man pages section 9E: DDI and DKI Driver Entry Points
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Preface

Both novice users and those familiar with the SunOS operating system can use online man pages to obtain information about the system and its features. A man page is intended to answer concisely the question “What does it do?” The man pages in general comprise a reference manual. They are not intended to be a tutorial.

Overview

The following contains a brief description of each man page section and the information it references:

- Section 1 describes, in alphabetical order, commands available with the operating system.
- Section 1M describes, in alphabetical order, commands that are used chiefly for system maintenance and administration purposes.
- Section 2 describes all of the system calls. Most of these calls have one or more error returns. An error condition is indicated by an otherwise impossible returned value.
- Section 3 describes functions found in various libraries, other than those functions that directly invoke UNIX system primitives, which are described in Section 2.
- Section 4 outlines the formats of various files. The C structure declarations for the file formats are given where applicable.
- Section 5 contains miscellaneous documentation such as character-set tables.
- Section 6 contains available games and demos.
- Section 7 describes various special files that refer to specific hardware peripherals and device drivers. STREAMS software drivers, modules and the STREAMS-generic set of system calls are also described.
Section 9 provides reference information needed to write device drivers in the
kernel environment. It describes two device driver interface specifications: the
Device Driver Interface (DDI) and the Driver/Kernel Interface (DKI).

Section 9E describes the DDI/DKI, DDI-only, and DKI-only entry-point routines a
developer can include in a device driver.

Section 9F describes the kernel functions available for use by device drivers.

Section 9S describes the data structures used by drivers to share information
between the driver and the kernel.

Below is a generic format for man pages. The man pages of each manual section
generally follow this order, but include only needed headings. For example, if there
are no bugs to report, there is no BUGS section. See the intro pages for more
information and detail about each section, and man(1) for more information about man
pages in general.

NAME
This section gives the names of the commands or
functions documented, followed by a brief
description of what they do.

SYNOPSIS
This section shows the syntax of commands or
functions. When a command or file does not exist
in the standard path, its full path name is shown.
Options and arguments are alphabetized, with
single letter arguments first, and options with
arguments next, unless a different argument order
is required.

The following special characters are used in this
section:

[ ] Brackets. The option or argument
enclosed in these brackets is optional. If
the brackets are omitted, the argument
must be specified.

... Ellipses. Several values can be provided
for the previous argument, or the
previous argument can be specified
multiple times, for example, "filename
...".

| Separator. Only one of the arguments
separated by this character can be
specified at a time.

{} Braces. The options and/or arguments
enclosed within braces are
interdependent, such that everything
enclosed must be treated as a unit.
PROTOCOL This section occurs only in subsection 3R to indicate the protocol description file.

DESCRIPTION This section defines the functionality and behavior of the service. Thus it describes concisely what the command does. It does not discuss OPTIONS or cite EXAMPLES. Interactive commands, subcommands, requests, macros, and functions are described under USAGE.

IOCTL This section appears on pages in Section 7 only. Only the device class that supplies appropriate parameters to the ioctl(2) system call is called ioctl and generates its own heading. ioctl calls for a specific device are listed alphabetically (on the man page for that specific device). ioctl calls are used for a particular class of devices all of which have an io ending, such as mtio(7I).

OPTIONS This section lists the command options with a concise summary of what each option does. The options are listed literally and in the order they appear in the SYNOPSIS section. Possible arguments to options are discussed under the option, and where appropriate, default values are supplied.

OPERANDS This section lists the command operands and describes how they affect the actions of the command.

OUTPUT This section describes the output – standard output, standard error, or output files – generated by the command.

RETURN VALUES If the man page documents functions that return values, this section lists these values and describes the conditions under which they are returned. If a function can return only constant values, such as 0 or −1, these values are listed in tagged paragraphs. Otherwise, a single paragraph describes the return values of each function. Functions declared void do not return values, so they are not discussed in RETURN VALUES.

ERRORS On failure, most functions place an error code in the global variable errno indicating why they failed. This section lists alphabetically all error codes a function can generate and describes the conditions that cause each error. When more than
one condition can cause the same error, each condition is described in a separate paragraph under the error code.

USAGE

This section lists special rules, features, and commands that require in-depth explanations. The subsections listed here are used to explain built-in functionality:

- Commands
- Modifiers
- Variables
- Expressions
- Input Grammar

EXAMPLES

This section provides examples of usage or of how to use a command or function. Wherever possible a complete example including command-line entry and machine response is shown. Whenever an example is given, the prompt is shown as `example%`, or if the user must be superuser, `example#`. Examples are followed by explanations, variable substitution rules, or returned values. Most examples illustrate concepts from the SYNOPSIS, DESCRIPTION, OPTIONS, and USAGE sections.

ENVIRONMENT VARIABLES

This section lists any environment variables that the command or function affects, followed by a brief description of the effect.

EXIT STATUS

This section lists the values the command returns to the calling program or shell and the conditions that cause these values to be returned. Usually, zero is returned for successful completion, and values other than zero for various error conditions.

FILES

This section lists all file names referred to by the man page, files of interest, and files created or required by commands. Each is followed by a descriptive summary or explanation.

ATTRIBUTES

This section lists characteristics of commands, utilities, and device drivers by defining the attribute type and its corresponding value. See `attributes(5)` for more information.

SEE ALSO

This section lists references to other man pages, in-house documentation, and outside publications.
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIAGNOSTICS</td>
<td>This section lists diagnostic messages with a brief explanation of the condition causing the error.</td>
</tr>
<tr>
<td>WARNINGS</td>
<td>This section lists warnings about special conditions which could seriously affect your working conditions. This is not a list of diagnostics.</td>
</tr>
<tr>
<td>NOTES</td>
<td>This section lists additional information that does not belong anywhere else on the page. It takes the form of an aside to the user, covering points of special interest. Critical information is never covered here.</td>
</tr>
<tr>
<td>BUGS</td>
<td>This section describes known bugs and, wherever possible, suggests workarounds.</td>
</tr>
</tbody>
</table>
Introduction
Section 9E describes the entry-point routines a developer may include in a device driver. These are called entry-point because they provide the calling and return syntax from the kernel into the driver. Entry-points are called, for instance, in response to system calls, when the driver is loaded, or in response to STREAMS events.

Kernel functions usable by the driver are described in section 9F.

In this section, reference pages contain the following headings:

- **NAME** describes the routine’s purpose.
- **SYNOPSIS** summarizes the routine’s calling and return syntax.
- **INTERFACE LEVEL** describes any architecture dependencies. It also indicates whether the use of the entry point is required, optional, or discouraged.
- **ARGUMENTS** describes each of the routine’s arguments.
- **DESCRIPTION** provides general information about the routine.
- **RETURN VALUES** describes each of the routine’s return values.
- **SEE ALSO** gives sources for further information.

By convention, a prefix string is added to the driver routine names. For a driver with the prefix `prefix`, the driver code may contain routines named `prefixopen`, `prefixclose`, `prefixread`, `prefixwrite`, and so forth. All global variables associated with the driver should also use the same prefix.

All routines and data should be declared as `static`.

Every driver MUST include `<sys/ddi.h>` and `<sys/sunddi.h>`, in that order, and after all other include files.

The following table summarizes the STREAMS driver entry points described in this section.

<table>
<thead>
<tr>
<th>Routine</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>put</td>
<td>DDI/DKI</td>
</tr>
<tr>
<td>srv</td>
<td>DDI/DKI</td>
</tr>
</tbody>
</table>

The following table summarizes the driver entry points described in this section.

<table>
<thead>
<tr>
<th>Routine</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>_fini</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>_info</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>Routine</td>
<td>Type</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>_init</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>aread</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>attach</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>awrite</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>chpoll</td>
<td>DDI/DKI</td>
</tr>
<tr>
<td>close</td>
<td>DDI/DKI</td>
</tr>
<tr>
<td>detach</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>devmap</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>devmap_access</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>devmap_contextmgt</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>devmap_dup</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>devmap_map</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>devmap_unmap</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>dump</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>getinfo</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>identify</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>ioctl</td>
<td>DDI/DKI</td>
</tr>
<tr>
<td>ks_update</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>mapdev_access</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>mapdev_dup</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>mapdev_free</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>mmap</td>
<td>DKI only</td>
</tr>
<tr>
<td>open</td>
<td>DDI/DKI</td>
</tr>
<tr>
<td>power</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>print</td>
<td>DDI/DKI</td>
</tr>
<tr>
<td>probe</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>prop_op</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>read</td>
<td>DDI/DKI</td>
</tr>
<tr>
<td>segmap</td>
<td>DKI only</td>
</tr>
</tbody>
</table>
Routine Type

<table>
<thead>
<tr>
<th>Routine</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>strategy</td>
<td>DDI/DKI</td>
</tr>
<tr>
<td>tran_abort</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_destroy_pkt</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_dmafree</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_getcap</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_init_pkt</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_reset</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_reset_notify</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_setcap</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_start</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_sync_pkt</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_tgt_free</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_tgt_init</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>tran_tgt_probe</td>
<td>Solaris DDI</td>
</tr>
<tr>
<td>write</td>
<td>DDI/DKI</td>
</tr>
</tbody>
</table>

The following table lists the error codes returned by a driver routine when it encounters an error. The error values are listed in alphabetic order and are defined in sys/errno.h. In the driver open(9E), close(9E), ioctl(9E), read(9E), and write(9E) routines, errors are passed back to the user by calling bioerror(9F) to set b_flags to the proper error code. In the driver strategy(9E) routine, errors are passed back to the user by setting the b_error member of the buf(9S) structure to the error code. For STREAMS ioctl routines, errors should be sent upstream in an M_IOCNAK message. For STREAMS read() and write() routines, errors should be sent upstream in an M_ERROR message. The driver print routine should not return an error code because the function that it calls, cmn_err(9F), is declared as void (no error is returned).

<table>
<thead>
<tr>
<th>Error Value</th>
<th>Error Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAGAIN</td>
<td>Kernel resources, such as the buf structure or cache memory, are not available at this time (device may be busy, or the system resource is not available). This is used in open, ioctl, read, write, and strategy.</td>
</tr>
</tbody>
</table>
### Error Values and Descriptions

<table>
<thead>
<tr>
<th>Error Value</th>
<th>Error Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFAULT</td>
<td>An invalid address has been passed as an argument; memory addressing error. This is used in open, close, ioctl, read, write, and strategy.</td>
</tr>
<tr>
<td>EINTR</td>
<td>Sleep interrupted by signal. This is used in open, close, ioctl, read, write, and strategy.</td>
</tr>
<tr>
<td>EINVAL</td>
<td>An invalid argument was passed to the routine. This is used in open, ioctl, read, write, and strategy.</td>
</tr>
<tr>
<td>EIO</td>
<td>A device error occurred; an error condition was detected in a device status register (the I/O request was valid, but an error occurred on the device). This is used in open, close, ioctl, read, write, and strategy.</td>
</tr>
<tr>
<td>ENXIO</td>
<td>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. This is used in open, close, ioctl, read, write, and strategy.</td>
</tr>
<tr>
<td>EPERM</td>
<td>A process attempting an operation did not have required permission. This is used in open, ioctl, read, write, and strategy.</td>
</tr>
<tr>
<td>EROFS</td>
<td>An attempt was made to open for writing a read-only device. This is used in open.</td>
</tr>
</tbody>
</table>

The table below cross references error values to the driver routines from which the error values can be returned.

<table>
<thead>
<tr>
<th>Error Value</th>
<th>open</th>
<th>close</th>
<th>ioctl</th>
<th>read, write and strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAGAIN</td>
<td>EFAULT</td>
<td>EAGAIN</td>
<td>EAGAIN</td>
<td></td>
</tr>
<tr>
<td>EFAULT</td>
<td>EINTR</td>
<td>EFAULT</td>
<td>EFAULT</td>
<td></td>
</tr>
<tr>
<td>EINTR</td>
<td>EIO</td>
<td>EINTR</td>
<td>EINTR</td>
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<tr>
<td>EINVAL</td>
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<td>EINVAL</td>
<td>EINVAL</td>
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<tr>
<td>EIO</td>
<td>ENXIO</td>
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<tr>
<td>ENXIO</td>
<td>EPERM</td>
<td>ENXIO</td>
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<tr>
<td>EPERM</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EROFS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Driver Entry Points
aread(9E)

NAME  aread – asynchronous read from a device

SYNOPSIS
#include <sys/uio.h>
#include <sys/aio_req.h>
#include <sys/cred.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

int aread(dev_t dev, struct aio_req *aio_reqp, cred_t *cred_p);

INTERFACE
Solaris DDI specific (Solaris DDI). This entry point is optional. Drivers that do not
support an aread() entry point should use nodev(9F)

LEVEL

PARAMETERS

dev  Device number.

aio_reqp  Pointer to the aio_req(9S) structure that describes where the data
is to be stored.

cred_p  Pointer to the credential structure.

DESCRIPTION
The driver’s aread() routine is called to perform an asynchronous read.
getminor(9F) can be used to access the minor number component of the dev
argument. aread() may use the credential structure pointed to by cred_p to check for
superuser access by calling drv_priv(9F). The aread() routine may also examine
the uio(9S) structure through the aio_req structure pointer, aio_req. aread() must
call aphysio(9F) with the aio_req pointer and a pointer to the driver’s
strategy(9E) routine.

No fields of the uio(9S) structure pointed to by aio_req, other than uio_offset or
uio_loffset, may be modified for non-seekable devices.

RETURN VALUES
The aread() routine should return 0 for success, or the appropriate error number.

CONTEXT
This function is called from user context only.

EXAMPLES

EXAMPLE 1 The following is an example of an aread() routine:

static int
xxaread(dev_t dev, struct aio_req *aio, cred_t *cred_p)
{
    int instance;
    struct xxstate *xsp;
    instance = getminor(dev);
    xsp = ddi_get_soft_state(statep, instance);
    /*Verify soft state structure has been allocated */
    if (xsp == NULL)
        return (ENXIO);
    return (aphysio(xxstrategy, anocancel, dev, B_READ, xxminphys, aio));
}
EXAMPLE 1 The following is an example of an aread() routine:

(Continued)

aread(9E)

SEE ALSO
read(2), aioread(3AIO), awrite(9E), read(9E), strategy(9E), write(9E),
anocancel(9F), aphysio(9F), ddi_get_soft_state(9F), drv_priv(9F),
getminor(9F), minphys(9F), nodev(9F), aio_req(9S), cb_ops(9S), uio(9S)

Writing Device Drivers

BUGS There is no way other than calling aphysio(9F) to accomplish an asynchronous read.
attach(9E)

NAME
attach – Attach a device to the system, or resume it

SYNOPSIS
#include <sys/ddi.h>
#include <sys/sunddi.h>

int prefix attach(dev_info_t *dip, ddi_attach_cmd_t cmd);

INTERFACE
Solaris DDI specific (Solaris DDI)

LEVEL
PARAMETERS

dip A pointer to the device’s dev_info structure.

cmd Attach type. Possible values are DDI_ATTACH, DDI_PM_RESUME (obsolete)
, and DDI_RESUME. Other values are reserved. The driver must return
DDI_FAILURE if reserved values are passed to it.

DESCRIPTION
The attach(9E) function is the device-specific initialization entry point. This entry
point is required and must be written.

DDI_ATTACH
The DDI_ATTACH command must be provided in the attach(9E) entry point.
DDI_ATTACH is used to initialize a given device instance. When attach(9E) is called
with cmd set to DDI_ATTACH, all normal kernel services (such as kmem_alloc(9F))
are available for use by the driver. Device interrupts are not blocked when attaching a
device to the system.

The attach(9E) function will be called once for each instance of the device on the
system with cmd set to DDI_ATTACH. Until attach(9E) succeeds, the only driver
entry points which may be called are open(9E) and getinfo(9E). See the Writing
Device Drivers for more information. The instance number may be obtained using
ddi_get_instance(9F).

DDI_PM_RESUME
The DDI_PM_RESUME command is required only if the device driver uses original
Power Management interfaces (driver calls pm_create_components(9F)). This entry
point is not needed if the device driver uses new automatic device Power
Management interfaces (driver exports pm-components(9) property instead of calling
pm_create_components(9F)). The DDI_PM_RESUME command is obsolete and will
be removed in a future release.

The attach() function may be called with cmd set to DDI_PM_RESUME after
detach(9E) has been successfully called with cmd set to DDI_PM_SUSPEND. When
called with cmd set to DDI_PM_RESUME, attach() must restore the hardware state of
a device (power may have been removed from the device), allow pending requests to
continue, and service new requests.

The driver must not make any assumptions about the state of the hardware, but must
restore it to the state it had when the detach(9E) entry point was called with
DDI_PM_SUSPEND.

DDI_RESUME
The attach() function may be called with cmd set to DDI_RESUME after detach(9E)
has been successfully called with cmd set to DDI_SUSPEND.
When called with `cmd` set to `DDI_RESUME`, `attach()` must restore the hardware state of a device (power may have been removed from the device), allow pending requests to continue, and service new requests. In this case, the driver must not make any assumptions about the state of the hardware, but must restore the state of the device except for the power level of components.

If the device driver uses original Power Management interfaces (driver calls `pm-components(9)` and device is still suspended by `DDI_PM_SUSPEND`, the only effect of `DDI_RESUME` is to allow the driver to call `ddi_dev_is_needed(9F)` for any new or pending requests, as a subsequent call to `attach()` will be made with `cmd` set to `DDI_PM_RESUME` to restore the hardware state.

If the device driver uses new automatic device Power Management interfaces (driver exports `pm-components(9)` property instead of calling `pm_create_components(9F)`), then while processing a `DDI_RESUME` command, the Power Management framework sets its notion of the power level of each component of a device to `unknown`

The driver can deal with components during `DDI_RESUME` in one of the following ways:

1. If the driver can determine the power level of the component without having to power it up (e.g. by calling `ddi.peek(9F)` or some other device-specific method) then it should notify the power level to the framework by calling `pm_power_has_changed(9F)`.

2. The driver must also set its own notion of the power level of the component to `unknown`. The system will consider the component idle or busy based on the most recent call to `pm_idle_component(9F)` or `pm_busy_component(9F)` for that component. If the component is idle for sufficient time, the framework will call into the driver's `power(9E)` entry point to turn the component off. If the driver needs to access the device, then it must call `pm.raise_power(9F)` to bring the component up to the level needed for the device access to succeed. The driver must honor any request to set the power level of the component, since it cannot make any assumption about what power level the component has (or it should have called `pm_power_has_changed(9F)` as outlined above). As a special case of this, the driver may bring the component to a known state because it wants to perform an operation on the device as part of its `DDI_RESUME` processing (such as loading firmware so that it can detect hot-plug events).

