SYNOPSIS [Block and Character]

```
#include <sys/types.h>
#include <sys/file.h>
#include <sys/errno.h>
#include <sys/open.h>
#include <sys/cred.h>
#include <sys/ddi.h>
```

int *prefix*close(dev_t *dev*, int *flag*, int *otyp*, cred_t **cred_p*);

ARGUMENTS

dev Device number.

flag File status flag, as set by the open(2) or modified by the fcntl(2) system calls. The flag is for information only—the file should always be closed completely. The flag is taken from the f_flag member of the file structure which is in file.h. Possible values are: FEXCL, FNDELAY, FREAD, and FWRITE. Refer to open(D2D) for more information.

otyp Parameter supplied so that the driver can determine how many times a device was opened and for what reasons. The flags assume the open routine may be called many times, but the close routine should only be called on the last close of a device.

OTYP_BLK	close was through block interface for the device
OTYP_CHAR	close was through the raw/character interface for the device
OTYP_MNT	close was called as a result of a umount(2) system call; unmount the file system associated with the block device
OTYP_SWP	close a swapping device
OTYP_LYR	close a layered process (a higher-level driver called the close routine of the device)

**cred_p* Pointer to the cred(D4D) user credential structure.

SYNOPSIS [STREAMS]

```
#include <sys/types.h>
#include <sys/stream.h>
#include <sys/file.h>
#include <sys/errno.h>
#include <sys/open.h>
#include <sys/cred.h>
#include <sys/ddi.h>
```

int *prefix*close(queue_t **q*, int *flag*, cred_t **cred_p*);

ARGUMENTS

**q*
Pointer to queue structure used to reference the read side of the driver. (A queue is the central node of a collection of structures and routines pointed to by a queue.)

flag
File status flag.

**cred_p*
Pointer to the cred(D4DK) user credential structure.

DESCRIPTION

For STREAMS drivers, the close routine is called by the kernel through the cdevsw table entry for the device. (Modules use the fmodsw table.) A non-null value in the d_str field of the cdevsw entry points to a streamtab structure, which points to a qinit structure containing a pointer to the close routine. Non-STREAMS close routines are called directly from the bdevsw (block) or cdevsw (character) tables.

The close routine ends the connection between the user process and the device, and prepares the device (hardware and software) so that it is ready to be opened again.

A device may be opened simultaneously by multiple processes and the open driver routine is called for each open, but the kernel will only call the close routine when the last process using the device issues a close(2) or umount(2) system call or exits. (An exception is a close occurring with the *otyp* argument set to OTYP_LYR, for which a close (also having *otyp* = OTYP_LYR) occurs for each open.)

In general, a close routine should always check the validity of the minor number component of the *dev* parameter. The routine should also check permissions as necessary, by using the cred(D4D) structure (if pertinent), and the appropriateness of the *flag* and *otyp* parameter values.

A close routine could perform any of the following general functions:

disable interrupts
hang up phone lines
rewind a tape
deallocate buffers from a private buffering scheme
unlock an unsharable device (that was locked in the open routine)
flush buffers
notify a device of the close
deallocate any resources allocated on open

The close routines of STREAMS drivers and modules are called when a stream is dismantled or a module popped. The steps for dismantling a stream are performed in the following order. First, any multiplexor links present are unlinked and the lower streams are closed. Next, the following steps are performed for each module or driver on the stream, starting at the head and working toward the tail:

1. The write queue is given a chance to drain.

2. The `close` routine is called.
3. The module or driver is removed from the stream.

RETURN VALUE

The `close` routine should return 0 for success, or the appropriate error number. Refer to Appendix A for a list of DDI/DKI error numbers. Return errors rarely occur, but if a failure is detected, the driver should decide whether the severity of the problem warrants either displaying a message on the console or, in worst cases, triggering a system panic. Generally, a failure in a `close` routine occurs because a problem occurred in the associated device.

SEE ALSO

`open`(D2D), `cred`(D4DK)

NAME

`init` – initialize a device

SYNOPSIS

`void` *prefix*`init();`

DESCRIPTION

`init` and `start`(D2D) routines are used to initialize drivers and the devices they control. `init` routines are executed during system initialization, and can be used in drivers that do not require low level system services in order to be initialized. `start` routines are executed after low level services are enabled, such as interrupts and lower level kernel interfaces, but before file systems are available. Most drivers can use either an `init` or a `start` routine, or they can be used in combination. However, an `init` routine must be used in any driver controlling a device required to bring the system up.

Not all drivers need an `init` or a `start` routine. However, a driver must have either an `init` or `start` routine if it needs to allocate any data structures.

`init` and `start` routines can perform functions such as:

allocating buffers for private buffering schemes

mapping a device into virtual address space

initializing hardware (for example, system generation or resetting the board)

initializing a serial device in a character driver

Because the `init` and `start` routines are executed before there is user context, no functions that require user-context, such as `sleep`(D3DK), may be called.

SEE ALSO

`start`(D2D)

NAME

`int` – process a device interrupt

SYNOPSIS

void *prefix*`int(int` *ivec*`);`

ARGUMENT

ivec Number used by the operating system to associate a driver's interrupt handler with an interrupting device. The makeup and interpretation of *ivec* is specific to each system implementation. In some systems, this number may be the logical device number, or a combination of logical device and logical controller numbers, used to map the correct interrupt routine with a subdevice. In others, this number could be the interrupt vector number.

DESCRIPTION

The `int` routine is the interrupt handler for both block and character hardware drivers. The interrupt handler is responsible for determining the reason for an interrupt, servicing the interrupt, and waking up any base-level driver processes sleeping on the interrupt completion. For example, when a disk drive has transfered information to the host to satisfy a read request, the disk drive's controller generates an interrupt. The CPU acknowledges the interrupt and calls the interrupt handler associated with that controller and disk drive. The interrupt routine services the interrupt and then wakes up the driver base-level process waiting for data. The base-level portion of the driver then conveys the data to the user.

In general, most interrupt routines must do the following tasks:

keep a record of interrupt occurrences

return immediately if no devices controlled by a driver caused the interrupt (only for systems supporting shared interrupts)

interpret the interrupt routine argument *ivec*

reject requests for devices that are not served by the device's controller

process interrupts that happen without cause (called spurious interrupts)

handle all possible device errors

wake processes that are sleeping on the resolution of an interrupt request

There are also many tasks the `int` routine must perform that are driver-type and device specific. For example, the following types of drivers require different functions from their `int` routines:

A block driver dequeues requests, wakes up processes sleeping on an I/O request, and ensures that system generation has completed.

A terminal driver receives and sends characters.

A printer driver ensures that characters are sent.

In addition, the functions of an `int` routine are device dependent. You should know the exact chip set that produces the interrupt for your device. You need to know the exact bit patterns of the device's control and status register and how data is transmitted into and out of your computer. These specifics differ for every device you access.

The int routine for an intelligent controller that does not use individual interrupt vectors for each subdevice must access the completion queue to determine which subdevice generated the interrupt. It must also update the status information, set/clear flags, set/clear error indicators, and so forth to complete the handling of a job. The code should also be able to handle a spurious completion interrupt identified by an empty completion queue. When the routine finishes, it should advance the unload pointer to the next entry in the completion queue.

If the driver called **biowait**(D3DK) or **sleep**(D3DK) to await the completion of an operation, the int routine must call **biodone**(D3DK) or **wakeup**(D3DK) to signal the process to resume.

int is only used with hardware drivers, not software drivers.

CAUTION: The int routine must never:

contain calls to the **sleep** kernel function

use functions that call **sleep**

drop the interrupt priority level below the level at which the interrupt routine was entered

call any function or routine that requires user context (that is, if it accesses or alters information associated with the running process)

NOTE: uiomove(D3DK) cannot be used in an interrupt routine when the uio_segflg member of the uio(D4DK) structure is set to UIO_USERSPACE (indicating a transfer between user and kernel space).

SEE ALSO

biowait(D3DK), sleep(D3DK), biodone(D3DK), wakeup(D3DK)

NAME

ioctl – control a character device

SYNOPSIS

```
#include <sys/cred.h>
#include <sys/types.h>
#include <sys/errno.h>
```

```
int prefixioctl(dev_t dev, int cmd, int arg, int mode, cred_t *cred_p,
     int *rval_p);
```

ARGUMENTS

dev Device number.

cmd Command argument the driver ioctl routine interprets as the operation to be performed. It should be defined, along with an integer value that is actually passed, in the header file.

The I/O control command name and value can be defined in the driver code itself, but this is not recommended. If I/O control commands are defined in a header file, the user program and the driver can both access the same definitions to ensure that they agree about what each I/O control command value represents.

The I/O control command name is traditionally an all uppercase alphabetic string. This alphabetic name can be a mnemonic. You should try to keep the values for your I/O control commands distinct from others on the system. Each driver's I/O control commands are discrete, but it is possible for user-level code to access a driver with an I/O control command that is intended for another driver, which can lead to serious consequences, such as if it meant to pass "drop carrier on a communication line," but instead sends the argument to a disk where it is interpreted as "reformat drive." Permissions can be set to prevent most such events, but the more unique your I/O control command values are, the safer you are.

A number of different schemes are legal for assigning values to I/O control command names. The most straightforward is to use decimal numbers; for example

```
#define COMMAND1     01
#define COMMAND2     02
```

Similarly, one can assign hexadecimal numbers as values

```
#define COMMANDA     0x0a
#define COMMANDFF    0xff
```

The drawback to these methods is that one quickly gets an operating system that contains several instances of each I/O control command value, with the inherent risks discussed above.

A common method to assign I/O control command values that are less apt to be duplicated is to use a left-shifted 8 scheme. For instance

```
#define COMMAND10    ('Q'<<8|10)
#define COMMAND11    ('Q'<<8|11)
#define COMMAND12    ('Q'<<8|12)
```

Alternately, the shift-left-8 scheme can be defined as a constant then used for the I/O control command definitions. For example

```
#define ROTA         ('q'<<8)
#define COMMAND23    (ROTA|234)
#define COMMAND25    (ROTA|254)
```

An alternative coding style is to use enumerations for the command argument, which allows the compiler to do additional type checking.

```
typedef enum   {
      XX_COMMAND10 = 'Q'<<8  | 10,
      XX_COMMAND11 = 'Q'<<8  | 11,
      XX_COMMAND12 = 'Q'<<8  | 12,
} xx_cmds_t; ;
```

`termio`(7) specifies the command types that must work for AT&T terminal drivers. Terminal drivers typically have a command to read the current `ioctl` settings and at least one other that defines new settings.

arg Passes parameters between a user program and the driver.

When used with terminals, the argument is the address of a user program structure containing driver or hardware settings. Alternatively, the argument may be an integer that has meaning only to the driver. The interpretation of the argument is driver dependent and usually depends on the command type; the kernel does not interpret the argument.

mode Contains values set when the device was opened.

Use of this mode is optional. However, the driver may use it to determine if the device was opened for reading or writing. The driver makes this determination by checking the `FREAD` or `FWRITE` setting (values are in `file.h`).

See the *flag* argument description of the `open` routine for further values for the `ioctl` routine's *mode* argument.

**cred_p* Pointer to the `cred`(D4DK) user credential structure.

**rval_p* Pointer to return value for calling process. The driver may elect to set the value which is valid only if the `ioctl`(D2DK) succeeds.

DESCRIPTION

The `ioctl`(D2DK) routine provides character-access drivers with an alternate entry point that can be used for almost any operation other than a simple transfer of characters in and out of buffers. Most often, `ioctl` is used to control device hardware parameters and establish the protocol used by the driver in processing data.

The kernel looks up the device's file table entry, determines that this is a character device, and looks up the entry point routines in `cdevsw`. The kernel then packages the user request and arguments as integers and passes them to the driver's `ioctl` routine. The kernel itself does no processing of the passed command, so it is up to the user program and the driver to agree on what the arguments mean.

I/O control commands are used to implement the terminal settings passed from `ttymon`(1M) and `stty`(1), to format disk devices, to implement a trace driver for debugging, and to clean up character queues. Since the kernel does not interpret the command type that defines the operation, a driver is free to define its own commands.

Drivers that use an `ioctl` routine typically have a command to "read" the current `ioctl` settings, and at least one other that sets new settings. You can use the mode argument to determine if the device unit was opened for reading or writing, if necessary, by checking the `FREAD` or `FWRITE` setting.

If the third argument, *arg*, is a pointer to user space, the driver should call the `copyin`(D3DK) and `copyout`(D3DK) functions to transfer data between kernel and user space.

To implement I/O control commands for a driver the following two steps are required:

1. Define the I/O control command names and the associated value in the driver's header file and comment the commands.
2. Code the `ioctl` routine in the driver that defines the functionality for each I/O control command name that is in the header file.

The `ioctl` routine is coded with instructions on the proper action to take for each command. It is basically a `switch` statement, with each `case` definition corresponding to an `ioctl` name to identify the action that should be taken. However, the command passed to the driver by the user process is an integer value associated with the command name in the header file.

It is critical that command definitions and routines be clearly commented. Because there is so much flexibility in how commands are used, uncommented commands can be very difficult to interpret at a later time.

Terminal drivers use and support the `ioctl` commands defined on the `termio`(7) manual page. For instance, `TCGETA` gets the parameters associated with the terminal and stores them in the structure referenced in the third argument of the routine call. `TCSETA` sets the parameters associated with the terminal from the structure referenced in the third argument.

NOTE: STREAMS drivers do not have `ioctl` routines. The stream head converts I/O control commands to `M_IOCTL` messages, which are handled by the driver's `put`(D2DK) or `srv`(D2DK) routine.

RETURN VALUE

The `ioctl` routine should return 0 for success, or the appropriate error number. Refer to Appendix A for a list of DDI/DKI error numbers. The driver may also set the value returned to the calling process through the *rval_p* pointer.

SEE ALSO

copyin(D3DK), copyout(D3DK)

NAME

mmap – check virtual mapping for memory mapped device

SYNOPSIS

```
#include <sys/types.h>
#include <sys/cred.h>
#include <sys/mman.h>
#include <sys/vm.h>
```

`int` *prefix*`mmap(dev_t` *dev*, `off_t` *off*, `int` *prot*`);`

ARGUMENTS

dev	Device whose memory is to be mapped.
off	Offset within device memory at which mapping begins.
prot	Protection flag from mman.h (e.g., PROT_WRITE, PROT_READ).

DESCRIPTION

The mmap entry point is a required entry point for character drivers supporting memory-mapped devices. A memory mapped device has memory that can be mapped into a process's address space. The mmap(2) system call, when applied to a character special file, allows this device memory to be mapped into user space for direct access by the user application (no kernel buffering overhead is required).

An mmap(D2K) routine checks if each offset is within the range of pages supported by the device. For example, a device that has 512 bytes of memory that can be mapped into user space should not support offsets greater than 512. If the offset does not exist, then -1 is returned. If the offset does exist, mmap returns the masked page table entry for the page at offset *off* in the device's memory.

mmap should only be supported for memory-mapped devices or pseudo-devices. See the segmap(D2K) reference page for further information on memory-mapped device drivers.

RETURN VALUE

If the protection and offset are valid for the device, the driver should return the masked page table entry, typically obtained using the function hat_getkpfnum(D3K), for the page at offset *off* in the device's memory. If not, -1 should be returned.

SEE ALSO

segmap(D2K), hat_getkpfnum(D3K)

NAME

open – gain access to a device

SYNOPSIS [Block and Character]

```
#include <sys/types.h>
#include <sys/file.h>
#include <sys/errno.h>
#include <sys/open.h>
#include <sys/cred.h>

prefixopen(dev_t *dev, int flag, int otyp, cred_t *cred_p);
```

ARGUMENTS

dev Pointer to a device number.

flag Information passed from the user program open(2) or create(2) system call instructs the driver on how to open the file. The bit settings for the flag are found in `file.h` associated with the `f_flag` member of the `file` structure. Valid settings are:

- `FNDELAY` open the device and return immediately without sleeping (do not block the open even if there is a problem)
- `FREAD` open the device with read-only permission (if ORed with `FWRITE`, then allow both read and write access)
- `FWRITE` open a device with write-only permission (if ORed with `FREAD`, then allow both read and write access)

otyp Parameter supplied so that the driver can determine how many times a device was opened and for what reasons. The flags assume the open routine may be called many times, but the `close` routine should only be called on the last `close` of a device. All flags are defined in `open.h`.

- `OTYP_BLK` open occurred through block interface for the device
- `OTYP_CHAR` open occurred through the raw/character interface for the device
- `OTYP_MNT` the file system on the block device is being opened due to a `mount`(2) system call
- `OTYP_SWP` open a swapping device
- `OTYP_LYR` open a layered process. This flag is used when one driver calls another driver's `open` or `close` routine. In this case, there is exactly one `close` for each `open` called. This permits software drivers to exist above hardware drivers and removes any ambiguity from the hardware driver regarding how a device is used. This flag applies to both block and character devices.

**cred_p* Pointer to the `cred`(D4DK) user credential structure.

SYNOPSIS [STREAMS]

```
#include <sys/file.h>
#include <sys/stream.h>
```

*prefix*open (queue_t **q*, dev_t **dev*, int *oflag*, int *sflag*, cred_t **cred_p*) ;

ARGUMENTS [STREAMS]

**q* A pointer to the read queue. (A queue is the central node of a collection of structures and routines pointed to by a queue.)

**dev* Pointer to a device number. For modules, **dev* always points to the device number associated with the driver at the end (tail) of the stream.

oflag Valid *oflag* values are the same as those listed above, with the exception that FAPPEND, FCREAT, and FTRUNC have no meaning to a STREAMS device. For modules, *oflag* is always set to 0.

sflag Valid values are as follows:

CLONEOPEN Eliminates the need for user processes to poll many minor devices when looking for an unused one. If the driver wishes to assign the device a device file, the open routine must assign and return a minor number. If no device file is required, the open routine does not have to return a minor number.

MODOPEN Indicates that an open routine is being called for a module, not a driver. Drivers should return error numbers or 0 if an open is attempted with *sflag* set to MODOPEN.

0 Indicates a driver opened directly, without calling the clone driver.

**cred_p* Pointer to the cred(D4DK) user credential structure.

DESCRIPTION

The driver's open routine is called by the kernel through the cdevsw or bdevsw entry for the device during an open(2) or a mount(2) on the special file for the device. The routine should verify that the minor number component of *dev* is valid, that the type of access requested by *otyp* and *flag* is appropriate for the device, and, if required, check permissions using the user credentials pointed to by *cred_p*.

RETURN VALUE

The open routine should return 0 for success, or the appropriate error number. Refer to Appendix A for a list of DDI/DKI error numbers.

SEE ALSO

close(D2DK)

NAME

print – display a driver message on system console

SYNOPSIS

```
#include <sys/types.h>
#include <sys/errno.h>

int prefixprint(dev_t dev, char *str);
```

ARGUMENTS

dev	Device number.
**str*	Pointer to a character string describing the problem. An explanation of the problem contained in the string should be included in the driver output.

DESCRIPTION

The `print` routine is called indirectly by the kernel through the **bdevsw** entry for the device when the kernel has detected an exceptional condition (such as out of space) in the device. To display the message on the console, the driver should use the `cmn_err`(D3DK) kernel function.

RETURN VALUE

The `print` routine should return 0 for success, or the appropriate error number. Refer to Appendix A for a list of DDI/DKI error numbers. The `print` routine can fail if the driver implemented a non-standard `print` routine that attempted to perform error logging, but was unable to complete the logging for whatever reason. Generally, since most `print` routines call the `cmn_err`(D3DK) function, and this function is declared as `void`, return values are seldom returned from this routine. If a failure occurs, call `cmn_err` to display a message to the operator.

SEE ALSO

`cmn_err`(D3DK)

NAME

put – receive messages from the preceding queue

SYNOPSIS

```
#include <sys/types.h>
#include <sys/stream.h>
#include <sys/stropts.h>

void prefixrput(queue_t *q, mblk_t mp);    /* read side */

void prefixwput(queue_t *q, mblk_t mp);    /* write side */
```

ARGUMENTS

**q* Pointer to the queue(D4DK) structure.

mp Pointer to the message block.

DESCRIPTION

The primary task of the put routine is to coordinate the passing of messages from one queue to the next in a stream. The put routine is called by the preceding stream component (module, driver, or stream head). put routines are designated "write" or "read" depending on the direction of message flow.

With few exceptions, a module or driver must have a put routine. One exception is the read side of a driver, which does not need a put routine because there is no component downstream to call it. The put routine is always called before the component's corresponding srv(D2DK) (service) routine, and so put should be used for the immediate processing of messages.

A put routine must do at least one of the following when it receives a message:

pass the message to the next component on the stream by calling the putnext(D3DK) function

process the message, if immediate processing is required (for example, high priority messages)

enqueue the message (with the putq(D3DK) function) for deferred processing by the service srv(D2DK) routine

Typically, a put routine will switch on message type, which is contained in the db_type member of the datab structure pointed to by *mp*. The action taken by the put routine depends on the message type. For example, a put routine might process high priority messages, enqueue normal messages, and handle an unrecognized message by changing its type to M_IOCNAK (negative acknowledgement) and sending it back to the stream head using the qreply(D3DK) function.

The putq(D3DK) function can be used as a module's put routine when no special processing is required and all messages are to be enqueued for the srv routine.

put routines do not have user context and so may not call sleep(D3DK).

SEE ALSO

The *BCI Driver Development Guide*, Chapter 7, "STREAMS"

The *STREAMS Programmer's Guide*

`streamtab`(D4DK), `putctl`(D3DK), `putctl1`(D3DK), `putnext`(D3DK), `putq`(D3DK), `qreply`(D3DK), `srv`(D2DK)

NAME

`read` – read data from a device

SYNOPSIS

```
#include <sys/types.h>
#include <sys/errno.h>
#include <sys/open.h>
#include <sys/uio.h>
#include <sys/cred.h>
```

prefix`read(dev_t` *dev,* `uio *`*uio_p,* `cred_t *`*cred_p*`);`

ARGUMENTS

dev
Device number.

**uio_p* Pointer to the `uio`(D4DK) structure that describes where the data is to be stored in user space.

**cred_p* Pointer to the `cred`(D4DK) user credential structure for the I/O transaction.

DESCRIPTION

The driver `read` routine is called indirectly through `cdevsw` by the `read`(2) system call. The `read` routine should check the validity of the minor number component of *dev* and the user credentials contained in the `cred`(D4DK) structure pointed to by **cred_p* (if pertinent). The `read` routine should supervise the data transfer into the user space described by the `uio`(D4DK) structure.

RETURN VALUE

The `read` routine should return `0` for success, or the appropriate error number. Refer to Appendix A for a list of error values.

SEE ALSO

`write`(D2DK)

NAME

segmap – map device memory into user space

SYNOPSIS

```
#include <sys/types.h>
#include <sys/mman.h>
#include <sys/param.h>
#include <sys/vm.h>

int prefixsegmap(dev_t dev, off_t off,struct as *asp, addr_t *addrp,
     off_t len, unsigned int prot, unsigned int maxprot,
     unsigned int flags, cred_t *cred_p);
```

ARGUMENTS

dev Device whose memory is to be mapped.

off Offset within device memory at which mapping begins.

**asp* Pointer to the address space into which the device memory should be mapped.

**addrp* Pointer to the address in the address space to which the device memory should be mapped.

len Length (in bytes) of the memory to be mapped.

prot Protection flag (from `sys/mman.h`) for example, `PROT_WRITE`, `PROT_READ`, `PROT_USER` (indicating the mapping is being done as a result of a mmap(2) system call).

maxprot Maximum protection flag possible for attempted map (`PROT_WRITE` may be masked out if the user opened the special file read-only). If `(maxprot & prot)` != prot then there is an access violation.

flags Flags indicating type of mmap (for example, `MAP_SHARED` vs. `MAP_PRIVATE`), whether the user specified an address (`MAP_FIXED`). Found in `sys/mman.h`.

**cred_p* Pointer to the `cred`(D4DK) user credentials structure.

DESCRIPTION

The `segmap` entry point is an optional routine for character drivers that support memory mapping. The mmap(2) system call, when applied to a character special file, allows device memory to be mapped into user space for direct access by the user application (no kernel buffering overhead is required).

Typically, a character driver that needs to support the mmap(2) system call supplies either a single mmap(D2K) entry point, or both an mmap and a `segmap` entry point routine (see the mmap(D2K) reference page). If no `segmap` entry point is provided for the driver, the default kernel `segmap` routine is called to perform the mapping.

A driver for a memory-mapped device would provide a `segmap` entry point if it:

> requires the mapping to be done through a virtual memory (VM) segment driver other than the default `seg_dev` driver provided by the kernel

needs to control the selection of the user address at which the mapping occurs in the case where the user did not specify an address in the mmap(2) system call

Among the responsibilities of a segmap entry point are:

Select a segment driver and check the memory map flags for appropriateness to the segment driver. For example, the seg_dev segment driver does not support memory maps that are marked MAP_PRIVATE (copy-on-write).

Verify that the range to be mapped makes sense in the context of the device (does the offset and length make sense for the device memory that is to be mapped). Typically, this task is performed by calling the mmap(D2K) entry point.

If MAP_FIXED is not set in *flags*, obtain a user address at which to map. Otherwise, unmap any existing mappings at the user address specified.

Perform the mapping and return the error status if it fails.

RETURN VALUE

The routine returns 0 if the driver is successful in performing the memory map of its device address space into the specified address space. An error number should be returned on failure. For example, valid error numbers would be ENXIO if the offset/length pair specified exceeds the limits of the device memory, or EINVAL if the driver detects an invalid type of mapping attempted.

SEE ALSO

mmap(D2K)

NAME

size – return size of logical device

SYNOPSIS

```
#include <sys/types.h>

prefixsize(dev_t dev);
```

ARGUMENT

dev The logical device number.

DESCRIPTION

Returns the number of 512-byte units on a logical device (partition). Although this routine is not required, it is recommended that new drivers include one as the Release 4.0 kernel calls the `size` routine on behalf of certain UNIX commands such as `stat`(3G).

RETURN VALUE

The number of 512 byte units on the logical device specified by *dev,* or `-1` on failure.

NAME

srv – service queued messages

SYNOPSIS

```
#include <sys/types.h>
#include <sys/stream.h>
#include <sys/stropts.h>

void prefixrsrv(queue_t q);    /* read side */

void prefixwsrv(queue_t q);    /* write side */
```

ARGUMENTS

**q*	Pointer to the queue(D4DK) structure

DESCRIPTION

The optional service (**srv**) routine may be included in a STREAMS module or driver for one or more of the following reasons:

to provide greater control over the flow of messages in a stream

to make it possible to defer the processing of some messages to avoid depleting system resources

to combine small messages into larger ones, or break large messages into smaller ones

to recover from resource allocation failure. A module's or driver's put(D3DK) routine can test for the availability of a resource, and if it is not available, enqueue the message for later processing by the srv routine.

A message is first passed to a module's or driver's put(D2DK) routine, which may or may not do some processing. It must then either

pass the message to the next stream component with putnext(D3DK)

if a srv routine has been included, it may call the putq(D3DK) function to place the message on the queue

Once a message has been enqueued, the STREAMS scheduler controls the calling of the service routine. Service routines are called in FIFO order by the scheduler. No guarantees can be made about how long it will take for a srv routine to be called except that it will happen before any user level process are run.

Every stream component (stream head, module or driver) has limit values it uses to implement flow control. Tunable high and low water marks are checked to stop and restart the flow of message processing. Flow control limits apply only between two adjacent components with srv routines.

