

# Linux Fast-STREAMS Porting Guide



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## Abstract:

This document is a Porting Guide containing technical details concerning the implementation of the Linux Fast-STREAMS for OpenSS7. It contains recommendations on software architecture as well as platform and system applicability of the Linux Fast-STREAMS.

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## Short Contents

Preface .....	1
1 Porting.....	5
2 Development.....	35
A Licenses.....	39
Indices .....	57



# Table of Contents

<b>Preface</b> .....	<b>1</b>
Acknowledgements.....	1
Sponsors.....	1
Contributors.....	1
Supporters.....	1
Telecommunications.....	1
Aerospace and Military.....	3
Financial, Business and Security.....	3
Education, Health Care and Nuclear Power.....	4
Agencies.....	4
<b>1 Porting</b> .....	<b>5</b>
1.1 Base Functions.....	5
1.1.1 Message Functions.....	5
1.1.1.1 Compatibilty Functions.....	5
1.1.2 UP Queue Functions.....	7
1.1.3 MP Queue Functions.....	8
1.1.4 DDI/DKI Functions.....	10
1.1.5 Some Common Extension Functions.....	11
1.1.6 Some Internal Functions.....	12
1.1.7 Some Oddball Functions.....	12
1.2 Porting from SVR 3.2.....	13
1.2.1 Differences from SVR 3.2.....	13
1.2.2 Commonalities with SVR 3.2.....	13
1.2.3 Compatibility functions for SVR 3.2.....	13
1.2.4 Configuration ala SVR 3.2.....	13
1.3 Porting from SVR 4.2 MP.....	14
1.3.1 Differences from SVR 4.2 MP.....	14
1.3.1.1 Priority Levels.....	14
1.3.2 Commonalities with SVR 4.2 MP.....	14
1.3.3 Compatibility functions for SVR 4.2 MP.....	14
1.3.3.1 STREAMS Locks.....	15
1.3.3.2 Basic Locks.....	15
1.3.3.3 Read-Write Locks.....	15
1.3.3.4 Sleep Locks.....	16
1.3.3.5 Synchronization Variables.....	16
1.3.3.6 Atomic Integers.....	17
1.3.3.7 Set Processor Level.....	17
1.3.3.8 Additional Compatibility Functions.....	17
1.3.4 Configuration ala SVR 4.2 MP.....	18
1.4 Porting from AIX 5L Version 5.1.....	19
1.4.1 Differences from AIX 5L Version 5.1.....	19
1.4.2 Commonalities with AIX 5L Version 5.1.....	19
1.4.3 Compatibility Functions for AIX 5L Version 5.1.....	19
1.4.4 Configuration ala AIX 5L Version 5.1.....	20
1.5 Porting from HP-UX 11.0i v2.....	21
1.5.1 Differences from HP-UX 11.0i v2.....	21