**RETURN VALUES**

The `attach()` function returns:

- `DDI_SUCCESS` Successful completion
- `DDI_FAILURE` Operation failed

**ATTRIBUTES**

See `attributes(5)` for descriptions of the following attributes:
attach(9E)

<table>
<thead>
<tr>
<th>ATTRIBUTE TYPE</th>
<th>ATTRIBUTE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface Stability</td>
<td>Evolving (DDI_PM_RESUME is obsolete.)</td>
</tr>
</tbody>
</table>

SEE ALSO
cpr(7), pm(7D), pm(9), pm-components(9), detach(9E), getinfo(9E), identify(9E), open(9E), probe(9E), ddi_add_intr(9F), ddi_create_minor_node(9F), ddi_get_instance(9F), ddi_map_regs(9F), kmem_alloc(9F), pm_create_components(9F), pm_raise_power(9F)

Writing Device Drivers
awrite(9E)

NAME
awrite – asynchronous write to a device

SYNOPSIS
#include <sys/uio.h>
#include <sys/aio_req.h>
#include <sys/cred.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

int awrite(dev_t dev, struct aio_req *aio_reqp, cred_t *cred_p);

INTERFACE LEVEL
Solaris DDI specific (Solaris DDI). This entry point is optional. Drivers that do not
support an awrite() entry point should use nodev(9F)

PARAMETERS
dev Device number.
aio_reqp Pointer to the aio_req(9S) structure that describes where the data
is stored.
cred_p Pointer to the credential structure.

DESCRIPTION
The driver’s awrite() routine is called to perform an asynchronous write.
getminor(9F) can be used to access the minor number component of the dev
argument. awrite() may use the credential structure pointed to by cred_p to check
for superuser access by calling drv_priv(9F). The awrite() routine may also
examine the uio(9S) structure through the aio_req structure pointer, aio_reqp.
awrite() must call aphysio(9F) with the aio_req pointer and a pointer to the
driver’s strategy(9E) routine.

No fields of the uio(9S) structure pointed to by aio_req, other than uio_offset or
uio_loffset, may be modified for non-seekable devices.

RETURN VALUES
The awrite() routine should return 0 for success, or the appropriate error number.

CONTEXT
This function is called from user context only.

EXAMPLES
EXAMPLE 1 Using the awrite routine:

The following is an example of an awrite() routine:

static int
xxawrite(dev_t dev, struct aio_req *aio, cred_t *cred_p)
{
    int instance;
    struct xxstate *xsp;

    instance = getminor(dev);
    xsp = ddi_get_soft_state(statep, instance);
    /*Verify soft state structure has been allocated */
    if (xsp == NULL)
        return (ENXIO);
    return (aphysio(xxstrategy, anocancel, dev, B_WRITE, xxminphys, aio));
}
EXAMPLE 1 Using the awrite routine: (Continued)

SEE ALSO write(2), aiowrite(3AIO), aread(9E), read(9E), strategy(9E), write(9E),
anocancel(9F), aphysio(9F), ddi_get_soft_state(9F), drv_priv(9F),
getminor(9F), minphys(9F), nodev(9F), aio_req(9S), cb_ops(9S), uio(9S)

Writing Device Drivers

BUGS There is no way other than calling aphysio(9F) to accomplish an asynchronous write.
chpoll – poll entry point for a non-STREAMS character driver

**SYNOPSIS**
```c
#include <sys/types.h>
#include <sys/poll.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

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

This entry point is optional. Architecture independent level 1 (DDI/DKI).

**PARAMETERS**
- `dev` The device number for the device to be polled.
- `events` The events that may occur. Valid events are:
  - **POLLIN** Data other than high priority data may be read without blocking.
  - **POLLOUT** Normal data may be written without blocking.
  - **POLLPRI** High priority data may be received without blocking.
  - **POLLHUP** A device hangup has occurred.
  - **POLLERR** An error has occurred on the device.
  - **POLLRDNORM** Normal data (priority band = 0) may be read without blocking.
  - **POLLRDBAND** Data from a non-zero priority band may be read without blocking.
  - **POLLWRNORM** The same as POLLOUT.
  - **POLLWRBAND** Priority data (priority band > 0) may be written.
- `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 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:
   
   ```c
   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() function whenever an event of type events listed above occur. This function should only be called with one event at a time. The driver must not hold any mutex across the call to pollwakeup(9F) that is acquired in its chpoll() entry point, or a deadlock may result.

chpoll() should return 0 for success, or the appropriate error number.

SEE ALSO

poll(2), nochpoll(9F), pollwakeup(9F)

Writing Device Drivers
close(9E)

<p>| NAME | close – relinquish access to a device |</p>
<table>
<thead>
<tr>
<th>Block and Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>close</td>
</tr>
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</table>

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

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

<table>
<thead>
<tr>
<th>STREAMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>prefixClose(queue_t *q, int flag, cred_t *cred_p);</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INTERFACE LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture independent level 1 (DDI/DKI). This entry point is required for block devices.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block and Character</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>dev</strong></td>
</tr>
<tr>
<td><strong>flag</strong></td>
</tr>
<tr>
<td><strong>otyp</strong></td>
</tr>
</tbody>
</table>

- **OTYP_BLK** | Close was through block interface for the device. |
- **OTYP CHR** | Close was through the raw/character interface for the device. |
- **OTYP_LYR** | Close a layered process (a higher-level driver called the close() routine of the device). |

<table>
<thead>
<tr>
<th>STREAMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>q</strong></td>
</tr>
</tbody>
</table>

| *cred_p* | Pointer to user credential structure. |
| **flag** | File status flag. |
close(9E)

*cred_p* Pointer to the user credential structure.

**DESCRIPTION**

For STREAMS drivers, the close() routine is called by the kernel through the cb_ops(9S) table entry for the device. (Modules use the fmodsw table.) A non-null value in the d_str field of the cb_ops entry points to a streamtab structure, which points to a qinit(9S) containing a pointer to the close() routine. Non-STREAMS close() routines are called directly from the cb_ops table.

close() 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 user credential structure (if pertinent), and the appropriateness of the flag and otyp parameter values.

close() 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 VALUES**

close() should return 0 for success, or the appropriate error number. 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

close(2), fcntl(2), open(2), umount(2), detach(9E), open(9E), cb_ops(9S), qinit(9S), queue(9S)

Writing Device Drivers

STREAMS Programming Guide
### csx_event_handler(9E)

<table>
<thead>
<tr>
<th>NAME</th>
<th>csx_event_handler – PC Card driver event handler</th>
</tr>
</thead>
</table>
| SYNOPSIS | #include <sys/pccard.h>

```c
int32_t prefiex_event_handler(event_t event, int32_t priority,
                              event_callback_args_t *args);
```

<table>
<thead>
<tr>
<th>INTERFACE LEVEL</th>
<th>Solaris architecture specific (Solaris DDI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARAMETERS</td>
<td></td>
</tr>
<tr>
<td>event</td>
<td>The event.</td>
</tr>
<tr>
<td>priority</td>
<td>The priority of the event.</td>
</tr>
<tr>
<td>args</td>
<td>A pointer to the event_callback_t structure.</td>
</tr>
</tbody>
</table>

### DESCRIPTION

Each instance of a PC Card driver must register an event handler to manage events associated with its PC Card. The driver event handler is registered using the event_handler field of the client_req_t structure passed to csx_RegisterClient(9F). The driver may also supply a parameter to be passed to its event handler function using the event_callback_args.client_data field. Typically, this argument is the driver instance’s soft state pointer. The driver also registers which events it is interested in receiving through the EventMask field of the client_req_t structure.

Each event is delivered to the driver with a priority, `priority`. High priority events with `CS_EVENT_PRI_HIGH` set in `priority` are delivered above lock level, and the driver must use its high-level event mutex initialized with the iblk_cookie returned by csx_RegisterClient(9F) to protect such events. Low priority events with `CS_EVENT_PRI_LOW` set in `priority` are delivered below lock level, and the driver must use its low-level event mutex initialized with a NULL interrupt cookie to protect these events.

csx_RegisterClient(9F) registers the driver’s event handler, but no events begin to be delivered to the driver until after a successful call to csx_RequestSocketMask(9F).

In all cases, Card Services delivers an event to each driver instance associated with a function on a multiple function PC Card.

### Event Indications

The events and their indications are listed below; they are always delivered as low priority unless otherwise noted:

- `CS_EVENT_REGISTRATION_COMPLETE`
  - A registration request processed in the background has been completed.

- `CS_EVENT_CARD_INSERTION`
  - A PC Card has been inserted in a socket.

- `CS_EVENT_CARD_READY`
  - A PC Card’s READY line has transitioned from the busy to ready state.
CS_EVENT_CARD_REMOVAL
A PC Card has been removed from a socket. This event is delivered twice; first as a high priority event, followed by delivery as a low priority event. As a high priority event, the event handler should only note that the PC Card is no longer present to prevent accesses to the hardware from occurring. As a low priority event, the event handler should release the configuration and free all I/O, window and IRQ resources for use by other PC Cards.

CS_EVENT_BATTERY_LOW
The battery on a PC Card is weak and is in need of replacement.

CS_EVENT_BATTERY_DEAD
The battery on a PC Card is no longer providing operational voltage.

CS_EVENT_PM_RESUME
Card Services has received a resume notification from the system’s Power Management software.

CS_EVENT_PM_SUSPEND
Card Services has received a suspend notification from the system’s Power Management software.

CS_EVENT_CARD_LOCK
A mechanical latch has been manipulated preventing the removal of the PC Card from the socket.

CS_EVENT_CARD_UNLOCK
A mechanical latch has been manipulated allowing the removal of the PC Card from the socket.

CS_EVENT_EJECTION_REQUEST
A request that the PC Card be ejected from a socket using a motor-driven mechanism.

CS_EVENT_EJECTION_COMPLETE
A motor has completed ejecting a PC Card from a socket.

CS_EVENT_ERASE_COMPLETE
A queued erase request that is processed in the background has been completed.

CS_EVENT_INSERTION_REQUEST
A request that a PC Card be inserted into a socket using a motor-driven mechanism.

CS_EVENT_INSERTION_COMPLETE
A motor has completed inserting a PC Card in a socket.

CS_EVENT_CARD_RESET
A hardware reset has occurred.

CS_EVENT_RESET_REQUEST
A request for a physical reset by a client.
CS_EVENT_RESET_COMPLETE
A reset request that is processed in the background has been completed.

CS_EVENT_RESET_PHYSICAL
A reset is about to occur.

CS_EVENT_CLIENT_INFO
A request that the client return its client information data. If
GET_CLIENT_INFO_SUBSVC(args->client_info.Attributes) is equal to
CS_CLIENT_INFO_SUBSVC_CS, the driver should fill in the other fields in the
client_info structure as described below, and return CS_SUCCESS. Otherwise, it
should return CS_UNSUPPORTED_EVENT.

args->client_data.Attributes
Must be OR’ed with CS_CLIENT_INFO_VALID.

args->client_data.Revision
Must be set to a driver-private version number.

args->client_data.CSLevel
Must be set to CS_VERSION.

args->client_data.RevDate
Must be set to the revision date of the PC Card driver, using
CS_CLIENT_INFO_MAKE_DATE(day, month, year). day must be the day of the
month, month must be the month of the year, and year must be the year, offset
from a base of 1980. For example, this field could be set to a revision date of July
4 1997 with CS_CLIENT_INFO_MAKE_DATE(4, 7, 17).

args->client_data.ClientName
A string describing the PC Card driver should be copied into this space.

args->client_data.VendorName
A string supplying the name of the PC Card driver vendor should be copied into
this space.

args->client_data.DriverName
A string supplying the name of the PC Card driver will be copied into this space
by Card Services after the PC Card driver has successfully processed this event;
the driver does not need to initialize this field.

CS_EVENT_WRITE_PROTECT
The write protect status of the PC Card in the indicated socket has changed. The
current write protect state of the PC Card is in the args->info field:

CS_EVENT_WRITE_PROTECT_WPOFF
Card is not write protected.

CS_EVENT_WRITE_PROTECT_WPON
Card is write protected.

STRUCTURE MEMBERS
The structure members of event_callback_args_t are:
The structure members of `client_info_t` are:

```c
unit32_t Attributes; /* attributes */
unit32_t Revisions; /* version number */
uint32_t CSLevel; /* Card Services version */
uint32_t RevDate; /* revision date */
char ClientName[CS_CLIENT_INFO_MAX_NAME_LEN]; /*PC Card driver description */
char VendorName[CS_CLIENT_INFO_MAX_NAME_LEN]; /*PC Card driver vendor name */
char DriverName[MODMAXNAMELEN]; /* PC Card driver name */
```

**RETURN VALUES**

- **CS_SUCCESS** The event was handled successfully.
- **CS_UNSUPPORTED_EVENT** Driver does not support this event.
- **CS_FAILURE** Error occurred while handling this event.

**CONTEXT**

This function is called from high-level interrupt context in the case of high priority events, and from kernel context in the case of low priority events.

**EXAMPLES**

**EXAMPLE 1**

```c
static int
xx_event(event_t event, int priority, event_callback_args_t *args)
{
    int rval;
    struct xxx *xxx = args->client_data;
    client_info_t *info = &args->client_info;

    switch (event) {
    case CS_EVENT_REGISTRATION_COMPLETE:
        ASSERT(priority & CS_EVENT_PRI_LOW);
        mutex_enter(&xxx->event_mutex);
        xxx->card_state |= XX_REGISTRATION_COMPLETE;
        mutex_exit(&xxx->event_mutex);
        rval = CS_SUCCESS;
        break;

    case CS_EVENT_CARD_READY:
        ASSERT(priority & CS_EVENT_PRI_LOW);
        rval = xx_card_ready(xxx);
        mutex_exit(&xxx->event_mutex);
        break;

    case CS_EVENT_CARD_INSERTION:
        ASSERT(priority & CS_EVENT_PRI_LOW);
        mutex_enter(&xxx->event_mutex);
        rval = xx_card_insertion(xxx);
        mutex_exit(&xxx->event_mutex);
        break;
    }
    return rval;
}
```
```c
break;

case CS_EVENT_CARD_REMOVAL:
    if (priority & CS_EVENT_PRI_HIGH) {
        mutex_enter(&xxx->hi_event_mutex);
        xxx->card_state &= ~XX_CARD_PRESENT;
        mutex_exit(&xxx->hi_event_mutex);
    } else {
        mutex_enter(&xxx->event_mutex);
        rval = xx_card_removal(xxx);
        mutex_exit(&xxx->event_mutex);
    }
    break;

case CS_EVENT_CLIENT_INFO:
    ASSERT(priority & CS_EVENT_PRI_LOW);
    if (GET_CLIENT_INFO_SUBSVC_CS(info->Attributes) ==
        CS_CLIENT_INFO_SUBSVC_CS) {
        info->Attributes |= CS_CLIENT_INFO_VALID;
        info->Revision = 4;
        info->CSLevel = CS_VERSION;
        info->RevDate = CS_CLIENT_INFO_MAKE_DATE(4, 7, 17);
        (void) strncpy(info->ClientName, "WhizBang Ultra Zowie PC card driver", CS_CLIENT_INFO_MAX_NAME_LEN);
        "ACME PC card drivers, Inc.",
        CS_CLIENT_INFO_MAX_NAME_LEN);
        rval = CS_SUCCESS;
    } else {
        rval = CS_UNSUPPORTED_EVENT;
    }
    break;

case CS_EVENT_WRITE_PROTECT:
    ASSERT(priority & CS_EVENT_PRI_LOW);
    mutex_enter(&xxx->event_mutex);
    if (args->info == CS_EVENT_WRITE_PROTECT_WPOFF) {
        xxx->card_state &= ~XX_WRITE_PROTECTED;
    } else {
        xxx->card_state |= XX_WRITE_PROTECTED;
    }
    mutex_exit(&xxx->event_mutex);
    rval = CS_SUCCESS;
    break;

default:
    rval = CS_UNSUPPORTED_EVENT;
    break;
}

return (rval);
```

EXAMPLE 1  (Continued)

SEE ALSO  csx_Event2Text(9F), csx_RegisterClient(9F), csx_RequestSocketMask(9F)

PC Card 95 Standard, PCMCIA/JEIDA
**NAME**
detach – Detach or suspend a device

**SYNOPSIS**
```c
#include <sys/ddi.h>
#include <sys/sunddi.h>

int prefix detach(dev_info_t *dip, ddi_detach_cmd_t cmd);
```

**INTERFACE LEVEL PARAMETERS**
- **dip** A pointer to the device's dev_info structure.
- **cmd** Type of detach; the driver should return DDI_FAILURE if any value other than DDI_DETACH, DDI_PM_SUSPEND (obsolete), or DDI_SUSPEND is passed to it.

**DESCRIPTION**
The `detach()` function complements the `attach(9E)` routine. If `cmd` is set to DDI_DETACH, `detach()` is used to remove the state associated with a given instance of a device node prior to the removal of that instance from the system.

The `detach()` function will be called once for each instance of the device for which there has been a successful `attach()`, once there are no longer any opens on the device. An attached instance of a driver can be successfully detached only once. The `detach()` function should clean up any per instance data initialized in `attach(9E)` and call `kmem_free(9F)` to free any heap allocations. For information on how to unregister interrupt handlers, see `ddi_add_intr(9F)`. This should also include putting the underlying device into a quiescent state so that it will not generate interrupts.

Drivers that set up `timeout(9F)` routines should ensure that they are cancelled before returning DDI_SUCCESS from `detach()`.

If `detach()` determines a particular instance of the device cannot be removed when requested because of some exceptional condition, `detach()` must return DDI_FAILURE, which prevents the particular device instance from being detached. This also prevents the driver from being unloaded. A driver instance failing the detach must ensure that no per instance data or state is modified or freed that would compromise the system or subsequent driver operation.

The system guarantees that the function will only be called for a particular dev_info node after (and not concurrently with) a successful `attach(9E)` of that device. The system also guarantees that `detach()` will only be called when there are no outstanding open(9E) calls on the device.

**DDI_PM_SUSPEND**
The DDI_PM_SUSPEND command is required only if the device driver uses original Power Management interfaces (driver calls `pm_create_components(9F)`). This entry point is not needed if the device driver uses new automatic device Power Management interfaces (driver exports `pm-components(9)` property instead of calling `pm_create_components(9F)`). The DDI_PM_SUSPEND command is obsolete and will be removed in a future release.
The `DDI_PM_SUSPEND` cmd is used to suspend all activity of a device before power is possibly removed from the device by setting component 0 to power level 0. In this case, `detach()` may be called with outstanding open(9E) requests. It must save the hardware state of the device to memory and block incoming or existing requests until `attach(9E)` is called with a command value of `DDI_PM_RESUME`. When the device is suspended using `DDI_PM_SUSPEND` and it receives a request which requires device to be powered on, it should call `ddi_dev_is_needed(9F)` to request the framework to resume the device.