STREAMS messages can be defined to have up to 256 different priorities to support some networking protocol requirements for multiple bands of data flow. At a minimum, a stream must distinguish between normal (priority zero) messages and high priority messages (such as M_IOCACK). High priority messages are always placed at the head of the srv routine's queue, after any other enqueued high priority messages. Next are messages from all included priority bands, which are enqueued in decreasing order of priority. Each priority band has its own flow control limits. If a flow controlled band is stopped, all lower priority bands are also stopped.

Once a `srv` routine is called by the STREAMS scheduler it must process all messages on its queue. The following steps are general guidelines for processing messages. Keep in mind that many of the details of how a `srv` routine should be written depend of the implementation, the direction of flow (upstream or downstream), and whether it is for a module or a driver.

1. Use the `getq`(D3DK) function to get the next enqueued message.
2. If the message is high priority, process (if appropriate) and pass to the next stream component with the `putnext`(D3DK) function.
3. If it is not a high priority message (and therefore subject to flow control), attempt to send it to the next stream component with a `srv` routine. Use `bcanput`(D3DK) to determine if this can be done.
4. If the message cannot be passed, put it back on the queue with `putbq`(D3DK). If it can be passed, process (if appropriate) and pass with `putnext`.

NOTE: Each stream module has a read and write service (`srv`) routine. If a service routine is not needed (because the `put` routine processes all messages), a `NULL` pointer should be placed in module's `qinit` structure. Do not use the `nulldev` routine instead of the `NULL` pointer. Use of `nulldev` for a `srv` routine may result in flow control errors.

SEE ALSO

The *BCI Driver Development Guide*, Chapter 7, "STREAMS"

The *STREAMS Programmer's Guide*, Chapter 5, "Messages"

`bcanput`(D3DK), `canput`(D3DK), `getq`(D3DK), `put`(D2DK), `putbq`(D3DK), `putnext`(D3DK), `putq`(D3DK), `queue`(D4DK)

NAME

`start` – start access to a device

SYNOPSIS

`void` *prefix*`start();`

DESCRIPTION

The `start` routine is called when a computer starts placing a device into a known state. At the time this routine is called, the developer cannot depend on `root` being mounted. However, the developer can depend on low level system services being available such as interrupts enabled.

A `start` routine may perform the following types of activities:

initialize data structures for device access

allocate buffers for private buffering scheme

map device into virtual address space

initialize hardware (for example, perform a system generation and reset the board)

initialize the serial device for character drivers

initialize any static data associated with the driver

SEE ALSO

`init`(D2DK)

NAME

strategy – perform block I/O

SYNOPSIS

```
#include <sys/types.h>
#include <sys/buf.h>

int prefixstrategy(struct buf *bp);
```

ARGUMENT

bp Pointer to the buf(D4DK) structure.

DESCRIPTION

The strategy routine is called indirectly (through bdevsw) by the kernel to read and write blocks of data on the block device. strategy may also be called directly or indirectly (via a call to the kernel function physiock(D3D)), to support the raw character interface of a block device (read(D2DK), write(D2DK) and ioctl(D2DK)). The strategy routine's responsibility is to set up and initiate the transfer.

RETURN VALUE

On an error condition, OR the b_flags member of the buf(D4DK) structure with B_ERROR and set the b_error member to the appropriate error value.

SEE ALSO

read(D2DK), write(D2DK)

NAME

`write` – write data to a device

SYNOPSIS

```
#include <sys/types.h>
#include <sys/errno.h>
#include <sys/open.h>
#include <sys/cred.h>

int prefixwrite(dev_t dev, uio_t *uio_p, cred_t *cred_p);
```

ARGUMENTS

dev
Device number.

uio_p Pointer to the `uio`(D4DK) structure that describes where the data is to be stored in user space.

cred_p Pointer to the `cred`(D4DK) user credential structure for the I/O transaction.

DESCRIPTION

Used for character or raw data I/O, the driver `write` routine is called indirectly through `cdevsw` by the `write`(2) system call. The `write` routine supervises the data transfer from user space to a device described by the `uio`(D4DK) structure.

The `write` routine should check the validity of the minor number component of *dev* and the user credentials pointed to by *cred_p* (if pertinent).

RETURN VALUE

The `write` routine should return 0 for success, or the appropriate error number. Refer to Appendix A for a list of DDI/DKI error numbers.

SEE ALSO

`read`(D2DK)

3. KERNEL FUNCTIONS (D3)

3. KERNEL FUNCTIONS (D3)

3 Kernel Functions (D3)

Introduction

This chapter describes the kernel functions available for use by device drivers. Each function is described in a separate entry. Most functions are part of both DDI and DKI—these are indicated by the (D3DK) cross reference code. Functions belonging only to DDI are cross-referenced by (D3D) and DKI-only functions are marked (D3K).

In this section, the information for each driver function is organized under the following headings:

- NAME summarizes the function's purpose.
- SYNOPSIS shows the syntax of the function's entry point in the source code. `#include` statements are shown for required header files.
- ARGUMENTS describes any arguments required to invoke the function.
- DESCRIPTION describes general information about the function.
- RETURN VALUE describes the return values and messages that can result from invoking the function.
- LEVEL indicates from which driver level (base or interrupt) the function can be called.
- SEE ALSO indicates functions that are related by usage and sources, and which can be referred to for further information.
- EXAMPLE shows how the function can be used in driver code.

NOTE The `ddi.h` header file undefines macros that have been reimplemented as functions in UNIX System V Release 4.0. Always place `ddi.h` at the end of the list of `include` statements to avoid contention between macro and function declarations.

Function Summary

Table 3-1 summarizes the STREAMS functions described in this section. STREAMS functions may be used in either DDI or DKI.

Table 3-1: STREAMS Kernel Function Summary

Routine	Description
adjmsg	remove the specified number of bytes from a message
allocb	allocate a message block
backq	get pointer to the previous queue
bcanput	test for flow control in specified priority band
bufcall	get buffer when allocb fails
canput	test for room in a message queue
copyb	copy a message block
copymsg	copy a message to a new message
datamsg	test whether a message is a data message
dupb	duplicate a message block descriptor
dupmsg	duplicate a message
enableok	enable a queue for service
esballoc	allocate a message block with a shared buffer
esbbcall	get message header when esballoc fails
flushband	flush messages for specified priority band
flushq	remove messages from a queue
freeb	free a message block
freemsg	free all message blocks in a message
getq	get a message from the front of a queue
insq	insert a message into a queue
linkb	concatenate two message blocks

Table 3-1: STREAMS Kernel Function Summary (continued)

Routine	Description
`msgdsize`	return the number of bytes in a message
`noenable`	prevent a queue from being scheduled
`OTHERQ`	get a pointer to a module's other queue
`pullupmsg`	concatenate bytes in a message
`putbq`	place a message at the head of a queue
`putctl`	put a control message on a queue
`putctl1`	put a control message with a one-byte parameter on a queue
`putnext`	send a message to the next module in the stream
`putq`	put a message on a queue
`qenable`	enable a queue
`qreply`	send a message in the reverse direction
`qsize`	find the number of messages on a queue
`RD`	get a pointer to a module's read queue
`rmvb`	remove a message block from a queue
`rmvq`	remove a message from a queue
`SAMESTR`	test if next queue is same type
`strlog`	submit messages for logging
`strqget`	get information about a queue
`strqset`	change information about a queue
`testb`	check for an available buffer
`unlinkb`	remove the message block from the head of a message
`WR`	get pointer to this module's write queue

Table 3-2 summarizes the functions not specific to STREAMS. Functions can be used in either DDI or DKI, except as noted.

Table 3-2: Kernel Functions Not Specific to STREAMS

Routine	Description	Type
bcopy	copy data between locations in the kernel, for example, from one buffer to another	
biodone	release buffer after block I/O and wakeup processes	
biowait	suspend processes pending completion of block I/O	
bp_mapin	allocate virtual address space	
bp_mapout	deallocate virtual address space	
brelse	return buffer to the kernel	
btop	return number of memory pages contained in specified number of bytes (downward rounding)	
btopr	return number of memory pages contained in specified number of bytes (upward rounding)	
bzero	clear memory for a number of bytes	
clrbuf	erase buffer contents	
cmn_err	display message or panic the system	
copyin	copy data from user space to the driver	
copyout	copy data from the driver to user space	
delay	delay for specified number of clock ticks	
dma_pageio	break up DMA requests	DDI only
drv_getparm	retrieve kernel state information	
drv_hztousec	convert from clock ticks to microseconds	
drv_priv	determine driver privileges	
drv_usectohz	convert from microseconds to clock ticks	

Table 3-2: Kernel Functions Not Specific to STREAMS (continued)

Routine	Description	Type
`drv_usecwait`	wait for specified number of microseconds	
`etoimajor`	convert external major number to internal major number	DDI only
`freerbuf`	free a raw buffer header	
`getemajor`	get external major number	DDI only
`geteminor`	get external minor number	DDI only
`geterror`	return an I/O error	
`getmajor`	get major number	
`getminor`	get minor number	
`getrbuf`	get a raw buffer header	
`getvec`	get an interrupt vector for a given virtual board address	DDI only
`hat_getkpfnum`	get page frame number for address	DKI only
`hdeeqd`	initialize error logging in the hard disk	DDI only
`hdelog`	log a hard disk error	DDI only
`itoemajor`	convert internal major number to external number	DDI only
`kmem_alloc`	allocate storage from kernel free space	
`kmem_free`	free previously allocated kernel memory	
`kmem_zalloc`	allocate and clear storage from kernel free memory	
`kvtophys`	convert kernel virtual to physical address	DDI only
`makedevice`	create a device number	
`max`	return the larger of two integers	
`min`	return the smaller of two integers	
`page_numtopp`	convert page frame number to page structure	

Table 3-2: Kernel Functions Not Specific to STREAMS (continued)

Routine	Description	Type
`page_pptonum`	convert page structure to page frame number	
`physiock`	validate and issue raw I/O request	DDI only
`pollwakeup`	inform a process that an event has occurred	
`ptob`	convert size in pages to size in bytes	
`rmalloc`	allocate space from a private space management map	
`rmfree`	free space back into a private space management map	
`rminit`	initialize a private space management map	
`rmsetwant`	set the map's wait flag for wakeup	
`rmwant`	wait for free memory	
`sleep`	suspend execution	
`spl`	suspend or allow interrupts	
`timeout`	call function in clock ticks	
`uiomove`	copy kernel data using `uio` structure	
`untimeout`	cancel `timeout` with matching ID	
`ureadc`	add character to `uio` structure	
`useracc`	verify user access to data structures	
`uwritec`	remove a character from a `uio` structure	
`vtop`	convert virtual to physical address	DDI only
`wakeup`	resume suspended execution	

NAME

adjmsg – trim bytes from a message

SYNOPSIS

```
#include <sys/stream.h>

int adjmsg(mblk_t *mp, int len);
```

ARGUMENTS

**mp*	Pointer to the message to be trimmed.
len	The number of bytes to be removed.

DESCRIPTION

adjmsg removes bytes from a message. |*len*| (the absolute value of *len*) specifies how many bytes are to be removed. If *len* is greater than 0, bytes are removed from the head of the message. If *len* is less than 0, bytes are removed from the tail. adjmsg fails if |*len*| is greater than the number of bytes in *mp*.

RETURN VALUE

If the message can be trimmed successfully, 1 is returned. Otherwise, 0 is returned.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

NAME

`allocb` – allocate a message block

SYNOPSIS

```
#include <sys/stream.h>

mblk_t *allocb(int size, int pri);
```

ARGUMENTS

size The number of bytes in the message block.

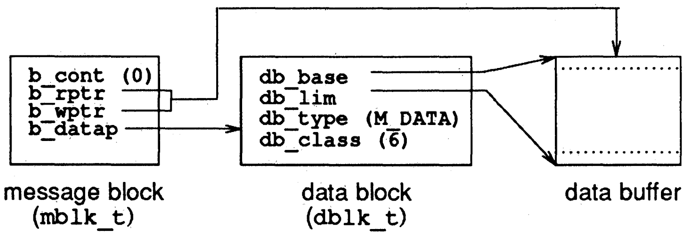
pri Priority of the request (no longer used).

DESCRIPTION

`allocb` tries to allocate a STREAMS message block. Buffer allocation fails only when the system is out of memory. If no buffer is available, the `bufcall`(D3DK) function can help a module recover from an allocation failure.

NOTE: The *pri* argument is no longer used in UNIX System V Release 4, but is retained for compatibility with existing drivers.

The following figure identifies the data structure members that are affected when a message block is allocated.



RETURN VALUE

If successful, `allocb` returns a pointer to the allocated message block of type `M_DATA` (defined in `sys/stream.h`). If a block cannot be allocated, a `NULL` pointer is returned.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

STREAMS Programmer's Guide, Chapter 5, "Messages"

`bufcall`(D3DK), `esballoc`(D3DK), `esbbcall`(D3DK), `testb`(D3DK)

EXAMPLE

Given a pointer to a queue (*q*) and an error number (*err*), the `send_error` routine sends an `M_ERROR` type message to the stream head.

If a message cannot be allocated, 0 is returned, indicating an allocation failure (line 8). Otherwise, the message type is set to `M_ERROR` (line 10). Line 11 increments the write pointer (bp->b_`wptr`) by the size (one byte) of the data in the message.

A message must be sent up the read side of the stream to arrive at the stream head. To determine whether *q* points to a read queue or a write queue, the `q->q_flag` member is tested to see if `QREADR` is set (line 13). If it is not set, *q* points to a write queue, and in line 14 the `RD`(D3DK) function is used to find the corresponding read queue. In line 15, the `putnext`(D3DK) function is used to send the message upstream, returning `1` if successful.

```
 1  send_error(q,err)
 2         queue_t *q;
 3         unsigned char err;
 4  {
 5         mblk_t *bp;
 6
 7         if ((bp = allocb(1, BPRI_HI)) == NULL) /* allocate msg. block */
 8              return(0);
 9
10         bp->b_datap->db_type = M_ERROR;    /* set msg type to M_ERROR */
11         *bp->b_wptr++ = err;               /* increment write pointer */
12
13         if(!q->q_flag & QREADR))           /* if not read queue     */
14              q = RD(q);                    /*    get read queue     */
15         putnext(q,bp);                     /* send message upstream */
16         return(1);
17  }
```

NAME

backq – get pointer to the queue behind the current queue

SYNOPSIS

```
#include <sys/stream.h>

queue_t *backq(queue_t *cq);
```

ARGUMENT

**cq* The pointer to the current queue. queue_t is an alias for the queue(D4DK) structure.

DESCRIPTION

backq returns a pointer to the queue preceding *cq* (the current queue). If *cq* is a read queue, backq returns a pointer to the queue downstream from *cq*, unless it is the stream end. If *cq* is a write queue, backq returns a pointer to the next queue upstream from *cq*, unless it is the stream head.

RETURN VALUE

If successful, backq returns a pointer to the queue preceding the current queue. Otherwise, it returns NULL.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

NAME

bcanput – test for flow control in specified priority band

SYNOPSIS

```
#include <sys/stream.h>

int bcanput(queue_t *q, unsigned char pri);
```

ARGUMENT

q	Pointer to the message queue.
pri	Message priority.

DESCRIPTION

Like the canput(D3DK) function, bcanput searches through the stream (starting at *q*) until it finds a queue containing a service routine where the message can be enqueued, or until it reaches the end of the stream. If found, the queue containing the service routine is tested to see if there is room for a message in the queue. If the queue is full, bcanput sets the **QWANTW** flag to back-enable the caller's service routine.

If *pri* is 0, the bcanput call is equivalent to a call to canput.

NOTE: You are responsible for both testing a queue with bcanput and refraining from placing a message on the queue if bcanput fails.

RETURN VALUE

A 1 is returned if a message of priority *pri* can be placed on the queue, or if the band does not yet exist on the queue. A 0 is returned if the priority band is flow-controlled.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

canput(D3DK), putbq(D3DK), putnext(D3DK)

NAME

bcopy – copy data between address locations in the kernel

SYNOPSIS

`#include <sys/types.h>`

`int bcopy(caddr_t` *from*, `caddr_t` *to*, `long` *bcount*`);`

ARGUMENTS

from	Source address from which the copy is made.
to	Destination address to which copy is made.
bcount	The number of bytes moved.

DESCRIPTION

bcopy copies *bcount* bytes from one kernel address to another. If the input and output addresses overlap, the command executes, but the results may not be as expected.

CAUTION: The *from* and *to* addresses must be within the kernel space. No range checking is done. If an address outside of the kernel space is selected, the driver may corrupt the system in an unpredictable way.

Note that bcopy should never be used to move data in or out of a user buffer, because it has no provision for handling page faults. The user address space can be swapped out at any time, and bcopy always assumes that there will be no paging faults. If bcopy attempts to access the user buffer when it is swapped out, the system will panic. It is safe to use bcopy to move data within kernel space, since kernel space is never swapped out.

RETURN VALUE

Under all conditions, 0 is returned.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 6, "Input/Output Operations"

copyin(D3DK), copyout(D3DK)

EXAMPLE

An I/O request is made for data stored in a RAM disk. If the I/O operation is a read request, the data is copied from the RAM disk to a buffer (line 7). If it is a write request, the data is copied from a buffer to the RAM disk (line 11). The bcopy function is used since both the RAM disk and the buffer are part of the kernel address space.

```
1  #define RAMDNBLK    1000            /* blocks in the RAM disk      */
2  #define RAMDBSIZ     512            /* bytes per block             */
3  char ramdblks[RAMDNBLK][RAMDBSIZ]; /* blocks forming RAM disk     */
      ...
4
5  if  (bp->b_flags & B_READ) /* if read request, copy data from RAM  */
6                             /* disk data block to system buffer     */
7       bcopy(&ramdblks[bp->b_blkno][0], bp->b_un.b_addr, bp->b_bcount);
8
```

```
else                            /* else write request, copy data from a */
                                /* system buffer to RAM disk data block */
     bcopy(bp->b_un.b_addr, &ramdblks[bp->b_blkno][0], bp->b_bcount);
```

NAME

biodone – release buffer after block I/O and wakeup processes

SYNOPSIS

```
#include <sys/types.h>
#include <sys/buf.h>

void biodone(struct buf *bp);
```

ARGUMENT

**bp* Pointer to the buffer header structure defined in buf.h. This is the address of the buffer header associated with the buffer where the I/O occurred.

DESCRIPTION

The biodone function is called by either the driver int(D2D) or strategy(D2DK) routines when a block I/O request is complete. In general, biodone awakens sleeping processes waiting for the I/O to complete, sets the B_DONE flag in the buf structure b_flags field, and releases the block if the I/O is asynchronous.

For drivers that wish to make multiple I/O requests without releasing and reallocating a buffer header for each individual request, biodone provides the capability to check for an additional function to be called before the buffer header is released. Additional routines to be called from biodone are referenced by the (*b_biodone) field of the buf structure.

biodone performs the following functions in the order presented:

checks the (*biodone) field of the buf structure for additional routines to be called. If an additional routine is referenced, it is called and the functions listed below are not completed.

awakens the process(es) that called sleep(D3DK) to wait for the buffer header if I/O is synchronous

releases the block if I/O is asynchronous and awakens processes awaiting asynchronous I/O

marks b_flags of buffer with B_DONE

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 9, "Synchronizing Hardware and Software Events"

biowait(D3DK), buf(D4DK), delay(D3DK), int(D3D), strategy(D3DK), sleep(D3DK), timeout(D3DK), untimeout(D3DK), wakeup(D3DK)

EXAMPLE

Generally, the first validation test performed by any block device strategy(D2DK) routine is a check for an end-of-file (EOF) condition. The strategy routine is responsible for determining an EOF condition when the device is accessed directly. If a `read` request is made for one block beyond the limits of the device (line 10), it will report an EOF condition. Otherwise, if the request is outside the limits of the device, the routine will report an error condition. In either case, report the I/O operation as complete (line 27).

```
 1  #define RAMDNBLK    1000            /* Number of blocks in RAM disk */
 2  #define RAMDBSIZ     512            /* Number of bytes per block */
 3  char ramdblks[RAMDNBLK][RAMDBSIZ];  /* Array containing RAM disk */
 4
 5  ramdstrategy(bp)
 6          register struct buf *bp;
 7  {
 8          register daddr_t blkno = bp->b_blkno;   /* get block number */
 9
10          if (blkno < 0 || blkno >= RAMDNBLK) {
11                /*
12                 * If requested block is outside RAM disk
13                 * limits, test for EOF which could result
14                 * from a direct (physiock) request.
15                 */
16               if (blkno == RAMDNBLK && bp->b_flags & B_READ) {
17                 /*
18                  * If read is for block beyond RAM disk
19                  * limits, mark EOF condition.
20                  */
21                  bp->b_resid -= bp->b_bcount;/* compute return value */
22
23               } else {                      /* I/O attempt is beyond */
24                  bp->b_error = ENXIO;       /*    limits of RAM disk */
25                  bp->b_flags |= B_ERROR;    /* return error */
26               } /* endif */
27               biodone(bp);             /* mark I/O complete (B_DONE) */
28                 /*
29                  * Wake any processes awaiting this I/O
30                  * or release buffer for asynchronous
31                  * (B_ASYNC) request.
32                  */
33               return;
34          } /* endif */
       ...
```

NAME

biowait – suspend processes pending completion of block I/O

SYNOPSIS

```
#include <sys/types.h>
#include <sys/buf.h>

int biowait(struct buf *bp);
```

ARGUMENT

**bp*	Pointer to the buf structure.

DESCRIPTION

The biowait function suspends process execution during a block I/O transfer by calling sleep(D3DK). Block driver routines using the buf structure to allocate buffers can use the biowait function to suspend a process while waiting for a read or write request to complete.

The biowait function is one of three functions used to aid block I/O transfers. The other functions in this group are biodone(D3DK), which notifies biowait that the I/O is complete, and brelse, which frees the buffer allocated for the transfer.

Drivers using the biowait function must also include the biodone(D3DK) function in their interrupt routines. The biodone function awakens biowait when the I/O transfer is complete.

Because biowait calls sleep, biowait cannot be called from an interrupt routine or from an init(D2D) routine.

RETURN VALUE

None. However, biowait returns any error that may have occured during the I/O transfer to the user using geterror(D3DK).

LEVEL

Base Only (Do not call from an interrupt routine)

SEE ALSO

biodone(D3DK), brelse(D3DK), sleep(D3DK), timeout(D3DK), untimeout(D3DK), wakeup(D3DK)

NAME

bp_mapin – allocate virtual address space

SYNOPSIS

```
#include <sys/types.h>
#include <sys/buf.h>

vaddr_t bp_mapin(struct buf *bp);
```

ARGUMENTS

**bp*	Pointer to the buffer header structure.

DESCRIPTION

The bp_mapin function is used to map virtual address space to a page list maintaned by the buffer header during a paged-I/O request. bp_mapin allocates system virtual address space, maps that space to the page list, and returns the offset into the map. The offset is stored in the bp->b_un.b_addr field of the of the buf structure (see buf(D4DK)). Virtual address space is then deallocated using the bp_mapout function.

If a NULL page list is encountered, bp_mapin returns without allocating space and no mapping is performed.

RETURN VALUE

The starting address of the allocated system virtual address space.

LEVEL

Base

SEE ALSO

bp_mapout(D3DK), buf(D4DK)

NAME

bp_mapout – deallocate virtual address space

SYNOPSIS

```
#include <sys/types.h>
#include <sys/buf.h>

void bp_mapin(struct buf *bp);
```

ARGUMENTS

bp Pointer to the buffer header structure.

DESCRIPTION

This function deallocates system virtual address space allocated by a previous call to bp_mapin(D3DK). bp_mapin maps virtual address space to a page list maintained by the buffer header for a paged-I/O request, then returns the offset into the map to the b_addr field of the buf structure.

RETURN VALUE

None

LEVEL

Base

SEE ALSO

bp_mapin(D3DK), buf(D4DK)

NAME

brelse – return buffer to the bfreelist

SYNOPSIS

```
#include <sys/types.h>
#include <sys/buf.h>

void brelse(struct buf *bp);
```

ARGUMENT

**bp* Pointer to the buf structure.

DESCRIPTION

The brelse function returns a previously allocated buffer to the buffer free list. First, brelse wakes up processes sleeping on the buffer. After the driver function is finished with the buffer, brelse returns the buffer header to a list of free buffers and awakens any processes that called sleep(D3DK) to wait for a free buffer on the bfreelist.

RETURN VALUE

None, however, if b_flags has B_ERROR enabled due to an error in an earlier I/O transfer, b_flags is ORed with B_STALE and B_AGE, B_ERROR and B_DELWRI are disabled, and b_error is set to 0.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 6, "Input/Output Operations"

clrbuf(D3DK), biodone(D3DK), biowait(D3DK)

NAME

btop – convert size in bytes to size in pages (round down)

SYNOPSIS

```
#include <sys/ddi.h>

unsigned long btop(unsigned long numbytes);
```

ARGUMENT

numbytes Number of bytes.

DESCRIPTION

The btop function returns the number of memory pages that are contained in the specified number of bytes, with downward rounding in the case that the byte count is not a page multiple. For example, if the page size is 2048, then btop(4096) returns 2, and btop(4097) returns 2 as well. btop(0) returns 0.

RETURN VALUE

The return value is always the number of pages. There are no invalid input values, and therefore no error return values.

LEVEL

Base or Interrupt

SEE ALSO

btopr(D3DK), ptob(D3DK)

NAME

`btopr` – convert size in bytes to size in pages (round up)

SYNOPSIS

```
#include <sys/ddi.h>

unsigned long btopr(unsigned long numbytes);
```

ARGUMENT

numbytes Number of bytes.

DESCRIPTION

This function returns the number of memory pages contained in the specified number of bytes memory, rounded up to the next whole page. For example, if the page size is 2048, then `btopr(4096)` returns `2`, and `btopr(4097)` returns `3`.

RETURN VALUE

The return value is always the number of pages. There are no invalid input values, and therefore no error return values.

LEVEL

Base or Interrupt

SEE ALSO

`btop`(D3DK), `ptob`(D3DK)

NAME

`bufcall` – call a function when a buffer becomes available

SYNOPSIS

```
#include <sys/stream.h>

int bufcall(int size, int pri, int (*func)(), long arg);
```

ARGUMENTS

size	Number of bytes in the buffer.
pri	Priority of the `allocb`(D3DK) allocation request (not used).
func	Function or driver routine to be called when a buffer becomes available.
arg	Argument to the function to be called when a buffer becomes available.

DESCRIPTION

`bufcall` serves as a `timeout`(D3DK) call of indeterminate length. When a buffer allocation request fails, `bufcall` can be used to schedule the routine *func*, to be called with the argument *arg* when a buffer becomes available. *func* may be a routine that calls `bufcall` or it may be another kernel function.

NOTE: Even when *func* is called by `bufcall`, `allocb`(D3DK) can still fail if another module or driver had allocated the memory before *func* was able to call `allocb`.

RETURN VALUE

If the `bufcall` scheduling fails, *func* is never called and `0` is returned. If successful, `bufcall` returns `1`.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

`allocb`(D3DK), `esballoc`(D3DK), `esbbcall`(D3DK), `testb`(D3DK), `timeout`(D3DK)

EXAMPLE

The purpose of this `srv`(D2DK) service routine is to add a header to all `M_DATA` messages. Service routines must process all messages on their queues before returning, or arrange to be rescheduled.