1.5.2	Commonalities with HP-UX 11.0i v2	21
1.5.3	Compatibility Functions for HP-UX 11.0i v2	21
1.5.4	Configuration ala HP-UX 11.0i v2	21
1.6	Porting from OSF/1 1.2/Digital UNIX	23
1.6.1	Differences from OSF/1 1.2/Digital UNIX	23
1.6.2	Commonalities with OSF/1 1.2/Digital UNIX	23
1.6.3	Compatibility Functions for OSF/1 1.2/Digital UNIX	23
1.6.4	Configuration ala OSF/1 1.2/Digital UNIX	23
1.7	Porting from UnixWare 7.1.3 (OpenUnix 8)	24
1.7.1	Differences from UnixWare 7.1.3 (OpenUnix 8)	24
1.7.2	Commonalities with UnixWare 7.1.3 (OpenUnix 8)	24
1.7.3	Compatibility Functions for UnixWare 7.1.3 (OpenUnix 8)	24
1.7.4	Configuration ala UnixWare 7.1.3 (OpenUnix 8)	24
1.8	Porting from Solaris 9/SunOS 5.9	25
1.8.1	Differences from Solaris 9/SunOS 5.9	25
1.8.2	Commonalities with Solaris 9/SunOS 5.9	25
1.8.3	Compatibility Functions for Solaris 9/SunOS 5.9	25
1.8.4	Configuration ala Solaris 9/SunOS 5.9	26
1.9	Porting from SUPER-UX	27
1.9.1	Differences from SUPER-UX	27
1.9.2	Commonalities with SUPER-UX	27
1.9.3	Compatibility Functions for SUPER-UX	27
1.9.4	Configuration ala SUPER-UX	27
1.10	Porting from UXP/V	28
1.10.1	Differences from UXP/V	28
1.10.2	Commonalities with UXP/V	28
1.10.3	Compatibility Functions for UXP/V	28
1.10.4	Configuration ala UXP/V	28
1.11	Porting from Mac Open Transport	29
1.11.1	Differences from Mac Open Transport	29
1.11.2	Commonalities with Mac Open Transport	29
1.11.3	Compatibility Functions for Mac Open Transport	29
1.11.4	Configuration ala Mac Open Transport	29
1.12	Porting from Mentat Portable STREAMS	30
1.12.1	Differences from Mentat Portable STREAMS	30
1.12.2	Commonalities with Mentat Portable STREAMS	30
1.12.3	Compatibility Functions for Mentat Portable STREAMS	30
1.12.4	Configuration ala Mentat Portable STREAMS	33
<b>2</b>	<b>Development</b>	<b>35</b>
2.1	Portable STREAMS Drivers and Modules	35
2.1.1	Memory Allocation	35
2.1.2	Alignment of Message Buffers	35
2.1.3	Disabling and Enabling Queue Procedures	35
2.1.4	Freezing and Unfreezing Streams	35
2.1.5	Passing Messages from Interrupt Service Routines	35
2.1.6	Timeout Call Back and Link Identifiers	35
2.1.7	Synchronization with Timeouts and Callback Functions	35
2.1.8	Synchronization with Callout Functions	36
2.1.9	Synchronization of Drivers and Modules	36
2.1.10	Special STREAMS Message Types	36
2.1.11	Use of Message Allocation Priorities	36
2.1.12	Registration/Deregistration and Device Numbering	36

<b>Appendix A Licenses</b> .....	<b>39</b>
A.1 GNU General Public License .....	40
A.1.1 Preamble .....	40
A.1.2 How to Apply These Terms to Your New Programs .....	49
A.2 GNU Free Documentation License .....	50
<b>Indices</b> .....	<b>57</b>
Concept Index .....	58
Type Index .....	63
Function and Macro Index .....	64
Variable and Constant Macro Index .....	65
Program and File Index .....	66



## Preface

### Acknowledgements

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- ATM Forum
- EIA/TIA (Electronic Industries Alliance)
- ETSI (European Telecommunications Standards Institute)
- ICAO (International Civil Aviation Organization)
- IEEE (Institute of Electrical and Electronic Engineers)
- IETF (The Internet Engineering Task Force)
- ISO (International Organization for Standardization)
- ITU (International Telecommunications Union)
- Multiservices Forum
- The Open Group

Of these, ICAO, ISO, IEEE and EIA have made at least some documents publicly available. ANSI is notably missing from the list: at one time draft documents were available from ANSI (ATIS), but that was curtailed some years ago. Telecordia does not release any standards publicly. Hopefully these organizations will see the light and realize, as the others have, that to remain current as a standards organization in today's digital economy requires providing individuals with free access to documents.

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<sup>4</sup> Ecole Nationale Supérieure des Télécommunications

<sup>5</sup> Hochschule für Technik und Wirtschaft des Saarlandes

# 1 Porting

Although each of the manual pages of supported functions and structures provides compatibility and porting information, this document attempts to gather together pertinent information concerning porting from various UNIX operating system supporting STREAMS.

The porting information is organized by the operating system from which porting is being attempted. Note that, aside from configuration details, any system not listed here that is based on SVR 4.2 MP or on another of the implementations, should start with that implementation's portability information.

Porting information is organized into sections as follows:

## 1.1 Base Functions

*OpenSS7* provides a complete set of base functions and utilities for STREAMS as defined in the *SVR 4 Programmer's Guide – STREAMS*. These are the base set of functions with which the STREAMS module and driver writer is familiar.