A return of `DDI_FAILURE` will result in component 0 of the device not being set to power level 0.

**DDI_SUSPEND**

The `DDI_SUSPEND` cmd is issued when the entire system is being suspended and power removed from it or when the system must be made quiescent. It will be issued only to devices which have a `reg` property or which export a `pm-hardware-state` property with the value `needs-suspend-resume`.

If `cmd` is set to `DDI_SUSPEND`, `detach()` is used to suspend all activity of a device before power is (possibly) removed from the device. In this case, `detach()` may be called with outstanding open(9E) requests. It must save the hardware state of the device to memory and block incoming or existing requests until `attach()` is called with `DDI_RESUME`.

If the device is used to store file systems, then after `DDI_SUSPEND` is issued, the device should still honor `dump(9E)` requests as this entry point may be used by suspend-resume operation (see `cpr(7)`) to save state file. It must do this, however, without disturbing the saved hardware state of the device.

If the device driver uses original Power Management interfaces (driver calls `pm_create_components(9F)` and it has also been suspended by `DDI_PM_SUSPEND`, it will need to call `ddi_dev_is_needed(9F)` to honor the `dump(9E)` request. If the device driver uses new automatic device Power Management interfaces (driver exports `pm-components(9)` property instead of calling `pm_create_components(9F)`), it might need to call `pm_raise_power(9F)` if the current power level is lower than required to complete the `dump(9E)` request.

Before returning successfully from a call to `detach()` with a command of `DDI_SUSPEND`, the driver must cancel any outstanding timeouts and make any driver threads quiescent.

If `DDI_FAILURE` is returned for the `DDI_SUSPEND` cmd, either the operation to suspend the system or to make it quiescent will be aborted.

**RETURN VALUES**

- **DDI_SUCCESS** For `DDI_DETACH`, the state associated with the given device was successfully removed. For `DDI_SUSPEND` and `DDI_PM_SUSPEND` (obsolete), the driver was successfully suspended.
- **DDI_FAILURE** The operation failed or the request was not understood. The associated state is unchanged.
detach(9E)

**CONTEXT**
This function is called from user context only.

**ATTRIBUTES**
See attributes(5) for descriptions of the following attributes:

<table>
<thead>
<tr>
<th>ATTRIBUTE TYPE</th>
<th>ATTRIBUTE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface Stability</td>
<td>Evolving (DDI_PM_SUSPEND is obsolete.)</td>
</tr>
</tbody>
</table>

**SEE ALSO**
cpr(7), pm(7D), pm(9), pm-components(9), attach(9E), dump(9E), open(9E), power(9E), ddi_add_intr(9F), ddi_dev_is_needed(9F), ddi_map_regs(9F), kmem_free(9F), pm_create_components(9F), pm_raise_power(9F), timeout(9F)

*Writing Device Drivers*
### NAME
devmap – validate and translate virtual mapping for memory mapped device

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

int prefixdevmap(dev_t dev, devmap_cookie_t dhp, offset_t off, size_t len, size_t *maplen, uint_t model);
```

### INTERFACE LEVEL PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dev</td>
<td>Device whose memory is to be mapped.</td>
</tr>
<tr>
<td>dhp</td>
<td>An opaque mapping handle that the system uses to describe the mapping.</td>
</tr>
<tr>
<td>off</td>
<td>User offset within the logical device memory at which the mapping begins.</td>
</tr>
<tr>
<td>len</td>
<td>Length (in bytes) of the mapping to be mapped.</td>
</tr>
<tr>
<td>maplen</td>
<td>Pointer to length (in bytes) of mapping that has been validated. maplen is less than or equal to len.</td>
</tr>
<tr>
<td>model</td>
<td>The data model type of the current thread.</td>
</tr>
</tbody>
</table>

### DESCRIPTION
devmap() is a required entry point for character drivers supporting memory-mapped devices if the drivers use the devmap framework to set up the mapping. 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 applications.

As a result of a `mmap(2)` system call, the system calls the devmap() entry point during the mapping setup when D_DEVMAP is set in the cb_flag field of the cb_ops(9S) structure, and any of the following conditions apply:
- ddi_devmap_segmap(9F) is used as the segmap(9E) entry point.
- segmap(9E) entry point is set to NULL.
- mmap(9E) entry point is set to NULL.
- ddi_devmap_segmap(9F) is used in the segmap(9E) entry point.

Otherwise EINVAL will be returned to mmap(2).

Device drivers should use devmap() to validate the user mappings to the device, to translate the logical offset, off, to the corresponding physical offset within the device address space, and to pass the mapping information to the system for setting up the mapping.

dhp is a device mapping handle that the system uses to describe a mapping to a memory that is either contiguous in physical address space or in kernel virtual address space. The system may create multiple mapping handles in one `mmap(2)` system call (for example, if the mapping contains multiple physically discontiguous memory regions).

model returns the C Language Type Model which the current thread expects. It is set to DDI_MODEL_ILP32 if the current thread expects 32-bit (ILP32) semantics, or

---

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DDI_MODEL_LP64 if the current thread expects 64-bit (LP64) semantics. model is used in combination with ddi_model_convert_from(9F) to determine whether there is a data model mismatch between the current thread and the device driver. The device driver might have to adjust the shape of data structures before exporting them to a user thread which supports a different data model.

devmap() should return EINVAL if the logical offset, off, is out of the range of memory exported by the device to user space. If off + len exceeds the range of the contiguous memory, devmap() should return the length from off to the end of the contiguous memory region. The system will repeatedly call devmap() until the original mapping length is satisfied. The driver sets *maplen to the validated length which must be either less than or equal to len.

The devmap() entry point must initialize the mapping parameters before passing them to the system through either devmap_devmem_setup(9F) (if the memory being mapped is device memory) or devmap_umem_setup(9F) (if the memory being mapped is kernel memory). The devmap() entry point initializes the mapping parameters by mapping the control callback structure (see devmap_callback_ctl(9S)), the device access attributes, mapping length, maximum protection possible for the mapping, and optional mapping flags. See devmap_devmem_setup(9F) and devmap_umem_setup(9F) for further information on initializing the mapping parameters.

The system will copy the driver’s devmap_callback_ctl(9S) data into its private memory so the drivers do not need to keep the data structure after the return from either devmap_devmem_setup(9F) or devmap_umem_setup(9F).

For device mappings, the system establishes the mapping to the physical address that corresponds to off by passing the register number and the offset within the register address space to devmap_devmem_setup(9F).

For kernel memory mapping, the system selects a user virtual address that is aligned with the kernel address being mapped for cache coherence.

**RETURN VALUES**

0 Successful completion.

Non-zero An error occurred.

**EXAMPLES**

**EXAMPLE 1 Implementing the devmap() Entry Point**

The following is an example of the implementation for the devmap() entry point. For mapping device memory, devmap() calls devmap_devmem_setup(9F) with the register number, rnumber, and the offset within the register, roff. For mapping kernel memory, the driver must first allocate the kernel memory using ddi_umem_alloc(9F). For example, ddi_umem_alloc(9F) can be called in the attach(9E) routine. The resulting kernel memory cookie is stored in the driver soft state structure, which is accessible from the devmap() entry point. See ddi_soft_state(9F). devmap() passes the cookie obtained from ddi_umem_alloc(9F) and the offset within the allocated kernel memory to
EXAMPLE 1 Implementing the devmap() Entry Point  (Continued)

devmap_umem_setup(9F). The corresponding ddi_umem_free(9F) can be made in the detach(9E) routine to free up the kernel memory.

```c
#define MAPPING_SIZE 0x2000 /* size of the mapping */
#define MAPPING_START 0x70000000 /* logical offset at beginning of the mapping */

static struct devmap_callback_ctl xxmap_ops = {
    DEVMAP_OPS_REV, /* devmap_ops version number */
    xxmap_map, /* devmap_ops map routine */
    xxmap_access, /* devmap_ops access routine */
    xxmap_dup, /* devmap_ops dup routine */
    xxmap_unmap, /* devmap_ops unmap routine */
};

static int
xxdevmap(dev_t dev, devmap_cookie_t dhp, offset_t off, size_t len, size_t *maplen, uint_t model)
{
    int instance;
    struct xxstate *xsp;
    struct ddi_device_acc_attr *endian_attr;
    struct devmap_callback_ctl *callbackops = NULL;
    ddi_umem_cookie_t cookie;
    dev_info_t *dip;
    offset_t roff;
    offset_t koff;
    uint_t rnumber;
    uint_t maxprot;
    uint_t flags = 0;
    size_t length;
    int err;

    /* get device soft state */
    instance = getminor(dev);
    xsp = ddi_get_soft_state(statep, instance);
    if (xsp == NULL)
        return (-1);
    dip = xsp->dip;
    /* check for a valid offset */
    if (off is invalid)
        return (-1);
    /* check if len is within the range of contiguous memory */
    if ((off + len) is contiguous.)
        length = len;
    else
        length = MAPPING_START + MAPPING_SIZE - off;

    /* device access attributes */
    endian_attr = xsp->endian_attr;
    ...
EXAMPLE 1 Implementing the devmap() Entry Point  

(Continued)

if (off is referring to a device memory.) {
    /* assign register related parameters */
    rnumber = XXX;  /* index to register set at off */
    roff = XXX;  /* offset of rnumber at local bus */
    callbacks = &xxmap_ops;  /* do all callbacks for this mapping */
    maxprot = PROT_ALL;  /* allowing all access */
    if ((err = devmap_devmem_setup(dhp, dip, callbacks, rnumber, roff,
                                     length, maxprot, flags, endian_attr)) < 0)
        return (err);
}

else if (off is referring to a kernel memory.) {
    cookie = xsp->cookie;  /* cookie is obtained from
                             ddi_umem_alloc(9F) */
    koff = XXX;  /* offset within the kernel memory. */
    callbacks = NULL;  /* don't do callback for this mapping */
    maxprot = PROT_ALL;  /* allowing all access */
    if ((err = devmap_umem_setup(dhp, dip, callbacks, cookie, koff,
                                  length, maxprot, flags, endian_attr)) < 0)
        return (err);
}

*maplen = length;
return (0);
}

SEE ALSO
mmap(2), attach(9E), detach(9E), mmap(9E), segmap(9E),
ddi_devmap_segmap(9F), ddi_model_convert_from(9F), ddi_soft_state(9F),
ddi_umem_alloc(9F), ddi_umem_free(9F), devmap_devmem_setup(9F),
devmap_setup(9F), devmap_umem_setup(9F), cb_ops(9S),
devmap_callback_ctl(9S)

Writing Device Drivers
**devmap_access(9E)**

### NAME

devmap_access – device mapping access entry point

---

### SYNOPSIS

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

int devmap_access(devmap_cookie_t dhp, void *pvtp, offset_t off,
                   size_t len, uint_t type, uint_t rw);
```

---

### INTERFACE LEVEL ARGUMENTS

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dhp</td>
<td>An opaque mapping handle that the system uses to describe the mapping.</td>
</tr>
<tr>
<td>pvtp</td>
<td>Driver private mapping data.</td>
</tr>
<tr>
<td>off</td>
<td>User offset within the logical device memory at which the access begins.</td>
</tr>
<tr>
<td>len</td>
<td>Length (in bytes) of the memory being accessed.</td>
</tr>
<tr>
<td>type</td>
<td>Type of access operation. Possible values are:</td>
</tr>
<tr>
<td>rw</td>
<td>Direction of access. Possible values are:</td>
</tr>
</tbody>
</table>

**type**

- DEVMAP_ACCESS Memory access.
- DEVMAP_LOCK Lock the memory being accessed.
- DEVMAP_UNLOCK Unlock the memory being accessed.

**rw**

- DEVMAP_READ Read access attempted.
- DEVMAP_WRITE Write access attempted.
- DEVMAP_EXEC Execution access attempted.

---

### DESCRIPTION

The **devmap_access()** entry point is an optional routine. It notifies drivers whenever an access is made to a mapping described by *dhp* that has not been validated or does not have sufficient protection for the access. The system expects **devmap_access()** to call either **devmap_do_ctxmgt(9F)** or **devmap_default_access(9F)** to load the memory address translations before it returns. For mappings that support context switching, device drivers should call **devmap_do_ctxmgt(9F)**. For mappings that do not support context switching, the drivers should call **devmap_default_access(9F)**.

In **devmap_access()**, drivers perform memory access related operations such as context switching, checking the availability of the memory object, and locking and unlocking the memory object being accessed. The **devmap_access()** entry point is set to **NULL** if no operations need to be performed.

**pvtp** is a pointer to the driver’s private mapping data that was allocated and initialized in the **devmap_map(9E)** entry point.

**off** and **len** define the range to be affected by the operations in **devmap_access()**. **type** defines the type of operation that device drivers should perform on the memory object. If **type** is either DEVMAP_LOCK or DEVMAP_UNLOCK, the length passed to
devmap_access(9E)

either devmap_do_ctxmgt(9F) or devmap_default_access(9F) must be same as len. rw specifies the direction of access on the memory object.

A non-zero return value from devmap_access() may result in a SIGSEGV or SIGBUS signal being delivered to the process.

RETURN VALUES

devmap_access() returns the following values:

0 Successful completion.

Non-zero An error occurred. The return value from devmap_do_ctxmgt(9F) or devmap_default_access(9F) should be returned.

EXAMPLES

EXAMPLE 1 devmap_access() entry point

The following is an example of the devmap_access() entry point. If the mapping supports context switching, devmap_access() calls devmap_do_ctxmgt(9F). Otherwise, devmap_access() calls devmap_default_access(9F).

```c
#define OFF_DO_CTXMGT 0x40000000
#define OFF_NORMAL 0x40100000
#define CTXMGT_SIZE 0x100000
#define NORMAL_SIZE 0x100000

/* Driver devmap_contextmgt(9E) callback function. */
static int xx_context_mgt(devmap_cookie_t dhp, void *pvtp, offset_t offset,
size_t length, uint_t type, uint_t rw)
{
    ......
    /* see devmap_contextmgt(9E) for an example */
}

/* Driver devmap_access(9E) entry point */
static int xxdevmap_access(devmap_cookie_t dhp, void *pvtp, offset_t off,
size_t len, uint_t type, uint_t rw)
{
    offset_t diff;
    int err;

    /* check if off is within the range that supports context management. */
    if ((diff = off - OFF_DO_CTXMGT) >= 0 && diff < CTXMGT_SIZE) {
```

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EXAMPLE 1  

```c
devmap_access() entry point  (Continued)

* calculates the length for context switching
*/
if ((len + off) > (OFF_DO_CTXMGT + CTXMGT_SIZE))
  return (-1);
/*
* perform context switching
*/
err = devmap_do_ctxmgt(dhp, pvtp, off, len, type,
  rw, xx_context_mgt);
/*
* check if off is within the range that does normal
* memory mapping.
*/
} else if ((diff = off - OFF_NORMAL) >= 0 && diff < NORMAL_SIZE) {
  if ((len + off) > (OFF_NORMAL + NORMAL_SIZE))
    return (-1);
  err = devmap_default_access(dhp, pvtp, off, len, type, rw);
} else
  return (-1);

return (err);
```

SEE ALSO  

`devmap_map(9E), devmap_default_access(9F), devmap_do_ctxmgt(9F),
devmap_callback_ctl(9S)`

Writing Device Drivers
# devmap_contextmgt(9E)

**NAME**

devmap_contextmgt – driver callback function for context management

**SYNOPSIS**

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

int devmap_contextmgt(devmap_cookie_t dhp, void *pvtp, offset_t off,
                      size_t len, uint_t type, uint_t rw);
```

**INTERFACE LEVEL ARGUMENTS**

Solaris DDI specific (Solaris DDI).

- `dhp` An opaque mapping handle that the system uses to describe the mapping.
- `pvtp` Driver private mapping data.
- `off` User offset within the logical device memory at which the access begins.
- `len` Length (in bytes) of the memory being accessed.
- `type` Type of access operation. Possible values are:
  - `DEVMAP_ACCESS` Memory access.
  - `DEVMAP_LOCK` Lock the memory being accessed.
  - `DEVMAP_UNLOCK` Unlock the memory being accessed.
- `rw` Direction of access. Possible values are:
  - `DEVMAP_READ` Read access attempted.
  - `DEVMAP_WRITE` Write access attempted.

**DESCRIPTION**

`devmap_contextmgt()` is a driver-supplied function that performs device context switching on a mapping. Device drivers pass `devmap_contextmgt()` as an argument to `devmap_do_ctxmgt(9F)` in the `devmap_access(9E)` entry point. The system will call `devmap_contextmgt()` when memory is accessed. The system expects `devmap_contextmgt()` to load the memory address translations of the mapping by calling `devmap_load(9F)` before returning.

`dhp` uniquely identifies the mapping and is used as an argument to `devmap_load(9F)` to validate the mapping. `off` and `len` define the range to be affected by the operations in `devmap_contextmgt()`.

The driver must check if there is already a mapping established at `off` that needs to be unloaded. If a mapping exists at `off`, `devmap_contextmgt()` must call `devmap_unload(9F)` on the current mapping. `devmap_unload(9F)` must be followed by `devmap_load()` on the mapping that generated this call to `devmap_contextmgt()`. `devmap_unload(9F)` unloads the current mapping so that a call to `devmap_access(9E)`, which causes the system to call `devmap_contextmgt()`, will be generated the next time the mapping is accessed.

`pvtp` is a pointer to the driver’s private mapping data that was allocated and initialized in the `devmap_map(9E)` entry point. `type` defines the type of operation that device drivers should perform on the memory object. If `type` is either `DEVMAP_LOCK` or `DEVMAP_UNLOCK`, the system expects `devmap_contextmgt()` to load the memory address translations of the mapping by calling `devmap_load(9F)` before returning.
DEVMAP_UNLOCK, the length passed to either devmap_unload(9F) or devmap_load(9F) must be same as len. rw specifies the access direction on the memory object.

A non-zero return value from devmap_contextmgt() will be returned to devmap_access(9E) and will cause the corresponding operation to fail. The failure may result in a SIGSEGV or SIGBUS signal being delivered to the process.