While there are message to be processed (line 13), check to see if it is a high priority message or a normal priority message that can be sent on (line 14). Normal priority message that cannot be sent are put back on the message queue (line 34). If the message was a high priority one, or if was normal priority and `canput`(D3DK) succeeded, then send all but `M_DATA` messages to the next stream entity with `putnext`(D3DK) (line16).

For `M_DATA` messages, try to allocate a buffer large enough to hold the header (line 18). If no such buffer is available, the service routine must be rescheduled for a time when a buffer is available. The original message is put back on the queue (line 20) and `bufcall` (line 21) is used to attempt the rescheduling. It will succeed if a buffer of the specified size (`sizeof (struct hdr)`) is available. If it does, `qenable`(D3DK) will put *q* on the list of queues to have their service routines called. If `bufcall` fails, `timeout`(D3DK) (line 22) is used to try again in about a half second (`HZ/2`).

If the buffer allocation was successful, initialize the header (lines 25–28), make the message type `M_PROTO` (line 29), link the `M_DATA` message to it (line 30), and pass it on (line 31).

```
 1  struct hdr {
 2        unsigned int h_size;
 3        int          h_version;
 4  };
 5
 6  modsrv(q)
 7        queue_t *q;
 8  {
 9        mblk_t *bp;
10        mblk_t *mp;
11        struct hdr *hp;
12
13       while ((mp = getq(q)) != NULL) {          /* get next message */
14         if (mp->b_datap->db_type >= QPCTL ||    /* if high priority */
               canput(q->q_next)) {          /* normal & can be passed */
15               if (mp->b_datap->db_type != M_DATA)
16                    putnext(q, mp);           /* send all but M_DATA */
17               else {
18                    bp = allocb(sizeof(struct hdr), BPRI_LO);
19                    if (bp == NULL) {               /* if unsuccessful */
20                      putbq(q, mp);               /* put it back */
21                      if (!bufcall(sizeof(struct hdr), BPRI_LO,
                            qenable, (long)q))    /* try to reschedule */
22                          timeout(qenable, (long)q, HZ/2);
23                      return;
24                    }
25                    hp = (struct hdr *)bp->b_wptr;
26                    hp->h_size = msgdsize(mp);  /* initialize header */
27                    hp->h_version = 1;
28                    bp->b_wptr += sizeof(struct hdr);
29                    bp->b_datap->db_type = M_PROTO; /* make M_PROTO  */
30                    bp->b_cont = mp;                  /* link it */
31                    putnext(q, bp);                    /* pass it on */
32               }
33         } else {                  /* normal priority, canput failed */
34              putbq(q, mp);         /* put back on the message queue */
35              return;
36         }
37       }
38  }
```

NAME

bzero – clear memory for a given number of bytes

SYNOPSIS

```
#include <sys/types.h>

int bzero(caddr_taddr, int bytes);
```

ARGUMENTS

addr	Starting virtual address of memory to be cleared.
bytes	The number of bytes to clear starting at *addr*.

DESCRIPTION

The bzero function clears a contiguous portion of memory by filling the memory with zeros.

CAUTION: The address range specified must be within the kernel space. No range checking is done. If an address outside of the kernel space is selected, the driver may corrupt the system in an unpredictable way.

RETURN VALUE

Under normal conditions, a 0 is returned. Otherwise, a -1 is returned.

LEVEL

Base or Interrupt

SEE ALSO

bcopy(D3DK), clrbuf(D3DK), kmem_zalloc(D3DK)

EXAMPLE

In a driver close(D2DK) routine, rather than clear each individual member of its private data structure, the driver could use bzero as shown here:

```
bzero(&drv_dat[minor(dev)], sizeof(struct drvr_data));
```

NAME

canput – test for room in a message queue

SYNOPSIS

```
#include <sys/stream.h>

int canput(queue_t *cq);
```

ARGUMENT

**cq* The pointer to the message queue. queue_t is an alias for the queue(D4DK) structure.

DESCRIPTION

canput searches through the stream (starting at *cq*) until it finds a queue containing a service routine where the message can be enqueued, or until it reaches the end of the stream. If found, the queue containing the service routine is tested to see if there is room for a message in the queue. If the queue is full, canput sets the **QWANTW** flag to back-enable the caller's service routine.

NOTE: You are responsible for both testing a queue with canput and refraining from placing a message on the queue if canput fails.

RETURN VALUE

If the message queue is not full, 1 is returned. A 0 is returned if the queue is full.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

bcanput(D3DK), putbq(D3DK), putnext(D3DK)

EXAMPLE

See the bufcall(D3DK) function page for an example of canput.

NAME

clrbuf – erase the contents of a buffer

SYNOPSIS

```
#include <sys/types.h>
#include <sys/buf.h>

void clrbuf(struct buf *bp);
```

ARGUMENT

bp Pointer to the buf(D4DK) structure

DESCRIPTION

The clrbuf function zeros a buffer and sets the b_resid member of the buf structure to 0. Zeros are placed in the buffer starting at bp->b_un.b_words for a length of bp->b_bcount bytes. b_un.b_words and b_bcount are members of the buf structure defined in sys/buf.h.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

brelse(D3DK), buf(D4DK)

EXAMPLE

See biowait(D3DK).

NAME

cmn_err – display an error message or panic the system

SYNOPSIS

```
#include <sys/cmn_err.h>

int cmn_err( int level, char *format, int args);
```

ARGUMENTS

level A constant defined in the sys/cmn_err.h header file. *level* indicates the severity of the error condition. The four severity levels are

CE_CONT used to continue another message or to display an informative message not connected with an error.

CE_NOTE used to display a message preceded with NOTICE. This message is used to report system events that do not necessarily require user action, but may interest the system administrator. For example, a message saying that a sector on a disk needs to be accessed repeatedly before it can be accessed correctly might be noteworthy.

CE_WARN used to display a message preceded with WARNING. This message is used to report system events that require immediate attention, such as those where if an action is not taken, the system may panic. For example, when a peripheral device does not initialize correctly, this level should be used.

CE_PANIC used to display a message preceded with PANIC or DOUBLE PANIC, and to panic the system. Drivers should specify this level only under the most severe conditions or when debugging a driver. A valid use of this level is when the system cannot continue to function. If the error is recoverable, or not essential to continued system operation, do not panic the system. This level halts multiuser processing.

format The message to be displayed. By default, the message is sent both to the system console and to the kernel buffer putbuf. If the first character in *format* is an exclamation point ("!"), the message goes only to putbuf. If the first character in *format* is a circumflex ("^"), the message goes only to the console. Except for the first character, the rules for *format* are the same as those for printf(3S) strings. To read putbuf, use the following crash(1M) commands:

```
od -d putbufsz
od -a putbuf size
```

The first command returns the size of putbuf (the default is 2000 bytes). The second command uses the returned *size* to read putbuf.

cmn_err appends \n to each *format*, even when a message is sent to putbuf, except when *level* is CE_CONT.

Vaild conversion specifications are %s, %u, %d, %o, and %x. The cmn_err function is otherwise similar to the printf(3S) library subroutine in displaying messages on the system console or storing on putbuf.

NOTE: cmn_err does not accept length specifications in conversion specifications. For example, %3d is ignored.

args the set of arguments passed with the message being displayed. Any argument within the range of supported conversion specifications can be passed.

DESCRIPTION

cmn_err displays a specified message on the console and/or stores it in the putbuf array. cmn_err can also panic the system.

At times, a driver may encounter error conditions requiring the attention of a primary or secondary system console monitor. These conditions may mean halting multiuser processing; however, this must be done with caution. Except during the debugging stage, a driver should never stop the system.

The cmn_err function with the CE_CONT argument can be used by driver developers as a driver code debugging tool. However, using cmn_err in this capacity can change system timing characteristics.

If CE_PANIC is set, cmn_err stops the machine.

RETURN VALUE

None. However, if an unknown *level* is passed to cmn_err, the following panic error message is displayed:

PANIC: unknown level in cmn_err (level=*level*, msg=*format*)

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 12

print(D2DK), printf(3S)

EXAMPLE

The cmn_err function can record tracing and debugging information only in the putbuf (lines 15 and 16); display problems with a device only on the system console (line 21); or stop the system if a required device malfunctions (line 27).

```
 1  struct  device {                /* physical device registers layout */
 2          int      control;          /* physical device control word */
 3          int      status;            /* physical device status word */
 4          int      error;                 /* error codes from device */
 5          short    recv_char;        /* receive character from device */
 6          short    xmit_char;          /* transmit character to device */
 7  }; /* end device */
 8
 9  extern struct device xx_addr[];        /* physical device registers */
10  extern int          xx_cnt;          /* number of physical devices */
```

```
  . . .
register struct device *rp;
rp = xx_addr[(getminor(dev) >> 4) & 0xf];        /* get dev registers */

#ifdef DEBUG               /* in debugging mode, log function call */
     cmn_err(CE_NOTE, "!xx_open function call, dev = 0x%x", dev);
     cmn_err(CE_CONT, "! flag = 0x%x", flag);      /* continue msg */
#endif  /* end DEBUG */

                 /* display device power failure on system console */
   if ((rp->status & POWER) == OFF)
      cmn_err(CE_WARN, "xx_open: Power is OFF on device %d port %d",
              ((getminor(dev) >> 4) & 0xf), (getminor(dev) & 0xf));

                        /* halt system if root device has bad VTOC */
                   /* send message to system console and to putbuf */
   if (rp->error == BADVTOC  &&  dev == rootdev)
      cmn_err(CE_PANIC, "xx_open: Bad VTOC on root device");
```

NAME

copyb – copy a message block

SYNOPSIS

```
#include <sys/stream.h>

mblk_t *copyb(mblk_t *bp);
```

ARGUMENT

bp Pointer to the message block from which data is copied.

DESCRIPTION

copyb allocates a new message block, and copies into it the data from the block pointed to by *bp*. The new block will be at least as large as the block being copied. The b_rptr and b_wptr members of *bp* are used to determine how many bytes to copy.

RETURN VALUE

If successful, copyb returns a pointer to the newly allocated message block containing the copied data. Otherwise, it returns a NULL pointer.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

allocb(D3DK)

EXAMPLE

For each message in the list, test to see if the downstream queue is full with the canput(D3DK) function (line 21). If it is not full, use copyb(D3DK) to copy a header message block, and dupmsg(D3DK) to duplicate the data to be retransmitted. If either operation fails, reschedule a timeout at the next valid interval.

Update the new header block with the correct destination address (line 34), link the message to it (line 35), and send it downstream (line 36). At the end of the list, reschedule this routine.

```
 1  struct retrns {
 2          mblk_t *r_mp;
 3          long r_address;
 4          queue_t *r_outq;
 5          struct retrns *r_next;
 6  };
 7
 8  struct protoheader {
           . . .
 9          long h_address;
           . . .
10  };
11
12  mblk_t *header;
13
14  retransmit(ret)
```

```
        register struct retrns *ret;
{
        register mblk_t *bp, *mp;
        struct protoheader *php;

        while (ret) {
                if (!canput(ret->r_outq->q_next)) { /* no room */
                     ret = ret->r_next;
                     continue;
                }
                bp = copyb(header);  /* copy header msg. block */
                if (bp == NULL)
                        break;
                mp = dupmsg(ret->r_mp);       /* duplicate data */
                if (mp == NULL) {            /* if unsuccessful */
                        freeb(bp);            /* free the block */
                        break;
                }
                php = (struct protoheader *)bp->b_rptr;
                php->h_address = ret->r_address; /* new header */
                bp->bp_cont = mp;           /* link the message */
                putnext(ret->r_outq, bp);   /* send downstream */
                ret = ret->r_next;
        }
       timeout(retransmit, (long)ret, RETRNS_TIME);  /* reschedule */
}
```

NAME

copyin – copy data from a user program to a driver buffer

SYNOPSIS

```
#include <sys/types.h>

int copyin(caddr_t userbuf, caddr_t driverbuf, int cn);
```

ARGUMENTS

userbuf	User program source address from which data is transferred.
driverbuf	Driver destination address to which data is transferred.
cn	Number of bytes transferred.

DESCRIPTION

copyin copies data from a user program source address to a driver buffer. The driver developer must ensure that adequate space is allocated for the destination address.

Addresses that are word-aligned are moved most efficiently. However, the driver developer is not obligated to ensure alignment. This function automatically finds the most efficient move according to address alignment.

RETURN VALUE

Under normal conditions a 0 is returned indicating a successful copy. A -1 is returned if one of the following occurs:

> paging fault; the driver tried to access a page of memory for which it did not have read or write access
>
> invalid user area or stack area
>
> invalid address that would have resulted in data being copied into the user block

If a -1 is returned, return EFAULT.

LEVEL

Base Only (Do not call from an interrupt routine)

SEE ALSO

BCI Driver Development Guide, Chapter 6, "Input/Output Operations"

bcopy(D3DK), copyout(D3DK), uiomove(D3DK)

NAME

copymsg – copy a message

SYNOPSIS

```
#include <sys/stream.h>

mblk_t *copymsg(mblk_t mp);
```

ARGUMENTS

mp Pointer to the message to be copied. mblk_t is an instance of the msgb(D4DK) structure.

DESCRIPTION

copymsg forms a new message by allocating new message blocks, copies the contents of the message referred to by *mp* (using the copyb(D3DK) function), and returns a pointer to the new message.

RETURN VALUE

If the copy is successful, copymsg returns a pointer to the new message. Otherwise, it returns a NULL pointer.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

allocb(D3DK), copyb(D3DK), msgb(D4DK)

EXAMPLE

The routine lctouc converts all the lowercase ASCII characters in the message to uppercase. If the reference count is greater than one (line 8), then the message is shared, and must be copied before changing the contents of the data buffer. If the call to the copymsg(D3DK) function fails (line 9), return NULL (line 10), otherwise, free the original message (line 11). If the reference count was equal to 1, the message can be modified. For each character (line 16) in each message block (line 15), if it is a lowercase letter, convert it to an uppercase letter line 18). A pointer to the converted message is returned (line 21).

```
 1 mblk_t *lctouc(mp)
 2    mblk_t *mp;
 3 {
 4    mblk_t *cmp;
 5    mblk_t *tmp;
 6    unsigned char *cp;
 7
 8    if (mp->b_datap->db_ref > 1) {
 9            if ((cmp = copymsg(mp)) == NULL)
10                    return(NULL);
11            freemsg(mp);
12    } else {
13            cmp = mp;
14    }
15    for (tmp = cmp; tmp; tmp = tmp->b_next) {
16            for (cp = tmp->b_rptr; cp < tmp->b_wptr; cp++) {
```

```
              if ((*cp <= 'z') && (*cp >= 'a'))
                    *cp -= 0x20;
        }
  }
  return(cmp);
}
```

NAME

copyout – copy data from a driver to a user program

SYNOPSIS

```
#include <sys/types.h>

int copyout(caddr_t driverbuf, caddr_t userbuf, long cn);
```

ARGUMENTS

driverbuf Source address in the driver from which the data is transferred.

userbuf Destination address in the user program to which the data is transferred.

cn Number of bytes moved.

DESCRIPTION

copyout copies data from driver buffers to user data space.

Addresses that are word-aligned are moved most efficiently. However, the driver developer is not obligated to ensure alignment. This function automatically finds the most efficient move algorithm according to address alignment.

RETURN VALUE

Under normal conditions a 0 is returned to indicate a successful copy. Otherwise, a −1 is returned if the specified address range is not valid.

If a −1 is returned, return EFAULT.

LEVEL

Base Only (Do not call from an interrupt routine)

SEE ALSO

BCI Driver Development Guide, Chapter 6, ''Input/Output Operations''

bcopy(D3DK), uiomove(D3DK), copyin(D3DK)

EXAMPLE

A driver ioctl(D2DK) routine (line 9) can be used to get or set device attributes or registers. In the XX_GETREGS condition (line 17), the driver copies the current device register values to a user data area (line 18). If the specified argument contains an invalid address, an error code is returned.

```
 1  struct  device  {       /* layout of physical device registers  */
 2          int      control;     /* physical device control word  */
 3          int      status;      /* physical device status word   */
 4          short    recv_char;   /* receive character from device */
 5          short    xmit_char;   /* transmit character to device  */
 6  }; /* end device */
 7
 8  extern struct device xx_addr[]; /* phys. device regs. location */
       . . .
 9  xx_ioctl(dev, cmd, arg, flag)
10          dev_t   dev;
11          caddr_t arg;
12               ...
13  {
14      register struct device *rp = &xx_addr[getminor(dev) >> 4];
```

```
switch(cmd)  {

 case XX_GETREGS:     /* copy device regs. to user program */
      if (copyout((caddr_t)rp, arg, sizeof(struct device))
          return(EFAULT);
          /* endif */
      break;
```

NAME

datamsg – test whether a message is a data message

SYNOPSIS

```
#include <sys/stream.h>
#include <sys/ddi.h>

int datamsg(unsigned char type);
```

ARGUMENT

type The type of message to be tested. The db_type field of the datab structure contains the message type. This field may be accessed through the message block using mp->b_datap->db_type.

DESCRIPTION

The datamsg function tests the type of message to determine if it is a data message type (M_DATA, M_DELAY, M_PROTO, or M_PCPROTO).

RETURN VALUE

datamsg returns 1 for TRUE, if the message is a data message; and 0 for FALSE for any other type of message.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

allocb(D3DK), datab(D4DK), msgb(D4DK)

EXAMPLE

The put(D2DK) routine enqueues all data messages for handling by the srv(D2DK) (service) routine. All non-data messages are handled in the put routine.

```
xxxput(q, mp)
      queue_t *q;
      mblk_t *mp;
{
  if (datamsg(mp->b_datap->db_type)) {
       putq(q, mp);
       return;
  }
  switch (mp->b_datap->db_type) {
     case M_FLUSH:
       . . .
  }
}
```

NAME

delay – delay process execution for a specified number of clock ticks

SYNOPSIS

`void delay(long` *ticks*`);`

ARGUMENT

ticks The number of clock cycles for a delay. *ticks* are frequently set as an expression containing the system variable HZ, the number of clock ticks in one second; HZ is defined in sys/param.h.

DESCRIPTION

delay provides a way to wait for an event to happen. Occasionally, a driver may need to wait a given period of time until work is available. The value of HZ can vary from system to system, and so the function drv_hztousec(D3DK) should be used when accurate timing is required.

The delay function calls timeout(D3DK) to schedule a wakeup call after the specified amount of time has elapsed. delay then goes to sleep until timeout wakes up the sleeping process. While delay is active, splhi is set. At completion, the former priority level is returned through splx.

delay requires user context.

RETURN VALUE

None

LEVEL

Base Only (Do not call from an interrupt routine)

SEE ALSO

BCI Driver Development Guide, Chapter 10, "Synchronizing Hardware and Software Events"

biodone(D3DK), biowait(D3DK), drv_hztousec(D3DK), drv_usectohz(D3DK), sleep(D3DK), timeout(D3DK), untimeout(D3DK), wakeup(D3DK)

EXAMPLE

Before a driver I/O routine allocates buffers and stores any user data in them, it checks the status of the device (line 12). If the device needs manual intervention (such as, needing to be refilled with paper), a message is displayed on the system console (line 14). The driver waits an allotted time (line 16) before repeating the procedure.

```
 1  struct  device  {            /* layout of physical device registers */
 2          int     control;     /* physical device control word      */
 3          int     status;      /* physical device status word       */
 4          short   xmit_char;   /* transmit character to device     */
 5  }; /* end device */
 6
 7  extern struct device xx_addr[]; /* physical device regs.  location */
       . . .
 9                                              /* get device registers  */
10  register struct device *rp = &xx_addr[getminor(dev)>>4)];
11
```

```
while(rp->status & NOPAPER) {     /* while printer is out of paper */
                /* display message and ring bell on system console */
    cmn_err(CE_WARN, "^xx_write: NO PAPER in printer %d\007",
                      (dev & 0xf));
    delay(60 * HZ);           /* wait one minute and try again */
} /* endwhile */
```

NAME

dma_pageio – break up an I/O request into manageable units

SYNOPSIS

```
#include <sys/buf.h>

void dma_pageio(void (*strat)() strat, struct buf *bp);
```

ARGUMENTS

**strat* Pointer to the strategy(D2DK) routine to call to complete the I/O transfer.

bp Pointer to the buf structure.

DESCRIPTION

dma_pageio breaks up a data transfer request from physiock(D3DK) into units of contiguous memory. This function enhances the capabilities of the direct memory access controller (DMAC). The data is broken into 512-byte sectors until the last data bytes are encountered. dma_pageio executes spl0 around its internal sleep calls on reads and writes after the strategy routine is called. This may alter previously set spl(D3D) calls.

The driver must modify b_flags to indicate whether the transfer is a read or a write. OR in B_READ to indicate a read; turn B_READ off to indicate a write.

RETURN VALUE

None. However, conditions in dma_pageio can cause the following to be set:

> If memory for a temporary buffer cannot be allocated, b_flags is ORed with B_ERROR and B_DONE, and b_error is set to EAGAIN (resource temporarily unavailable). All allocated temporary buffers are deallocated when the transfer completes.
>
> If the I/O transfer is incomplete (b_flags does not contain B_DONE), then b_flags is set to B_WANTED and sleep(D3DK) is called to wait until a buffer can be allocated. The sleep priority is set to PRIBIO.
>
> The sleep code section is surrounded by a spl6-spl0 function set which may alter a previously set spl value.
>
> If B_ERROR is set after the strategy(D2DK) routine completes, allocated memory is freed and dma_pageio returns.
>
> When the transfer completes, any allocated buffers are freed.

LEVEL

Base Only

SEE ALSO

BCI Driver Development Guide, Chapter 6, "Input/Output Operations"

EXAMPLE

The following example shows how dma_pageio is used when reading or writing disk data.

```
struct  dsize    {
        daddr_t nblocks;  /* number of blocks in disk partition    */
        int     cyloff;   /* starting cylinder # of partition      */
} my_sizes[4] = {

        20448, 21,        /* partition 0 = cyl 21-305             */
        21888, 1          /* partition 1 = cyl  1-305             */
};

/*    physical read    */
my_read(dev, uio_p, cred_p)
        dev_t   dev;
        uio_t   *uio_p;
        cred_t  *cred_p;
{
        register int nblks;
        /* get number of blocks in the partition                   */
        nblks = my_sizes[getminor(dev) & 0x7].nblocks;

        /* if request is within limits for the device, schedule I/O*/
        physiock(my_breakup, 0, dev, B_READ, nblks, uio_p);

}
/*    physical write    */
my_write(dev, uio_p, cred_p)
        dev_t   dev;
        uio_t   *uio_p;
        cred_t  *cred_p;
{
        register int nblks;
        /* get the number of blocks in the partition                */
        nblks = my_sizes[getminor(dev) & 0x7].nblocks;

        /* if request is within limits for the device, schedule I/O */
         physiock(my_breakup, 0, dev, B_WRITE, nblks, uio_p);
        }
}
/*
 *    break up the request that came from physio into chunks of
 *    contiguous memory.  Pass at least 512 bytes (one sector) at a
 *    time (except for the last request).
 */

static
my_breakup(bp)
       register struct buf *bp;
{
       dma_pageio(my_strategy, bp);
}
```

NAME

drv_getparm – retrieve kernel state information

SYNOPSIS

```
#include <sys/ddi.h>

int drv_getparm(unsigned long parm, unsigned long *value_p);
```

ARGUMENTS

parm The kernel parameter to be obtained from `ddi.h`. Possible values are

`LBOLT`	Read the value of the `lbolt`. (`lbolt` is an integer that represents the number of clock ticks since the last system reboot. This value is used as a counter or timer inside the system kernel.)
`PPGRP`	Read the process group identification number. This number determines which processes should receive a `HANGUP` or `BREAK` signal when detected by a driver.
`UPROCP`	Read the process table token value. This information is used for the second argument of the `vtop`(D3D) function.
`PPID`	Read process identification number.
`PSID`	Read process session identification number.
`TIME`	Read time in seconds.

value_p A pointer to the data space in which the value of the parameter is to be copied.

DESCRIPTION

This function verifies that *parm* corresponds to a kernel parameter that may be read. If the value of *parm* does not correspond to a parameter or corresponds to a parameter that may not be read, `-1` is returned. Otherwise, the value of the parameter is stored in the data space pointed to by *value_p*.

`drv_getparm` does not explicitly check to see whether the device has the appropriate context when the function is called and the function does not check for correct alignment in the data space pointed to by *value_p*. It is the responsibility of the driver writer to use this function only when it is appropriate to do so and to correctly declare the data space needed by the driver.

RETURN VALUE

`drv_getparm` returns 0 to indicate success, `-1` to indicate failure. The value stored in the space pointed to by *value_p* is the value of the parameter if 0 is returned, undefined if `-1` is returned. `-1` is returned if you specify a value other than `LBOLT`, `PPGRP`, `PPID`, `PSID`, `TIME` or `UPROCP`. Always check the return code when using this function.

LEVEL

Base only when using the `PPGRP`, `PPID`, `PSID`, `TIME`, or `UPROCP` argument values.

Interrupt usable when using the LBOLT argument value.

SEE ALSO

vtop(D3D), buf(D4DK)

NAME

drv_hztousec – convert clock ticks to microseconds

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ddi.h>

clock_t drv_hztousec(clock_t hz);
```

ARGUMENT

hz The length of time (expressed in HZ units) to convert to its microsecond equivalent

DESCRIPTION

drv_hztousec converts into microseconds the length of time expressed by *hz*, which is in units of time based on the value of HZ, the kernel parameter whose value is defined in sys/param.h.

The kernel variable lbolt, which is readable through drv_getparm(D3DK), is the length of time the system has been up since boot and is expressed in HZ units. Drivers often use the value of lbolt before and after an I/O request to measure the amount of time it took the device to process the request. drv_hztousec can be used by the driver to convert the reading from HZ units, which could potentially vary between system implementations, to a known unit of time.

RETURN VALUE

The number of microseconds equivalent to the *hz* argument. No error value is returned. If the microsecond equivalent to *hz* is too large to be represented as a clock_t, then the maximum clock_t value will be returned.

LEVEL

Base or Interrupt

SEE ALSO

drv_getparm(D3DK), drv_usectohz(D3DK)

NAME

drv_priv – determine driver privilege

SYNOPSIS

```
int drv_priv(cred_t *cr);
```

ARGUMENT

**cr*   Pointer to the cred(D4DK) (credential) structure.

DESCRIPTION

The drv_priv function provides a general interface to the system privilege policy. It determines whether the credentials supplied by the cred structure pointed to by *cr* identify a priviledged process. This function should only be used when file access modes and special minor device numbers are insufficient to provide protection for the requested driver function. It is intended to replace all calls to suser() and any explicit checks for effective user ID = 0 in driver code.

RETURN VALUE

This routine returns 0 if it succeeds, EPERM if it fails.

LEVEL

Base or Interrupt

SEE ALSO

cred(D4DK)

NAME

drv_usectohz – convert microseconds to clock ticks

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ddi.h>

clock_t drv_usectohz(clock_t microsecs);
```

ARGUMENTS

microsecs The number of microseconds to convert to its HZ equivalent.

DESCRIPTION

drv_usectohz converts a length of time expressed in microseconds to HZ, the unit of time based on the the kernel parameter HZ whose value is defined in sys/param.h. The time arguments to **timeout**(D3DK) and **delay**(D3DK) are expressed in HZ, as well as the kernel variable **lbolt**, which is readable through drv_getparm(LBOLT).

drv_usectohz is a portable way for drivers to make calls to timeout(D3DK) and delay(D3DK) and remain binary compatible should the driver object file be made part of a kernel that was compiled with a value of HZ different from that with which the driver was compiled.