### 1.1.1 Message Functions

*OpenSS7* performs stricter message block, data block and buffer alignment than most STREAMS implementations to maintain maximum compatibility with other implementations. Message blocks, data blocks and data buffers are always aligned at least to an SMP cache boundary, permitting DMA of message blocks, data blocks and data buffers. ISA DMA capability is not ensured for message blocks or data blocks, however, external data buffers can be so allocated with *Linux* allocators and attached to a message and data buffer with **esballoc(9)**.

Data buffers of size less than the value *FASTBUF* are allocated of size *FASTBUF* and are internal to the data block. A *FASTBUF* is at least 64-bytes on 32-bit architectures and at least 128-bytes on 64-bit architectures. Internal data buffers of size *FASTBUF* are aligned to a 64-byte boundary on 32-bit architecture and to a 128-byte boundary on 64-bit architectures.

Data buffers of larger than a *FASTBUF* are allocated using general purpose *Linux* allocators (i.e. **kmem\_alloc(9)**). *Linux* always allocates a memory extent of a power of two in size that fits the requested number of bytes and always aligns the memory extent to the memory boundary that is the same power of two as the resulting size. This is stricter in alignment than the description of most *UNIX* memory allocators.

*OpenSS7* also supports the *BPRI\_WAITOK* priority to **allocb(9)** that will allocate memory block, data block and data buffer using *KM\_SLEEP* and will block the calling process if either memory block, data block or data buffer are not immediately available.

#### 1.1.1.1 Compatibility Functions

Following are the basic STREAMS message functions. Most portability issues concerning STREAMS message functions have to do with allocation, alignment of the data buffer, priority of allocation, disposition of unused message blocks, handling of *NULL* pointer arguments, buffer callback and message free routine handling.

- adjmsg(9)** Trim bytes from the front or back of a STREAMS message. Trimmed message blocks are not freed but simply have their *b\_wptr* set to their *b\_rptr*.
- allocb(9)** Allocate a STREAMS message and data block. This function also accepts the *BPRI\_WAITOK* flag which allocates all parts of the message 3-tuple using *KM\_SLEEP* allocation. Allocation of less than *FASTBUF* bytes will allocate a data

buffer of size *FASTBUF*. *FASTBUF* sized data buffers are internal to the data block, and message block, data block and data buffer 3-types are allocated as a unit for speed. Data buffers are allocated on a memory boundary that is the same as the next power of two sized buffer.

- bufcall(9)** Install a buffer callback. *OpenSS7* provides the additional assurance that the callback routine will not be called until the caller returns from the calling function block.
- copyb(9)** Copy a STREAMS message block. A *NULL* pointer passed as an argument will panic the kernel.
- copymsg(9)** Copy a STREAMS message. Performs a block-wise copy using **copyb(9)**.
- datamsg(9)** Tests a STREAMS message type for data.
- dupb(9)** Duplicate a STREAMS message block. *OpenSS7* uses a global lock to protect the *db\_refs* member of the data block.
- dupmsg(9)** Duplicate a STREAMS message. Performs a block-wise duplication using **dupb(9)**.
- esballoc(9)** Allocate a STREAMS message and data block with a caller supplied data buffer. This is the most portable method of allocating a data buffer that requires some particular alignment. The callback free routine is inherently unsafe when the function is provided by a module and modules are permitted to unload.
- freeb(9)** Frees a STREAMS message block.
- freemsg(9)** Frees a STREAMS message. Performs a block-wise free using **freeb(9)**.
- linkb(9)** Link a message block to a STREAMS message. Panics if either argument is *NULL*.
- msgdsiz(9)** Calculate the size of the data in a STREAMS message. Accepts a *NULL* pointer, in which case the function returns zero ('0').
- msgpullup(9)** Pull up bytes in a STREAMS message. Might allocate a new message to satisfy the request.
- pcmsg(9)** Test a data block message type for priority control.
- pullupmsg(9)** Pull up the bytes in a STREAMS message. Does not allocate a new initial message block, but may allocate a new initial data block and data buffer. The pointers '*mp->b\_wptr*' and '*mp->b\_rptr*' are potentially invalidated by the call.
- rmvb(9)** Remove a message block from a STREAMS message. The message block must exist in the message. Passing *NULL* pointers will panic the kernel.
- testb(9)** Test if a STREAMS message can be allocated. Because the test is not atomic, when this function returns true, a subsequent call to **allobc(9)** could still fail.
- unbufcall(9)** Remove a STREAMS buffer callback. *OpenSS7* provides the *SVR 4* assurance that before the call returns the callback function will either have been cancelled or execution of the callback will be complete.
- unlinkb(9)** Unlink a message block from a STREAMS message.