RETURN VALUES

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Successful completion.</td>
</tr>
<tr>
<td>Non-zero</td>
<td>An error occurred.</td>
</tr>
</tbody>
</table>

EXAMPLES

**EXAMPLE 1 managing a device context**

The following shows an example of managing a device context.

```c
struct xxcontext cur_ctx;
static int xxdevmap_contextmgt(devmap_cookie_t dhp, void *pvtp, offset_t off,
    size_t len, uint_t type, uint_t rw)
{
    devmap_cookie_t cur_dhp;
    struct xxpvtdata *p;
    struct xxpvtdata *pvtp = (struct xxpvtdata *)pvtp;
    struct xx_softc *softc = pvtp->softc;
    int err;

    mutex_enter(&softc->mutex);

    /*
     * invalidate the translations of current context before
     * switching context.
     */
    if (cur_ctx != NULL && cur_ctx != pvtp->ctx) {
        p = cur_ctx->pvt;
        cur_dhp = p->dhp;
        if ((err = devmap_unload(cur_dhp, off, len)) != 0)
            return (err);
    }

    /* Switch device context - device dependent*/
    ...

    /* Make handle the new current mapping */
    cur_ctx = pvtp->ctx;

    /*
     * Load the address translations of the calling context.
     */
    err = devmap_load(pvtp->dhp, off, len, type, rw);

    mutex_exit(&softc->mutex);

    return (err);
}
```

Driver Entry Points 47
EXAMPLE 1 managing a device context  (Continued)

SEE ALSO  

devmap_access(9E), devmap_do_ctxmgt(9F)  
devmap_load(9F),  
devmap_unload(9F)

Writing Device Drivers
### NAME

devmap_dup – device mapping duplication entry point

### SYNOPSIS

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

int prefixdevmap_dup(devmap_cookie_t dhp, void *pvtp,
                      devmap_cookie_t new_dhp, void **new_pvtp);
```

### INTERFACE LEVEL ARGUMENTS

Solaris DDI specific (Solaris DDI).

- **dhp**
  An opaque mapping handle that the system uses to describe the mapping currently being duplicated.

- **pvtp**
  Driver private mapping data for the mapping currently being duplicated.

- **new_dhp**
  An opaque data structure that the system uses to describe the duplicated device mapping.

- **new_pvtp**
  A pointer to be filled in by device drivers with the driver private mapping data for the duplicated device mapping.

### DESCRIPTION

The system calls `devmap_dup()` when a device mapping is duplicated, such as during the execution of the `fork(2)` system call. The system expects `devmap_dup()` to generate new driver private data for the new mapping, and to set `new_pvtp` to point to it. `new_dhp` is the handle of the new mapped object.

A non-zero return value from `devmap_dup()` will cause a corresponding operation such as `fork()` to fail.

### RETURN VALUES

`devmap_dup()` returns the following values:

- **0**
  Successful completion.

- **Non-zero**
  An error occurred.

### EXAMPLES

**EXAMPLE 1**

```c
static int
xxdevmap_dup(devmap_cookie_t dhp, void *pvtp, devmap_cookie_t new_dhp,
              void **new_pvtp)
{
    struct xxpvtdatadrvtdata;
    struct xxpvtdata  *p = (struct xxpvtdatadrvtdata *)pvtp;
    struct xx_softc  *softc = p->softc;
    mutex_enter(&softc->mutex);
    /* Allocate a new private data structure */
    prvtdata = kmem_alloc(sizeof (struct xxpvtdata), KM_SLEEP);
    /* Return the new data */
    prvtdata->off = p->off;
    prvtdata->len = p->len;
    prvtdata->ctx = p->ctx;
    prvtdata->dhp = new_dhp;
    prvtdata->softc = p->softc;
    *new_pvtp = prvtdata;
    return 0;
}
```

---

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mutex_exit(&softc->mutex);
return (0);
}

SEE ALSO fork(2), devmap_callback_ctl(9S)

Writing Device Drivers
**NAME**

devmap_map – device mapping create entry point

**SYNOPSIS**

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

int prefixdevmap_map(devmap_cookie_t dhp, dev_t dev, uint_t flags,
                      offset_t off, size_t len, void **pvtp);
```

Solaris DDI specific (Solaris DDI).

**INTERFACE LEVEL ARGUMENTS**

- **dhp**
  An opaque mapping handle that the system uses to describe the mapping currently being created.

- **dev**
  The device whose memory is to be mapped.

- **flags**
  Flags indicating type of mapping. Possible values are:
  - MAP_PRIVATE
    Changes are private.
  - MAP_SHARED
    Changes should be shared.

- **off**
  User offset within the logical device memory at which the mapping begins.

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

- **pvtp**
  A pointer to be filled in by device drivers with the driver private mapping data.

**DESCRIPTION**

The `devmap_map()` entry point is an optional routine that allows drivers to perform additional processing or to allocate private resources during the mapping setup time. For example, in order for device drivers to support context switching, the drivers allocate private mapping data and associate the private data with the mapping parameters in the `devmap_map()` entry point.

The system calls `devmap_map()` after the user mapping to device physical memory has been established. (For example, after the devmap(9E) entry point is called.)

`devmap_map()` receives a pointer to the driver private data for this mapping in `pvtp`. The system expects the driver to allocate its private data and set `pvtp` to the allocated data. The driver must store `off` and `len`, which define the range of the mapping, in its private data. Later, when the system calls `devmap_unmap(9E)`, the driver will use the `off` and `len` stored in `pvtp` to check if the entire mapping, or just a part of it, is being unmapped. If only a part of the mapping is being unmapped, the driver must allocate a new private data for the remaining mapping before freeing the old private data. The driver will receive `pvtp` in subsequent event notification callbacks.

If the driver support context switching, it should store the mapping handle `dhp` in its private data `pvtp` for later use in `devmap_unload(9F)`.

For a driver that supports context switching, `flags` indicates whether or not the driver should allocate a private context for the mapping. For example, a driver may allocate a memory region to store the device context if `flags` is set to MAP_PRIVATE.
devmap_map(9E)

**RETURN VALUES**

- devmap_map() returns the following values:
  - 0: Successful completion.
  - Non-zero: An error occurred.

**EXAMPLES**

**EXAMPLE 1** devmap_map() implementation

The following shows an example implementation for devmap_map().

```c
static int
xxdevmap_map(devmap_cookie_t dhp, dev_t dev, uint_t flags, offset_t off,
              size_t len, void **pvtp)
{
    struct xx_resources *pvt;
    struct xx_context *this_context;
    struct xx_softc *softc;
    softc = ddi_get_soft_state(statep, getminor(dev));
    this_context = get_context(softc, off, len);

    /* allocate resources for the mapping - Device dependent */
    pvt = kmem_zalloc(sizeof (struct xx_resources), KM_SLEEP);
    pvt->off = off;
    pvt->len = len;
    pvt->dhp = dhp;
    pvt->ctx = this_context;
    *pvtp = pvt;
}
```

**SEE ALSO**

devmap_unmap(9E), devmap_unload(9F), devmap_callback_ctl(9S)

Writing Device Drivers
Nome: devmap_unmap – device mapping unmapping entry point

Síntese:
#include <sys/ddi.h>
#include <sys/sunddi.h>

void prefixdevmap unmap(devmap_cookie_t dhp, void *pvtp, offset_t off,
size_t len, devmap_cookie_t new_dhp1, void **new_pvtp1,
devmap_cookie_t new_dhp2, void **new_pvtp2);

Interface Level Descrição:
Solaris DDI specific (Solaris DDI).

dhp
An opaque mapping handle that the system uses to describe the
mapping.

pvtp
Driver private mapping data.

off
User offset within the logical device memory at which the
unmapping begins.

len
Length (in bytes) of the memory being unmapped.

new_dhp1
The opaque mapping handle that the system uses to describe the
new region that ends at (off - 1). new_dhp1 may be NULL.

new_pvtp1
A pointer to be filled in by the driver with the driver private
mapping data for the new region that ends at (off - 1); ignored if
new_dhp1 is NULL.

new_dhp2
The opaque mapping handle that the system uses to describe the
new region that begins at (off + len); new_dhp2 may be NULL.

new_pvtp2
A pointer to be filled in by the driver with the driver private
mapping data for the new region that begins at (off + len); ignored
if new_dhp2 is NULL.

Descrição:
devmap unmap() is called when the system removes the mapping in the range [off,
off + len], such as in the munmap(2) or exit(2) system calls. Device drivers use
devmap unmap() to free up the resources allocated in devmap_map(9E).

dhp is the mapping handle that uniquely identifies the mapping. The driver stores the
mapping attributes in the driver's private data, pvtp, when the mapping is created. See
devmap_map(9E) for details.

off and len define the range to be affected by devmap_unmap(). This range is within
the boundary of the mapping described by dhp.

If the range [off, off + len] covers the entire mapping, the system passes NULL to
new_dhp1, new_pvtp1, new_dhp2, and new_pvtp2. The system expects device drivers to
free all resources allocated for this mapping.

If off is at the beginning of the mapping and len does not cover the entire mapping, the
system sets NULL to new_dhp1 and to new_pvtp1. The system expects the drivers to
devmap_unmap(9E)

allocate new driver private data for the region that starts at \texttt{off} + \texttt{len} and to set *\texttt{new_pvtp2} to point to it. \texttt{new_dhp2} is the mapping handle of the newly mapped object.

If \texttt{off} is not at the beginning of the mapping, but \texttt{off} + \texttt{len} is at the end of the mapping the system passes \texttt{NULL} to \texttt{new_dhp2} and \texttt{new_pvtp2}. The system then expects the drivers to allocate new driver private data for the region that begins at the beginning of the mapping (for example, stored in \texttt{pvtp}) and to set *\texttt{new_pvtp1} to point to it. \texttt{new_dhp1} is the mapping handle of the newly mapped object.

The drivers should free up the driver private data, \texttt{pvtp}, previously allocated in \texttt{devmap_map(9E)} before returning to the system.

\textbf{EXAMPLES}

EXAMPLE 1 devmap_unmap() implementation

\begin{verbatim}
static void
xxdevmap_unmap(devmap_cookie_t dhp, void *pvtp, offset_t off, size_t len, devmap_cookie_t new_dhp1, void **new_pvtp1, devmap_cookie_t new_dhp2, void **new_pvtp2)
{
    struct xxpvtdata *ptmp;
    struct xxpvtdata *p = (struct xxpvtdata *)pvtp;
    struct xx_softc *softc = p->softc;
    mutex_enter(&softc->mutex);
    /*
     * If new_dhp1 is not NULL, create a new driver private data
     * for the region from the beginning of old mapping to off.
     */
    if (new_dhp1 != NULL) {
        ptmp = kmem_zalloc(sizeof (struct xxpvtdata), KM_SLEEP);
        ptmp->dhp = new_dhp1;
        ptmp->off = pvtp->off;
        ptmp->len = off - pvtp->off;
        *new_pvtp1 = ptmp;
    }
    /*
     * If new_dhp2 is not NULL, create a new driver private data
     * for the region from off+len to the end of the old mapping.
     */
    if (new_dhp2 != NULL) {
        ptmp = kmem_zalloc(sizeof (struct xxpvtdata), KM_SLEEP);
        ptmp->dhp = new_dhp2;
        ptmp->off = off + len;
        ptmp->len = pvtp->len - (off + len - pvtp->off);
        *new_pvtp2 = ptmp;
    }
    /* Destroy the driver private data - Device dependent */
    ...
    kmem_free(pvtp, sizeof (struct xxpvtdata));
    mutex_exit(&softc->mutex);
}
\end{verbatim}

SEE ALSO

\texttt{exit(2), munmap(2), devmap_map(9E), devmap_callback_ctl(9S)}

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\textbf{Sun Proprietary/Confidential: Need to Know}
Writing Device Drivers

devmap_unmap(9E)
### dump(9E)

**NAME**
dump – dump memory to device during system failure

**SYNOPSIS**
```c
#include <sys/types.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

int prefixdump(dev_t dev, caddr_t addr, daddr_t blkno, int nblk);
```

**INTERFACE LEVEL**
Solaris specific (Solaris DDI). This entry point is required. For drivers that do not implement dump() routines, nodev(9F) should be used.

**ARGUMENTS**
- `dev` Device number.
- `addr` Address for the beginning of the area to be dumped.
- `blkno` Block offset to dump memory.
- `nblk` Number of blocks to dump.

**DESCRIPTION**
dump() is used to dump a portion of virtual address space directly to a device in the case of system failure. It can also be used for checking the state of the kernel during a checkpoint operation. The memory area to be dumped is specified by `addr` (base address) and `nblk` (length). It is dumped to the device specified by `dev` starting at offset `blkno`. Upon completion dump() returns the status of the transfer.

When the system is panicking, the calls of functions scheduled by timeout(9F) and ddi_trigger_softintr(9F) will never occur. Neither can delay(9F) be relied upon, since it is implemented via timeout(). See ddi_in_panic(9F).

dump() is called at interrupt priority.

**RETURN VALUES**
dump() returns 0 on success, or the appropriate error number.

**SEE ALSO**
cpr(7), nodev(9F)

*Writing Device Drivers*
Driver Entry Points

NAME

_fini, _info, _init – loadable module configuration entry points

SYNOPSIS

#include <sys/modctl.h>

int _fini(void);
int _info(struct modinfo *modinfop);
int _init(void);

INTERFACE LEVEL

Solaris DDI specific (Solaris DDI). These entry points are required. You must write them.

_info()

modinfop A pointer to an opaque modinfo structure.

_DESCRIPTION

_init() initializes a loadable module. It is called before any other routine in a loadable module. _init() returns the value returned by mod_install(9F). The module may optionally perform some other work before the mod_install(9F) call is performed. If the module has done some setup before the mod_install(9F) function is called, then it should be prepared to undo that setup if mod_install(9F) returns an error.

_info() returns information about a loadable module. _info() returns the value returned by mod_info(9F).

_fini() prepares a loadable module for unloading. It is called when the system wants to unload a module. If the module determines that it can be unloaded, then _finit() returns the value returned by mod_remove(9F). Upon successful return from _finit() no other routine in the module will be called before _init() is called.

RETURN VALUES

_init() should return the appropriate error number if there is an error, otherwise it should return the return value from mod_install(9F).

_info() should return the return value from mod_info(9F)

_fini() should return the return value from mod_remove(9F). _fini() is permitted to return EBUSY prior to calling mod_remove(9F) if the driver should not be unloaded. Driver global resources, such as mutexes and calls to ddi_soft_state_fini(9F), should only be destroyed in _fini() after mod_remove() returns successfully.

EXAMPLES

EXAMPLE 1 Initializing and Freeing a Mutex

The following example demonstrates how to initialize and free a mutex(9F).

#include <sys/modctl.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>
static struct dev_ops drv_ops;
/*
 * Module linkage information for the kernel.
 */
static struct modldrvmodldrvm = {

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EXAMPLE 1 Initializing and Freeing a Mutex  

(DContinued)

static struct modlinkage modlinkage = {
    MODREV_1,
    &modldrv,
    NULL
};

/*
 * Global driver mutex
 */
static kmutex_t xx_global_mutex;

int _init(void)
{
    int i;

    /*
     * Initialize global mutex before mod_install’ing driver.
     * If mod_install() fails, must clean up mutex initialization
     */
    mutex_init(&xx_global_mutex, "XXX Global Mutex",
                MUTEX_DRIVER, (void *)NULL);

    if ((i = mod_install(&modlinkage)) != 0) {
        mutex_destroy(&xx_global_mutex);
    }

    return (i);
}

int _info(struct modinfo *modinfop)
{
    return (mod_info(&modlinkage, modinfop));
}

int _fini(void)
{
    int i;

    /*
     * If mod_remove() is successful, we destroy our global mutex
     */
    if ((i = mod_remove(&modlinkage)) == 0) {
        mutex_destroy(&xx_global_mutex);
    }

    return (i);
}
EXAMPLE 1 Initializing and Freeing a Mutex  (Continued)

    } return (i);
}

SEE ALSO  add_drv(1M), mod_info(9F), mod_install(9F), mod_remove(9F), mutex(9F),
           modldrv(9S), modlinkage(9S), modlstrmod(9S)

Writing Device Drivers

WARNINGS  Do not change the structures referred to by the modlinkage structure after the call to
mod_install(), as the system may copy or change them.

NOTES     Even though the identifiers _fini(), _info(), and _init() appear to be declared
as globals, their scope is restricted by the kernel to the module that they are defined in.

BUGS      On some implementations _info() may be called before _init().
### NAME
getinfo – get device driver information

### SYNOPSIS
```c
#include <sys/ddi.h>
#include <sys/sunddi.h>

int prefix_getinfo(dev_info_t *dip, ddi_info_cmd_t cmd, void *arg,
                    void **resultp);
```

### INTERFACE LEVEL
Solaris DDI specific (Solaris DDI). This entry point is required for drivers which export cb_ops(9S) entry points.

### ARGUMENTS
- **dip**: Do not use.
- **cmd**: Command argument – valid command values are `DDI_INFO_DEVT2DEVINFO` and `DDI_INFO_DEVT2INSTANCE`.
- **arg**: Command specific argument.
- **resultp**: Pointer to where the requested information is stored.

### DESCRIPTION
When `cmd` is set to `DDI_INFO_DEVT2DEVINFO`, `getinfo()` should return the `dev_info_t` pointer associated with the `dev_t` arg. The `dev_info_t` pointer should be returned in the field pointed to by `resultp`.

When `cmd` is set to `DDI_INFO_DEVT2INSTANCE`, `getinfo()` should return the instance number associated with the `dev_t` arg. The instance number should be returned in the field pointed to by `resultp`.

Drivers which do not export `cb_ops` entry points are not required to provide a `getinfo()` entry point, and may use `nodev(9F)` in the `devo_getinfo` field of the `dev_ops` structure. A SCSI HBA driver is an example of a driver which is not required to provide `cb_ops` entry points.

### RETURN VALUES
`getinfo()` should return:
- `DDI_SUCCESS` on success.
- `DDI_FAILURE` on failure.

### EXAMPLES
#### EXAMPLE 1 `getinfo()` implementation
```c
/*ARGSUSED*/
static int
rd_getinfo(dev_info_t *dip, ddi_info_cmd_t infocmd, void *arg, void **resultp)
{
    /* Note that in this simple example
    * the minor number is the instance
    * number. */

    devstate_t *sp;
    int error = DDI_FAILURE;
    switch (infocmd) {
        case DDI_INFO_DEVT2DEVINFO:
            if ((sp = ddi_get_soft_state(statep, getminor((dev_t) arg)))) != NULL) {
                /* ...
```

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EXAMPLE 1  getinfo() implementation  (Continued)

    *resultp = sp->devi;
    error = DDI_SUCCESS;
} else
    *result = NULL;
break;

    case DDI_INFO_DEVT2INSTANCE:
        *resultp = (void *) getminor((dev_t) arg);
        error = DDI_SUCCESS;
        break;
    }

    return (error);

SEE ALSO  nodev(9F), cb_ops(9S), dev_ops(9S)

Writing Device Drivers
identify(9E)

NAME     identify – determine if a driver is associated with a device

SYNOPSIS #include <sys/conf.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

int prefixidentify(dev_info_t *dip);

INTERFACE LEVEL Solaris DDI specific (Solaris DDI). This entry point is obsolete and is no longer required. This entry point may not be supported in future releases. nulldev(9F) should be specified in the dev_ops(9S) structure.