RETURN VALUE

The value returned is the number of HZ units equivalent to the *microsecs* argument. No error value is returned. If the HZ equivalent to *microsecs* is too large to be represented as a clock_t, then the maximum clock_t value will be returned.

LEVEL

Base or Interrupt

SEE ALSO

drv_hztousec(D3DK)

NAME

`drv_usecwait` – busy-wait for specified interval

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ddi.h>

void drv_usecwait(clock_t microsecs);
```

ARGUMENT

microsecs The number of microseconds to busy-wait.

DESCRIPTION

The kernel function `delay`(D3DK) can be used by a driver to delay for a specified number of system ticks (given by parameter `HZ` in `sys/param.h`, which indicates how many system ticks occur per second). There are two limitations: (1) the granularity of the wait time is limited to `1/HZ` second, which may be more time than is needed for the delay, and (2) `delay`(D3DK) may only be invoked with user context and hence cannot be used at interrupt time or system initialization.

Often, drivers need to delay for only a few microseconds, waiting for a write to a device register to be picked up by the device. In this case, even with user context, `delay`(D3DK) produces too long a wait period. The function `drv_usecwait` is provided to give drivers a means of busy-waiting for a specified microsecond count. The amount of time spent busy-waiting may be greater than the microsecond count but will minimally be the number of microseconds specified.

Note that the driver wastes processor time by making this call since `drv_usecwait` does not invoke sleep but simply busy-waits. The driver should only make calls to `drv_usecwait` as needed, and only for as much time as needed. `drv_usecwait` does not raise the processor interrupt level; if the driver wishes to mask out interrupts, it is its responsibility to set the priority level before the call and restore it to its original value afterward.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

`delay`(D3DK), `timeout`(D3DK), `untimeout`(D3DK)

NAME

dupb – duplicate a message block descriptor

SYNOPSIS

```
#include <sys/stream.h>

mblk_t *dupb(mblk_t *bp);
```

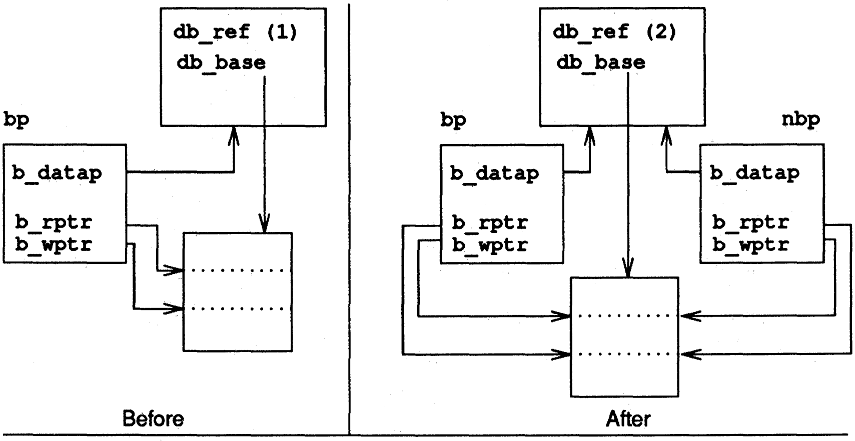
ARGUMENTS

**bp* Pointer to the message block to be duplicated. mblk_t is an instance of the msgb(D4DK) structure.

DESCRIPTION

dupb creates a new mblk_t structure to reference the message block pointed to by *bp*. Unlike copyb(D3DK), dupb does not copy the information in the data block, but creates a new structure to point to it.

The following figure shows how the db_ref field of the dblk_t structure has been changed from 1 to 2, reflecting the increase in the number of references to the data block. The new mblk_t contains the same information as the first. Note that b_rptr and b_wptr are copied from *bp*, and that db_ref is incremented.



nbp=dupb(bp);

RETURN VALUE

If successful, dupb returns a pointer to the new message block. Otherwise, it returns a NULL pointer.

LEVEL

Base or Interrupt

SEE ALSO

copyb(D3DK)

EXAMPLE

This srv(D3DK) (service) routine adds a header to all M_DATA messages before passing them along. The message block for the header was allocated elsewhere. For each message on the queue, if it is a priority message, pass it along immediately (lines 9–10). Otherwise, if it is anything other than an M_DATA message (line 11), and if it can be sent along (line 12), then do so (line 13). Otherwise, put the message back on the queue and return (lines 15–16). For all M_DATA messages, first check to see if the stream is flow-controlled (line 19). If it is, put the message back on the queue and return (line 22); if it is not, the header block is duplicated (line 20). If dupb fails, the service routine is rescheduled in one tenth of a second (HZ/10) with timeout and then we return (lines 23–24). If dupb succeeds, link the M_DATA message to it (line 26) and pass it along (line 27). dupb can be used here instead of copyb(D3DK) because the contents of the header block are not changed.

```
 1  xxxsrv(q)
 2      queue_t *q;
 3  {
 4    mblk_t *mp;
 5    mblk_t *bp;
 6    extern mblk_t *hdr;
 7
 8    while ((mp = getq(q)) != NULL) {
 9          if (mp->b_datap->db_type >= QPCTL) {
10                putnext(q, mp);
11          } else if (mp->b_datap->db_type != M_DATA) {
12                if (canput(q->q_next))
13                      putnext(q, mp);
14                else {
15                      putbq(q, mp);
16                      return;
17                }
18          } else {      /* M_DATA */
19                if (canput(q->q_next)) {
20                      bp = dupb(hdr);
21                      if (bp == NULL) {
22                            putbq(q, mp);
23                            timeout(qenable, (long)q, HZ/10);
24                            return;
25                      }
26                      linkb(bp, mp);
27                      putnext(q, bp);
28                } else {
29                      putbq(q, mp);
30                      return;
31                }
32          }
33    }
34  }
```

NAME

dupmsg – duplicate a message

SYNOPSIS

```
#include <sys/stream.h>

mblk_t *dupmsg(mblk_t *mp);
```

ARGUMENTS

mp	Pointer to the message block.

DESCRIPTION

dupmsg forms a new message by copying the message block descriptors pointed to by *mp* and linking them. dupb(D3DK) is called for each message block. The data blocks themselves are not duplicated.

RETURN VALUE

If successful, dupmsg returns a pointer to the new message block. Otherwise, it returns a NULL pointer.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

copyb(D3DK), copymsg(D3DK), dupb(D3DK)

EXAMPLE

See the copyb(D3DK) function page for an example of dupmsg.

NAME

`enableok` – reschedule a queue for service

SYNOPSIS

```
#include <sys/stream.h>
#include <sys/ddi.h>

void enableok(queue_t *q);
```

ARGUMENT

q	A pointer to the queue to be rescheduled.

DESCRIPTION

The `enableok` function allows queue *q* to be rescheduled for service. It cancels the effect of a previous use of the `noenable`(D3DK) function on *q* by turning off the `QNOENB` flag in the queue.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

`noenable`(D3DK), `qenable`(D3DK)

EXAMPLE

The `qrestart` routine uses two STREAMS functions to restart a queue that has been disabled. The `enableok` function turns off the `QNOENB` flag, allowing the `qenable`(D3DK) function to schedule the queue for immediate processing.

```
void
qrestart(rdwr_q)
     register queue_t *rdwr_q;

{
   enableok(rdwr_q);
   /* re-enable a queue that has been disabled */
   (void) qenable(rdwr_q);

}
```

NAME

esballoc – allocate a message block using a shared buffer

SYNOPSIS

```
#include <sys/stream.h>

mblk_t *esballoc(unsigned char *base, int size, int pri,
     frtn_t *fr_rtnp);
```

ARGUMENTS

base Address of user supplied data buffer.

size Number of bytes in data buffer.

pri Priority of allocation request (to be used by allocb(D3DK) function, called by esballoc).

fr_rtnp Free routine data structure.

DESCRIPTION

esballoc creates a STREAMS message and attaches a user-supplied data buffer in place of a STREAMS data buffer. It calls allocb(D3DK) to get a message and data block header only. The user-supplied data buffer, pointed to by *base,* is used as the data buffer for the message.

The free_rtn structure is referenced by the dp_freep member of the datab structure. When freeb(D3DK) is called to free the message, the driver's message freeing routine (referenced through the free_rtn structure) is called, with arguments, to free the data buffer.

The free_rtn structure has the following declaration:

```
struct free_rtn {
     void (*free_func)(); /* user's freeing routine */
     char *free_arg;      /* arguments to free_func() */
}
typedef struct free_rtn frtn_t;
```

Instead of requiring a specific number of arguments, the free_arg field is defined of type char *. This way, the driver can pass a pointer to a structure if more than one argument is needed.

NOTE: The free_func function must be defined in kernel space, should be declared void and accept one argument. It has no user context and must not sleep.

RETURN VALUE

On success, a pointer to the newly allocated message block is returned. On failure, NULL is returned.

LEVEL

Base or Interrupt

SEE ALSO

allocb(D3DK), freeb(D3DK), datab(D4DK), free_rtn(D4DK)

NAME

`esbbcall` – call function when buffer is available

SYNOPSIS

```
#include <sys/stream.h>

mblk_t *esbbcall(int pri, int func, long arg);
```

ARGUMENTS

pri Priority of allocation request (to be used by `allocb`(D3DK) function, called by `esbbcall`)

func Function to be called when buffer becomes available.

arg Argument to *func.*

DESCRIPTION

`esbbcall`, like `bufcall`(D3DK), serves as a `timeout`(D3DK) call of indeterminate length. If `esballoc`(D3DK) is unable to allocate a message and data block header to go with its externally supplied data buffer, `esbbcall` can be used to schedule the routine *func,* to be called with the argument *arg* when a buffer becomes available. *func* may be a routine that calls `esbbcall` or it may be another kernel function.

RETURN VALUE

On success, 1 is returned. On failure, 0 is returned.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

`allocb`(D3DK), `bufcall`(D3DK), `datab`(D4DK), `esballoc`(D3DK)

NAME

etoimajor – convert external to internal major device number

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ddi.h>

int etoimajor(major_t emaj);
```

ARGUMENT

emaj An external major number.

DESCRIPTION

etoimajor converts the external major number (*emaj*) to an internal major number.

RETURN VALUE

etoimajor returns the internal major number or NODEV if the external major number exceeds the bdevsw and cdevsw count.

LEVEL

Base or Interrupt

SEE ALSO

getemajor(D3D), geteminor(D3D), getmajor(D3DK), getminor(D3DK), itoemajor(D3D), makedevice(D3DK)

NAME

`flushband` – flush messages for a specified priority band

SYNOPSIS

```
#include <sys/stream.h>

void flushband(queue_t q, unsigned char pri, int flag);
```

ARGUMENTS

q	Pointer to the queue.
pri	Priority of messages to be flushed.
flag	Valid *flag* values are:

`FLUSHDATA`	Flush only data messages (types `M_DATA`, `M_DELAY`, `M_PROTO`, and `M_PCPROTO`).
`FLUSHALL`	Flush all messages.

DESCRIPTION

The `flushband` function flushes messages associated with the priority band specified by *pri*. If *pri* is `0`, only normal and high priority messages are flushed. Otherwise, messages are flushed from the band *pri* according to the value of *flag*.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

`flushq`(D3DK)

NAME

`flushq` – remove messages from a queue

SYNOPSIS

`#include <sys/stream.h>`

`void flushq(queue_t *`*q*`, int `*flag*`);`

ARGUMENTS

**q* Pointer to the queue to be flushed.

flag Valid *flag* values are:

`FLUSHDATA` Flush only data messages (types `M_DATA`, `M_DELAY`, `M_PROTO`, and `M_PCPROTO`).

`FLUSHALL` Flush all messages.

DESCRIPTION

`flushq` frees messages and their associated data structures by calling `freemsg`(D3DK). If the queue's count falls below the low water mark and `QWANTW` is set, the nearest upstream service procedure is enabled.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

`freemsg`(D3DK), `putq`(D3DK)

EXAMPLE

This example depicts the canonical flushing code for STREAMS modules. The module has a write service procedure and potentially has messages on the queue. If it receives an `M_FLUSH` message, and if the `FLUSHR` bit is on in the first byte of the message (line 10), then the read queue is flushed (line 11). If the `FLUSHW` bit is on (line 12), then the write queue is flushed (line 13). Then the message is passed along to the next entity in the stream (line 14). See the example for `qreply`(D3DK) for the canonical flushing code for drivers.

```
 1  /*
 2   * Module write-side put procedure.
 3   */
 4  xxxwput(q, mp)
 5      queue_t *q;
 6      mblk_t *mp;
 7  {
 8     switch(mp->b_datap->db_type) {
 9     case M_FLUSH:
10             if (*mp->b_rptr & FLUSHR)
11                     flushq(RD(q), FLUSHALL);
12             if (*mp->b_rptr & FLUSHW)
13                     flushq(q, FLUSHALL);
14             putnext(q, mp);
```

```
        break;
        . . .
    }
}
```

NAME

`freeb` – free a message block

SYNOPSIS

```
#include <sys/stream.h>

void freeb(mblk_t *bp);
```

ARGUMENTS

bp Pointer to the message block to be deallocated. `mblk_t` is an instance of the `msgb`(D4DK) structure.

DESCRIPTION

`freeb` deallocates a message block. If the reference count of the `db_ref` member of the `datab`(D4DK) structure is greater than `1`, `freeb` decrements the count. If `db_ref` equals `1`, it deallocates the message block and the corresponding data block and buffer.

If the data buffer to be freed was allocated with the `esballoc`(D3DK) function, the buffer may be a non-STREAMS resource. In that case, the driver must be notified that the attached data buffer needs to be freed, and run its own freeing routine. To make this process independent of the driver used in the stream, `freeb` finds the `free_rtn`(D4DK) structure associated with the buffer. The `free_rtn`(D4DK) structure contains a pointer to the driver-dependent routine, which releases the buffer. Once this is accomplished, `freeb` releases the STREAMS resources associated with the buffer.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

`allocb`(D3DK), `dupb`(D3DK), `esballoc`(D3DK), `free_rtn`(D4DK)

EXAMPLE

See the `copyb`(D3DK) function page for an example of `freeb`.

NAME

`freemsg` – free all message blocks in a message

SYNOPSIS

```
#include <sys/stream.h>

int freemsg(mblk_t *mp);
```

ARGUMENT

mp Pointer to the message blocks to be deallocated. `mblk_t` is an instance of the `msgb`(D4DK) structure.

DESCRIPTION

`freemsg` calls `freeb`(D3DK) to free all message and data blocks associated with the message pointed to by *mp*.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

`freeb`(D3DK)

EXAMPLE

See the `copymsg`(D3DK) function page for an example of `freemsg`.

NAME

freerbuf – free a raw buffer header

SYNOPSIS

```
#include <sys/buf.h>
#include <sys/ddi.h>

void freerbuf(struct buf *bp);
```

ARGUMENTS

**bp* Pointer to a previously allocated buffer header structure.

DESCRIPTION

`freerbuf` frees a raw buffer header previously allocated by `getrbuf`(D3DK). This function does not sleep and so may be called from an interrupt routine.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

`getrbuf`(D3DK), `kmem_alloc`(D3DK), `kmem_free`(D3DK), `kmem_zalloc`(D3DK)

NAME

getemajor − get external major device number

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ddi.h>

major_t getemajor(dev_t dev);
```

ARGUMENT

dev An external device number (contains both the major and minor number).

DESCRIPTION

getemajor returns the external major number given a device number, *dev*.

RETURN VALUE

The external major number.

LEVEL

Base or Interrupt

SEE ALSO

geteminor(D3D), etoimajor(D3D), getmajor(D3DK), makedevice(D3DK), getminor(D3DK)

NAME

geteminor – get external minor device number

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ddi.h>

minor_t geteminor(dev_t dev);
```

ARGUMENT

dev	External device number.

DESCRIPTION

geteminor returns the external minor number given a device number, *dev*.

RETURN VALUE

The external minor number.

LEVEL

Base or Interrupt

SEE ALSO

getemajor(D3D), etoimajor(D3D), getmajor(D3DK), makedevice(D3DK), getminor(D3DK)

NAME

geterror – return I/O error

SYNOPSIS

```
#include <sys/types.h>
#include <sys/buf.h>

int geterror(struct buf *bp);
```

ARGUMENT

bp Pointer to the block interface buffer structure defined in buf.h.

DESCRIPTION

geterror is called to retrieve the error number from the error field of the buffer header structure.

RETURN VALUE

An error number indicating the error condition of the I/O request is returned. If the I/O requested is completed successfully, 0 is returned.

LEVEL

Base or Interrupt

SEE ALSO

buf(D4DK)

NAME

getmajor – get major or internal major device number

SYNOPSIS

```
#include <sys/types.h>
#include <sys/mkdev.h>
#include <sys/ddi.h>

major_t getmajor(dev_t dev);
```

ARGUMENT

dev Device number.

DESCRIPTION

The getmajor function extracts either the major number or the internal major number from a device number. For the 3B2, getmajor returns the internal major number. For architectures that do not make a distinction between internal and external major numbers, getmajor returns the major number.

RETURN VALUE

The major number or internal major number.

NOTE: No validty checking is performed. If *dev* is invalid, an invalid number is returned.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 3, "Drivers in the UNIX Operating System"

makedevice(D3DK), getminor(D3DK)

EXAMPLE

The following example shows both the getmajor and getminor(D3DK) functions used in a debug cmn_err(D3DK) statement to return the major and minor numbers for the device supported by the driver. This example is 3B2 specific.

```
dev_t dev;

#ifdef DEBUG
cmn_err(CE_NOTE,"Driver Started.  Internal Major# = %d,
     Internal Minor# = %d", getmajor(dev), getminor(dev));
#endif
```

NAME

getminor – get minor or internal minor device number

SYNOPSIS

```
#include <sys/types.h>
#include <sys/mkdev.h>
#include <sys/ddi.h>

minor_t getminor(dev_t dev);
```

ARGUMENT

dev Device number.

DESCRIPTION

The getminor function extracts either the minor number or the internal minor number from a device number. For the 3B2, getminor returns the internal minor number. For architectures that do not make a distinction between internal and external minor numbers, getminor returns the minor number.

RETURN VALUE

The minor number or internal minor number.

NOTE: No validty checking is performed. If *dev* is invalid, an invalid number is returned.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 3, "Drivers in the UNIX Operating System"

getmajor(D3DK), makedevice(D3DK)

NAME

getq – get the next message from a queue

SYNOPSIS

```
#include <sys/stream.h>

mblk_t *getq(queue_t *q);
```

ARGUMENTS

q Pointer to the queue from which the message is to be retrieved.

DESCRIPTION

getq is used by a service (srv(D2DK)) routine to retrieve its enqueued messages.

A module or driver may include a service routine to process enqueued messages. Once the STREAMS scheduler calls srv it must process all enqueued messages, unless prevented by flow control. getq gets the next available message from the top of the queue pointed to by *q*. It should be called in a while loop that should be exited only when there are no more messages.

getq turns the QWANTR flag off when a queue is being read, and turns QWANTR on when there are no more messages. When QWANTW is set it means an attempt has been made to write to the queue while it was blocked by flow control. If this is the case, getq back-enables (restarts) the service routine once it falls below the low water mark.

RETURN VALUE

If there is a message to retrieve, getq returns a pointer to it. If no message is queued, getq returns a NULL pointer.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

STREAMS Programmer's Guide, Chapter 5, "Messages"

bcanput(D3DK), canput(D3DK), putbq(D3DK), putq(D3DK), qenable(D3DK), srv(D2DK)

EXAMPLE

See the dupb(D3DK) function page for an example of getq.

NAME

getrbuf – get a raw buffer header

SYNOPSIS

```
#include <sys/buf.h>
#include <sys/kmem.h>
#include <sys/ddi.h>

struct buf *getrbuf(long sleepflag);
```

ARGUMENT

sleepflag Indicates whether driver should sleep for free space.

DESCRIPTION

getrbuf allocates the space for a buffer header to the caller. It is used in cases where a block driver is performing raw (character interface) I/O and needs to set up a buffer header that is not associated with the buffer cache.

getrbuf calls kmem_alloc(D3DK) to perform the memory allocation. kmem_alloc requires the information included in the *sleepflag* argument. If *sleepflag* is set to KM_SLEEP, the driver may sleep until the space is freed up. If *sleepflag* is set to KM_NOSLEEP, the driver will not sleep. In either case, a pointer to the allocated space is returned or NULL to indicate that no space was available.

RETURN VALUE

A pointer to the allocated buffer header, or NULL if no space is available.

LEVEL

Base or Interrupt (must not sleep if calling from interrupt routine)

SEE ALSO

freerbuf(D3DK), kmem_alloc(D3DK), kmem_free(D3DK)

NAME

getvec – get an interrupt vector for a virtual feature card address

SYNOPSIS

`unsigned char getvec(long` *baddr*`);`

ARGUMENTS

baddr A virtual feature card address.

DESCRIPTION

getvec returns an interrupt vector for a specified virtual feature card address. getvec is used in an init(D2D) routine. NOTE: If the feature card address is 0, a divide-by-zero error can occur.

RETURN VALUE

Under all conditions, an unsigned char numeric value is returned. The only abnormal return value is a number not logical for the circumstances.

LEVEL

Base Only (Do not call from an interrupt routine)

EXAMPLE

With a 3B2 computer, each device that generates an interrupt must be given an interrupt vector location code. During system initialization, the driver init routine gets the interrupt vector location code (line 17) and stores the code in a predefined address on the interface card (an address on the card in the range of 0x0 to 0x200000 can be defined to hold the code).

When a device generates an interrupt, the interface card presents the code to the CPU, which uses it to locate the interrupt handling routine(s) of the driver.

```
 1  struct  device  {               /* physical device registers layout   */
 2          char    reserve[4];     /* reserve space on card              */
 3          ushort  control;        /* physical device control word       */
 4          char    status;         /* physical device status word        */
 5          char    ivec_num;       /* device interrupt vector number in  */
 6                                  /* 0xf0; subdevice reporting in 0x0f  */
 7          paddr_t addr;           /* address of data to be read/written */
 8          int     count;          /* amount of data to be read/written  */
 9  }; /* end device */
10
11  extern struct device *xx_addr[]; /* physical dev registers location */
12
13  xx_init()
14  {
15                                          /* get device register struct */
16      register struct device *rp = xx_addr[0];
17      rp->ivec_num = getvec(xx_addr[0]); /* get interrupt vector code */
18
19  } /* end xx_init */
```

NAME

`hat_getkpfnum` – get page frame number for kernel address

SYNOPSIS

```
#include <sys/vm.h>
#include <sys/types.h>

u_int hat_getkpfnum(caddr_t addr);
```

ARGUMENT

addr The kernel virtual address for which the page frame number is to be returned.

DESCRIPTION

Drivers implementing the mmap(D2K) entry point must return `-1` (for error) or the page frame number corresponding to the virtual address of the device memory *addr*. This frame number can be obtained by a call to `hat_getkpfnum`.

RETURN VALUE

The page frame number corresponding to virtual address *addr*. There is no special error return value; invalid addresses will produce meaningless return values.

LEVEL

Base or interrupt. Although there is no reason why `hat_getkpfnum` cannot be called at interrupt level, there is no need since it only needs to be called from mmap(D2K).

SEE ALSO

mmap(D2K), `page_numtopp`(D2DK), `page_pptonum`(D2DK)

NAME

hdeeqd – initialize hard disk error logging

SYNOPSIS

```
#include <sys/types.h>
#include <sys/hdelog.h>
#include <sys/mkdev.h>

int hdeeqd(o_dev_t dev, daddr_t pdsno, short edtyp);
```

ARGUMENTS

dev External device number (contains both the major number and the minor number). The driver must call the cmpdev macro (defined in mkdev.h) to compress the device number.

pdsno Physical description sector

edtyp Error device type. The valid values are

EQD_EFC	external floppy controller
EQD_EHDC	external hard disk controller
EQD_ID	integral disk drive
EQD_IF	integral floppy disk drive
EQD_TAPE	cartridge tape drive

DESCRIPTION

hdeeqd initializes information in the hard disk error logging table for the device specified by *dev*. This function is called once per device.

NOTE: This function is not part of the default set of kernel functions. Ensure that the HDE bootable object module is placed in the /boot directory.

RETURN VALUE

Under all conditions, a 0 is returned. However, internal errors can occur in hdeeqd causing a warning message to display on the console. Errors occur in the following conditions:

The internal major device number is greater than or equal to the number of the controllers, called cdevcnt, which is assigned by lboot when the operating system is loaded. The message is

```
WARNING: hdeeqd: major(ddev) = int-major (>=cdevcnt)
```

int-major is the internal major device number.

The count of used disk slots in the error logging table exceeds the number of available slots. The message is

```
WARNING:  Too few HDE equipped slots
bad block handling skipped for maj/min = ext-maj, ext-min
```

ext-maj and *ext-min* are the external major and minor numbers.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 12, "Error Reporting"

hdelog(D3D), hdedata(D4D)

EXAMPLE

When a device is opened for the first time, the driver open(D2DK) or init(D2D) routines (open in this example) must identify the device and set up controlling information about the device. In this example, the information is kept on a controlling sector on the disk. If the controlling sector does not exist, the information is encoded as a static table in the driver.

```
 #define XX_CNTLBLKNO    0       /* controlling sector block number   */
 struct  device {                /* physical device registers layout  */
         char     reserve[4]; /* reserve space on card            */
         ushort   control;    /* physical device control word      */
         char     status;     /* physical device status word       */
         char     ivec_num;   /* device interrupt vector number in */
                              /* 0xf0; subdevice reporting in 0x0f */
         paddr_t  addr;       /* data address to be read/written   */
         int      count;      /* amount of data to be read/written */
}; /* end device */
struct xx_     {                 /* logical device structure          */
         struct buf    *xx_head; /* I/O buffer queue head pointer  */
         struct buf    *xx_tail; /* I/O buffer queue tail pointer  */
         short          xx_flag; /* logical status flag            */
         struct hdedata xx_edata; /* disk error log error record   */
         struct iostat  xx_stat; /* unit I/O statistics for        */
                /* establishing an error rate during error logging */
}; /* end xx_ */

struct xx_info   {               /* information on control sector  */
         long    xx_id;          /* disk device id code            */
         long    xx_cyl;         /* total number of cylinders      */
         long    xx_trk;         /* number of tracks per cylinder  */
         long    xx_sec;         /* number of sectors per track    */
         char    xx_serial[12];  /* device serial number           */
}; /* end xx_info */

extern struct xx_   xx_devtab[]; /* logical device structures table */
extern struct device *xx_addr[]; /* physical dev registers location */
extern struct xx_info xx_info[]; /* device control information      */
extern int            xx_cnt;    /* number of devices               */
  . . .
xx_open(dev, flag, otyp, crp)
        dev_t   *dev;
        int       flag, otype;
        struct cred *crp;
{
    register struct xx_     *dp;
    register struct device  *rp;
```

```
39      register int unit;
          . . .
40      unit = getminor(dev) >> 4;            /* get drive unit number */
41      dp   = &xx_devtab[unit];       /* get logical device information */
42  if  ((dp->xx_flag & XX_OPEN) == 0) { /* if first time device opened */
43      register struct buf *bp;
44      hdeeqd(cmpdev(dev), XX_CNTLBLKNO, EQD_ID); /* initialize error logging  */
45      bp = kmem_alloc(1024, KM_NOSLEEP); /* get control sector buffer */
46      bp->b_flags = B_READ;                  /* set up buffer to read */
47      bp->b_blkno = XX_CNTLBLKNO;         /* control sector from disk */
48      bp->b_count = 512;
49      bp->b_dev = dev;
50      xx_strategy(bp);                         /* read control sector */
51      biowait(bp);                       /* wait for read to complete */
52      if  ((bp->b_flags & B_ERROR) != 0 )  {
53                /* if data error occurred, display message on console */
54          xx_print(dev, "xx_open: cannot read control sector");
55      } else {              /* copy control sector data to info table */
56          bcopy(bp->b_un.b_addr, &xx_info[unit], sizeof(struct xx_info));
57          hdeeqd(cmpdev(dev), XX_CNTLBLKNO, EQD_ID);    /* start error logging */
58          dp->flag |= XX_OPEN;           /* indicate device open       */
59      } /* endif */
60      brelse(bp);                        /* release system buffer      */
61  } /* endif */
```

If this is the first open, hdeeqd (line 44) is used to initiate error logging for the device. A system buffer is allocated (line 45) and the driver reads the controlling sector from the xx_strategy routine (line 50). If an error occurred on the read attempt, an error message is displayed (line 54) and an error condition is returned. Otherwise, the driver saves information from the controlling sector with bcopy (line 56) and indicates the device has been opened. Finally, the system buffer is released (line 60).