### 1.1.2 UP Queue Functions

Single processor queue functions are those functions that existed in *SVR 4* before multi-processor support was added in *SVR 4.1 MP* and *SVR 4.2*. Most portability issues associated with these functions concern queue *q\_next* pointer dereferencing and freezing of Streams when directly manipulating queues. *OpenSS7* provides the added assurance that *q\_next* pointers can always be reliably dereferenced from within a queue put, service, open, close or synchronized callback procedure.

**backq(9)** Find the upstream or downstream queue. *OpenSS7* protects this pointer dereference when called from within a put, service, open, close or callback procedure.

**bcanput(9)** Test flow control on a STREAMS message queue. *OpenSS7* follows *SVR 4* semantics for queue enabling, queue flags and back-enabling.

**canenable(9)** Test whether a STREAMS message queue can be scheduled. This only effects normal priority messages as per *SVR 4* semantics.

**enableok(9)** Allow a STREAMS message queue to be scheduled. This only effects normal priority messages as per *SVR 4* semantics.

**flushband(9)** Flushes band STREAMS messages from a message queue. *OpenSS7* provides a mechanism that efficiently flushes large numbers of messages from a queue: messages are unlinked from the queue and freed later by the STREAMS scheduler.

**flushq(9)** Flushes messages from a STREAMS message queue. *OpenSS7* provides a mechanism that efficiently flushes large numbers of messages from a queue: messages are unlinked from the queue and freed later by the STREAMS scheduler.

**getq(9)** Gets a message from a STREAMS message queue. *OpenSS7* follows *SVR 4* semantics for queue enabling, queue flags and back-enabling.

**insq(9)** Inserts a message into a STREAMS message queue. *OpenSS7* recommends, but does not require, that the Stream be first frozen by the caller with a call to **freezestr(9)**.<sup>1</sup>

**noenable(9)** Disable a STREAMS message queue from being scheduled. This only effects normal priority messages as per *SVR 4* semantics.

**OTHERQ(9)** Return the other queue of a STREAMS queue pair.

**putbq(9)** Put a message back on a STREAMS message queue. *OpenSS7* follows *SVR 4* semantics for queue enabling, queue flags and back-enabling.

**putctl(9)** Put a control message on a STREAMS message queue.

**putctl1(9)** Put a 1 byte control message on a STREAMS message queue.

**putq(9)** Put a message on a STREAMS message queue. *OpenSS7* follows *SVR 4* semantics for queue enabling, queue flags and back-enabling.

<sup>1</sup> It is possible that the STREAMS module or driver writer can make such assurances with mechanisms other than **freezestr(9)**. See the **freezestr(9)** manual page for more information.

- qenable(9)** Schedules a STREAMS message queue service routine.
- qreply(9)** Replies to a message from a STREAMS message queue.
- qsize(9)** Return the number of messages on a queue.
- RD(9)** Return the read queue of a STREAMS queue pair. Although *OpenSS7* accepts a read queue pointer as an argument, doing so could panic some implementations. The macro **\_RD(9)** is also provided that has this stricter behaviour.
- rmvq(9)** Remove a message from a STREAMS message queue. *OpenSS7* recommends, but does not require, that the Stream be first frozen by the caller with a call to **freezestr(9)**.<sup>2</sup>
- SAMESTR(9)**  
Test for STREAMS pipe or fifo.
- WR(9)** Return the write queue of a STREAMS queue pair. Although *OpenSS7* accepts a write queue pointer as an argument, doing so could panic some implementations. The macro **\_WR(9)** is also provided that has this stricter behaviour.

### 1.1.3 MP Queue Functions

When multiprocessing support was added to STREAMS in *SVR 4.1 MP* and *SVR 4.2*, it became necessary to enhance the STREAMS interface with a number of additional functions intended on easing multiprocessor implementation of STREAMS. Most portability issues with functions in this category involve queue pointer dereferencing, and queue manipulation.