ARGUMENTS dip     A pointer to a dev_info structure.

DESCRIPTION identify() was used to determine whether a driver drives the device pointed to by dip. identify() is currently supported to provide backward compatibility with older drivers and should not be implemented. See the INTERFACE LEVEL section.

RETURN VALUES The return value from identify() is ignored.

SEE ALSO nulldev(9F), dev_ops(9S)

WARNINGS This routine may be called multiple times. It may also be called at any time. The driver should not infer anything from the the sequence or the number of times this entry point has been called.

This entry point may not be supported in future releases.

ATTRIBUTES See attributes(5) for a description of the following attributes:

<table>
<thead>
<tr>
<th>ATTRIBUTE TYPE</th>
<th>ATTRIBUTE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability Level</td>
<td>Obsolete*</td>
</tr>
</tbody>
</table>

* Schedule for removal in a minor release after 8/98.
**NAME**
ioctl – control a character device

**SYNOPSIS**
```c
#include <sys/cred.h>
#include <sys/file.h>
#include <sys/types.h>
#include <sys/errno.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

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

**INTERFACE LEVEL**
Architecture independent level 1 (DDI/DKI). This entry point is optional.

**ARGUMENTS**
- `dev` Device number.
- `cmd` Command argument the driver ioctl() routine interprets as the operation to be performed.
- `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 a value 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` A bit field that contains:
  - Information set when the device was opened. The driver may use it to determine if the device was opened for reading or writing. The driver can make this determination by checking the FREAD or FWRITE flags. See the flag argument description of the open() routine for further values.
  - Information on whether the caller is a 32-bit or 64-bit thread.
  - In some circumstances address space information about the arg argument. See below.
- `cred_p` Pointer to the 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() succeeds.

**DESCRIPTION**
ioctl() 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 determines that this is a character device, and looks up the entry point routines in cb_ops(9S). 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. Drivers 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 a user buffer, the driver can call the copyin(9F) and copyout(9F) functions to transfer data between kernel and user space.

Other kernel subsystems may need to call into the drivers ioctl() routine. Drivers that intend to allow their ioctl() routine to be used in this way should publish the ddi-kernel_ioctl property on the associated devinfo node(s).

When the ddi-kernel_ioctl property is present, the mode argument is used to pass address space information about arg through to the driver. If the driver expects arg to contain a buffer address, and the FKIOC TL flag is set in mode, then the driver should assume that it is being handed a kernel buffer address. Otherwise, arg may be the address of a buffer from a user program. The driver can use ddi_copyin(9F) and ddi_copyout(9F) perform the correct type of copy operation for either kernel or user address spaces. See the example on ddi_copyout(9F).

Drivers have to interact with 32-bit and 64-bit applications. If a device driver shares data structures with the application (for example, through exported kernel memory) and the driver gets recompiled for a 64-bit kernel but the application remains 32-bit, binary layout of any data structures will be incompatible if they contain longs or pointers. The driver needs to know whether there is a model mismatch between the current thread and the kernel and take necessary action. The mode argument has additional bits set to determine the C Language Type Model which the current thread expects. mode has FILP32 set if the current thread expects 32-bit (ILP32) semantics, or FILP64 if the current thread expects 64-bit (LP64) semantics. mode is used in combination with ddi_model_convert_from(9F) and the FMODELS mask to determine whether there is a data model mismatch between the current thread and the device driver (see the example below). The device driver might have to adjust the shape of data structures before exporting them to a user thread which supports a different data model.

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 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.
The `ioctl()` routine is coded with instructions on the proper action to take for each command. It is commonly 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.

**RETURN VALUES**

`ioctl()` should return 0 on success, or the appropriate error number. The driver may also set the value returned to the calling process through `rval_p`.

**EXAMPLES**

**EXAMPLE 1 ioctl() entry point**

The following is an example of the `ioctl()` entry point and how to support 32-bit and 64-bit applications with the same device driver.

```c
struct passargs32 {
    int len;
    caddr32_t addr;
};

struct passargs {
    int len;
    caddr_t addr;
};

xxioctl(dev_t dev, int cmd, intptr_t arg, int mode,
        cred_t *credp, int *rvalp) {
    struct passargs pa;

    #ifdef _MULTI_DATAMODEL
    switch (ddi_model_convert_from(mode & FMODELS)) {
        case DDI_MODEL_ILP32:
            { struct passargs32 pa32;
              ddi_copyin(arg, &pa32, sizeof (struct passargs32), mode);
              pa.len = pa32.len;
              pa.address = pa32.address;
              break;
            }
        case DDI_MODEL_NONE: 
            ddi_copyin(arg, &pa, sizeof (struct passargs), mode);
            break;
    }
    #endif /* _MULTI_DATAMODEL */
    ddi_copyin(arg, &pa, sizeof (struct passargs), mode);

    do_ioctl(&pa);
    ....
}
```

**SEE ALSO**

`stty(1), ttymon(1M), dkio(7I), fbio(7I), termio(7I), open(9E), put(9E), srv(9E), copyin(9F), copyout(9F), ddi_copyin(9F), ddi_copyout(9F), ddi_model_convert_from(9F), cb_ops(9S)`
Non-STREAMS driver ioctl() routines must make sure that user data is copied into or out of the kernel address space explicitly using copyin(9F), copyout(9F), ddi_copyin(9F), or ddi_copyout(9F), as appropriate. It is a severe error to simply dereference pointers to the user address space, even when in user context. Failure to use the appropriate copying routines can result in panics under load on some platforms, and reproducible panics on others.

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(9E) or srv(9E) routine.
ks_update – dynamically update kstats

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

int prefix_ks_update(kstat_t *ksp, int rw);
```

Solaris DDI specific (Solaris DDI)

**PARAMETERS**

- **ksp**  
  Pointer to a kstat(9S) structure.

- **rw**  
  Read/Write flag. Possible values are
  - **KSTAT_READ**  
    Update kstat structure statistics from the driver.
  - **KSTAT_WRITE**  
    Update driver statistics from the kstat structure.

**DESCRIPTION**

The kstat mechanism allows for an optional `ks_update()` function to update kstat data. This is useful for drivers where the underlying device keeps cheap hardware statistics, but extraction is expensive. Instead of constantly keeping the kstat data section up to date, the driver can supply a `ks_update()` function which updates the kstat's data section on demand. To take advantage of this feature, set the `ks_update` field before calling `kstat_install(9F)`.

The `ks_update()` function must have the following structure:

```
static int
xx_kstat_update(kstat_t *ksp, int rw)
{
    if (rw == KSTAT_WRITE) {
        /* update the native stats from ksp->ks_data */
        /* return EACCES if you don’t support this */
    } else {
        /* update ksp->ks_data from the native stats */
    }
    return (0);
}
```

In general, the `ks_update()` routine may need to refer to provider-private data; for example, it may need a pointer to the provider’s raw statistics. The `ks_private` field is available for this purpose. Its use is entirely at the provider’s discretion.

No kstat locking should be done inside the `ks_update()` routine. The caller will already be holding the kstat’s `ks_lock` (to ensure consistent data) and will prevent the kstat from being removed.

**RETURN VALUES**

`ks_update()` should return

- **0** For success.
- **EACCES** If `KSTAT_WRITE` is not allowed.
- **EIO** For any other error.
SEE ALSO  kstat_create(9F), kstat_install(9F), kstat(9S)

Writing Device Drivers
mapdev_access (9E)

NAME
mapdev_access – device mapping access entry point

SYNOPSIS
#include <sys/sunddi.h>

int mapdev_access(ddi_mapdev_handle_t handle, void *devprivate, 
off_t offset);

INTERFACE LEVEL
Solaris DDI specific (Solaris DDI).

PARAMETERS
handle An opaque pointer to a device mapping.
devprivate Driver private mapping data from ddi_mapdev(9F).
offset The offset within device memory at which the access occurred.

DESCRIPTION
Future releases of Solaris will provide this function for binary and source compatibility. However, for increased functionality, use devmap_access(9E) or devmap_contextmgt(9E) instead. See devmap_access(9E) or devmap_contextmgt(9E) for details.

mapdev_access() is called when an access is made to a mapping that has either been newly created with ddi_mapdev(9F) or that has been enabled with a call to ddi_mapdev_intercept(9F).

mapdev_access() is passed the handle of the mapped object on which an access has occurred. This handle uniquely identifies the mapping and is used as an argument to ddi_mapdev_intercept(9F) or ddi_mapdev_nointercept(9F) to control whether or not future accesses to the mapping will cause mapdev_access() to be called. In general, mapdev_access() should call ddi_mapdev_intercept() on the mapping that is currently in use and then call ddi_mapdev_nointercept() on the mapping that generated this call to mapdev_access(). This will ensure that a call to mapdev_access() will be generated for the current mapping next time it is accessed.

mapdev_access() must at least call ddi_mapdev_nointercept() with offset passed in in order for the access to succeed. A request to allow accesses affects the entire page containing the offset.

Accesses to portions of mappings that have been disabled by a call to ddi_mapdev_nointercept() will not generate a call to mapdev_access(). A subsequent call to ddi_mapdev_intercept() will enable mapdev_access() to be called again.

A non-zero return value from mapdev_access() will cause the corresponding operation to fail. The failure may result in a SIGSEGV or SIGBUS signal being delivered to the process.

RETURN VALUES
mapdev_access() should return 0 on success, -1 if there was a hardware error, or the return value from ddi_mapdev_intercept() or ddi_mapdev_nointercept().
mapdev_access(9E)

CONTEXT
This function is called from user context only.

EXAMPLES
EXAMPLE 1 Managing a One Page Device Context

The following shows an example of managing a device context that is one page in length.

```c
ddi_mapdev_handle_t cur_hdl;
static int
xxmapdev_access(ddi_mapdev_handle_t handle, void *devprivate,
    off_t offset)
{
    int err;
    /* enable calls to mapdev_access for the current mapping */
    if (cur_hdl != NULL) {
        if ((err = ddi_mapdev_intercept(cur_hdl, off, 0)) != 0)
            return (err);
    }
    /* Switch device context - device dependent*/
    ...
    /* Make handle the new current mapping */
    cur_hdl = handle;
    /*
    * Disable callbacks and complete the access for the
    * mapping that generated this callback.
    */
    return (ddi_mapdev_nointercept(handle, off, 0));
}
```

SEE ALSO
mmap(2), mapdev_dup(9E), mapdev_free(9E), segmap(9E), ddi_mapdev(9F),
ddi_mapdev_intercept(9F), ddi_mapdev_nointercept(9F),
ddi_mapdev_ctl(9S)

Writing Device Drivers
mapdev_dup(9E)

NAME
mapdev_dup – device mapping duplication entry point

SYNOPSIS
#include <sys/sunddi.h>

int prefix mapdev_dup(ddi_mapdev_handle_t handle, void *devprivate,
                        ddi_mapdev_handle_t new_handle, void **new_devprivatep);

INTERFACE
Solaris DDI specific (Solaris DDI).

LEVEL
PARAMETERS
handle The handle of the mapping that is being duplicated.
devprivate Driver private mapping data from the mapping that is being
duplicated.
new_handle An opaque pointer to the duplicated device mapping.
new_devprivatep A pointer to be filled in by the driver with the driver private
mapping data for the duplicated device mapping.

DESCRIPTION
Future releases of Solaris will provide this function for binary and source
compatibility. However, for increased functionality, use devmap_dup(9E) instead. See
devmap_dup(9E) for details.

mapdev_dup() is called when a device mapping is duplicated such as through
fork(2). mapdev_dup() is expected to generate new driver private data for the new
mapping, and set new_devprivatep to point to it. new_handle is the handle of the new
mapped object.

A non-zero return value from mapdev_dup() will cause the corresponding operation,
such as fork() to fail.

RETURN VALUES
mapdev_dup() returns 0 for success or the appropriate error number on failure.

CONTEXT
This function is called from user context only.

EXAMPLES
EXAMPLE 1

static int
xxmapdev_dup(ddi_mapdev_handle_t handle, void *devprivate,
             ddi_mapdev_handle_t new_handle, void **new_devprivatep)
{
    struct xxpvtdata *pvtdata;
    /* Allocate a new private data structure */
    pvtdata = kmalloc(sizeof (struct xxpvtdata), KM_SLEEP);
    /* Copy the old data to the new - device dependent*/
    ...
    /* Return the new data */
    *new_pvtdata = pvtdata;
    return (0);
}
EXAMPLE 1  (Continued)

SEE ALSO  

fork(2), mmap(2), mapdev_access(9E), mapdev_free(9E), segmap(9E),
ddi_mapdev(9F), ddi_mapdev_intercept(9F), ddi_mapdev_nointercept(9F),
ddi_mapdev_ctl(9S)

Writing Device Drivers
mapdev_free(9E)

NAME
mapdev_free – device mapping free entry point

SYNOPSIS
#include <sys/sunddi.h>

void pre
fi
x
mapdev_free(ddi_mapdev_handle_t handle, void *devprivate);

INTERFACE
Solaris DDI specific (Solaris DDI).

LEVEL
PARAMETERS
handle An opaque pointer to a device mapping.

devprivate Driver private mapping data from ddi_mapdev(9F).

DESCRIPTION
Future releases of Solaris will provide this function for binary and source
compatibility. However, for increased functionality, use devmap_unmap(9E) instead.
See devmap_unmap(9E) for details.

mapdev_free() is called when a mapping created by ddi_mapdev(9F) is being
destroyed. mapdev_free() receives the handle of the mapping being destroyed and a
pointer to the driver private data for this mapping in devprivate.

The mapdev_free() routine is expected to free any resources that were allocated by
the driver for this mapping.

CONTEXT
This function is called from user context only.

EXAMPLES
EXAMPLE 1 Using mapdev_free()

static void
xxmapdev_free(ddi_mapdev_handle_t hdl, void *pvtdata)
{
    /* Destroy the driver private data - Device dependent */
    ...
    kmem_free(pvtdata, sizeof (struct xxpvtdata));
}

SEE ALSO
exit(2), mmap(2), munmap(2), mapdev_access(9E), mapdev_dup(9E), segmap(9E),
ddi_mapdev(9F), ddi_mapdev_intercept(9F), ddi_mapdev_nointercept(9F),
ddi_mapdev_ctl(9S)

Writing Device Drivers
mmap(9E)

<table>
<thead>
<tr>
<th>NAME</th>
<th>mmap – check virtual mapping for memory mapped device</th>
</tr>
</thead>
</table>
| SYNOPSIS   | `#include <sys/types.h>`
|            | `#include <sys/cred.h>`
|            | `#include <sys/mman.h>`
|            | `#include <sys/ddi.h>`
|            | `int prefix mmap(dev_t dev, off_t off, int prot);` |
| INTERFACE  | Architecture independent level 1 (DDI/DKI).          |
| LEVEL      |                                                     |
| PARAMETERS | dev Device whose memory is to be mapped.             |
|            | off Offset within device memory at which mapping begins. |
|            | prot A bit field that specifies the protections this page of memory will receive. Possible settings are: |
|            | PROT_READ Read access will be granted.               |
|            | PROT_WRITE Write access will be granted.             |
|            | PROT_EXEC Execute access will be granted.            |
|            | PROT_USER User-level access will be granted.         |
|            | PROT_ALL All access will be granted.                 |
| DESCRIPTION| Future releases of Solaris will provide this function for binary and source compatibility. However, for increased functionality, use devmap(9E) instead. See devmap(9E) for details. |
|            | 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. |
|            | The mmap() entry point is called as a result of an mmap(2) system call, and also as a result of a page fault. mmap() is called to translate the offset off in device memory to the corresponding physical page frame number. |
|            | The mmap() entry point checks if the offset off is within the range of pages exported 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 value returned by hat_getkpfnnum(9F) for the physical page in device memory containing the offset off. |
|            | hat_getkpfnnum(9F) accepts a kernel virtual address as an argument. A kernel virtual address can be obtained by calling ddi_regs_map_setup(9F) in the driver's attach(9E) routine. The corresponding ddi_regs_map_free(9F) call can be made in the driver's detach(9E) routine. Refer to Example 1 below for more information. |
mmap() should only be supported for memory-mapped devices. See the segmap(9E) and ddi_mapdev(9F) reference pages for further information on memory-mapped device drivers.

If a device driver shares data structures with the application, for example through exported kernel memory, and the driver gets recompiled for a 64-bit kernel but the application remains 32-bit, the binary layout of any data structures will be incompatible if they contain longs or pointers. The driver needs to know whether there is a model mismatch between the current thread and the kernel and take necessary action. ddi_mmap_get_model(9F) can be use to get the C Language Type Model which the current thread expects. In combination with ddi_model_convert_from(9F) the driver can determine whether there is a data model mismatch between the current thread and the device driver. The device driver might have to adjust the shape of data structures before exporting them to a user thread which supports a different data model. See ddi_mmap_get_model(9F) for an example.

RETURN VALUES
If the protection and offset are valid for the device, the driver should return the value returned by hat_getkpfnum(9F), for the page at offset off in the device's memory. If not, -1 should be returned.