NAME

hdelog – log hard disk error

SYNOPSIS

```
#include <sys/types.h>
#include <sys/hdelog.h>
#include <sys/mkdev.h>

int hdelog(struct hdedata *eptr);
```

ARGUMENT

eptr Pointer to the hdedata(D4D) structure defined in sys/hdelog.h. The driver developer places information in the structure before hdelog is called.

DESCRIPTION

hdelog logs a hard disk error in the error logging queue and displays a warning message on the console to alert the operator to the problem.

The console message is

```
WARNING: severity readtype hard disk error:
maj/min = external-major-num, external-minor-num
```

where *severity* is "marginal" or "unreadable", and *readtype* is "CRC" (cyclic redundancy check) or "ECC" (error check and correction).

hdeeqd(D3D) must be called once before this function to initialize error logging. hdelog logs disk drive media errors. **NOTE:** This function is not part of the default kernel. Ensure that the HDE bootable object module is placed in the /boot directory.

Before calling this function, values must be assigned to the hdedata(D4D) structure. These members include the device number; the disk pack serial number; the physical block address; the type of read operation CRC or ECC; whether the error is marginal or whether the disk is unreadable; the number of unreadable tries; the bit width of the corrected error; and a time stamp.

RETURN VALUE

Under all conditions, a 0 is returned. However, an internal error can occur in hdelog causing a warning message to display on the console. This error occurs when the error logging table is full. In this case, the usual disk error warning message is prefaced with

```
WARNING:  HDE queue full, following report not logged
```

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 12, "Error Reporting"

hdeeqd(D3D), hdedata(D4D)

EXAMPLE

A driver interrupt routine must check for data transfer errors (called data checks). When a data check occurs (reported by the device in the status or error register), the driver determines if there have been sufficient attempts to resolve the error.

If so, the driver abandons the I/O request by marking the buffer as being in error, logging an unresolved error (line 60), and marking the I/O operation complete (line 61). When an error persists in spite of multiple attempts to resolve it, the driver logs marginal errors (line 75) and attempts the I/O operation again. The driver may try to resolve the error with software by using the error correction bits in an error check and correction (ECC) register. See `hdedata`(D4D) for a description of the `xx_edata` structure shown in this example line 17).

```
 1  struct  device  {
 2                                  /* layout of physical device regs */
 3          char     reserve[4];    /* reserve space on card          */
 4          ushort   control;       /* physical device control word   */
 5          char     status;        /* physical device status word    */
 6          char     ivec_num;      /* device interrupt vector no. in */
 7                                  /* 0xf0; subdevice in 0x0f        */
 8          paddr_t  addr;          /* address of data read/written   */
 9          int      count;         /* amount of data read/written    */
10   }; /* end device */
11
12  struct xx_  {
13                                  /* logical device structure       */
14         struct buf    *xx_head;  /* I/O buffer queue head pointer  */
15         struct buf    *xx_tail;  /* I/O buffer queue tail pointer  */
16         short          xx_flag;  /* logical status flag            */
17         struct hdedata xx_edata; /* hard disk error record         */
18         struct iostat  xx_stat;  /* unit I/O stats for setting an  */
19                                 /* error rate during error logging */
20  }; /* end xx_ */
21
22  struct xx_info  {
23                              /* information on disk control sector */
24         long    xx_id;           /* device id code                 */
25         long    xx_cyl;          /* total number of cylinders      */
26         long    xx_trk;          /* number of tracks per cylinder  */
27         long    xx_sec;          /* number of sectors per track    */
28         char    xx_serial[12];   /* device serial number           */
29  }; /* end xx_info */
30  extern struct xx_     xx_devtab[];/* logical dev structures table   */
31  extern struct device *xx_addr[];  /* physical dev register location */
32  extern struct xx_info xx_info[];  /* device control information     */
33  extern int            xx_cnt;     /* number of devices              */
34  xx_int(board)
35          int  board;
36  {                                             /* get dev registers */
37    register struct device  *rp = xx_addr[board];
38    register struct xx_     *dp;
39    register struct buf     *bp;
40    register int     unit;
41
42    unit = (board << 4) | (rp->ivec_num & 0xf);   /* make unit number */
```

```
  dp = &xx_devtab[unit];
  if ((rp->status & DATACHK) != 0) {
                                    /* if data check error occurred */
    if (++dp->xx_edata.badrtcnt > XX_MAXTRY)  {   /* if sufficient  */
           /* attempts have been made, then abandon the I/O request */
        bp = dp->xx_head;               /* get buffer from I/O queue */
        dp->xx_head = bp->av_forw;  /* remove buffer from I/O queue */
        bp->b_flags |= B_ERROR;    /* mark buffer as being in error */
        bp->b_error = EIO;                /* supply error condition */
                     /* supply information needed for error logging */
        dp->xx_edata.diskdev = cmpdev(bp->b_dev);  /* device number */
        dp->xx_edata.blkaddr = bp->b_blkno;    /* block no. in error */
        dp->xx_edata.readtype = HDEECC;  /* error type: error check */
        dp->xx_edata.severity = HDEUNRD;  /* data was unreadable    */
        dp->xx_edata.bitwidth = 0;
        dp->xx_edata.timestmp = time;   /* time recording occurred  */
        bcopy(dp->xx_edata.dskserno, xx_info[unit].serial, 12);
        hdelog(&dp->xx_edata);       /* log abandoned I/O operations*/
        biodone(bp);                 /* mark I/O operation complete */

    } else if(dp->xx_edata.badrtcnt > 1) {/* if more than one retry */
                                            /* log error as marginal */
       bp = dp->xx_head;  /* get buffer from I/O queue but leave on */
                     /* I/O queue so that I/O operation is repeated */
       /* supply information needed for error logging */
       dp->xx_edata.diskdev = cmpdev(bp->b_dev);    /* device number */
       dp->xx_edata.blkaddr = bp->b_blkno;     /* error block number */
       dp->xx_edata.readtype = HDEECC;     /* err. type: error check */
       dp->xx_edata.severity = HDEMARG;            /* marginal error */
       dp->xx_edata.bitwidth = 0;
       dp->xx_edata.timestmp = time;     /* time recording occurred */
       bcopy(dp->xx_edata.dskserno, xx_info[unit].serial, 12);
       hdelog(&dp->xx_edata);                /* log data check error  */
    } /* endif */
  } /* endif */
}
```

NAME

insq – insert a message into a queue

SYNOPSIS

```
#include <sys/stream.h>

int insq(queue_t *q, mblk_t *emp, mblk_t *nmp);
```

ARGUMENTS

q Pointer to the queue containing message *emp*.

emp Enqueued message before which the new message is to be inserted (mblk_t is an instance of the msgb(D4DK) structure).

nmp Message to be inserted.

DESCRIPTION

insq inserts a message into a queue. The message to be inserted, *nmp*, is placed in *q* immediately before the message *emp*. If *emp* is NULL, the new message is placed at the end of the queue. The queue class of the new message is ignored. All flow control parameters are updated. The service procedure is enabled unless QNOENB is set.

CAUTION: If *emp* is non-NULL, it must point to a message on *q* or a system panic could result.

RETURN VALUE

insq returns 1 on success, and 0 on failure.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

EXAMPLE

This routine illustrates the steps a transport provider may take to place expedited data ahead of normal data on a queue (assume all M_DATA messages are converted into M_PROTO T_DATA_REQ messages). Normal T_DATA_REQ messages are just placed on the end of the queue (line 14). However, expedited T_EXDATA_REQ messages are inserted before any normal messages already on the queue (line 28). If there are no normal messages on the queue, bp will be NULL and we will fall out of the for loop (line 21). insq will act like putq(D3DK) in this case.

```
 1  #include <sys/tihdr.h>
 2
 3  xxxwput(q, mp)
 4      queue_t *q;
 5      mblk_t *mp;
 6  {
 7    union T_primitives *tp;
 8
 9    switch (mp->b_datap->db_type) {
10    case M_PROTO:
11          tp = (union T_primitives *)mp->b_rptr;
```

```
        switch (tp->type) {
        case T_DATA_REQ:
                putq(q, mp);
                break;

        case T_EXDATA_REQ:
                mblk_t *bp;
                union T_primitives *ntp;

                for (bp = q->q_first; bp; bp = bp->b_next) {
                    if (bp->b_datap->db_type == M_PROTO) {
                      ntp = (union T_primitives *)bp->b_rptr;
                      if (ntp->type != T_EXDATA_REQ)
                          break;
                    }
                }
                insq(q, bp, mp);
                break;
        . . .
            }
    }
}
```

NAME

itoemajor – convert internal to external major device number

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ddi.h>

int itoemajor(major_t imaj, int prevemaj);
```

ARGUMENTS

imaj An internal major number.

prevemaj Most recently obtained external major number (or NODEV, if this is the first time the function has been called).

DESCRIPTION

itoemajor converts the internal major number to the external major number. The external-to-internal major number mapping is many-to-one, and so any internal major number may correspond to more than one external major number. By repeatedly invoking this function and passing the most recent external major number obtained, the driver can obtain all possible external major number values.

RETURN VALUE

External major number, or NODEV, if all have been searched

LEVEL

Base or Interrupt

SEE ALSO

getemajor(D3D), geteminor(D3D), etoimajor(D3D), getmajor(D3DK), getminor(D3DK), makedevice(D3DK)

NAME

kmem_alloc – allocate space from kernel free memory

SYNOPSIS

```
#include <sys/types.h>
#include <sys/kmem.h>

_VOID *kmem_alloc(size_t size, int flag);
```

ARGUMENTS

size Number of bytes to allocate.

flag Determines if caller will sleep to wait for free space. Possible flags are KM_SLEEP to sleep while waiting for free space, and KM_NOSLEEP to return NULL if space is not available.

DESCRIPTION

The kmem_alloc function allocates a specified amount of kernel memory in bytes and returns a pointer to the allocated memory. The *flag* argument determines whether the function will sleep while waiting for free space to be released. If *flag* has KM_SLEEP set, the caller may sleep until free space is available. If *flag* has KM_NOSLEEP set and space is not available, NULL will be returned.

NOTE: Memory allocated by kmem_alloc is not paged. Available memory is therefore limited. Excessive use of this memory is likely to affect overall system performance.

RETURN VALUE

If successfull, kmem_alloc returns a pointer to the allocated space. NULL is returned if KM_NOSLEEP is set and memory cannot be allocated.

LEVEL

Base (interrupt only if KM_NOSLEEP is set in *flag*)

SEE ALSO

freerbuf(D3DK), getrbuf(D3DK), kmem_free(D3DK), kmem_zalloc(D3DK), rmalloc(D3DK), rmfree(D3DK), rminit(D3DK), rmsetwant(D3DK), rmwant(D3DK)

NAME

kmem_free – free previously allocated kernel memory

SYNOPSIS

```
#include <sys/tpes.h>
#include <sys/kmem.h>

void kmem_free(_VOID *cp, size_t size);
```

ARGUMENTS

cp Address of the allocated storage from which to return *size* of allocated memory.

size Number of bytes to free (same number of bytes as allocated by kmem_alloc(D3DK) or kmem_zalloc(D3DK).

DESCRIPTION

This function returns *size* of storage to kernel free space previously allocated by kmem_alloc(D3DK) or kmem_zalloc(D3DK). The *cp* and *size* values must specify exactly one complete area of allocated memory. One kmem_free call must correspond to one allocation.

RETURN VALUE

Under all conditions, no value is returned.

LEVEL

Base or Interrupt

SEE ALSO

freerbuf(D3DK), getrbuf(D3DK), kmem_alloc(D3DK), kmem_zalloc(D3DK), rmalloc(D3DK), rmfree(D3DK), rminit(D3DK), rmsetwant(D3DK), rmwant(D3DK)

NAME

`kmem_zalloc` – allocate and clear space from kernel free memory

SYNOPSIS

```
#include <sys/types.h>
#include <sys/kmem.h>

_VOID *kmem_zalloc(unsigned long size, unsigned long flag);
```

ARGUMENTS

size Number of bytes to allocate.

flag Determines if caller may sleep to wait for free space. Possible flags are `KM_SLEEP` to sleep while waiting for free space, and `KM_NOSLEEP` to return NULL if space is not available.

DESCRIPTION

This function allocates *size* of storage from kernel free space, clears it, and returns a pointer to the allocated memory. If *flag* has `KM_SLEEP` set, the caller may sleep until free space is available. If *flag* has `KM_NOSLEEP` set and space is not available, `NULL` will be returned.

NOTE: Memory allocated by `kmem_zalloc` is not paged. Available memory is therefore limited. Excessive use of this memory is likely to affect overall system performance.

RETURN VALUE

`kmem_zalloc` returns `NULL` if memory cannot be allocated. Otherwise, it returns a pointer to the allocated space.

LEVEL

Base (interrupt only if `KM_NOSLEEP` is set in *flag*)

SEE ALSO

`freerbuf`(D3DK), `getrbuf`(D3DK), `kmem_alloc`(D3DK), `kmem_free`(D3DK), `rmalloc`(D3DK), `rmfree`(D3DK), `rminit`(D3DK), `rmsetwant`(D3DK), `rmwant`(D3DK)

NAME

kvtophys – convert kernel virtual address to physical address

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ddi.h>

paddr_t kvtophys(caddr_t caddr);
```

ARGUMENTS

caddr Kernel virtual address to translate.

DESCRIPTION

This function returns the physical address equivalent of the specified kernel virtual address. The same functionality is provided in the `vtop`(D3D) function.

RETURN VALUE

`kvtophys` returns `NULL` if *caddr* is invalid; otherwise, a physical address is returned. CAUTION: If *caddr* is invalid, `kvtophys` could panic the system.

LEVEL

Base or Interrupt

SEE ALSO

`vtop`(D3D)

NAME

linkb – concatenate two message blocks

SYNOPSIS

```
#include <sys/stream.h>

void linkb(mblk_t *mp1, mblk_t *mp2);
```

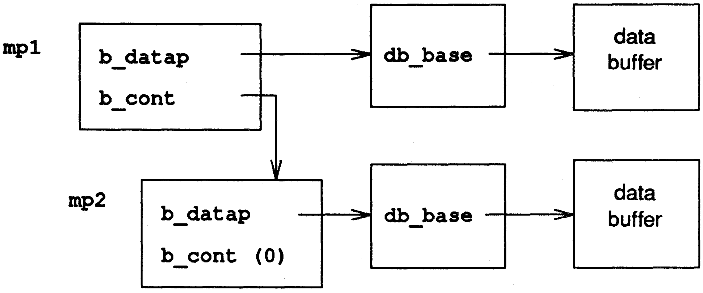
ARGUMENTS

mp1 The message to which *mp2* is to be added. mblk_t is an instance of the msgb(D4DK) structure.

mp2 The message to be added.

DESCRIPTION

linkb creates a new message by adding *mp2* to the tail of *mp1*. The continuation pointer (b_cont) of the first message is set to point to the second message:



linkb(mp1, mp2);

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

unlinkb(D3DK)

EXAMPLE

See the dupb(D3DK) function page for an example of linkb.

NAME

makedevice – make device number from external major and minor

SYNOPSIS

```
#include <sys/types.h>
#include <sys/makedev.h>
#include <sys/ddi.h>
```

`dev_t makedevice(major_t` *majnum*, `minor_t` *minnum*`);`

ARGUMENTS

majnum External major number.

minnum External minor number.

DESCRIPTION

The makedevice function creates a device number from an external major and external minor device number. makdevice should be used to create device numbers so that additional overhead on the driver can be avoided, and so the driver will port easily to releases that treat device numbers differently.

RETURN VALUE

The device number, containing both the major number and the minor number, is returned. No validation of the external major or minor numbers is performed.

NOTE: The numbers returned by getmajor(D3DK) and getminor(D3DK) are not valid arguments to makedevice in systems where there is a distinction between internal and external numbers. The functions getemajor(D3D) and geteminor(D3D) should be used on those systems.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 3, "Drivers in the UNIX Operating System"

getemajor(D3D), geteminor(D3D), getmajor(D3DK), getminor(D3DK)

EXAMPLE

In the following example makedevice creates device numbers for every device supported by the example init(D2D) routine. The init routine initializes each device by calling the xxx_dev_init() routine (line 8) with the device number for each device. The device numbers are created from the preconfigured major device number, XXMAJOR, and the range of valid minor numbers for the device.

```
1  xxxinit()
2  {
3          dev_t dev;
4          minor_t min;
5
6          for (min = 0; min < XXMAXMIN; min++) {
7                  dev = makedevice(XXMAJOR, min);
8                  xxx_dev_init(dev);
9          }
10 }
```

NAME

max – return the larger of two integers

SYNOPSIS

`int max(int int1, int int2);`

ARGUMENTS

int1, int2 The integers to be compared.

DESCRIPTION

max compares two integers and returns the larger of two.

RETURN VALUE

The larger of the two numbers.

LEVEL

Base or Interrupt

SEE ALSO

min(D3DK)

NAME

`min` – return the lesser of two integers

SYNOPSIS

`int min(int` *int1*, `int` *int2*`);`

ARGUMENTS

int1, *int2* The integers to be compared.

DESCRIPTION

`min` compares two integers and returns the lesser of the two.

RETURN VALUE

The lesser of the two integers.

LEVEL

Base or Interrupt

SEE ALSO

`max`(D3DK)

NAME

msgdsize – return the number of bytes in a message

SYNOPSIS

```
#include <sys/stream.h>

int msgdsize(mblk_t *mp);
```

ARGUMENT

mp Message to be evaluated.

DESCRIPTION

msgdsize counts the number of bytes in a data message. Only bytes included in the data blocks of type M_DATA are included in the count.

RETURN VALUE

The number of data bytes in a message, expressed as an integer.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

EXAMPLE

See the bufcall(D3DK) function page for an example of the msgdsize function.

NAME

`noenable` – prevent a queue from being scheduled

SYNOPSIS

```
#include <sys/stream.h>
#include <sys/ddi.h>

void noenable(queue_t *q);
```

ARGUMENT

q	Pointer to the queue.

DESCRIPTION

The `noenable` function prevents the queue `q` from being scheduled for service by `insq`(D3DK), or by `putq`(D3DK) or `putbq`(D3DK) when enqueuing an ordinary priority message. The queue can be re-enabled with the `enableok`(D3DK) function.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

`enableok`(D3DK), `insq`(D3DK), `putq`(D3DK), `putbq`(D3DK), `qenable`(D3DK)

NAME

OTHERQ – get pointer to queue's partner queue

SYNOPSIS

```
#include <sys/stream.h>
#include <sys/ddi.h>

queue_t *OTHERQ(queue_t *q);
```

ARGUMENT

q Pointer to the queue.

DESCRIPTION

The OTHERQ function returns a pointer to the other of the two queue structures that make up a STREAMS module or driver. If *q* points to the read queue the write queue will be returned, and vice versa.

RETURN VALUE

OTHERQ returns a pointer to a queue's partner.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

EXAMPLE

This routine sets the minimum packet size, the maximum packet size, the high water mark, and the low water mark for the read and write queues of a given module or driver. It is passed either one of the queues. This could be used if a module or driver wished to update its queue parameters dynamically.

```
void
set_q_params(q, min, max, hi, lo)
    queue_t *q;
    short min;
    short max;
    ushort hi;
    ushort lo;
{
  q->q_minpsz = min;
  q->q_maxpsz = max;
  q->q_hiwat = hi;
  q->q_lowat = lo;
  OTHERQ(q)->q_minpsz = min;
  OTHERQ(q)->q_maxpsz = max;
  OTHERQ(q)->q_hiwat = hi;
  OTHERQ(q)->q_lowat = lo;
}
```

NAME

page_numtopp – convert page frame number to page structure

SYNOPSIS

```
#include <sys/types.h>
#include <vm/page.h>

page_t page_numtopp(u_int pfn);
```

ARGUMENT

pfn The page frame number to be converted.

DESCRIPTION

page_numtopp converts a page frame number to its corresponding page structure.

RETURN VALUE

A pointer to the page structure is returned. If the page frame number is invalid, NULL is returned.

LEVEL

Base or Interrupt

SEE ALSO

page_pptonum(D3DK)

NAME

page_pptonum – convert page structure to page frame number

SYNOPSIS

```
#include <sys/types.h>
#include <vm/page.h>

u_int page_pptonum(page_t *pp);
```

ARGUMENT

pp Pointer to a page structure.

DESCRIPTION

page_pptonum is called to convert a page structure to its corresponding page frame number.

RETURN VALUE

The page frame number corresponding to the page structure is returned. No error is returned. If *pp* (the page structure address) is invalid, the system will panic.

LEVEL

Base or Interrupt

SEE ALSO,

page_numtopp(D3DK),

NAME

physiock – validate and issue raw I/O request

SYNOPSIS

```
#include<sys/types.h>
#include <sys/buf.h>
#include <sys/errno.h>
#include <sys/uio.h>
#include <sys/cred.h>

int physiock(int (*(strategy) (), struct buf *buf, dev_t dev,
     int rwflag, daddr_t nblocks, uio_t *uio_p);
```

ARGUMENTS

strategy Address of the driver strategy routine.

buf Pointer to the buf structure describing the I/O request. If set to NULL, then a buffer is allocated from the buffer pool and returned to the free list after the transfer completes.

dev Device number.

rwflag Flag indicating whether the access is a read (B_READ) or a write (B_WRITE). Note that B_WRITE cannot be directly tested as it is 0

nblocks Number of blocks that a logical device can support, for example, a disk partition, or tape.

uio_p Pointer to the uio structure that defines the user space of the I/O request.

DESCRIPTION

physiock is called by the character interface to block driver read(D2DK) and write(D2DK) routines to help perform unbuffered I/O while maintaining the buffer header as the interface structure.

physiock performs the following functions:

verifies the requested transfer is valid by checking if the offset is at or past the end of the device

sets up a buffer header describing the transfer

faults pages in and locks the pages impacted by the I/O transfer so they can not be swapped out

calls the driver strategy(D2DK) routine passed to it

sleeps until the transfer is complete and is awakened by the biodone(D3DK) function in the driver's interrupt routine

performs the necessary cleanup and updates, then returns to the driver routine

A transfer using physiock is considered valid if the specified data location exists on the device, and the user has specified a storage area that exists in user memory space.

RETURN VALUE

physiock returns 0 if the result is successful, the appropriate error number upon failure. physiock returns the ENXIO error (see *Appendix A* for more information) if an attempt is made to read beyond the end of the device. If a read is performed at the end of the device, 0 is returned. ENXIO is also returned if an attempt is made to write at the end of a device or beyond the end of the device. EFAULT is returned if user memory is not available. EAGAIN is returned if physiock could not lock pages for DMA.

LEVEL

Base Only (Do not call from an interrupt routine)

SEE ALSO

dma_pageio(D3D), strategy(D2DK)

EXAMPLE

```
struct  dsize      {
        daddr_t nblocks;  /* disk partition block number */
        int     cyloff;   /* starting cylinder # of partition   */
} DISKsizes[16] = {

        20448,  21,   /* partition 0 = cyl 21-305   */
        12888,  126,  /*     "     1 = cyl 126-305  */
        9360,   175,  /*     "     2 = cyl 175-305  */
        7200,   205,  /*     "     3 = cyl 205-305  */
        3600,   255,  /*     "     4 = cyl 255-305  */
        21816,  3,    /*     "     5 = cyl 2-305    */
        21888,  1,    /*     "     6 = cyl 1-305    */
        72,     1,    /*     "     7 = cyl 1        */
};

DISKread(dev, uio_p, cred_p)  /* direct read request from block device */
        dev_t   dev;
        uio_t   *uio_p;
        cred_t  *cred_p;
{
        register int nblks;

         /* get number of blocks in the partition */
        nblks = DISKsizes[minor(dev) & 0x7].nblocks;

        /*
         * Check limits of read request.  If request is in
         * the limits of the disk partition, schedule direct I/O.
         */

        physiock(DISKstrat, 0, dev, B_READ, nblks, uio_p);

} /* end DISKread */


```

```
DISKwrite(dev, uio_p, cred_p)  /* direct write request to block device */
        dev_t   dev;
        uio_t   *uio_p;
        cred_t  *cred_p
{
        register int nblks;

        /* get number of blocks in the partition */
        nblks = DISKsizes[minor(dev) & 0x7].nblocks;

        /*
         * Check limits of write request.  If request is in
         * the limits of the disk partition, schedule direct I/O.
         */

        physiock(DISKstrat, 0, dev, B_WRITE, nblks, uio_p);

} /* end DISKwrite */
```

NAME

pollwakeup – inform a process that an event has occurred

SYNOPSIS

```
#include <sys/poll.h>

void pollwakeup(struct pollhead *php, short event);
```

ARGUMENTS

php	Pointer to a pollhead structure.
event	Event to notify the process about.

DESCRIPTION

The pollwakeup function wakes a process waiting on the occurrence of an event. It should be called from a driver for each occurrence of an event. The pollhead structure will usually be associated with the driver's private data structure associated with the particular minor device where the event has occurred. See chpoll(D2DK) and poll(2) for more detail.

RETURN

None

LEVEL

Base or Interrupt

SEE ALSO

chpoll(D2DK), poll(2)

NAME

`ptob` – convert size in pages to size in bytes

SYNOPSIS

```
#include <sys/ddi.h>

unsigned long ptob(unsigned long numpages);
```

ARGUMENT

numpages Size in number of pages to convert to size in bytes.

DESCRIPTION

This function returns the number of bytes that are contained in the specified number of pages. For example, if the page size is 2048, then `ptob(2)` returns `4096`. `ptob(0)` returns `0`.

RETURN VALUE

The return value is always the number of bytes in the specified number of pages. There are no invalid input values, and no checking will be performed for overflow in the case of a page count whose corresponding byte count cannot be represented by an `unsigned long`. Rather, the higher order bits will be ignored.

LEVEL

Base or interrupt

SEE ALSO

`btop`(D3DK), `btopr`(D3DK)

NAME

pullupmsg – concatenate bytes in a message

SYNOPSIS

```
#include <sys/stream.h>

int pullupmsg(mblk_t *mp, int len);
```

ARGUMENTS

**mp* Pointer to the message whose blocks are to be concatenated. mblk_t is an instance of the msgb(D4DK) structure.

len Number of bytes to concatenate.

DESCRIPTION

pullupmsg tries to combine multiple data blocks into a single block. pullupmsg concatenates and aligns the first *len* data bytes of the message pointed to by *mp*. If *len* equals -1, all data is concatenated. If *len* bytes of the same message type cannot be found, pullupmsg fails and returns 0.

RETURN VALUE

On success, 1 is returned; on failure, 0 is returned.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

allocb(D3DK)

EXAMPLE

This is a driver write srv(D2DK) (service) routine for a device that does not support scatter/gather DMA. For all M_DATA messages, the data will be transferred to the device with DMA.

First, try to pull up the message into one message block with the pullupmsg function (line 12). If successful, the transfer can be accomplished in one DMA job. Otherwise, it must be done one message block at a time (lines 19–22). After the data has been transferred to the device, free the message and continue processing messages on the queue.

```
 1 xxxwsrv(q)
 2      queue_t *q;
 3 {
 4    mblk_t *mp;
 5    mblk_t *tmp;
 6    caddr_t dma_addr;
 7    int dma_len;
 8
 9    while ((mp = getq(q)) != NULL) {
10          switch (mp->b_datap->db_type) {
11          case M_DATA:
12                if (pullupmsg(mp, -1)) {
13                      dma_addr = vtop(mp->b_rptr);
14                      dma_len = mp->b_wptr - mp->b_rptr;
```

```
                    xxx_do_dma(dma_addr, dma_len);
                    freemsg(mp);
                    break;
              }
              for (tmp = mp; tmp; tmp = tmp->b_cont) {
                    dma_addr = vtop(tmp->b_rptr);
                    dma_len = tmp->b_wptr - tmp->b_rptr;
                    xxx_do_dma(dma_addr, dma_len);
              }
              freemsg(mp);
              break;
  . . .
        }
  }
}
```

NAME

putbq – place a message at the head of a queue

SYNOPSIS

```
#include <sys/stream.h>

int putbq(queue_t *q, mblk_t *bp);
```

ARGUMENTS

q Pointer to the queue.

bp Pointer to the message block.

DESCRIPTION

putbq places a message at the beginning of the appropriate section of the message queue. There are always sections for high priority and ordinary messages. If other priority bands are used, each will have its own section of the queue, in priority band order, after high priority messages and before ordinary messages. putbq can be used only for ordinary and priority band messages. High priority messages are not subject to flow control, and so cannot be put back on the queue.

This function is usually called when bcanput(D3DK) or canput(D3DK) determines that the message cannot be passed on to the next stream component. The flow control parameters are updated to reflect the change in the queue's status. If QNOENB is not set, the service routine is enabled.

RETURN VALUE

putbq returns 1 on success and 0 on failure.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

STREAMS Programmer's Guide, Chapter 5, "Messages"

bcanput(D3DK), canput(D3DK), getq(D3DK), putq(D3DK)

EXAMPLE

See the bufcall(D3DK) function page for an example of putbq.

NAME

putctl – send a control message to a queue

SYNOPSIS

```
#include <sys/stream.h>

int putctl(queue_t *q, int type);
```

ARGUMENTS

q	Queue to which the message is to be sent.
type	Message type (must be control, not data type).

DESCRIPTION

putctl tests the *type* argument to make sure a data type has not been specified, and then attempts to allocate a message block. putctl fails if *type* is M_DATA,M_DELAY, M_PROTO, or M_PCPROTO, or if a message block cannot be allocated. If successful, putctl calls the put(D2DK) routine of the queue pointed to by *q*.

RETURN VALUE

On success, 1 is returned. If *type* is a data type, or if a message block cannot be allocated, 0 is returned.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

datamsg(D3DK), putctl1(D3DK)

EXAMPLE

The send_ctl routine is used to pass control messages downstream. M_BREAK messages are handled with putctl (line 11). putctl1 (line 16) is used for M_DELAY messages, so that *parm* can be used to specify the length of the delay. In either case, if a message block cannot be allocated a variable recording the number of allocation failures is incremented (lines 12, 17). If an invalid message type is detected, cmn_err(D3DK) panics the system (line 21).

```
 1  void
 2  send_ctl(wrq, type, parm)
 3      queue_t *wrq;
 4      unchar type;
 5      unchar parm;
 6  {
 7    extern int num_alloc_fail;
 8
 9    switch (type) {
10    case M_BREAK:
11          if (!putctl(wrq->q_next, M_BREAK))
12                num_alloc_fail++;
13          break;
14
15    case M_DELAY:
16          if (!putctl1(wrq->q_next, M_DELAY, parm))
```

```
                num_alloc_fail++;
         break;

  default:
         cmn_err(CE_PANIC, "send_ctl: bad message type passed");
         break;
  }
}
```

NAME

putctl1 – send a control message with a one-byte parameter to a queue

SYNOPSIS

```
#include <sys/stream.h>

int putctl1(queue_t *q, int type, int p);
```

ARGUMENTS

q	Queue to which the message is to be sent.
type	Type of message.
p	One-byte parameter.

DESCRIPTION

putctl1, like putctl(D3DK), tests the *type* argument to make sure a data type has not been specified, and attempts to allocate a message block. The *p* parameter can be used, for example, to specify how long the delay will be when an M_DELAY message is being sent. putctl1 fails if type is M_DATA, M_PROTO, or M_PCPROTO, or if a mesage block cannot be allocated. If successful, putctl1 calls the put(D2DK) routine of the queue pointed to by *q*.

RETURN VALUE

On success, 1 is returned. 0 is returned if *type* is a data type, or if a message block cannot be allocated.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

allocb(D3DK), datamsg(D3DK), putctl(D3DK)

EXAMPLE

See the putctl(D3DK) function page for an example of putctl1.

NAME

putnext – send a message to the next queue

SYNOPSIS

```
#include <sys/stream.h>
#include <sys/ddi.h>

int putnext(queue_t *q, mblk_t *mp);
```

ARGUMENTS

q	Pointer to the queue from which the message *mp* will be sent.
mp	Message to be passed.

DESCRIPTION

The putnext function is used to pass a message to the put(D2DK) routine of the next queue in the stream.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

EXAMPLE

See the allocb(D3DK) function page for an example of putnext.

NAME

putq – put a message on a queue

SYNOPSIS

```
#include <sys/stream.h>

int putq(queue_t *q, mblk_t *bp);
```

ARGUMENTS

q	Pointer to the queue to which the message is to be added.
bp	Message to be put on the queue.

DESCRIPTION

putq is used to put messages on a driver's queue after the module's put routine has finished processing the message. The message is placed after any other messages of the same priority, and flow control parameters are updated. If QNOENB is not set, the service routine is enabled. If no processing is done, putq can be used as the module's put routine.

RETURN VALUE

putq returns 1 on success and 0 on failure.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

putbq(D3DK), qenable(D3DK), rmvq(D3DK)

EXAMPLE

See the datamsg(D3DK) function page for an example of putq.

NAME

`qenable` – enable a queue

SYNOPSIS

```
#include <sys/stream.h>
#include <sys/ddi.h>

void qenable(queue_t *q);
```

ARGUMENT

q	Pointer to the queue to be enabled.

DESCRIPTION

`qenable` puts the queue pointed to by *q* on the linked list of those whose service routines are ready to be called by the STREAMS scheduler.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

EXAMPLE

See the `dupb`(D3DK) function page for an example of the `qenable`.

NAME

`qreply` – send a message on a stream in the reverse direction

SYNOPSIS

```
#include <sys/stream.h>

void qreply(queue_t *q, mblk_t *bp);
```

ARGUMENTS

q	Pointer to the queue.
bp	Pointer to the message to be sent in the opposite direction.

DESCRIPTION

`qreply` sends a message on a stream in the opposite direction from *q*. It calls the `OTHERQ`(D3DK) function to find *q*'s module partner, and passes the message by calling the `put`(D2DK) routine of the next queue in the stream after *q*'s partner.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

STREAMS Programmer's Guide

`OTHERQ`(D3DK), `putnext`(D3DK)

EXAMPLE

This example depicts the canonical flushing code for STREAMS drivers. The driver has a write `srv`(D2DK) (service) routine that may have messages on the queue. If it receives an `M_FLUSH` message (line 6), and if the `FLUSHW` bit is on in the first byte of the message (line 7), then the write queue is flushed (line 8) and the `FLUSHW` bit is turned off (line 9). If the `FLUSHR` bit is on, then the read queue is flushed (line 12) and the message is sent back up the read side of the stream with the `qreply`(D3DK) function (line 13). If the `FLUSHR` bit is off, then the message is freed (line 15). See the example for `flushq`(D3DK) for the canonical flushing code for modules.

`qreply` does two things. First, it calls the `OTHERQ` function to change pointer `q` to the module's other `queue`(D4DK) structure, reversing the direction of the flow. Then it uses that `queue's` `q_next` pointer to call the next module's `put`(D2DK) routine with the `M_IOCNAK` message.

```
 1  xxxwput(q, mp)
 2      queue_t *q;
 3      mblk_t *mp;
 4  {
 5    switch(mp->b_datap->db_type) {
 6    case M_FLUSH:
 7          if (*mp->b_rptr & FLUSHW) {
 8                flushq(q, FLUSHALL);
 9                *mp->b_rptr &= ~FLUSHW;
10          }
```

```
        if (*mp->b_rptr & FLUSHR) {
              flushq(RD(q), FLUSHALL);
              qreply(q, mp);
        } else {
              freemsg(mp);
        }
        break;
  . . .
  }
}
```

NAME

`qsize` – find the number of messages on a queue

SYNOPSIS

```
#include <sys/stream.h>

int qsize(queue_t *q);
```

ARGUMENT

q	Queue to be evaluated.

DESCRIPTION

`qsize` evaluates the queue *q* and returns the number of messages it contains.

RETURN VALUE

If there are no message on the queue, `qsize` returns `0`. Otherwise, it returns the integer representing the number of messages on the queue.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

NAME

RD – get pointer to the read queue

SYNOPSIS

```
#include <sys/stream.h>
#include <sys/ddi.h>

queue_t RD(queue_t *q);
```

ARGUMENT

q Pointer to the *write* queue whose *read* queue is to be returned.

DESCRIPTION

The RD function accepts a *write* queue pointer as an argument and returns a pointer to the *read* queue of the same module.

CAUTION: Make sure the argument to this function is a pointer to a *write* queue. RD will not check for queue type, and a system panic could result if it is not the right type.

RETURN VALUE

The pointer to the *read* queue.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

WR(D3DK)

EXAMPLE

See the qreply(D3DK) function page for an example of RD.

NAME

rmalloc – allocate space from a private space management map

SYNOPSIS

```
#include <sys/map.h>
#include <sys/ddi.h>

unsigned long rmalloc(struct map *mp, long size);
```

ARGUMENTS

mp Memory map from where the resource is drawn.

size Number of units of the resource.

DESCRIPTION

rmalloc is used by a driver to allocate space from a previously defined and initialized private space management map. The map itself is declared as a structure using the driver prefix in the form *prefix*map. Memory is initially allocated for the map either by a data array, or by the kmem_alloc(D3DK) function. rmalloc is one of five functions used for private map management. The other functions include

rmfree Return previously allocated space to a map.
rminit Define a map structure and initialize a map table.
rmwant Return the number of processes waiting for free space.
rmsetwant Increment the count of the number of processes waiting for free space in the map.

The rmalloc function allocates space from a memory map in terms of arbitrary units. The system maintains the map structure by size and index, computed in units appropriate for the memory map. For example, units may be byte addresses, pages of memory, or blocks. The elements of the memory map are sorted by index, and the system uses the *size* member to combine adjacent objects into one memory map entry. The system allocates objects from the memory map on a first-fit basis. The normal return value is an unsigned long set to the value of m_addr from the map structure.

RETURN VALUE

Under normal conditions, rmalloc returns the base of the allocated space. Otherwise, rmalloc function returns a 0 if all memory map entries are already allocated.

LEVEL

Base

Interrupt if rmwant is not set

SEE ALSO

BCI Driver Development Guide, Chapter 6, "Input/Output Operations"

dma_pageio(D3D), rminit(D3DK), rmwant(D3DK), rmfree(D3DK)

EXAMPLE

The following example is a simple memory map, but it illustrates the principles of map management. A driver initializes the map table by calling both the rminit(D3DK) and rmfree(D3DK) functions. rminit(D3DK) establishes the number of slots or entries in the map, and rmfree to initialize the total buffer area the map is to manage. The following example is a fragment from a hypothetical `start` routine and illustrates the following procedures:

Declaration of the map structure (line 4). The defined map array must be initialized to zero before calling `rminit`.

The use of **kmem_alloc**(D3DK) to allocate memory for the map. This example panics the system if the required amount of memory can not be allocated (lines 10–14).

The use of **mapinit** to configure the total number of entries in the map, and of **rmfree** to configure the total buffer area.

```
1   #define XX_MAPSIZE    12
2   #define XX_BUFSIZE  2560
3
4   struct map  xx_map[XX_MAPSIZE]; /* Space management map for */
5                                   /*    a private buffer       */
    ...
6   xx_start()
7        /*
8         *  Allocate private buffer.  If insufficient memory,
9         *  display message and halt system.
10        */
11  {
12      register caddr_t bp;

13      if ((bp = kmem_alloc(XX_BUFSIZE, KM_NOSLEEP) == 0)  {
14
15          cmn_err(CE_PANIC, "xx_start: kmem_alloc failed before %d buffer
                    allocation", XX_BUFSIZE);
16      } /* endif */
17       /*
18        * Initialize space management map with number
19        * of slots in map.
20        */
21  rminit(xx_map, XX_MAPSIZE);
22       /*
23        * Initialize space management map with total
24        * buffer area it is to manage.
25        */
26  rmfree(xx_map, XX_BUFSIZE, bp);
    ...
```

The **rmalloc**(D3DK) function is then used by the driver's `read` or `write` routine to allocate buffers for specific data transfers. If the appropriate space cannot be allocated, the **rmsetwant**(D3DK) function is used to wait for a free buffer and the process is put to sleep until a buffer is available. When a buffer becomes available, the **rmfree**(D3DK) function is called to return the buffer to the map and to wake the sleeping process (no **wakeup**(D3DK) call is required). The **uiomove**(D3DK) function is used to move the data between user space and local driver memory. The device then moves data between itself and local driver memory through DMA.

The next example illustrates the following procedures:

The size of the I/O request is calculated and stored in the **size** variable (lines 14–15).

While buffers are available, buffers are allocated through the **rmalloc** function using the **size** value (line 25).

If there are not enough buffers free for use, the **rmsetwant**(D3DK) function is called, and the process is put to sleep (lines 26–28). When a buffer becomes available, the **rmfree**(D3DK) function returns the buffer to the map and wakes the process.

The **uiomove**(D3DK) function is used to move data to the allocated buffer (line 35).

If the address passed to the **uiomove** function is invalid, the **rmfree** function is called to release the previously allocated buffer, and an **EFAULT** error is returned.

```
1   #define XX_MAPPRIO (PZERO + 6)
2   #define XX_MAPSIZE    12
3   #define XX_BUFSIZE  2560
4   #define XX_MAXSIZE  (XX_BUFSIZE / 4)
5
6   struct map  xx_map[XX_MAPSIZE];          /* Private buffer space map */
7          char xx_buffer[XX_BUFSIZE];         /* driver xx_ buffer area */
    ...
8   read(dev, uio_p, cred_p)
9       dev_t   dev;
10      uio_t   uio_p;          /* Pointer to uio structure for I/O */
11      cred_t  cred_p;
12
13  register caddr_t addr;
14  register int      size;
15      size = min(COUNT, XX_MAXSIZE);  /* Break large I/O request */
16                                                    /* into small ones */
17       /*
18        * Get buffer.  If space is not available, then
19        * request a wakeup when space is returned. Wait
20        * for space; rmfree will check rmsetwant and
21        * supply the wakeup call.
22        */
23      oldlevel = spl4();
24
25      while((addr = (caddr_t)rmalloc(xx_map, size)) == NULL) {
26          rmsetwant(xx_map)
27          sleep(xx_map, XX_MAXPRIO);
28      } /* endwhile */
29      splx(oldlevel);
```

```

 /*
  * Move data to buffer.  If invalid address is found,
  * return buffer to map and return error code.
  */
if (uiomove(addr, size, UIO_READ, uio_p) == -1)  {
    oldlevel = spl4();
    rmfree(xx_map, size, addr);
    splx(oldlevel);
    return(EFAULT);
} /* endif */
```

NAME

`rmfree` – free space back into a private space management map

SYNOPSIS

```
#include <sys/map.h>
#include <sys/ddi.h>

void rmfree(struct map *mp, long size, unsigned long index);
```

ARGUMENTS

**mp*	Pointer to the `map`(D4DK) structure.
size	Number of units being freed.
index	Index of the first unit of the allocated resource.

DESCRIPTION

`rmfree` releases space back into a private space management map. It is the opposite of `rmalloc`(D3DK), which allocates space that is controlled by a private `map` structure.

Drivers may define private space management buffers for allocation of memory space, in terms of arbitrary units, using the `rmalloc`(D3DK), `rmfree` and `rminit`(D3DK) functions. The drivers must include the file `map.h`. The system maintains the memory map list structure by size and index, computed in units appropriate for the memory map. For example, units may be byte addresses, pages of memory, or blocks. The elements of the memory map are sorted by index, and the system uses the size member so that adjacent objects are combined into one memory map entry. The system allocates objects from the memory map on a first-fit basis. `rmfree` frees up unallocated memory for re-use.

RETURN VALUE

None. However, if the `m_addr` member of the `map` structure is returned as `0`, the following warning message is displayed on the console:

`WARNING: rmfree map overflow` *mp* `lost` *size* `items at` *index*

where *mp* is the hexadecimal address of the `map` structure, *size* is the decimal number of buffers freed, and *index* is the decimal address to the first buffer unit freed.

LEVEL

Base or Interrupt

SEE ALSO

`rmalloc`(D3DK), `rminit`(D3DK), `rmwant`(D3DK)

EXAMPLE

See `rmalloc`(D3DK).

NAME

`rminit` – initialize a private space management map

SYNOPSIS

```
#include <sys/map.h>
#include <sys/ddi.h>

void rminit(struct map *mp, unsigned long mapsize);
```

ARGUMENTS

**mp* Pointer to the memory map from where the resource is drawn.

mapsize Number of entries for the memory map table.

DESCRIPTION

The `rminit` function initializes a private map structure that can be used for the allocation of memory space. The map itself is declared as a structure using the driver prefix in the form *prefix*`map`. Memory is initially allocated for the map either by a data array, or by the `kmem_alloc`(D3DK) function.

The driver must initialize the `map` structure by calling `rminit`. However, `rminit` does not cause the memory map entries to be labeled available. This must be done through `rmfree`(D3DK) before objects can actually be allocated from the memory map.

The system maintains the memory map list structure by size and index, computed in units appropriate for the memory map. Units may be byte addresses, pages of memory, or blocks. The elements of the memory map are sorted by index.

Two memory map table entries are reserved for internal system use and they are not available for memory map use.

NOTE: The map array must be initialized to zero before calling `rminit`.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 6, "Input/Output Operations"

`rmalloc`(D3DK), `rmwant`(D3DK), `rmfree`(D3DK), `rmsetwant`(D4DK)

EXAMPLE

See `rmalloc`(D3DK).

NAME

`rmsetwant` – set the map's wait flag for a wakeup

SYNOPSIS

```
#include <sys/map.h> #include <sys/ddi.h>

void rmsetwant(struct map *map_p);
```

ARGUMENTS

map_p Pointer to the map the driver is waiting for.

DESCRIPTION

The `rmsetwant` function increments the counter on the wait flag of the map pointed to by *map_p*. It is typically called from the driver's `read` or `write` routine after an unsuccessful attempt to allocate space from the map using `rmalloc`(D3DK).

Typically, a driver will sleep on `map_p` after calling `rmsetwant`. When the `rmfree` function returns space to the map, it calls `wakeup`(D3DK).

RETURN VALUE

None

LEVEL

Base only

SEE ALSO

`rmalloc`(D3DK), `rmfree`(D3DK), `rminit`(D3DK), `rmwant`(D3DK), `map`(D4DK)

EXAMPLE

See `rmalloc`(D3DK).

NAME

rmvb – remove a message block from a message

SYNOPSIS

`#include <sys/stream.h>`

`mblk_t *rmvb(mblk_t *mp, mblk_t *bp);`

ARGUMENTS

**mp*	Message from which a block is to be removed. `mblk_t` is an instance of the `msgb`(D4DK) structure.
bp	Message block to be removed.

DESCRIPTION

`rmvb` removes a message block (*bp*) from a message (*mp*), and returns a pointer to the altered message. The message block is not freed, merely removed from the message. It is the module or driver's responsibility to free the message block.

RETURN VALUE

If successful, a pointer to the message (minus the removed block) is returned. The pointer is `NULL` if *bp* was the only block of the message before `rmvb` was called. If the designated message block (*bp*) does not exist, `-1` is returned.

LEVEL

Base or Interrupt

EXAMPLE

This routine removes all zero-length `M_DATA` message blocks from the given message. For each message block in the message, save the next message block (line 10). If the current message block is of type `M_DATA` and has no data in its buffer (line 11), then remove it from the message (line 12) and free it (line 13). In either case, continue with the next message block in the message (line 16).

```
 1  void
 2  xxclean(mp)
 3      mblk_t *mp;
 4  {
 5     mblk_t *tmp;
 6     mblk_t *nmp;
 7
 8     tmp = mp;
 9     while (tmp) {
10             nmp = tmp->b_next;
11             if ((tmp->b_datap->db_type == M_DATA) &&
                   (tmp->b_rptr == tmp->b_wptr)) {
12                    rmvb(mp, tmp);
13                    freeb(tmp);
14             }
15             tmp = nmp;
16     }
17  }
```

NAME

`rmvq` – remove a message from a queue

SYNOPSIS

```
#include <sys/stream.h>

void rmvq(queue_t *q, mblk_t *mp);
```

ARGUMENTS

q Queue containing the message to be removed.

mp Message to remove.

DESCRIPTION

`rmvq` removes a message from a queue. A message can be removed from anywhere on a queue. To prevent modules and drivers from having to deal with the internals of message linkage on a queue, either `rmvq` or `getq`(D3DK) should be used to remove a message from a queue.

CAUTION: Make sure that the message *mp* exists to avoid a possible system panic.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

EXAMPLE

This code fragment illustrates how one may flush one type of message from a queue. In this case, only `M_PROTO` `T_DATA_IND` messages are flushed. For each message on the queue, if it is an `M_PROTO` message (line 8) of type `T_DATA_IND` (line 10), save a pointer to the next message (line 11), remove the `T_DATA_IND` message (line 12) and free it (line 13). Continue with the next message in the list (line 19).

```
 1  mblk_t *mp;
 2  mblk_t *nmp;
 3  queue_t *q;
 4  union T_primitives *tp;
 5
 6  mp = q->q_first;
 7  while (mp) {
 8     if (mp->b_datap->db_type == M_PROTO) {
 9             tp = (union T_primitives *)mp->b_rptr;
10             if (tp->type == T_DATA_IND) {
11                     nmp = mp->b_next;
12                     rmvq(q, mp);
13                     freemsg(mp);
14                     mp = nmp;
15             } else {
16                     mp = mp->b_next;
17             }
```

```
    } else {
            mp = mp->b_next;
    }
}
```

NAME

rmwant – wait for free memory

SYNOPSIS

```
#include <sys/map.h>
#include <sys/ddi.h>

unsigned long rmwant(struct map *map_p);
```

ARGUMENT

map_p Pointer to the map(D4DK) structure on which the driver is waiting for space.

DESCRIPTION

The rmwant function returns the number of processes waiting for free space in the map.

RETURN VALUE

The number of processes waiting for free space in the map.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 6, ''Input/Output Operations''

rmalloc(D3DK), rminit(D3DK), rmfree(D3DK), rmsetwant(D3DK), map(D4DK)

NAME

SAMESTR – test if next queue is same type

SYNOPSIS

```
#include <sys/stream.h>

int SAMESTR(queue_t *q);
```

ARGUMENT

*q Pointer to the queue.

DESCRIPTION

The SAMESTR function is used to see if the next queue in a stream (if it exists) is the same type as the current queue (that is, both are read queues or both are write queues).

RETURN VALUE

SAMESTR returns 1 if the next queue is the same type as the current queue. It returns 0 if the next queue does not exist or if it is not the same type.

LEVEL

Base or Interrupt

SEE ALSO

OTHERQ(D3DK)

NAME

`sleep` – suspend process activity pending execution of an event

SYNOPSIS

```
#include <sys/types.h>
#include <sys/param.h>

int sleep(caddr_t event, int priority);
```

ARGUMENTS

event Address (signifying an event) for which the process will wait to be updated.

priority Priority that is assigned to the process when it is awakened. If *priority* is ORed with the defined constant `PCATCH`, the `sleep` function does not call `longjmp` on receipt of a signal. Instead, it returns the value `1` to the calling routine.

DESCRIPTION

`sleep` suspends execution of a process to await certain events such as reaching a known system state in hardware or software. For instance, when a process wants to read a device and no data is available, the driver may need to call `sleep` to wait for data to become available before returning. This causes the kernel to suspend executing the process that called `sleep` and schedule another process. The process that called `sleep` can be restarted by a call to the `wakeup`(D3DK) function with the same *event* specified as that used to call `sleep`.

A driver (with data stored in local variables) may call `sleep` while waiting for an event to occur. Make sure another process will not interrupt the driver and overwrite the local variables.

The *event* address used when calling `sleep` should be the address of a kernel data structure or one of the driver's own data structures. The `sleep` address is an arbitrary address that has no meaning except to the corresponding `wakeup` function call. This does not mean that any arbitrary kernel address should be used for `sleep`. Doing this could conflict with other, unrelated `sleep/wakeup` operations in the kernel. A kernel address used for `sleep` should be the address of a kernel data structure directly associated with the driver I/O operation (for example, a buffer assigned to the driver).

Before a process calls `sleep`, the driver usually sets a flag in a driver data structure indicating the reason why `sleep` is being called.

The *priority* argument, called the `sleep` priority, is used for scheduling purposes when the process awakens. This parameter has critical effects on how the process that called `sleep` reacts to signals. If the numerical value of the `sleep` priority is less than or equal to the constant `PZERO` (defined in the `sys/param.h` header file), then the sleeping process will not be awakened by a signal. However, if the numerical value is greater than `PZERO`, the system awakens the process that called `sleep` prematurely (that is, before the event on which `sleep` was called occurred) on receipt of a non-ignored, non-held signal. In this case, it returns the value `1` to the calling routine if `PCATCH` is set; otherwise it does a `longjmp` and never returns to the driver. If the event occurred, `0` is returned.

To pick the correct sleep priority, base your decision on whether or not the process should be awakened on the receipt of a signal. If the driver calls sleep for an event that is certain to happen, the driver should use a priority numerically less than or equal to PZERO. (However, you should only use priorities less than or equal to PZERO if your driver is crucial to system operation.) If the driver calls sleep while it awaits an event that may not happen, use a priority numerically greater than PZERO.

An example of an event that may not happen is the arrival of data from a remote device. When the system tries to read data from a terminal, the terminal driver might call sleep to suspend the current process while waiting for data to arrive from the terminal. If data never arrives, the sleep call will never be answered. When a user at the terminal presses the BREAK key or hangs up, the terminal driver interrupt handler sends a signal to the reading process, which is still executing sleep. The signal causes the reading process to finish the system call without having read any data. If sleep is called with a priority value that is not awakened by signals, the process can be awakened only by a specific wakeup call. If that wakeup call never happened (the user hung up the terminal), then the process executes sleep until the system is rebooted.