EXAMPLES
EXAMPLE 1 The mmap() Entry Point

The following is an example of the mmap() entry point. If offset off is valid, hat_getkpfnum(9F) is called to obtain the page frame number corresponding to this offset in the device's memory. In this example, xsp->regp->csr is a kernel virtual address which maps to device memory. ddi_regs_map_setup(9F) can be used to obtain this address. For example, ddi_regs_map_setup(9F) can be called in the driver's attach(9E) routine. The resulting kernel virtual address is stored in the xxstate structure, which is accessible from the driver's mmap() entry point. See ddi_soft_state(9F). The corresponding ddi_regs_map_free(9F) call can be made in the driver's detach(9E) routine.

struct reg {
    uint8_t csr;
    uint8_t data;
};
struct xxstate {
    ...
    struct reg *regp
    ...
};
struct xxstate *xsp;
...

static int
xxmmap(dev_t dev, off_t off, int prot)
{
    int instance;
    struct xxstate *xsp;
EXAMPLE 1 The mmap() Entry Point  (Continued)

    /* No write access */
    if (prot & PROT_WRITE)  
        return (-1);

    instance = getminor(dev);
    xsp = ddi_get_soft_state(statep, instance);
    if (xsp == NULL)
        return (-1);

    /* check for a valid offset */
    if (off is invalid)
        return (-1);
    return (hat_getkpfnum (xsp->regp->csr + off));

SEE ALSO  mmap(2), attach(9E), detach(9E), devmap(9E), segmap(9E), ddi_btop(9F),
          ddi_get_soft_state(9F), ddi_mmap_get_model(9F),
          ddi_model_convert_from(9F), ddi_regs_map_free(9F),
          ddi_regs_map_setup(9F), ddi_soft_state(9F), devmap_setup(9F),
          getminor(9F), hat_getkpfnum(9F)

Writing Device Drivers

NOTES  For some devices, mapping device memory in the driver’s attach(9E) routine and
unmapping device memory in the driver’s detach(9E) routine is a sizeable drain on
system resources. This is especially true for devices with a large amount of physical
address space.

One alternative is to create a mapping for only the first page of device memory in
attach(9E). If the device memory is contiguous, a kernel page frame number may be
obtained by calling hat_getkpfnum(9F) with the kernel virtual address of the first
page of device memory and adding the desired page offset to the result. The page
offset may be obtained by converting the byte offset off to pages. See ddi_btop(9F).

Another alternative is to call ddi_regs_map_setup(9F) and
ddi_regs_map_free(9F) in mmap(). These function calls would bracket the call to
hat_getkpfnum(9F).

However, note that the above alternatives may not work in all cases. The existence of
intermediate nexus devices with memory management unit translation resources that
are not locked down may cause unexpected and undefined behavior.

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Sun Proprietary/Confidential: Need to Know
open – gain access to a device

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

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

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

int prefixopen(queue_t *q, dev_t *devp, int oflag, int sflag, cred_t *cred_p);

Architecture independent level 1 (DDI/DKI). This entry point is required, but it can be
nulldev(9F)

Block and Character

devp Pointer to a device number.

flag A bit field passed from the user program open(2) system call that instructs
the driver on how to open the file. Valid settings are:

FEXCL Open the device with exclusive access; fail all other
attempts to open the device.

FNDELAY Open the device and return immediately. Do not block
the open even if something is wrong.

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. For OTYP_BLK and OTYP_CHR, the
open() routine may be called many times, but the close(9E) routine
is called only when the last reference to a device is removed. If the device is
accessed through file descriptors, this is by a call to close(2) or exit(2) If
the device is accessed through memory mapping, this is by a call to
munmap(2) or exit(2) For OTYP_LYR, there is exactly one close(9E) 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.

OTYP_BLK Open occurred through block interface for the device

OTYP_CHR Open occurred through the raw/character interface for the device

Sun Proprietary/Confidential: Need to Know
**open(9E)**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTYP_LYR</td>
<td>Open a layered process. This flag is used when one driver calls another driver’s open() or close(9E) routine. The calling driver will make sure that there is one layered close for each layered open. This flag applies to both block and character devices.</td>
</tr>
<tr>
<td>cred_p</td>
<td>Pointer to the user credential structure.</td>
</tr>
<tr>
<td>q</td>
<td>A pointer to the read queue.</td>
</tr>
<tr>
<td>devp</td>
<td>Pointer to a device number. For STREAMS modules, devp always points to the device number associated with the driver at the end (tail) of the stream.</td>
</tr>
<tr>
<td>oflag</td>
<td>Valid oflag values are FEXCL, FNDELAY, FREAD, and FWRITEL, the same as those listed above for flag. For STREAMS modules, oflag is always set to 0.</td>
</tr>
<tr>
<td>sflag</td>
<td>Valid values are as follows: CLONEOPEN Indicates that the open() routine is called through the clone driver. The driver should return a unique device number. MODOPEN Modules should be called with sflag set to this value. Modules should return an error if they are called with sflag set to a different value. Drivers should return an error if they are called with sflag set to this value. 0 Indicates a driver is opened directly, without calling the clone driver.</td>
</tr>
<tr>
<td>cred_p</td>
<td>Pointer to the user credential structure.</td>
</tr>
</tbody>
</table>

**DESCRIPTION**

The driver’s open() routine is called by the kernel 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 *devp 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.

The open() routine is passed a pointer to a device number so that the driver can change the minor number. This allows drivers to dynamically create minor instances of the device. An example of this might be a pseudo-terminal driver that creates a new pseudo-terminal whenever it is opened. A driver that chooses the minor number dynamically, normally creates only one minor device node in attach(9E) with ddi_create_minor_node(9F) then changes the minor number component of *devp using makedevice(9F) and getmajor(9F) The driver needs to keep track of available minor numbers internally:

*devp = makedevice(getmajor(*devp), new_minor);

**RETURN VALUES**

The open() routine should return 0 for success, or the appropriate error number.
Do not attempt to change the major number.

SEE ALSO close(2), exit(2), mmap(2), mount(2), munmap(2), open(2), intro(9E), attach(9E), close(9E), ddi_create_minor_node(9F), getmajor(9F), getminor(9F), makedevice(9F), nulldev(9F)

Writing Device Drivers

STREAMS Programming Guide

WARNINGS Do not attempt to change the major number.
### NAME
power – power a device attached to the system

### SYNOPSIS
```c
#include <sys/ddi.h>
#include <sys/sunddi.h>

int prefix power (dev_info_t *dip, int component, int level);
```

### INTERFACE LEVEL
Solaris DDI specific (Solaris DDI). This entry point is required. If the driver writer does not supply this entry point, the value NULL must be used in the cb_ops(9S) structure instead.

### PARAMETERS
- **dip**: Pointer to the device's dev_info structure.
- **component**: Component of the driver to be managed.
- **level**: Desired component power level.

### DESCRIPTION
The `power()` function is the device-specific Power Management entry point. This function is called when the system wants the driver to set the power level of `component` to `level`.

The `power()` entry points behave as described under NEW BEHAVIOR if the device driver uses new automatic device Power Management interfaces (driver exports `pm-components`(9) property). The `power()` entry point behaves as described under OBSOLETE BEHAVIOR if the device driver uses original Power Management interfaces (driver does not export the `pm-components` property but instead calls `pm_create_components`(9F)). The behavior described under OBSOLETE BEHAVIOR is obsolete and will be removed in a future release.

The `level` argument is the driver-defined power level to which the component needs to be set. Except for power level 0, which is interpreted by the framework to mean "powered off," the interpretation of `level` is entirely up to the driver.

The `component` argument is the component of the device to be power-managed. The interpretation of `component` is entirely up to the driver.

When a requested power transition would cause the device to lose state, the driver must save the state of the device in memory. When a requested power transition requires state to be restored, the driver must restore that state.

If a requested power transition for one component requires another component to change power state before it can be completed, the driver must call `pm_raise_power`(9F) to get the other component changed, and the `power`(9E) entry point must support being re-entered.

If the system requests an inappropriate power transition for the device (for example, a request to power down a device which has just become busy), then the power level should not be changed and power should return DDI_FAILURE.

---

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Sun Proprietary/Confidential: Need to Know
The level argument is the driver-defined power level to which component must be set. Except for power level 0 which is defined by the framework to mean “powered off,” the interpretation of level is entirely up to the driver.

The component argument is the component of the device to be power-managed. Except for component 0, which must represent the entire device, the interpretation of component is entirely up to the driver.

The power() function can assume that the driver will be suspended (using detach(9E) with command DDI_PM_SUSPEND), before a request is made to set component 0 to power level 0 and resumed (using attach(9E) with command DDI_PM_RESUME) after setting component 0 from power level 0 to a non-zero power level.

If the system requests an inappropriate power transition for the device (for example, a request to power down a device which has just become busy), then the power level should not be changed and the power(9E) function should return DDI_FAILURE.

RETURN VALUES
The power() function returns:

DDI_SUCCESS  Successfully set the power to the requested level.
DDI_FAILURE   Failed to set the power to the requested level.

CONTEXT
The power() function is called from user or kernel context only.

ATTRIBUTES
See attributes(5) for descriptions of the following attributes:

<table>
<thead>
<tr>
<th>ATTRIBUTE TYPE</th>
<th>ATTRIBUTE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface stability</td>
<td>Evolving (Interfaces under OBSOLETE BEHAVIOR are obsolete.)</td>
</tr>
</tbody>
</table>

SEE ALSO
attach(9E), detach(9E), pm-components(9), pm_busy_component(9F), pm_create_components(9F), pm_destroy_components(9F), pm_idle_component(9F), pm_raise_power(9F), cb_ops(9S)

Writing Device Drivers

Using Power Management
NAME
print – display a driver message on system console

SYNOPSIS
#include <sys/types.h>
#include <sys/errno.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

int print(dev_t dev, char *str);

INTERFACE LEVEL
Architecture independent level 1 (DDI/DKI). This entry point is required for block devices.

PARAMETERS
dev Device number.
str Pointer to a character string describing the problem.

DESCRIPTION
The print() routine is called by the kernel when it 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(9F) kernel function. The driver should print the message along with any driver specific information.

RETURN VALUES
The print() routine should return 0 for success, or the appropriate error number. 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.

SEE ALSO
cmn_err(9F)

Writing Device Drivers
probe(9E)

NAME
probe – determine if a non-self-identifying device is present

SYNOPSIS
#include <sys/conf.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

static int prefix probe(dev_info_t *dip);

INTERFACE
LEVEL
Solaris DDI specific (Solaris DDI). This entry point is required for non-self-identifying
devices. You must write it for such devices. For self-identifying devices, nulldev(9F)
should be specified in the dev_ops(9S) structure if a probe routine is not necessary.

ARGUMENTS
dip Pointer to the device’s dev_info structure.

DESCRIPTION
probe() determines whether the device corresponding to dip actually exists and is a
valid device for this driver. probe() is called after identify(9E) and before
attach(9E) for a given dip. For example, the probe() routine can map the device
registers using ddi_map_regs(9F) then attempt to access the hardware using
ddi.peek(9F) or ddi.poke(9F) and determine if the device exists. Then the device
registers should be unmapped using ddi_unmap_regs(9F).

probe() should only probe the device. It should not create or change any software
state. Device initialization should be done in attach(9E).

For a self-identifying device, this entry point is not necessary. However, if a device
exists in both self-identifying and non-self-identifying forms, a probe() routine can
be provided to simplify the driver. ddi_dev_is_sid(9F) can then be used to
determine whether probe() needs to do any work. See ddi_dev_is_sid(9F) for an
example.

RETURN VALUES
DDI_PROBE_SUCCESS If the probe was successful.
DDI_PROBE_FAILURE If the probe failed.
DDI_PROBE_DONTCARE If the probe was unsuccessful, yet attach(9E) should
still be called.
DDI_PROBE_PARTIAL If the instance is not present now, but may be present
in the future.

SEE ALSO
attach(9E), identify(9E), ddi_dev_is_sid(9F), ddi_map_regs(9F),
ddi.peek(9F), ddi.poke(9F), nulldev(9F), dev_ops(9S)

Writing Device Drivers
prop_op(9E)

NAME
prop_op - report driver property information

SYNOPSIS
#include <sys/types.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

int prefixprop_op(dev_t dev, dev_info_t *dip, ddi_prop_op_t prop_op,
                   int flags, char *name, caddr_t valuep, int *lengthp);

INTERFACE
Solaris DDI specific (Solaris DDI). This entry point is required, but it can be
ddi_prop_op(9F).

LEVEL
ARGUMENTS

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dev</td>
<td>Device number associated with this device.</td>
</tr>
<tr>
<td>dip</td>
<td>A pointer to the device information structure for this device.</td>
</tr>
</tbody>
</table>
| prop_op   | Property operator. Valid operators are: PROP_LEN
            | Get property length only. (valuep unaffected).
            | PROP_LEN_AND_VAL_BUF
            | Get length and value into caller’s buffer. (valuep used as input).
            | PROP_LEN_AND_VAL_ALLOC
            | Get length and value into allocated buffer. (valuep returned as
            | pointer to pointer to allocated buffer). |
| flags     | The only possible flag value is: DDI_PROP_DONTPASS
            | Do not pass request to parent if property not found. |
| name      | Pointer to name of property to be interrogated.  |
| valuep    | If prop_op is PROP_LEN_AND_VAL_BUF, this should be a pointer to
            | the user’s buffer. If prop_op is PROP_LEN_AND_VAL_ALLOC, this
            | should be the address of a pointer. |
| lengthp   | On exit, *lengthp will contain the property length. If prop_op is
            | PROP_LEN_AND_VAL_BUF then lengthp should point to an int
            | that contains the length of caller’s buffer, before calling
            | prop_op() . |

DESCRIPTION
prop_op() is an entry point which reports the values of certain properties of the
driver or device to the system. Each driver must have a prefix prop_op entry point,
but most drivers that do not need to create or manage their own properties can use
ddi_prop_op() for this entry point. Then the driver can use ddi_prop_update(9F)
to create properties for its device.

RETURN VALUES
prop_op() should return:

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDI_PROP_SUCCESS</td>
<td>Property found and returned.</td>
</tr>
<tr>
<td>DDI_PROP_NOT_FOUND</td>
<td>Property not found.</td>
</tr>
</tbody>
</table>

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Sun Proprietary/Confidential: Need to Know
**EXAMPLE 1 Using prop_op() to Report Property Information**

In the following example, prop_op() intercepts requests for the `temperature` property. The driver tracks changes to `temperature` using a variable in the state structure in order to avoid frequent calls to ddi_prop_update(9F). The `temperature` property is only updated when a request is made for this property. It then uses the system routine ddi_prop_op(9F) to process the property request. If the property request is not specific to a device, the driver does not intercept the request. This is indicated when the value of the `dev` parameter is equal to DDI_DEV_T_ANY.

```c
int temperature; /* current device temperature */
...
static int xxprop_op(dev_t dev, dev_info_t *dip, ddi_prop_op_t prop_op,
        int flags, char *name, caddr_t valuep, int *lengthp)
{
    int instance;
    struct xxstate *xsp;
    if (dev == DDI_DEV_T_ANY)
        goto skip;
    instance = getminor(dev);
    xsp = ddi_get_soft_state(statep, instance);
    if (xsp == NULL)
        return (DDI_PROP_NOTFOUND);
    if (strcmp(name, "temperature") == 0) {
        ddi_prop_update_int(dev, dip, "temperature", temperature);
    }
    /* other cases... */
    skip:
    return (ddi_prop_op(dev, dip, prop_op, flags, name, valuep, lengthp));
}
```

**SEE ALSO**

Intro(9E), ddi_prop_op(9F), ddi_prop_update(9F)

*Writing Device Drivers*
NAME
put – receive messages from the preceding queue

SYNOPSIS
#include <sys/types.h>
#include <sys/stream.h>
#include <sys/stropts.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

int prefixput(queue_t *q, mblk_t *mp);
/* read side */

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

INTERFACE
Architecture independent level 1 (DDI/DKI). This entry point is required for
LEVEL
STREAMS.

ARGUMENTS
q Pointer to the queue(9S) 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 (stream module, driver, or stream head). put() routines are designated
“write” or “read” depending on the direction of message flow.

With few exceptions, a streams 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(9E) (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(9F)
  function;
- process the message, if immediate processing is required (for example, to handle
  high priority messages); or
- enqueue the message (with the putq(9F) function) for deferred processing by the
  service srv(9E) 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 M_IOCTL message by changing its type to M_IOCNAK (negative
acknowledgement) and sending it back to the stream head using the qreply(9F)
function.
The `putq(9F)` 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(9E)` routine.

**RETURN VALUES**

Ignored.

**CONTEXT**

`put()` routines do not have user context.

**SEE ALSO**

`srv(9E), putctl(9F), putctl1(9F), putnext(9F), putnextctl(9F), putnextctl1(9F), putq(9F), qreply(9F), queue(9S), streamtab(9S)`

*Writing Device Drivers*

*STREAMS Programming Guide*
read(9E)

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

int prefixread(dev_t dev, struct uio *uio_p, cred_t *cred_p);

INTERFACE LEVEL PARAMETERS
Architecture independent level 1 (DDI/DKI). This entry point is optional.

dev
Device number.

uio_p
Pointer to the uio(9S) structure that describes where the data is to
be stored in user space.

cred_p
Pointer to the user credential structure for the I/O transaction.

DESCRIPTION
The driver read() routine is called indirectly through cb_ops(9S) by the read(2)
system call. The read() routine should check the validity of the minor number
component of dev and the user credential structure pointed to by cred_p (if pertinent).
The read() routine should supervise the data transfer into the user space described
by the uio(9S) structure.

RETURN VALUES
The read() routine should return 0 for success, or the appropriate error number.

EXAMPLES
EXAMPLE 1 read() routine using physio()

The following is an example of a read() routine using physio(9F) to perform reads
from a non-seekable device:

static int
xxread(dev_t dev, struct uio *uiop, cred_t *credp)
{
    int rval;
    offset_t off;
    int instance;
    xx_t xx;

    instance = getminor(dev);
    xx = ddi_get_soft_state(xxstate, instance);
    if (xx == NULL)
        return (ENXIO);
    off = uiop->uio_loffset;
    rval = physio(xxstrategy, NULL, dev, B_READ,
        xxmin, uiop);
    uiop->uio_loffset = off;
    return (rval);
}

SEE ALSO
read(2), write(9E), physio(9F), cb_ops(9S), uio(9S)
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>
#include <sys/ddi.h>
#include <sys/sunddi.h>

int segmap(dev_t dev, off_t off, struct asp, caddr_t *addrp,
    off_t len, unsigned int prot, unsigned int maxprot, unsigned int flags,
    cred_t *cred_p);

ARCHITECTURE
Architecture independent level 2 (DKI only).

LEVEL

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 A bit field that specifies the protections. Possible settings are:

| PROT_READ | Read access is desired. |
| PROT_WRITE | Write access is desired. |
| PROT_EXEC | Execute access is desired. |
| PROT_USER | User-level access is desired (the mapping is being done as a result of a mmap(2) system call). |
| PROT_ALL | All access is desired. |

maxprot Maximum protection flag possible for attempted mapping; the PROT_WRITE bit may be masked out if the user opened the special file read-only.

flags Flags indicating type of mapping. Possible values are (other bits may be set):

| MAP_SHARED | Changes should be shared. |
| MAP_PRIVATE | Changes are private. |

cred_p Pointer to the user credentials structure.
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.