Another important criteria for selecting the appropriate priority is how important the event or resource being waited for is to overall system performance. For example, disk I/O is often a bottleneck, so the priority for disk I/O is higher than most other priorities. In contrast, terminal I/O is a much lower priority. The sooner the process runs, the faster the resource will be used and freed again.

Drivers calling sleep must occasionally perform cleanup operations before returning. Typical items that need cleaning up are locked data structures that should be unlocked when the system call completes. This is done by ORing *priority* with PCATCH and executing sleep. If sleep returns a 1, then you can cleanup any locked structures or free any allocated resources, and return. CAUTION: If sleep is called from the driver strategy(D2DK) routine, you should OR the *priority* argument with PCATCH or select a *priority* of PZERO or less.

RETURN VALUE

If the sleep *priority* argument is ORed with the defined constant PCATCH, the sleep function does not call longjmp on receipt of a signal; instead, it returns the value 1 to the calling routine. If the process put in a wait state by sleep is awakened by an explicit wakeup call rather than by a signal, the sleep call returns 0.

LEVEL

Base Only (Do not call from an interrupt routine)

SEE ALSO

BCI Driver Development Guide, Chapter 10, "Synchronizing Hardware and Software Events"

delay(D3DK), biodone(D3DK), biowait(D3DK), timeout(D3DK), untimeout(D3DK), wakeup(D3DK)

EXAMPLE

See the untimeout(D3DK) function page for an example of sleep.

NAME

spl – block/allow interrupts

SYNOPSIS

```
#include <sys/inline.h>

int spl0();
int spl1();
int spl4();
int spl5();
int spl6();
int spl7();
int splvm();
int splhi();
int splstr();
int spltty();

int splx(int oldlevel);
```

ARGUMENT

oldlevel Last set priority value (only splx has an input argument).

DESCRIPTION

spl blocks or allows interrupts. When a process is executing code in a driver, the system will not switch context from that process to another executing process unless it is explicitly told to do so by the driver. This protects the integrity of the kernel and driver data structures. However, the system does allow devices to interrupt the processor and handle these interrupts immediately.

The integrity of system data structures would be destroyed if an interrupt handler were to manipulate the same data structures as a process executing in the driver. To prevent such problems, the kernel provides the spl functions allowing a driver to set processor execution levels, prohibiting the handling of interrupts below the level set.

The selection of the appropriate spl function is important. The execution level to which the processor is set must be high enough to protect the region of code; but this level should not be so high that it unnecessarily locks out interrupts that need to be processed quickly. A hardware device is assigned to an interrupt priority level depending on the type of device. By using the appropriate spl function, a driver can inhibit interrupts from its device or other devices at the same or lower interrupt priority levels.

The spl command changes the state of the processor status word (PSW). The PSW stores the current processor execution level, in addition to information relating to the operating system internals. The spl functions block out interrupts that come in at a priority level at or below a machine-dependent interrupt priority level. The spl functions include the following:

spl0 Restores all interrupts when executing on the base level. A driver routine may use spl0 when the routine has been called through a system call; that is, if it is known that the level being restored is indeed at base level.

`spl1` Used in context and process switch to protect critical code.

`spl4` Used in character drivers to protect critical code.

`spl5` Used in character drivers to protect critical code (this function has the same effect as `spl4`).

`spl6` Used in block drivers to protect critical code.

`spl7` Used in any type of driver to mask out all interrupts including the clock, and should be used very sparingly.

`splvm` Used in memory management code to protect critical regions.

`splhi` Used in any type of driver to mask out all interrupts including the clock, and should be used very sparingly. (This function is identical to `spl7`.)

`spltty` Used by a TTY driver to protect critical code.

`splstr` Used to protect STREAMS driver and module critical regions of code. This is defined to be high enough to block interrupts from the highest priority STREAMS device. `splstr` is mapped to `spltty`.

`splx` Used to terminate a section of protected critical code. This function restores the interrupt level to the previous level specified by its argument *oldlevel.*

NOTE: `spl` functions should not be used in interrupt routines unless you save the old interrupt priority level in a variable as it was returned from an `spl` call. Later, `splx` must be used to restore the saved old level. Never drop the interrupt priority level below the level at which an interrupt routine was entered. For example, if an interrupt routine is entered at the interrupt priority level of an `spl6`, do not call `spl0` through `spl5` or the stack may become corrupted.

RETURN VALUE

All `spl` functions (except `splx`) return the former priority level.

EXAMPLE

See the `untimeout`(D3DK) function page for an example of `spl`.

NAME

`strlog` – submit messages to the `log` driver

SYNOPSIS

```
#include <sys/stream.h>
#include <sys/strlog.h>
#include <sys/log.h>
```

```
int strlog(short mid, short sid, char level, unsigned short flags,
     char *fmt, unsigned arg1, . . .);
```

ARGUMENTS

mid Identification number of the module or driver submitting the message.

sid Identification number for a particular minor device.

level Tracing level for selective screening of low priority messages.

flags Valid flag values are:

`SL_ERROR`	Message is for error logger.
`SL_TRACE`	Message is for trace.
`SL_NOTIFY`	Mail copy of message to system administrator.
`SL_CONSOLE`	Log message to console.
`SL_FATAL`	Error is fatal.
`SL_WARN`	Error is a warning.
`SL_NOTE`	Error is a notice.

fmt `printf`(3S) style format string. `%s`, `%e`, `%g`, and `%G` formats are not allowed.

arg1 Zero or more arguments to `printf`.

DESCRIPTION

`strlog` submits formatted messages to the `log`(7) driver. The messages can be retrieved with the `getmsg`(2) system call. The *flags* argument specifies the type of the message and where it is to be sent. `strace`(1M) receives messages from the `log` driver and sends them to the standard output. `strerr`(1M) receives error messages from the `log` driver and appends them to a file called `/var/adm/streams/error.`*mm-dd*, where *mm-dd* identifies the date of the error message.

RETURN VALUE

`strlog` returns `0` if the message is not seen by all the readers, `1` otherwise.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 12, "Error Reporting"

`log`(7)

NAME

strqget – get information about a queue or band of the queue

SYNOPSIS

```
#include <sys/stream.h>

int strqget(queue_t *q, qfields_t what, unsigned char pri,
     long *valp);
```

ARGUMENTS

q Pointer to the queue

what Which field of the queue structure to return information about. Valid values are specified in stream.h:

```
typedef enum qfields {
        QHIWAT    = 0,    /* q_hiwat or qb_hiwat */
        QLOWAT    = 1,    /* q_lowat or qb_lowat */
        QMAXPSZ   = 2,    /* q_maxpsz */
        QMINPSZ   = 3,    /* q_minpsz */
        QCOUNT    = 4,    /* q_count or qb_count */
        QFIRST    = 5,    /* q_first or qb_first */
        QLAST     = 6,    /* q_last or qb_last */
        QFLAG     = 7,    /* q_flag or qb_flag */
        QBAD      = 8
} qfields_t;
```

pri Priority of request.

valp The value for the requested field.

DESCRIPTION

strqget gives drivers and modules a way to get information about a queue or a particular band of a queue without directly accessing STREAMS data structures.

RETURN VALUE

On success, 0 is returned. An error number is returned on failure.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

strqset(D3DK)

NAME

strqset – change information about a queue or band of the queue

SYNOPSIS

```
#include <sys/stream.h>

int strqset(queue_t *q, qfields_t what, unsigned char pri,
    long *val);
```

ARGUMENTS

q Pointer to the queue.

what Which field of the queue structure to return information about. Valid values are specified in stream.h:

```
typedef enum qfields {
        QHIWAT    = 0,    /* q_hiwat or qb_hiwat */
        QLOWAT    = 1,    /* q_lowat or qb_lowat */
        QMAXPSZ   = 2,    /* q_maxpsz */
        QMINPSZ   = 3,    /* q_minpsz */
        QCOUNT    = 4,    /* q_count or qb_count */
        QFIRST    = 5,    /* q_first or qb_first */
        QLAST     = 6,    /* q_last or qb_last */
        QFLAG     = 7,    /* q_flag or qb_flag */
        QBAD      = 8
} qfields_t;
```

pri Priority of request.

val The value for the field to be changed.

DESCRIPTION

strqset gives drivers and modules a way to change information about a queue or a particular band of a queue without directly accessing STREAMS data structures. The fields that can be returned are defined in the enumerated type qfields. qfields defines the following fields:

RETURN VALUE

On success, 0 is returned. An error number is returned on failure. If the *what* field is read-only, EPERM is returned and the field is left unchanged.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

strqget(D3DK)

NAME

testb – check for an available buffer

SYNOPSIS

```
#include <sys/stream.h>

int testb(int size, int pri);
```

ARGUMENTS

size Size of the requested buffer.

pri Priority of the allocb request.

DESCRIPTION

testb checks to see if an allocb(D3DK) call is likely to succeed if a buffer of *size* bytes at priority *pri* is requested. Even if testb returns successfully, the call to allocb can fail.

RETURN VALUE

Returns 1 if a buffer of the requested size is available, and 0 if one is not.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

allocb(D3DK), bufcall(D3DK)

EXAMPLE

In a srv(D2DK) (service) routine, if copymsg(D3DK) fails (line 6), the message is put back on the queue (line 7) and a routine, tryagain, is scheduled to be run in one tenth of a second (HZ/10). Then the service routine returns.

When the timeout(D3DK) function runs, if there is no message on the front of the queue, it just returns. Otherwise, for each message block in the first message, check to see if an allocation would succeed. If the number of message blocks equals the number we can allocate, then enable the service procedure. Otherwise, reschedule tryagain to run again in another tenth of a second. Note that tryagain is merely an approximation. Its accounting may be faulty. Consider the case of a message comprised of two 1024-byte message blocks. If there is only one free 1024-byte message block and no free 2048-byte message blocks, then testb will still succeed twice. If no message blocks are freed of these sizes before the service procedure runs again, then the copymsg(D3DK) will still fail. The reason testb is used here is because it is significantly faster than calling copymsg. We must minimize the amount of time spent in a timeout routine.

```
1  xxxsrv(q)
2      queue_t *q;
3  {
4    mblk_t *mp;
5    mblk_t *nmp;
       . . .
6    if ((nmp = copymsg(mp)) == NULL) {
7          putbq(q, mp);
8          timeout(tryagain, (long)q, HZ/10);
```

```
         return;
   }
   . . .
}

tryagain(q)
    queue_t *q;
{
   register int can_alloc = 0;
   register int num_blks = 0;
   register mblk_t *mp;

   if (!q->q_first)
         return;
   for (mp = q->q_first; mp; mp = mp->b_cont) {
         num_blks++;
         can_alloc += testb((mp->b_datap->db_lim -
             mp->b_datap->db_base), BPRI_MED);
   }
   if (num_blks == can_alloc)
         qenable(q);
   else
         timeout(tryagain, (long)q, HZ/10);
}
```

NAME

`timeout` – execute a function after a specified length of time

SYNOPSIS

```
#include <sys/types.h>

int timeout(int (*ftn)(), caddr_t arg, long ticks);
```

ARGUMENTS

ftn Kernel function to invoke when the time increment expires.

arg Argument to the function.

ticks Number of clock ticks to wait before the function is called.

DESCRIPTION

The `timeout` function schedules the specified function to be called after a specified time interval. Control is immediately returned to the caller. This is useful when an event is known to occur within a specific time frame, or when you want to wait for I/O processes when an interrupt is not available or might cause problems. For example, some robotics applications do not provide a status flag for determining when to pump information to the robot's controller. By using `timeout`, the driver can wait a predetermined interval and then begin transferring data to the robot.

The exact time interval over which the timeout takes effect cannot be guaranteed, but the value given is a close approximation. The function called by `timeout` must adhere to the same restrictions as a driver interrupt handler. It can neither sleep nor use previously set local variables.

RETURN VALUE

Under normal conditions, an integer timeout identifier is returned (which may, in unusual circumstances, be set to 0). Otherwise, if the `timeout` table is full, the following panic message results:

```
PANIC:  Timeout table overflow
```

The `timeout` function returns an identifier that may be passed to the `untimeout`(D3DK) function to cancel a pending request. **NOTE:** No value is returned from the called function.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 10, ''Synchronizing Hardware and Software Events''

`delay`(D3DKK), `biodone`(D3DK), `biowait`(D3DK), `sleep`(D3DK), `untimeout`(D3DK), `wakeup`(D3DK)

EXAMPLE

See the `bufcall`(D3DK) function page for an example of `timeout`.

NAME

uiomove – copy kernel data using uio(D4DK) structure

SYNOPSIS

```
#include <sys/types.h>
#include <sys/uio.h>

int uiomove(caddr_t address, long nbytes, enum uio_rw rwflag,
     struct uio * uio_p);
```

ARGUMENTS

address	Source/destination kernel address of the copy.
nbytes	Number of bytes to copy.
rwflag	Flag indicating read or write operation. Possible values are UIO_READ and UIO_WRITE.
uio_p	Pointer to the uio structure for the copy.

DESCRIPTION

The uiomove function copies *nbytes* of data to or from the space defined by the uio structure (described in uio.h) and the driver.

The uio_segflg member of the uio structure determines the the type of space to or from which the transfer being made. If it is set to UIO_SYSSPACE the data transfer is between addresses in the kernel. If it is set to UIO_USERSPACE the transfer is between a user program and kernel space.

In addition to moving the data, uiomove adds the number of bytes moved to the iov_base member of the iovec(D4DK) structure, decreases the iov_len member, increases the uio_offset member of the uio structure, and decreases the uio_resid member.

This function does automatic page boundary checking. *nbytes* does not have to be word-aligned.

CAUTION: If uio_segflg is set to UIO_SYSSPACE and *address* is selected from user space, the system panics.

RETURN VALUE

uiomove returns 0 upon success or -1 on failure. The driver entry point routine through which uiomove was called should return EFAULT if -1 is returned.

LEVEL

Base.

SEE ALSO

uio(D4DK), ureadc(D3DK), uwritec(D3DK)

EXAMPLE

See rmalloc.

NAME

unlinkb – remove a message block from the head of a message

SYNOPSIS

```
#include <sys/stream.h>

mblk_t *unlinkb(mblk_t *mp);
```

ARGUMENT

mp Pointer to the message.

DESCRIPTION

unlinkb removes the first message block from the message pointed to by *mp*. A new message, minus the removed message block, is returned.

RETURN VALUE

If successful, unlinkb returns a pointer to the message with the first message block removed. If there is only one message block in the message, NULL is returned.

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 7, "STREAMS"

linkb(D3DK)

EXAMPLE

The routine expects to get passed an M_PROTO T_DATA_IND message. It will remove and free the M_PROTO header and return the remaining M_DATA portion of the message.

```
mblk_t *
makedata(mp)
    mblk_t *mp;
{
  mblk_t *nmp;

  nmp = unlinkb(mp);
  freeb(mp);
  return(nmp);
}
```

NAME

untimeout – cancel previous timeout(D3DK) function call

SYNOPSIS

```
#include <sys/types.h>

int untimeout(int id);
```

ARGUMENTS

id Identification value generated by a previous timeout function call.

DESCRIPTION

untimeout cancels a pending timeout(D3DK) request.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 10, "Synchronizing Hardware and Software Events"

delay(D3DK), biodone(D3DK), biowait(D3DK), sleep(D3DK), timeout(D3DK), wakeup(D3DK)

EXAMPLE

A driver may have to repeatedly request outside help from a computer operator. The timeout function is used to delay a certain amount of time between requests. However, once the request is honored, the driver will want to cancel the timeout operation. This is done with the untimeout function.

In a driver open(D2DK) routine, after the input arguments have been verified, the status of the device is tested. If the device is not on-line, a message is displayed on the system console. The driver schedules a wakeup(D3DK) call and waits for five minutes (line 41). If the device is still not ready, the procedure is repeated.

When the device is made ready, an interrupt is generated. The driver interrupt handling routine notes there is a suspended process. It cancels the timeout request (line 59) and wakens the suspended process (line 61).

```
 1  struct  mtu_device  {
 2                                /* layout of physical device registers */
 3          int      control;  /* physical device control word        */
 4          int      status;   /* physical device status word         */
 5          int      byte_cnt; /* number of bytes to be transferred   */
 6          paddr_t  baddr:    /* DMA starting physical address       */
 7  }; /* end device */
 8
 9  struct mtu      {
10                                /* magnetic tape unit logical structure */
11         struct buf *mtu_head;  /* pointer to I/O queue head           */
12         struct buf *mtu_tail;  /* pointer to buffer I/O queue tail    */
13         int           mtu_flag;  /* logical status flag                 */
```

```
       int         mtu_to_id; /* time out ID number                 */
         ...
}; /* end mtu */

extern struct mtu_device *mtu_addr[];     /* location of dev regs */
extern struct mtu        mtu_tbl[];    /* location of dev structs */
extern int    mtu_cnt;
  ...
mtu_open(dev, flag, type, c_ptr)
    dev_t dev;
{
    register struct mtu *dp;
    register struct mtu_device *rp;
    if ((getminor(dev) >> 3) > mtu_cnt) { /* if dev doesn't exist */
        return(ENXIO);            /* then return error condition  */
    } /* endif */

    dp = &mtu_tbl[getminor(dev)];   /* get logical device struct */
    if  (dp->mtu_flag & MTU_BUSY) != 0) {  /* if device is in use, */
        return(EBUSY);                      /* return busy status */
    } /* endif */

    dp->mtu_flag = MTU_BUSY;   /* mark device in use & clear flags */
    rp = xx_addr[getminor(dev) >> 3];          /* get device regs */
    oldlevel2 = splhi();
    while((rp->status & MTU_LOAD) == 0) { /* while tape not loaded */
                              /* display mount request on console */
        cmn_err(CE_NOTE, "!Tape MOUNT, drive %d", minor(dev) & 0x3);
        dp->mtu_flag |= MTU_WAIT;   /* indicate process suspended  */
        dp->mtu_to_id = timeout(wakeup, dp, 5*60*HZ); /* wait 5 min */
        if (sleep(dp, (PCATCH | PZERO+2)) == 1){/*wait on tape load */
                                /* if user aborts process, release */
            dp->mtu_flag = 0;     /* tape device by clearing flags */
            untimeout(dp->mtu_to_id);
            splx(oldlevel2);
         } /* endif */
    } /* endwhile */
    splx(oldlevel2);
} /* end mtu_open */
   ...
mtu_int(cntr)
    int cntr;              /* controller that caused the interrupt */
{
register struct mtu_device *rp = xx_addr[cntr]; /* get device regs */
register struct mtu *dp = &mtu_tbl[cntr << 3 | (rp->status & 0x3)];
   ...
   if ((dp->mtu_flag & MTU_WAIT) != 0){ /* if process is suspended */
                                       /* waiting for tape mount, */
        untimeout(dp->mtu_to_id);       /* cancel timeout request */
        dp->flag &= ~MTU_WAIT;                  /* clear wait flag */
        wakeup(dp);                    /* awaken suspended process */
    } /* endif */
    ...
```

NAME

ureadc – add character to a uio structure

SYNOPSIS

```
#include <sys/uio.h>

int ureadc(int c, uio_t *uio_p);
```

ARGUMENTS

c The character added to the uio structure.

**uio_p* Pointer to the uio(D4DK) structure.

DESCRIPTION

ureadc transfers the character *c* into the address space of the uio structure pointed to by *uio_p*, and updates the uio structure as for uiomove(D3DK).

RETURN VALUE

0 is returned on success and **EFAULT** on failure.

LEVEL

Base or Interrupt

SEE ALSO

uiomove(D3DK), uwritec(D3DK), iovec(D4DK), uio(D4DK)

NAME

useracc – verify whether user has access to memory

SYNOPSIS

```
#include <sys/types.h>
#include <sys/buf.h>
```

int useracc(caddr_t *base*, uint *count*, int *access*);

ARGUMENTS

base The start address of the user data area

count The size of the data transfer in bytes

access A flag to determine whether the access is a read or write. The defined constant B_READ specifies a read from the device and a write to memory. This requires that the user have write access permission for the specified data area. The defined constant B_WRITE specifies a read from memory and a write to the device. It requires read access permission for the data area. (B_READ and B_WRITE are defined in the system header file sys/buf.h.)

DESCRIPTION

useracc verifies if a user has proper access to memory. It is not necessary to use useracc for buffered I/O (including use of the copyin(D3DK) and copyout(D3DK) functions).

RETURN VALUE

Under normal conditions, 1 is returned. If the user does not have the proper access permission to the memory specified return EFAULT.

LEVEL

Base Only (Do not call from an interrupt routine)

SEE ALSO

drv_priv(D3DK)

NAME

uwritec – remove a character from a uio structure

SYNOPSIS

```
#include <sys/uio.h>

int uwritec (uio_t *uio_p);
```

ARGUMENTS

**uio_p* Pointer to the uio(D4DK) structure.

DESCRIPTION

uwritec returns a character from the uio structure pointed to by *uio_p*, and updates the uio structure as for uiomove(D3DK).

RETURN VALUE

The next character for processing is returned on success, and -1 is returned if uio is empty or there is an error.

LEVEL

Base or Interrupt

SEE ALSO

uiomove(D3DK), ureadc(D3DK), iovec(D4DK), uio(D4DK)

NAME

vtop – convert virtual to physical address

SYNOPSIS

```
#include <sys/types.h>

paddr_t vtop(long vaddr, proc_t *p);
```

ARGUMENTS

vaddr Virtual address to convert.

p Pointer to the proc(D4X) structure used by vtop to locate the information tables used for memory management. To indicate that the address is in kernel virtual space or in the virtual space of the current process, set *p* to NULL. Block drivers that can transfer data directly in and out of user memory space must set *p* to the b_proc member of the buf(D4DK) structure.

DESCRIPTION

vtop converts a virtual address to a physical address. When a driver receives a memory address from the kernel, that address is virtual. Generally, memory management is performed by the MMU. However, devices that access memory directly (DMA) deal only with physical memory addresses. In such cases, the driver must provide the device with physical memory addresses.

The virtual address is the memory address being translated. The vtop function returns the translated address.

The same functionality is provided by the kvtophys(D3D) function.

RETURN VALUE

Under normal conditions, a physical address is returned. Otherwise, the following can be returned:

–1	if the virtual address to be translated is not a valid one
0	if there is no physical memory mapped to the virtual address

LEVEL

Base or Interrupt.

SEE ALSO

BCI Driver Development Guide, Chapter 6, "Input/Output Operations"

btop(D3DK), btopr(D3DK), ptob(D3DK), kvtophys(D3D)

NAME

wakeup – resume suspended process execution

SYNOPSIS

```
#include <sys/types.h>

void wakeup(caddr_t event);
```

ARGUMENT

event Address that is the same address used by sleep(D3DK) to suspend process execution.

DESCRIPTION

wakeup awakens all processes that called sleep with an address as the *event* argument. This lets the processes execute according to the scheduler. Ensure that the same *event* argument is used for both sleep and wakeup. It is recommended for code readability and for efficiency to have a one-to-one correspondence between events and sleep addresses. Also, there is usually one bit in the driver flag member that corresponds to the reason for calling sleep.

Whenever a driver calls sleep, it should test to ensure the event on which the driver called sleep occurred. There is an interval between the time the process that called sleep is awakened and the time it resumes execution where the state forcing the sleep may have been reentered. This can occur because all processes waiting for an event are awakened at the same time. The first process given control by the scheduler usually gains control of the event. All other processes awakened should recognize that they cannot continue and should reissue sleep.

RETURN VALUE

None

LEVEL

Base or Interrupt

SEE ALSO

BCI Driver Development Guide, Chapter 10, "Synchronizing Hardware and Software Events"

delay(D3DK), biodone(D3DK), biowait(D3DK), sleep(D3DK),
timeout(D3DK), untimeout(D3DK)

EXAMPLE

See the untimeout(D3DK) function page for an example of wakeup.

NAME

WR – get pointer to the write queue for this module or driver

SYNOPSIS

```
#include <sys/stream.h>
#include <sys/ddi.h>

queue_t WR(queue_t *q);
```

ARGUMENTS

q Pointer to the *read* queue whose *write* queue is to be returned.

DESCRIPTION

The WR function accepts a *read* queue pointer as an argument and returns a pointer to the *write* queue of the same module.

CAUTION: Make sure the argument to this function is a pointer to a *read* queue. WR will not check for queue type, and a system panic could result if the pointer is not to a *read* queue.

RETURN VALUE

The pointer to the *write* queue.

LEVEL

Base or Interrupt

SEE ALSO

STREAMS Programmer's Guide

OTHERQ(D3DK), RD(D3DK)

EXAMPLE

In a STREAMS close routine, the driver or module is passed a pointer to the read queue. The driver must zero out the q_ptr field of both the read and write queues if it had previously initialized them in its open routine. These usually are set to the address of the module-specific data structure for the minor device.

```
xxxclose(q, flag)
    queue_t *q;
    int flag;
{
   q->q_ptr = NULL;
   WR(q)->q_ptr = NULL;
   . . .
}
```

4. DATA STRUCTURE (D4)

4. DATA STRUCTURE (D4)

4 Data Structures (D4)

Introduction

This chapter describes the data structures used by drivers to share information between the driver and the kernel. All driver data structures shared by both DDI and DKI are identified with the (D4DK) cross reference code. All DDI-only or DKI-only structures are identified with the (D4D) or (D4K) cross reference codes respectively.

In this section, reference pages contain the following headings:

- NAME summarizes the structure's purpose.
- SYNOPSIS lists the include file that defines the structure.
- DESCRIPTION provides general information about the structure.
- STRUCTURE MEMBERS lists all accessible structure members.
- SEE ALSO gives sources for further information.

Table 4-1 summarizes the STREAMS structures described in this section. STREAMS structures may be used in either DDI or DKI.

Table 4-1: STREAMS Data Structure Summary

Routine	Description
`datab`	STREAMS message data structure
`free_rtn`	structure specifying routine that frees non-STREAMS data buffers
`module_info`	STREAMS driver identification and limit value structure
`msgb`	STREAMS message block structure
`qband`	STREAMS queue flow control information structure
`qinit`	structure specifying STREAMS queue processing procedures
`queue`	STREAMS queue structure
`streamtab`	structure specifying `qinit` structures

Table 4-2 summarizes structures that are not specific to STREAMS I/O. These structures may be used in either DDI or DKI, except as noted.

Table 4-2: Data Structures not Specific to STREAMS

Routine	Description	Type
`buf`	block I/O data transfer structure	
`cred`	access credential structure	
`hdedata`	hard disk error data structure	DDI only
`iovec`	structure specifying address and size of I/O request using `uio`(D4DK)	
`map`	private memory map structure	
`uio`	scatter/gather I/O request structure	

CAUTION

Do not declare arrays of structures as the size of the structures may change between releases. Rely only on the structure members listed in this chapter and not on unlisted members or the position of a member in a structure.

NAME

buf – block I/O data transfer structure

SYNOPSIS

```
#include <sys/buf.h>
```

DESCRIPTION

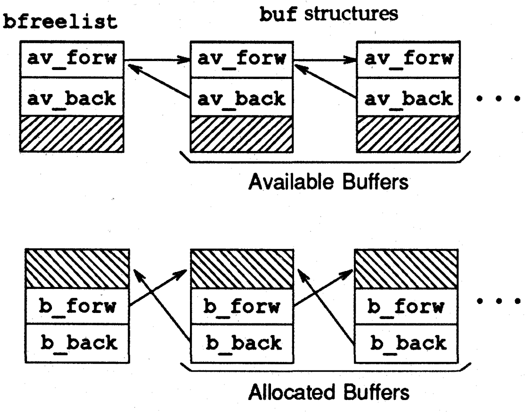
The buf structure is the basic data structure for block I/O transfers. Each block I/O transfer has an associated buffer header. The header contains all the buffer control and status information. For drivers, the buffer header pointer is the sole argument to a block driver strategy(D2DK) routine. Do not depend on the size of the buf structure when writing a driver.