Typically, a character driver that needs to support the mmap(2) system call supplies either an devmap(9E) entry point, or both an devmap(9E) and a segmap() entry point routine (see the devmap(9E) reference page). If no segmap() entry point is provided for the driver, devmap_setup(9F) is used as a default.

A driver for a memory-mapped device would provide a segmap() entry point if it:
- needs to maintain a separate context for each user mapping. See devmap_setup(9F) for details.
- needs to assign device access attributes to the user mapping.

The responsibilities of a segmap() entry point are:
- Verify that the range, defined by offset and len, to be mapped is valid for the device. Typically, this task is performed by calling the devmap(9E) entry point. Note that if you are using ddi_devmap_segmap(9F) or devmap_setup(9F) to set up the mapping, it will call your devmap(9E) entry point for you to validate the range to be mapped.
- Assign device access attributes to the mapping. See ddi_devmap_segmap(9F), and ddi_device_acc_attr(9S) for details.
- Set up device contexts for the user mapping if your device requires context switching. See devmap_setup(9F) for details.
- Perform the mapping with ddi_devmap_segmap(9E), or devmap_setup(9F) and return the status if it fails.

The segmap() routine should return 0 if the driver is successful in performing the memory map of its device address space into the specified address space.

The segmap() must return an error number 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.

If one of the mapping routines ddi_devmap_segmap() or devmap_setup() fails, you must return the error number returned by the respective routine.

SEE ALSO
mmap(2), devmap(9E), devmap_setup(9F), ddi_devmap_segmap(9F),
ddi_device_acc_attr(9S)

Writing Device Drivers
<table>
<thead>
<tr>
<th>NAME</th>
<th>srv – service queued messages</th>
</tr>
</thead>
</table>
| SYNOPSIS | #include <sys/types.h>  
#include <sys/stream.h>  
#include <sys/stropts.h>  
#include <sys/ddi.h>  
#include <sys/sunddi.h>  

    int prefixsrv(queue_t *q);  
    /* read side */  

    int prefixsrv(queue_t *q);  
    /* write side */ |
| INTERFACE LEVEL | Architecture independent level 1 (DDI/DKI). This entry point is required for STREAMS. |
| ARGUMENTS | q Pointer to the queue(9S) structure. |
| DESCRIPTION | The optional service `srv()` routine may be included in a STREAMS module or driver for many possible reasons, including:  
- 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(9E)` 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(9E)` routine, which may or may not do some processing. It must then either:  
- Pass the message to the next stream component with `putnext(9F)`.  
- If a `srv()` routine has been included, it may call `putq(9F)` to place the message on the queue.  

Once a message has been enqueued, the STREAMS scheduler controls the service routine’s invocation. The scheduler calls the service routines in FIFO order. The scheduler cannot guarantee a maximum delay `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. Each component should check the tunable high and low water marks 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 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_IOCTL). 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 the STREAMS scheduler calls a srv() routine, 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 getq(9F) to get the next enqueued message.
2. If the message is high priority, process (if appropriate) and pass to the next stream component with putnext(9F).
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 bcanputnext(9F) to determine if this can be done.
4. If the message cannot be passed, put it back on the queue with putbq(9F). If it can be passed, process (if appropriate) and pass with putnext().

**RETURN VALUES**
Ignored.

**SEE ALSO**
put(9E), bcanput(9F), bcanputnext(9F), canput(9F), canputnext(9F), getq(9F), nulldev(9F), putbq(9F), putnext(9F), putq(9F), qinit(9S), queue(9S)

**WARNINGS**
Each stream module must specify a read and a 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(9S) structure. Do not use nulldev(9F) instead of the NULL pointer. Use of nulldev(9F) for a srv() routine may result in flow control errors.
```plaintext
strategy(9E)

NAME
strategy – perform block I/O

SYNOPSIS
#include <sys/types.h>
#include <sys/buf.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

int prefixstrategy(struct buf *bp);

INTERFACE LEVEL
Architecture independent level 1 (DDI/DKI). This entry point is required for block devices.

PARAMETERS
bp Pointer to the buf(9S) structure.

DESCRIPTION
The strategy() routine is called indirectly (through cb_ops(9S)) by the kernel to read and write blocks of data on the block device. strategy() may also be called directly or indirectly to support the raw character interface of a block device (read(9E), write(9E) and ioctl(9E)). The strategy() routine’s responsibility is to set up and initiate the transfer.

RETURN VALUES
The strategy() routine should always return 0. On an error condition, it should call bioerror(9f) to set b_flags to the proper error code, and call biodone(9f). Note that a partial transfer is not considered to be an error.

SEE ALSO
ioctl(9E), read(9E), write(9E), biodone(9F), bioerror(9F), buf(9S), cb_ops(9S)
Writing Device Drivers
```
#include <sys/scsi/scsi.h>

int prefix tran_abort(struct scsi_address *ap, struct scsi_pkt *pkt);

## Solaris architecture specific (Solaris DDI).

### Arguments
- **ap**: Pointer to a scsi_address(9S) structure.
- **pkt**: Pointer to a scsi_pkt(9S) structure.

### Description
The `tran_abort()` vector in the `scsi_hba_tran(9S)` structure must be initialized during the HBA driver's `attach(9E)` to point to an HBA entry point to be called when a target driver calls `scsi_abort(9F)`.

`tran_abort()` should attempt to abort the command `pkt` that has been transported to the HBA. If `pkt` is NULL, the HBA driver should attempt to abort all outstanding packets for the target/logical unit addressed by `ap`.

Depending on the state of a particular command in the transport layer, the HBA driver may not be able to abort the command.

While the abort is taking place, packets issued to the transported layer may or may not be aborted.

For each packet successfully aborted, `tran_abort()` must set the `pkt_reason` to `CMD_ABORTED`, and `pkt_statistics` must be OR'ed with `STAT_ABORTED`.

### Return Values
`tran_abort()` must return:
- 1 upon success or partial success.
- 0 upon failure.

### See Also
- `attach(9E)`, `scsi_abort(9F)`, `scsi_hba_attach(9F)`, `scsi_address(9S)`, `scsi_hba_tran(9S)`, `scsi_pkt(9S)`

### Writing Device Drivers

### Notes
If `pkt_reason` already indicates that an earlier error had occurred, `tran_abort()` should not overwrite `pkt_reason` with `CMD_ABORTED`. 
tran_bus_reset(9e)

NAME
tran_bus_reset – reset a SCSI bus

SYNOPSIS
#include <sys/scsi/scsi.h> int prefix

tran_bus_reset(dev_info_t *hba_dip, int level);

INTERFACE LEVEL
Solaris DDI

PARAMETERS
hba_dip The dev_info_t pointer associated with the SCSI HBA.
level The level of reset required.

DESCRIPTION
The tran_bus_reset() vector in the scsi_hba_tran(9S) structure should be initialized during the HBA driver's attach(9E). It is an HBA entry point to be called when a user initiates a bus reset through device control interfaces.

tran_bus_reset() must reset the SCSI bus without resetting targets.

level will be one of the following:
RESET_BUS Reset the SCSI bus only, not the targets.

Implementation is hardware specific. If it is not possible to reset the SCSI bus without changing the state and operating mode of the targets, the HBA driver should not initialize this vector or return failure.

RETURN VALUES
tran_bus_reset() should return:
1 on success.
0 on failure.

ATTRIBUTES
See attributes(5) for a description of the following attributes:

<table>
<thead>
<tr>
<th>ATTRIBUTE TYPE</th>
<th>ATTRIBUTE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability Level</td>
<td>Evolving</td>
</tr>
</tbody>
</table>

SEE ALSO
attributes(5), tran_quiesce(9E), scsi_hba_tran(9S)
### NAME
tran_dmafree – SCSI HBA DMA deallocation entry point

### SYNOPSIS
```
#include <sys/scsi/scsi.h>

void prefixtran_dmafree(struct scsi_address *ap, struct scsi_pkt *pkt);
```

### INTERFACE LEVEL
Solaris architecture specific (Solaris DDI).

### ARGUMENTS
- **ap**
  A pointer to a `scsi_address` structure. See `scsi_address(9S)`.
- **pkt**
  A pointer to a `scsi_pkt` structure. See `scsi_pkt(9S)`.

### DESCRIPTION
The `tran_dmafree()` vector in the `scsi_hba_tran` structure must be initialized during the HBA driver's `attach()` to point to an HBA entry point to be called when a target driver calls `scsi_dmafree(9F)`. See `attach(9E)` and `scsi_hba_tran(9S)`.

`tran_dmafree()` must deallocate any DMA resources previously allocated to this `pkt` in a call to `tran_init_pkt(9E)`. `tran_dmafree()` should not free the structure pointed to by `pkt` itself. Since `tran_destroy_pkt(9E)` must also free DMA resources, it is important that the HBA driver keeps accurate note of whether `scsi_pkt(9S)` structures have DMA resources allocated.

### SEE ALSO
- `attach(9E)`, `tran_destroy_pkt(9E)`, `tran_init_pkt(9E)`, `scsi_dmafree(9F)`, `scsi_dmaget(9F)`, `scsi_hba_attach(9F)`, `scsi_init_pkt(9F)`, `scsi_address(9S)`, `scsi_hba_tran(9S)`, `scsi_pkt(9S)`

Writing Device Drivers

### NOTES
A target driver may call `tran_dmafree()` on packets for which no DMA resources were allocated.
### tran_getcap(9E)

**NAME**
tran_getcap, tran_setcap – get/set SCSI transport capability

**SYNOPSIS**
```
#include <sys/scsi/scsi.h>

int prefix tran_getcap(struct scsi_address *ap, char *cap, int whom);
int prefix tran_setcap(struct scsi_address *ap, char *cap, int value, int whom);
```

**INTERFACE LEVEL PARAMETERS**
Solaris architecture specific (Solaris DDI).

- **ap**  
  Pointer to the `scsi_address(9S)` structure.

- **cap**  
  Pointer to the string capability identifier.

- **value**  
  Defines the new state of the capability.

- **whom**  
  Specifies whether all targets or only the specified target is affected.

**DESCRIPTION**
The `tran_getcap()` and `tran_setcap()` vectors in the `scsi_hba_tran(9S)` structure must be initialized during the HBA driver's `attach(9E)` to point to HBA entry points to be called when a target driver calls `scsi_ifgetcap(9F)` and `scsi_ifsetcap(9F)`.

- `tran_getcap()` is called to get the current value of a capability specific to features provided by the HBA hardware or driver. The name of the capability `cap` is the NULL terminated capability string.
  
  If `whom` is non-zero, the request is for the current value of the capability defined for the target specified by the `scsi_address(9S)` structure pointed to by `ap`; if `whom` is 0, all targets are affected; else, the target specified by the `scsi_address` structure pointed to by `ap` is affected.

- `tran_setcap()` is called to set the value of the capability `cap` to the value of `value`. If `whom` is non-zero, the capability should be set for the target specified by the `scsi_address(9S)` structure pointed to by `ap`; if `whom` is 0, all targets are affected; else, the target specified by the `scsi_address` structure pointed to by `ap` is affected.

  It is recommended that HBA drivers do not support setting capabilities for all targets, that is, `whom` is 0.

  A device may support only a subset of the defined capabilities.

  Refer to `scsi_ifgetcap(9F)` for the list of defined capabilities.

  HBA drivers should use `scsi_hba_lookup_capstr(9F)` to match `cap` against the canonical capability strings.

**RETURN VALUES**
- `tran_setcap()` must return 1 if the capability was successfully set to the new value, 0 if the HBA driver does not support changing the capability, and −1 if the capability was not defined.
tran_getcap(9E)

tran_getcap() must return the current value of a capability or −1 if the capability was not defined.

SEE ALSO
attach(9E), scsi_hba_attach(9F), scsi_hba_lookup_capstr(9F),
scsi_ifgetcap(9F), scsi_address(9S), scsi_hba_tran(9S)

Writing Device Drivers
TRAN_INIT_PKT, TRAN_DESTROY_PKT – SCSI HBA packet preparation and deallocation

#include <sys/scsi/scsi.h>

struct scsi_pkt *prefixtran_init_pkt(struct scsi_address *ap, struct scsi_pkt *pkt, struct buf *bp, int cmdlen, int statuslen, int tgtlen, int flags, int (*callback, caddr_t, caddr_t arg);

void prefixtran_destroy_pkt(struct scsi_address *ap, struct scsi_pkt *pkt);

Solaris architecture specific (Solaris DDI).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ap</td>
<td>Pointer to a scsi_address(9S) structure.</td>
</tr>
<tr>
<td>pkt</td>
<td>Pointer to a scsi_pkt(9S) structure allocated in an earlier call, or NULL.</td>
</tr>
<tr>
<td>bp</td>
<td>Pointer to a buf(9S) structure if DMA resources are to be allocated for the pkt, or NULL.</td>
</tr>
<tr>
<td>cmdlen</td>
<td>The required length for the SCSI command descriptor block (CDB) in bytes.</td>
</tr>
<tr>
<td>statuslen</td>
<td>The required length for the SCSI status completion block (SCB) in bytes.</td>
</tr>
<tr>
<td>tgtlen</td>
<td>The length of the packet private area within the scsi_pkt to be allocated on behalf of the SCSI target driver.</td>
</tr>
<tr>
<td>flags</td>
<td>Flags for creating the packet.</td>
</tr>
<tr>
<td>callback</td>
<td>Pointer to either NULL_FUNC or SLEEP_FUNC.</td>
</tr>
<tr>
<td>arg</td>
<td>Always NULL.</td>
</tr>
</tbody>
</table>

The tran_init_pkt() and tran_destroy_pkt() vectors in the scsi_hba_tran structure must be initialized during the HBA driver’s attach(9E) to point to HBA entry points to be called when a target driver calls scsi_init_pkt(9F) and scsi_destroy_pkt(9F).

The tran_init_pkt() function is the entry point into the HBA which is used to allocate and initialize a scsi_pkt structure on behalf of a SCSI target driver. If pkt is NULL, the HBA driver must use scsi_hba_pkt_alloc(9F) to allocate a new scsi_pkt structure.

If bp is non-NULL, the HBA driver must allocate appropriate DMA resources for the pkt, for example, through ddi_dma_buf_setup(9F) or ddi_dma_buf_bind_handle(9F).

If the PKT_CONSISTENT bit is set in flags, the buffer was allocated by scsi_alloc_consistent_buf(9F). For packets marked with PKT_CONSISTENT, the HBA driver must synchronize any cached data transfers before calling the target driver’s command completion callback.
If the PKT_DMA_PARTIAL bit is set in flags, the HBA driver should set up partial data transfers, such as setting the DDI_DMA_PARTIAL bit in the flags argument if interfaces such as ddi_dma_buf_setup(9F) or ddi_dma_buf_bind_handle(9F) are used.

If only partial DMA resources are available, tran_init_pkt() must return in the pkt_resid field of pkt the number of bytes of DMA resources not allocated.

If both pkt and bp are non-NULL, if the PKT_DMA_PARTIAL bit is set in flags, and if DMA resources have already been allocated for the pkt with a previous call to tran_init_pkt() that returned a non-zero pkt_resid field, this request is to move the DMA resources for the subsequent piece of the transfer.

The contents of scsi_address(9S) pointed to by ap are copied into the pkt_address field of the scsi_pkt(9S) by scsi_hba_pkt_alloc(9F).

tgtlen is the length of the packet private area in the scsi_pkt structure to be allocated on behalf of the SCSI target driver.

statuslen is the required length for the SCSI status completion block. If the requested status length is greater than or equal to sizeof(struct scsi_arq_status) and the auto_rqsense capability has been set, automatic request sense (ARS) is enabled for this packet. If the status length is less than sizeof(struct scsi_arq_status), automatic request sense must be disabled for this pkt.

If the HBA driver is not capable of disabling ARQ on a per-packet basis and tran_init_pkt() is called with a statuslen that is less than sizeof(struct scsi_arq_status), the driver's tran_init_pkt routine should allocate at least sizeof(struct scsi_arq_status). If an ARS is needed, upon successful ARS done by the HBA driver, the driver must copy the sense data over and set STAT_ARQ_DONE in pkt_state.

cmdlen is the required length for the SCSI command descriptor block.

Note: tgtlen, statuslen, and cmdlen are used only when the HBA driver allocates the scsi_pkt(9S), in other words, when pkt is NULL.

callback indicates what the allocator routines should do when resources are not available:

NULL_FUNC Do not wait for resources. Return a NULL pointer.
SLEEP_FUNC Wait indefinitely for resources.

tran_destroy_pkt(9E) is the entry point into the HBA that must free all of the resources that were allocated to the scsi_pkt(9S) structure during tran_init_pkt().

RETURN VALUES tran_init_pkt() must return a pointer to a scsi_pkt(9S) structure on success, or NULL on failure.
If `pkt` is `NULL` on entry, and `tran_init_pkt()` allocated a packet through `scsi_hba_pkt_alloc(9F)` but was unable to allocate DMA resources, `tran_init_pkt()` must free the packet through `scsi_hba_pkt_free(9F)` before returning `NULL`.

**SEE ALSO**
- `attach(9E)`, `tran_sync_pkt(9E)`, `biodone(9F)`, `bioerror(9F)`
- `ddi_dma_buf_bind_handle(9F)`, `ddi_dma_buf_setup(9F)`
- `scsi_alloc_consistent_buf(9F)`, `scsi_destroy_pkt(9F)`
- `scsi_hba_attach(9F)`, `scsi_hba_pkt_alloc(9F)`, `scsi_hba_pkt_free(9F)`
- `scsi_init_pkt(9F)`, `buf(9S)`, `scsi_address(9S)`, `scsi_hba_tran(9S)`, `scsi_pkt(9S)`

**Writing Device Drivers**

**NOTES**
If a DMA allocation request fails with `DDI_DMA_NOMAPPING`, indicate the error by calling `bioerror(9F)` with `bp` and an error code of `EFAULT`.

If a DMA allocation request fails with `DDI_DMA_TOO_BIG`, indicate the error by calling `bioerror(9F)` with `bp` and an error code of `EINVAL`.
 tran_quiesce(9e)

NAME tran_quiesce, tran_unquiesce – quiesce and unquiesce a SCSI bus

SYNOPSIS

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

int prefix
tran_quiesce(dev_info_t *hba_dip);

int prefix
tran_unquiesce(dev_info_t *hba_dip);
```

INTERFACE LEVEL Solaris DDI
PARAMETERS

```
hba_dip The dev_info_t pointer associated with the SCSI HBA.
```

DESCRIPTION

The `tran_quiesce()` and `tran_unquiesce()` vectors in the `scsi_hba_tran(9S)` structure should be initialized during the HBA driver’s `attach(9E)`. They are HBA entry points to be called when a user initiates quiesce and unquiesce operations through device control interfaces.

`tran_quiesce()` should wait for all outstanding commands to complete and blocks (or queues) any I/O requests issued. `tran_unquiesce()` should allow I/O activities to resume on the SCSI bus.

Implementation is hardware specific.

RETURN VALUES

`tran_quiesce()` and `tran_unquiesce()` should return:

```
1 on success.
0 on failure.
```

ATTRIBUTES

See `attributes(5)` for a description of the following attributes:

```
<table>
<thead>
<tr>
<th>ATTRIBUTE TYPE</th>
<th>ATTRIBUTE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability Level</td>
<td>Evolving</td>
</tr>
</tbody>
</table>
```

SEE ALSO

`attributes(5), tran_bus_reset(9E), scsi_hba_tran(9S)`
### tran_reset(9E)

**NAME**
tran_reset – reset a SCSI bus or target

**SYNOPSIS**
```
#include <sys/scsi/scsi.h>

int prefix tran_reset(struct scsi_address *ap, int level);
```

**INTERFACE LEVEL**
Solaris architecture specific (Solaris DDI).

**PARAMETERS**
- `ap` Pointer to the scsi_address(9S) structure.
- `level` The level of reset required.

**DESCRIPTION**
The `tran_reset()` vector in the scsi_hba_tran(9S) structure must be initialized during the HBA driver's attach(9E) to point to an HBA entry point to be called when a target driver calls scsi_reset(9F).

#### level
`tran_reset()` must reset the SCSI bus or a SCSI target as specified by `level`.

- **RESET_ALL** reset the SCSI bus.
- **RESET_TARGET** reset the target specified by `ap`.

`tran_reset()` should set the pkt_reason field of all outstanding packets in the transport layer associated with each target that was successfully reset to CMD_RESET and the pkt_statistics field must be OR'ed with either STAT_BUS_RESET or STAT_DEV_RESET.

The HBA driver should use a SCSI Bus Device Reset Message to reset a target device.

Packets that are in the transport layer but not yet active on the bus should be returned with pkt_reason set to CMD_RESET, and pkt_statistics OR'ed with STAT_ABORTED.

**RETURN VALUES**
- `tran_reset()` should return:
  - 1 on success.
  - 0 on failure.

**SEE ALSO**
- attach(9E), ddi_dma_buf_setup(9F), scsi_hba_attach(9F), scsi_reset(9F), scsi_address(9S), scsi_hba_tran(9S)

*Writing Device Drivers*

**NOTES**
If `pkt_reason` already indicates that an earlier error had occurred for a particular `pkt`, `tran_reset()` should not overwrite `pkt_reason` with CMD_RESET.
tran_reset_notify(9E)

NAME
tran_reset_notify – request to notify SCSI target of bus reset

SYNOPSIS
#include <sys/scsi/scsi.h>

int tran_reset_notify(struct scsi_address *ap, int flag, void (*callback, caddr_t), caddr_t arg);

INTERFACE
Solaris architecture specific (Solaris DDI).

LEVEL
PARAMETERS

PARAMETERS

DESCRIPTION
The tran_reset_notify() entry point is called when a target driver requests notification of a bus reset.

The tran_reset_notify() vector in the scsi_hba_tran(9S) structure may be initialized in the HBA driver’s attach(9E) routine to point to the HBA entry point to be called when a target driver calls scsi_reset_notify(9F).

The argument flag is used to register or cancel the notification. The supported values for flag are as follows:

SCSI_RESET_NOTIFY Register callback as the reset notification function for the target.

SCSI_RESET_CANCEL Cancel the reset notification request for the target.

The HBA driver maintains a list of reset notification requests registered by the target drivers. When a bus reset occurs, the HBA driver notifies registered target drivers by calling the callback routine, callback, with the argument, arg, for each registered target.

RETURN VALUES
For SCSI_RESET_NOTIFY requests, tran_reset_notify() must return DDI_SUCCESS if the notification request has been accepted, and DDI_FAILURE otherwise.

For SCSI_RESET_CANCEL requests, tran_reset_notify() must return DDI_SUCCESS if the notification request has been canceled, and DDI_FAILURE otherwise.

SEE ALSO
attach(9E), scsi_ifgetcap(9F), scsi_reset_notify(9F), scsi_address(9S), scsi_hba_tran(9S)

Writing Device Drivers
### NAME

tran_start – request to transport a SCSI command

### SYNOPSIS

```c
#include <sys/scsi/scsi.h>

int prefix tran_start(struct scsi_address *ap, struct scsi_pkt *pkt);
```

### INTERFACE LEVEL PARAMETERS

- **pkt**
  - Pointer to the `scsi_pkt(9S)` structure that is about to be transferred.
- **ap**
  - Pointer to a `scsi_address(9S)` structure.

### DESCRIPTION

The `tran_start()` vector in the `scsi_hba_tran(9S)` structure must be initialized during the HBA driver's `attach(9E)` to point to an HBA entry point to be called when a target driver calls `scsi_transport(9F)`.

`tran_start()` must perform the necessary operations on the HBA hardware to transport the SCSI command in the `pkt` structure to the target/logical unit device specified in the `ap` structure.

If the flag `FLAG_NOINTR` is set in `pkt_flags` in `pkt`, `tran_start()` should not return until the command has been completed. The command completion callback `pkt_comp` in `pkt` must not be called for commands with `FLAG_NOINTR` set, since the return is made directly to the function invoking `scsi_transport(9F)`.

When the flag `FLAG_NOINTR` is not set, `tran_start()` must queue the command for execution on the hardware and return immediately. The member `pkt_comp` in `pkt` indicates a callback routine to be called upon command completion.

Refer to `scsi_pkt(9S)` for other bits in `pkt_flags` for which the HBA driver may need to adjust how the command is managed.

If the `auto_rqsense` capability has been set, and the status length allocated in `tran_init_pkt(9E)` is greater than or equal to `sizeof(struct scsi_arq_status)`, automatic request sense is enabled for this `pkt`. If the command terminates with a Check Condition, the HBA driver must arrange for a Request Sense command to be transported to that target/logical unit, and the members of the `scsi_arq_status` structure pointed to by `pkt_scbp` updated with the results of this Request Sense command before the HBA driver completes the command pointed by `pkt`.

The member `pkt_time` in `pkt` is the maximum number of seconds in which the command should complete. A `pkt_time` of 0 means no timeout should be performed.

For a command which has timed out, the HBA driver must perform some recovery operation to clear the command in the target, typically an Abort message, or a Device or Bus Reset. The `pkt_reason` member of the timed out `pkt` should be set to `CMD_TIMEOUT`, and `pkt_statistics` OR'ed with `STAT_TIMEOUT`. If the HBA driver can successfully recover from the timeout, `pkt_statistics` must also be OR'ed with one of `STAT_ABORTED`, `STAT_BUS_RESET`, or `STAT_DEV_RESET`, as appropriate. This informs the target driver that timeout recovery has already been
The pkt_comp completion callback, if not NULL, must also be called at the conclusion of the timeout recovery.

If the timeout recovery was accomplished with an Abort Tag message, only the timed out packet is affected, and the packet must be returned with pkt_statistics OR’ed with STAT_ABORTED and STAT_TIMEOUT.

If the timeout recovery was accomplished with an Abort message, all commands active in that target are affected. All corresponding packets must be returned with pkt_reason, CMD_TIMEOUT, and pkt_statistics OR’ed with STAT_TIMEOUT and STAT_ABORTED.

If the timeout recovery was accomplished with a Device Reset, all packets corresponding to commands active in the target must be returned in the transport layer for this target. Packets corresponding to commands active in the target must be returned returned with pkt_reason set to CMD_TIMEOUT, and pkt_statistics OR’ed with STAT_DEV_RESET and STAT_TIMEOUT. Currently inactive packets queued for the device should be returned with pkt_reason set to CMD_RESET and pkt_statistics OR’ed with STAT_ABORTED.

If the timeout recovery was accomplished with a Bus Reset, all packets corresponding to commands active in the target must be returned in the transport layer. Packets corresponding to commands active in the target must be returned with pkt_reason set to CMD_TIMEOUT and pkt_statistics OR’ed with STAT_TIMEOUT and STAT_BUS_RESET. All queued packets for other targets on this bus must be returned with pkt_reason set to CMD_RESET and pkt_statistics OR’ed with STAT_ABORTED.

Note that after either a Device Reset or a Bus Reset, the HBA driver must enforce a reset delay time of 'scsi-reset-delay' milliseconds, during which time no commands should be sent to that device, or any device on the bus, respectively.

tran_start() should initialize the following members in pkt to 0. Upon command completion, the HBA driver should ensure that the values in these members are updated to accurately reflect the states through which the command transitioned while in the transport layer.

pkt_resid
For commands with data transfer, this member must be updated to indicate the residual of the data transferred.

pkt_reason
The reason for the command completion. This field should be set to CMD_CMPLT at the beginning of tran_start(), then updated if the command ever transitions to an abnormal termination state. To avoid losing information, do not set pkt_reason to any other error state unless it still has its original CMD_CMPLT value.

pkt_statistics
Bit field of transport-related statistics.
tran_start(9E)

pkt_state Bit field with the major states through which a SCSI command can transition. Note: The members listed above, and pkt_hba_private member, are the only fields in the scsi_pkt(9S) structure which may be modified by the transport layer.

RETURN VALUES tran_start() must return:

TRAN_ACCEPT The packet was accepted by the transport layer.

TRAN_BUSY The packet could not be accepted because there was already a packet in progress for this target/logical unit, the HBA queue was full, or the target device queue was full.

TRAN_BADPKT The DMA count in the packet exceeded the DMA engine’s maximum DMA size, or the packet could not be accepted for other reasons.

TRAN_FATAL_ERROR A fatal error has occurred in the HBA.

SEE ALSO

attach(9E), tran_init_pkt(9E), scsi_hba_attach(9F), scsi_transport(9F), scsi_address(9S), scsi_arq_status(9S), scsi_hba_tran(9S), scsi_pkt(9S)

Writing Device Drivers
### tran_sync_pkt(9E)

**NAME**
tran_sync_pkt – SCSI HBA memory synchronization entry point

**SYNOPSIS**
```
#include <sys/scsi/scsi.h>

void prefx tran_sync_pkt(struct scsi_address *ap, struct scsi_pkt *pkt);
```

**INTERFACE LEVEL**
Solaris architecture specific (Solaris DDI).

**PARAMETERS**
- `ap` A pointer to a scsi_address(9S) structure.
- `pkt` A pointer to a scsi_pkt(9S) structure.

**DESCRIPTION**
The `tran_sync_pkt()` vector in the `scsi_hba_tran(9S)` structure must be initialized during the HBA driver’s `attach(9E)` to point to an HBA driver entry point to be called when a target driver calls `scsi_sync_pkt(9F)`.

`tran_sync_pkt()` must synchronize a HBA’s or device’s view of the data associated with the `pkt`, typically by calling `ddi_dma_sync(9F)`. The operation may also involve HBA hardware-specific details, such as flushing I/O caches, or stalling until hardware buffers have been drained.

**SEE ALSO**
- `attach(9E), tran_init_pkt(9E), ddi_dma_sync(9F), scsi_hba_attach(9F),
  scsi_init_pkt(9F), scsi_sync_pkt(9F), scsi_address(9S),
  scsi_hba_tran(9S), scsi_pkt(9S)`

Writing Device Drivers

**NOTES**
A target driver may call `tran_sync_pkt()` on packets for which no DMA resources were allocated.
# tran_tgt_free(9E)

## NAME
tran_tgt_free – request to free HBA resources allocated on behalf of a target

## SYNOPSIS
```c
#include <sys/scsi/scsi.h>

void prefix tran_tgt_free(dev_info_t *hba_dip, dev_info_t *tgt_dip,
                          scsi_hba_tran_t *hba_tran, struct scsi_device *sd);
```

## INTERFACE LEVEL
Solaris architecture specific (Solaris DDI).

## PARAMETERS
- **hba_dip**: Pointer to a `dev_info_t` structure, referring to the HBA device instance.
- **tgt_dip**: Pointer to a `dev_info_t` structure, referring to the target device instance.
- **hba_tran**: Pointer to a `scsi_hba_tran_t` structure, consisting of the HBA’s transport vectors.
- **sd**: Pointer to a `scsi_device` structure, describing the target.

## DESCRIPTION
The `tran_tgt_free()` vector in the `scsi_hba_tran_t` structure may be initialized during the HBA driver’s `attach(9E)` to point to an HBA driver function to be called by the system when an instance of a target device is being detached. The `tran_tgt_free()` vector, if not `NULL`, is called after the target device instance has returned successfully from its `detach(9E)` entry point, but before the `dev_info` node structure is removed from the system. The HBA driver should release any resources allocated during its `tran_tgt_init()` or `tran_tgt_probe()` initialization performed for this target device instance.

## SEE ALSO
- `attach(9E)`, `detach(9E)`, `tran_tgt_init(9E)`, `tran_tgt_probe(9E)`, `scsi_device(9S)`, `scsi_hba_tran(9S)`

Writing Device Drivers
**NAME**
tran_tgt_init – request to initialize HBA resources on behalf of a particular target

**SYNOPSIS**
```
#include <sys/scsi/scsi.h>

void prefinx tran_tgt_init(dev_info_t *hba_dip, dev_info_t *tgt_dip,
                      scsi_hba_tran_t *hba_tran, struct scsi_device *sd);
```

**INTERFACE LEVEL**
Solaris architecture specific (Solaris DDI).

**PARAMETERS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>hba_dip</td>
<td>Pointer to a dev_info_t structure, referring to the HBA device instance.</td>
</tr>
<tr>
<td>tgt_dip</td>
<td>Pointer to a dev_info_t structure, referring to the target device instance.</td>
</tr>
<tr>
<td>hba_tran</td>
<td>Pointer to a scsi_hba_tran(9S) structure, consisting of the HBA's transport vectors.</td>
</tr>
<tr>
<td>sd</td>
<td>Pointer to a scsi_device(9S) structure, describing the target.</td>
</tr>
</tbody>
</table>

**DESCRIPTION**
The tran_tgt_init() vector in the scsi_hba_tran(9S) structure may be initialized during the HBA driver's attach(9E) to point to an HBA driver function to be called by the system when an instance of a target device is being created. The tran_tgt_init() vector, if not NULL, is called after the dev_info node structure is created for this target device instance, but before probe(9E) for this instance is called. Before receiving transport requests from the target driver instance, the HBA may perform any initialization required for this particular target during the call of the tran_tgt_init() vector.

Note that hba_tran will point to a cloned copy of the scsi_hba_tran_t structure allocated by the HBA driver if the SCSI_HBA_TRAN_CLONE flag was specified in the call to scsi_hba_attach(9F). In this case, the HBA driver may choose to initialize the tran_tgt_private field in the structure pointed to by hba_tran, to point to the data specific to the particular target device instance.

**RETURN VALUES**
tran_tgt_init() must return:

- **DDI_SUCCESS** the HBA driver can support the addressed target, and was able to initialize per-target resources.
- **DDI_FAILURE** the HBA driver cannot support the addressed target, or was unable to initialize per-target resources. In this event, the initialization of this instance of the target device will not be continued, the target driver's probe(9E) will not be called, and the tgt_dip structure destroyed.

**SEE ALSO**
attach(9E), probe(9E), tran_tgt_free(9E), tran_tgt_probe(9E), scsi_hba_attach_setup(9F), scsi_device(9S), scsi_hba_tran(9S)

Writing Device Drivers
tran_tgt_probe(9E)

NAME
tran_tgt_probe – request to probing SCSI bus for a particular target

SYNOPSIS
#include <sys/scsi/scsi.h>

int prefixed_tran_tgt_probe(struct scsi_device *sd, int (*waitfunc, void));

INTERFACE
Solaris architecture specific (Solaris DDI).

LEVEL

PARAMETERS
sd Pointer to a scsi_device(9S) structure.

waitfunc Pointer to either NULL_FUNC or SLEEP_FUNC.

DESCRIPTION
The tran_tgt_probe() vector in the scsi_hba_tran(9S) structure may be initialized during the HBA driver's attach(9E) to point to a function to be called by scsi_probe(9F) when called by a target driver during probe(9E) and attach(9E) to probe for a particular SCSI target on the bus. In the absence of an HBA-specific tran_tgt_probe() function, the default scsi_probe(9F) behavior is supplied by the function scsi_hba_probe(9F).

The possible choices the HBA driver may make are:

- Initialize the tran_tgt_probe vector to point to scsi_hba_probe(9F), which results in the same behavior.
- Initialize the tran_tgt_probe vector to point to a private function in the HBA, which may call scsi_hba_probe(9F) before or after any necessary processing, as long as all the defined scsi_probe(9F) semantics are preserved.

waitfunc indicates what tran_tgt_probe() should do when resources are not available:

NULL_FUNC Do not wait for resources. See scsi_probe(9F) for defined return values if no resources are available.

SLEEP_FUNC Wait indefinitely for resources.

SEE ALSO
attach(9E), probe(9E), tran_tgt_free(9E), tran_tgt_init(9E),
scsi_hba_probe(9F), scsi_probe(9F), scsi_device(9S), scsi_hba_tran(9S)

Writing Device Drivers
### NAME
write – write data to a device

### SYNOPSIS
```c
#include <sys/types.h>
#include <sys/errno.h>
#include <sys/open.h>
#include <sys/cred.h>
#include <sys/ddi.h>
#include <sys/sunddi.h>

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

### INTERFACE LEVEL
Architecture independent level 1 (DDI/DKI). This entry point is optional.

### PARAMETERS
- **dev**: Device number.
- **uio_p**: Pointer to the uio(9S) structure that describes where the data is to be stored in user space.
- **cred_p**: Pointer to the 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 `cb_ops(9S)` by the `write(2)` system call. The `write()` routine supervises the data transfer from user space to a device described by the `uio(9S)` 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 VALUES
The `write()` routine should return 0 for success, or the appropriate error number.

### EXAMPLES
**EXAMPLE 1**
The following is an example of a `write()` routine using `physio(9F)` to perform writes to a seekable device:

```c
static int xxwrite(dev_t dev, struct uio *uiop, cred_t *credp)
{
    int instance;
    xx_t xx;

    instance = getminor(dev);
    xx = ddi_get_soft_state(xxstate, instance);
    if (xx == NULL)
        return (ENXIO);
    return (physio(xxstrategy, NULL, dev, B_WRITE,
                   xxmin, uiop));
}
```

### SEE ALSO
- `read(2), write(2), read(9E), physio(9F), cb_ops(9S), uio(9S)`
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