It is important to note that a buffer header may be linked in multiple lists simultaneously. Because of this, most of the members in the buffer header cannot be changed by the driver, even when the buffer header is in one of the drivers' work lists.

Buffer headers are also used by the system for unbuffered or physical I/O for block drivers. In this case, the buffer describes a portion of user data space that is locked into memory (see physiock(D3D)).

Block drivers often chain block requests so that overall throughput for the device is maximized. The av_forw and the av_back members of the buf structure can serve as link pointers for chaining block requests.

The following figure illustrates two linked lists of buffers. The top illustration is the bfreelist, the list of available buffers. The bottom illustration is a queue of allocated buffers. The lined areas indicate other buffer members.



STRUCTURE MEMBERS

```
int             b_flags;        /* Buffer status */
struct buf      *b_forw;        /* headed by d_tab of conf.c */
struct buf      *b_back;        /* headed by d_tab of conf.c */
struct buf      *av_forw;       /* Driver work list link */
struct buf      *av_back;       /* Driver work lists link */
o_dev_t         b_dev;          /* Major/minor device numbers */
unsigned        b_bcount;       /* # of bytes to transfer */
caddr_t         b_addr;         /* Buffer's virtual address */
daddr_t         b_blkno;        /* Block number on device */
char            b_oerror;       /* Old post-I/O error number */
unsigned int    b_resid;        /* # of bytes not transferred */
clock_t         b_start;        /* request start time */
struct proc     *b_proc;        /* Process table entry address */
struct page     *b_pages;       /* page list for PAGEIO */
unsigned long   b_reltime;      /* previous release time */
long            b_bufsize;      /* size of allocated buffer */
int             (*b_iodone);    /* function called by biodone */
struct vnode    *b_vp;          /* vnode associated with block */
int             b_error;        /* expanded error field */
dev_t           b_edev;         /* expanded dev field */
```

CAUTION: Buffers are a shared resource within the kernel. Drivers should read or write only the members listed in this section. Drivers that attempt to use undocumented members of the buf structure risk corrupting data in the kernel or on the device.

The paddr macro (defined in buf.h) provides access to the b_un.b_addr member of the buf structure. (b_un is a union that contains b_addr.)

The members of the buffer header available to test or set by a driver are as follows:

b_flags stores the buffer status and tells the driver whether to read or write to the device. The driver must never clear the b_flags member. If this is done, unpredictable results can occur including loss of disk sanity and the possible failure of other kernel processes.

Valid flags are as follows:

B_BUSY indicates the buffer is in use.

B_DONE indicates the data transfer has completed.

B_ERROR indicates an I/O transfer error.

B_KERNBUF indicates the buffer is allocated by the kernel and not by a driver.

B_PAGEIO indicates the buffer is being used in a paged I/O request. If B_PAGEIO is set, the b_pages field of the buffer header will point to a sorted list of page structures. Also, the b_addr field of the buffer header will be offset into the first page of the page list. If B_PAGEIO is not set, the b_addr field of the buffer header will contain the kernel virtual address of the I/O request. The b_pages field of the buffer header is not used.

B_PHYS indicates the buffer header is being used for physical (direct) I/O to a user data area. The b_un member contains the starting address of the user data area.

B_READ indicates data is to be read from the peripheral device into main memory.

B_WANTED indicates the buffer is sought for allocation.

B_WRITE indicates the data is to be transferred from main memory to the peripheral device. B_WRITE is a pseudo flag that occupies the same bit location as B_READ. B_WRITE cannot be directly tested; it is only detected as the NOT form of B_READ.

av_forw and av_back can be used by the driver to link the buffer into driver work lists.

b_dev contains the external major and minor device numbers of the device accessed. For Release 4.0, this field is replaced by the expanded device number field b_edev. b_dev is maintained for compatibility.

b_bcount specifies the number of bytes to be transferred in both a paged and a non-paged I/O request.

b_addr is either the virtual address of the I/O request, or an offset into the first page of a page list depending on whether B_PAGEIO is set. If it is set, the b_pages field of the buffer header will point to a sorted list of page structures and b_addr will be the offset into the first page. If B_PAGEIO is not set, b_addr is the virtual address from which data is read or to which data is written.

b_blkno identifies which logical block on the device (the device is defined by the device number) is to be accessed. The driver may have to convert this logical block number to a physical location such as a cylinder, track, and sector of a disk.

The b_oerror with a char data type and the expanded b_error with an int data type both may hold an error code that should be passed as a return code from your driver routine. b_error and b_oerror is set in conjunction with the B_ERROR flag (set by the operating system in the b_flags member). The error codes are described in Appendix A.

b_resid indicates the number of bytes not transferred because of an error.

b_start holds the time the I/O request was started.

b_proc contains the process table entry address for the process requesting an unbuffered (direct) data transfer to a user data area (this member is set to 0 when the transfer is buffered). The process table entry is used to perform proper virtual to physical address translation of the b_un member.

b_pages contains a pointer to the page structure list used in a paged I/O operation.

b_bufsize contains the size of the allocated buffer.

(*b_iodone) identifies a specific biodone routine to be called by the driver when the I/O is complete.

b_vp identifies the vnode associated with the block.

SEE ALSO

strategy(D2DK), physiock(D3D), brelse(D3DK), clrbuf(D3DK), iovec(D4DK), uio(D4DK)

NAME

cred – access credential structure

SYNOPSIS

```
#include <sys/cred.h>
```

DESCRIPTION

This structure is used to check the access credentials of the process requesting access to kernel space.

The size of the cr_groups[] array is configurable, however, its size is the same for all cred structures. Note that cr_ngroups records the number of elements currently in use, not the array size.

STRUCTURE MEMBERS

```
ushort  cr_ref;         /* reference count on processes using */
                        /* cred structure.  Not set by drivers. */
ushort  cr_ngroups;     /* number of groups in cr_groups */
uid_t   cr_uid;         /* effective user ID */
gid_t   cr_gid;         /* effective group ID */
uid_t   cr_ruid;        /* real user ID */
gid_t   cr_rgid;        /* real group ID */
uid_t   cr_suid;        /* "saved" user ID (from exec) */
gid_t   cr_sgid;        /* "saved" group ID (from exec) */
gid_t   cr_groups[1];   /* supplementary groups list */
```

The cred structure is defined as type cred_t.

SEE ALSO

open(D2DK), close(D2DK), ioctl(D2DK), mmap(D2DK), read(D2DK), write(D2DK), segmap(D2DK)

NAME

datab – STREAMS message data structure

SYNOPSIS

```
#include <sys/stream.h>
```

DESCRIPTION

The datab structure describes the data of a STREAMS message. The actual data contained in a STREAMS message is stored in a data buffer pointed to by this structure. A msgb (message block) structure includes a field that points to a datab structure.

A data block can have more than one message block pointing to it at one time, so the db_ref member keeps track of a data block's references, preventing it from being deallocated until all message blocks are finished with it.

STRUCTURE MEMBERS

```
union {
  struct datab     *freep;       /* routine to free non-STREAMS buffer */
  struct free_rtn  *frtnp;
} db_f;
unsigned char      *db_base;     /* first byte of buffer */
unsigned char      *db_lim;      /* last byte (+1) of buffer */
unsigned char      db_ref;       /* # of message pointers to this data */
unsigned char      db_type;      /* message type */
unsigned char      db_iswhat;    /* status of msg/data/buffer triplet */
unsigned int       db_size;      /* used internally */
caddr_t            db_msgaddr;   /* triplet mesg header; points to datab */
long               db_filler;    /* reserved for future use */
```

A datab structure is defined as type dblk_t.

SEE ALSO

BCI Driver Development Guide, Chapter 4, "Header Files and Data Structures"

free_rtn(D4DK), msgb(D4DK)

NAME

free_rtn – structure that specifies a driver's message freeing routine

SYNOPSIS

```
#include <sys/stream.h>
```

DESCRIPTION

The free_rtn structure is referenced by the dp_freep member of the datab structure. When freeb(D3D) is called to free the message, the driver's message freeing routine (referenced through the free_rtn structure) is called, with arguments, to free the data buffer.

STRUCTURE MEMBERS

```
void  (*free_func)()  /* user's freeing routine */
char  *free_arg       /* arguments to free_func() */
```

The free_rtn structure is defined as type frtn_t.

SEE ALSO

datab(D4DK), esballoc(D3DK)

NAME

hdedata – hard disk error data structure

SYNOPSIS

```
#include <sys/hdelog.h>
```

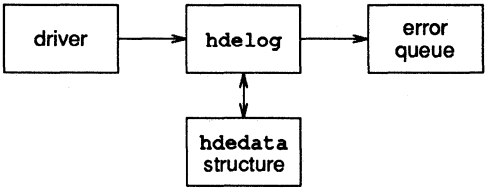
DESCRIPTION

The hdedata data structure temporarily stores hard disk error information sent to an error queue. A hdedata structure is initialized for every disk on the system by hdeeqd(D3D) when the system is booted. An error queue is also initialized by hdeeqd.

When the disk driver finds an error, it provides hdelog(D3D) with the error information. hdelog passes the hdedata structure for the error to the error queue. This error queue is a queue of bad block reports that have not been remapped. This queue resides in the kernel and not on the disk.

After a number or errors are accumulated, an administrator examines the list of errors collected in the queue. If any of the errors need to be "fixed," the administrator remaps the bad block. Remapping means that the block address is rewritten to a defect table on the disk. Physical Description sector information points to this defect table.

The following figure illustrates the logging of hard disk errors:



STRUCTURE MEMBERS

```
o_dev_t  diskdev;        /* Major/minor disk device number */
                         /* (major number for character device) */
char     dskserno[12];   /* Disk pack serial number (can be all zeros) */
daddr_t  blkaddr;        /* Physical block address */
                         /* in machine-independent form */
char     readtype;       /* Error type:CRC (cyclical redundancy check) */
                         /* or ECC (error check and correction) */
char     severity;       /* Severity type:  marginal or unreadable */
char     badrtcnt;       /* Number of unreadable tries */
char     bitwidth;       /* Bitwidth of corrected error: 0 if CRC */
time_t   timestmp;       /* Time stamp */
```

NOTE: The disk pack serial number is not currently evaluated, but it must contain a value. Set to all zeros.

SEE ALSO

hdeeqd(D3D), hdelog(D3D)

NAME

iovec – data storage structure for I/O using uio(D4DK)

SYNOPSIS

```
#include <sys/uio.h>
```

DESCRIPTION

An iovec structure describes a data storage area for transfer in a uio structure. Conceptually, it may be thought of as a base address and length specification.

STRUCTURE MEMBERS

```
caddr_t  iov_base;  /* base address of the data storage area */
                    /* represented by the iovec structure */
int      iov_len;   /* size of the data storage area in bytes */
```

SEE ALSO

uio(D4DK)

NAME

map – private memory map structure

SYNOPSIS

```
#include <sys/map.h>
```

DESCRIPTION

The map structure defines the size and index into a private space management map. The private map is declared as an instance of the map structure using the driver prefix in the form *prefix*map. The size is defined in the m_size field as the number of arbitrary units used to make up the map. The index is defined in m_addr as the first available unit of the map.

Private maps are managed through a set five functions:

rmalloc	allocates space from a defined and initialized map
rmfree	returns previously allocated space to map
rminit	defines a map structure and initializes a map table
rmwant	returns the number of processes waiting for free space
rmsetwant	increments the count of the number of processes waiting for free space in the map

Private maps can be made up of any units appropriate for the specific uses of the map. For example, units may be byte addresses, pages of memory, or blocks. The map itself does not define the resource, and the size of the map is not related to the size of the map structure.

STRUCTURE MEMBERS

```
unsigned long  m_size  /* number of units available */
unsigned long  m_addr  /* address of first available unit */
```

SEE ALSO

rmalloc(D3DK), rmfree(D3DK), rminit(D3DK), rmsetwant(D3DK), rmwant(D3DK)

NAME

module_info – STREAMS driver identification and limit value structure

SYNOPSIS

```
#include <sys/stream.h>
```

DESCRIPTION

When a module or driver is declared, several identification and limit values can be set. These values are stored in the module_info structure.

The module_info structure is intended to be read-only. However, the flow control limits (mi_hiwat and mi_lowat) and the packet size limits (mi_minpsz and mi_maxpsz) are copied to the QUEUE structure, where they may be modified.

STRUCTURE MEMBERS

```
ushort  mi_idnum;    /* module ID number */
char    *mi_idname;  /* module name */
short   mi_minpsz;   /* minimum packet size */
short   mi_maxpsz;   /* maximum packet size */
ushort  mi_hiwat;    /* high water mark */
ushort  mi_lowat;    /* low water mark */
```

The constant FMNAMESZ, limiting the length of a module's name, is currently set to a value of eight.

SEE ALSO

queue(D4DK)

NAME

msgb – STREAMS message block structure

SYNOPSIS

```
#include <sys/stream.h>
```

DESCRIPTION

A STREAMS message is made up of one or more message blocks, referenced by a pointer to a msgb structure. The b_next and b_prev pointers are used to link messages together on a QUEUE's message queue. The b_cont pointer links message blocks together when a message is composed of more than one block.

Each msgb structure also includes a pointer to a datab structure, the data block (which contains pointers to the actual data of the message), and the type of the message.

STRUCTURE MEMBERS

```
struct msgb     *b_next;   /* next message on queue */
struct msgb     *b_prev;   /* previous message on queue */
struct msgb     *b_cont;   /* next message block */
unsigned char   *b_rptr;   /* 1st unread data byte of buffer */
unsigned char   *b_wptr;   /* 1st unwritten data byte of buffer */
struct datab    *b_datap;  /* pointer to data block */
unsigned char   b_band;    /* message priority  */
unsigned char   b_pad1;    /* used internally  */
unsigned short  b_flag;    /* used by stream head  */
long            b_pad2;    /* used internally  */
```

The msgb structure is defined as type mblk_t.

SEE ALSO

BCI Driver Development Guide, Chapter 4, ''Header Files and Data Structures''

datab(D4DK)

NAME

qband – STREAMS queue flow control information structure

SYNOPSIS

```
#include <sys/stream.h>
```

DESCRIPTION

The qband structure contains flow control information for each priority band in a queue.

The qband structure is defined as type qband_t.

STRUCTURE MEMBERS

```
struct qband  *qb_next;   /* next band's info */
ulong         qb_count    /* number of bytes in band */
struct msgb   *qb_first;  /* start of band's data */
struct msgb   *qb_last;   /* end of band's data */
ulong         *qb_hiwat;  /* band's high water mark */
ulong         *qb_lowat;  /* band's low water mark */
ulong         *qb_flag;   /* band's status */
long          *qb_pad1;   /* reserved for future use */
```

SEE ALSO

msgb(D4DK), queue(D4DK)

NAME

qinit – STREAMS queue processing procedures structure

SYNOPSIS

```
#include <sys/stream.h>
```

DESCRIPTION

The qinit structure contains pointers to processing procedures for a QUEUE. The streamtab structure for the module or driver contains pointers to one qinit structure for both upstream and downstream processing.

STRUCTURE MEMBERS

```
int                   (*qi_putp)();     /* put procedure */
int                   (*qi_srvp)();     /* service procedure */
int                   (*qi_qopen)();    /* open procedure */
int                   (*qi_qclose)();   /* close procedure */
int                   (*qi_qadmin)();   /* unused */
struct module_info    *qi_minfo;        /* module parameters */
struct module_stat    *qi_mstat;        /* module statistics */
```

SEE ALSO

BCI Driver Development Guide, Chapter 4, "Header Files and Data Structures"

queue(D4DK), streamtab(D4DK)

NAME

queue – STREAMS queue structure

SYNOPSIS

```
#include <sys/stream.h>
```

DESCRIPTION

A STREAMS driver or module consists of two queue structures, one for upstream processing (read) and one for downstream processing (write). This structure is the major building block of a stream. It contains pointers to the processing procedures, pointers to the next and previous queues in the stream, flow control parameters, and a pointer defining the position of its messages on the STREAMS scheduler list.

The queue structure is defined as type queue_t.

STRUCTURE MEMBERS

```
struct qinit   *q_qinfo;   /* module or driver entry points */
struct msgb    *q_first;   /* first message in queue */
struct msgb    *q_last;    /* last message in queue */
struct queue   *q_next;    /* next queue in stream */
struct queue   *q_link;    /* used internally */
_VOID          q_ptr;      /* pointer to private data structure */
ulong          q_count;    /* approximate size of message queue */
ulong          q_flag;     /* status of queue */
long           q_minpsiz;  /* smallest packet accepted by QUEUE */
long           q_maxpsiz;  /* largest packet accepted by QUEUE */
ulong          q_hiwat;    /* high water mark */
ulong          q_lowat;    /* low water mark */
struct qband   *q_bandp;   /* separate flow info */
unsigned char  q_nband;    /* number of priority band > 0 */
unsigned char  q_pad1[3];  /* reserved for future use */
long           q_pad2[2];  /* reserved for future use */
```

SEE ALSO

msgb(D4DK), qband(D4DK)

NAME

streamtab – STREAMS entity declaration structure

SYNOPSIS

```
#include <sys/stream.h>
```

DESCRIPTION

Each STREAMS driver or module must have a streamtab structure. Drivers access this structure through the cdevsw table, and modules use the fmodsw table.

streamtab is made up of qinit structures for both the read and write queue portions of each module or driver. (Multiplexing drivers require both upper and lower qinit structures.) The qinit structure contains the entry points through which the module or driver routines are called.

Normally, the read QUEUE contains the open and close routines. Both the read and write queue can contain put and service procedures.

STRUCTURE MEMBERS

```
struct qinit  *st_rdinit;    /* read QUEUE */
struct qinit  *st_wrinit;    /* write QUEUE */
struct qinit  *st_muxrinit;  /* lower read QUEUE*/
struct qinit  *st_muxwinit;  /* lower write QUEUE*/
```

SEE ALSO

qinit(D4DK)

NAME

uio – scatter/gather I/O request structure

SYNOPSIS

```
#include <sys/uio.h>
```

DESCRIPTION

A uio structure describes an I/O request that can be broken up into different data storage areas (scatter/gather I/O). A request is a list of iovec structures (base/length pairs) indicating where in user space or kernel space the I/O data is to be read/written.

The contents of uio structures passed to the driver through the entry points should not be written by the driver. The uiomove(D3D) function takes care of all overhead related to maintaining the state of the uio structure.

STRUCTURE MEMBERS

```
iovec_t  *uio_iov;    /* pointer to the start of the iovec */
                      /* list for the uio structure */
int      uio_iovcnt;  /* the number of iovecs in the list */
off_t    uio_offset;  /* offset into file where data is */
                      /* transferred from or to */
short    uio_segflg;  /* identifies the type of I/O transfer: */
                      /*    UIO_SYSSPACE:  kernel <-> kernel */
                      /*    UIO_USERSPACE: kernel <-> user */
short    uio_fmode;   /* file mode flags (not driver setable) */
daddr_t  uio_limit;   /* ulimit for file (maximum block offset). */
                      /* not driver setable */
int      uio_resid;   /* residual count */
```

The uio_iov member is a pointer to the beginning of the iovec(D4DK) list for the uio. When the uio structure is passed to the driver through an entry point, the driver should not set uio_iov. When the uio structure is created by the driver, uio_iov should be initialized by the driver and not written to afterward.

SEE ALSO

iovec(D4DK)

APPENDIX A: ERROR CODES

APPENDIX A: ERROR CODES

Appendix A: Error Codes

This appendix lists the error codes that should be returned by a driver routine when an error is encountered. Table A-1 lists the error values in alphabetic order. All the error values are defined in /usr/include/sys/errno.h. In the driver open(D2D), close(D2D), ioctl(D2D), read(D2D), and write(D2D) routines, errors are passed back to the user with the return instruction at the end of the routine. In the driver strategy(D2D) routine, errors are passed back to the user by setting the b_error member of the buf(D4D) structure to the error codes.

For STREAMS ioctl routines, error numbers translate to the error numbers sent upstream in an M_IOCNAK message. For STREAMS read and write routines, error numbers translate to the error numbers sent upstream in an M_ERROR message.

NOTE The driver print routine should not return an error code, as the function that it calls, cmn_err(D3D), is declared as void (no error is returned).

Table A-1: Driver Error Codes

Error Value	Error Description	Use in these Driver Routines (D2D)
EAGAIN	Kernel resources, such as the buf structure or cache memory, are not available at this time; cannot open device (device may be busy, or the system resource is not available).	open, ioctl, read, write, strategy
EFAULT	An invalid address has been passed as an argument; memory addressing error.	open, close, ioctl, read, write, strategy
EINTR	PCATCH set, wake with signal; sleep interrupted by signal.	open, close, ioctl, read, write, strategy
EINVAL	An invalid argument was passed to the routine.	open, ioctl, read, write, strategy

Table A-1: Driver Error Codes (continued)

EIO	A device error occurred; a problem was detected in a device status register (the I/O request was valid, but an error occurred on the device).	open, close, ioctl, read, write, strategy
ENXIO	An attempt was made to access a device or subdevice that does not exist (one that is not configured); an attempt was made to perform an invalid I/O operation; an incorrect minor number was specified.	open, close, ioctl, read, write, strategy
EPERM	A process attempting an operation did not have required permission.	open, ioctl, read, write, close
EROFS	An attempt was made to open for writing a read-only device.	open

Table A-2 cross references error values to the driver routines from which the error values can be returned.

Table A-2: Error Codes by Driver Routine

open	close	ioctl	read, write, and strategy
EAGAIN	EFAULT	EAGAIN	EAGAIN
EFAULT	EINTR	EFAULT	EFAULT
EINTR	EIO	EINTR	EINTR
EINVAL	ENXIO	EINVAL	EINVAL
EIO		EIO	EIO
ENXIO		ENXIO	ENXIO
EPERM		EPERM	
EROFS			

APPENDIX B: MIGRATION FROM RELEASE 3.2 TO RELEASE 4.0

APPENDIX B: MIGRATION FROM RELEASE 3.2 TO RELEASE 4.0

Appendix B: Migration from Release 3.2 to Release 4.0

The *UNIX System V Block and Character Interface (BCI) Reference Manual* defined the functions, routines, and structures appropriate for use in the UNIX System V Release 3.2 environment. Table B-1 presents all of the kernel utility functions included in the BCI followed by information about changes to the functions for Release 4.0. Most of the functions fall into one of these categories:

- No change. The function behaves the same way it did in BCI.
- Not supported. The function is not included in either DDI or DKI. No replacement is provided.
- Supported but obsolete. The function is included in DDI or DKI but a replacement is suggested.
- Macro reimplemented as function. The calling and return syntax has not changed for macros converted to functions.
- Replaced. The function is not included in either DDI or DKI but a replacement is provided.
- Renamed only. The function was renamed, but the functionality is the same as it was under the old name.

Table B-1: 3.2 to 4.0 Migration

BCI	Comments	DDI/DKI
adjmsg	No change	adjmsg
allocb	For memory mapped I/O, use esballoc	allocb
backq	No change	backq
bcopy	No change	bcopy
brelse	Supported but obsolete. Allocate buffer with kmem_alloc or getrbuf(D3DK).	kmem_free or freerbuf
btoc	Replaced	btop, btopr
bufcall	Do not use with esballoc	bufcall
bzero	Word alignment no longer required	bzero
canon	Not supported	None
canput	Use bcanput to test specific priority band	canput
clrbuf	buf structure has changed	clrbuf
cmn_err	No change	cmn_err
copyb	No change	copyb
copyin	Supported but obsolete. Use uiomove	uiomove
copymsg	No change	copymsg
copyout	Supported but obsolete. Use uiomove	uiomove
ctob	Replaced	ptob
datamsg	No change	datamsg
delay	No change	delay
dma_alloc	Not supported	None
dma_breakup	Replaced	dma_pageio
drv_rfile	Not supported	None
dupb	No change	dupb
dupmsg	No change	dupmsg
enableok	Macro reimplemented as function	enableok
flushq	Use flushband to flush specific priority band	flushq

Table B-1: 3.2 to 4.0 Migration (continued)

BCI	Comments	DDI/DKI
freeb	Frees allocb and esballoc allocated buffers	freeb
freemsg	No change	freemsg
fubyte	Replaced	uiomove
fuword	Replaced	uiomove
getc	Not supported	None
getcb	Not supported	None
getcf	Not supported	None
geteblk	Replaced. Use kmem_alloc or getrbuf to allocate a buffer header	kmem_alloc or getrbuf
getq	No change	getq
getvec	No change	getvec
hdeeqd	No change	hdeeqd
hdelog	No change	hdelog
inb	Not supported	None
ind	Not supported	None
insq	No change	insq
iodone	Renamed only	biodone
iomove	Replaced	uiomove
iowait	Renamed only	biowait
kseg	Not supported	None
linkb	No change	linkb
logmsg	Not supported	None
logstray	Not supported	None
longjmp	Not supported	None
major	Renamed. Macro reimplemented as function	getmajor
makedev	Renamed. Macro reimplemented as function	makedevice
malloc	Renamed only	rmalloc
mapinit	Renamed only	rminit
mapwant	Renamed only	rmsetwant

Table B-1: 3.2 to 4.0 Migration (continued)

BCI	Comments	DDI/DKI
max	No change	max
mfree	Renamed only	rmfree
min	No change	min
minor	Renamed. Macro reimplemented as function	getminor
msgdsize	No change	msgdsize
noenable	Macro reimplemented as function	noenable
OTHERQ	Macro reimplemented as function	OTHERQ
physck	Replaced. Functionality included in physiock	physiock
physio	Replaced. Functionality included in physiock	physiock
psignal	Not supported	None
pullupmsg	No change	pullupmsg
putbq	No change	putbq
putc	Not supported	None
putcb	Not supported	None
putcf	Not supported	None
putctl	No change	putctl
putctl1	No change	putctl1
putnext	Macro reimplemented as function	putnext
putq	No change	putq
qenable	Macro reimplemented as function	qenable
qreply	No change	qreply
qsize	No change	qsize
RD	Macro reimplemented as function	RD
rmvb	No change	rmvb
rmvq	No change	rmvq
signal	Not supported	None
sleep	No change	sleep
spl	No change	spl

Table B-1: 3.2 to 4.0 Migration (continued)

BCI	Comments	DDI/DKI
splx	No change	splx
sptalloc	Not supported	kmem_alloc
sptfree	Not supported	kmem_free
strlog	No change	strlog
subyte	Replaced	uiomove
suser	Replaced	drv_priv
suword	Replaced	uiomove
testb	No change	testb
timeout	No change	timeout
ttclose	Not supported	None
ttin	Not supported	None
ttinit	Not supported	None
ttiocom	Not supported	None
ttioctl	Not supported	None
ttopen	Not supported	None
ttout	Not supported	None
ttread	Not supported	None
ttrstrt	Not supported	None
tttimeo	Not supported	None
ttwrite	Not supported	None
ttyflush	Not supported	None
ttywait	Not supported	None
ttxput	Not supported	None
unkseg	Not supported	None
unlinkb	No change	unlinkb
untimeout	No change	untimeout
useracc	No change	useracc
vtop	No change	vtop
wakeup	No change	wakeup
WR	Macro reimplemented as function	WR

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