*OpenSS7* provides stronger assurances for *q\_next* pointer dereferencing that are experienced on most other STREAMS implementations, to maintain maximum compatibility. *OpenSS7* acquires a Stream head plumbing read lock before entering queue put, service, open, close and queue synchronous callback procedures within the Stream. This means that a function call such as ‘**canput(q->q\_next)**’ and ‘**canputnext(q)**’ have identical effect within the synchronous procedure.

#### **bcanputnext(9)**

Test flow control on a message queue. *OpenSS7* ensures the validity of *q\_next* pointer dereferencing for any queue in the queue pair for which a queue put, service, open, close or synchronized callback procedure is the context of the dereference. For other *q\_next* dereferences (e.g. at a Stream end or across a multiplexing driver), the **bcanputnext(9)** utility should be used instead of the **bcanput(9)** utility. ‘**bcanputnext(q, band)**’ should always be preferred over ‘**bcanput(q->q\_next, band)**’.

#### **canputnext(9)**

Test flow control on a message queue. *OpenSS7* ensures the validity of *q\_next* pointer dereferencing for any queue in the queue pair for which a queue put, service, open, close or synchronized callback procedure is the context of the dereference. For other *q\_next* dereferences (e.g. at a Stream end or across a multiplexing driver), the **canputnext(9)** utility should be used instead of the **canput(9)** utility. ‘**canputnext(q)**’ should always be preferred over ‘**canput(q->q\_next)**’.

#### **freezestr(9)**

Freeze the state of a stream queue. **freezestr(9)** was provided in the MP environment to behave in the same fashion as **spl(9)** did in the UP environment. In the UP environment it was a simply matter to suppress interrupts before directly manipulating queue structures and then re-enable interrupts after queue manipulation was complete.

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<sup>2</sup> It is possible that the STREAMS module or driver writer can make such assurances with mechanisms other than **freezestr(9)**. See the **freezestr(9)** manual page for more information.

- put(9)** Invoke the put procedure for a STREAMS module or driver with a STREAMS message. In the UP environment, the queue at a Stream end could be called directly such as `(*q->q_qinfo->q_i_putp)(q, mp)`. In the MP environment, this would circumvent the STREAMS synchronization model and the **put(9)** utility function should be used instead.
- putnext(9)** Put a message on the downstream STREAMS message queue. In the UP environment, the adjacent queue put procedure could be called directly such as `(*q->q_next->q_qinfo->q_i_putp)(q, mp)`. In the MP environment, this would circumvent the STREAMS synchronization model and the **putnext(9)** utility function should be used instead. `putnext(q, mp)` should always be used in preference to `put(q->q_next, mp)`.
- putnextctl(9)** Put a 1 byte control message on the downstream STREAMS message queue. A `q_next` pointer dereferencing version of **putctl(9)**. `putnextctl(q, type, param)` should always be used in preference to `putctl(q->q_next, type, param)`.
- putnextctl(9)** Put a control message on the downstream STREAMS message queue. A `q_next` pointer dereferencing version of **putctl(9)**. `putnextctl(q, type)` should always be used in preference to `putctl(q->q_next, type)`.
- qprocsoff(9)** Disables STREAMS message queue processing for multi-processing.
- qprocson(9)** Enables STREAMS message queue processing for multi-processing. In the UP environment, it was possible to prepare the queue service and put procedures for proper operation before returning and permitting the queue to run put or service procedures. In the MP environment, it became necessary to indicate within the open procedure when queue procedures are to be permitted to run before returning (or blocking). **qprocson(9)** was added to accomplish this. *SVR 4* says that this function must be cause before returning from the queue open routine. *OpenSS7* will invoke the function implicitly if it is not called before the queue open routine returns (but must still be called explicitly if the queue open routine blocks awaiting an event on the queue).
- strqget(9)** Gets information about a STREAMS message queue. In the UP environment, it was possible to directly manipulate streamtab or queue structures after suppressing interrupts. The **strqget(9)** utility provides a mechanism for manipulating these structures in the MP environment. Some implementations conflict on whether a Stream must first be frozen with **freezestr(9)** or not. *OpenSS7* recommends that the Stream be frozen across a call to **strqget(9)**, but it is not required.
- strqset(9)** Sets attributes of a STREAMS message queue. In the UP environment, it was possible to directly manipulate streamtab or queue structures after suppressing interrupts. The **strqset(9)** utility provides a mechanism for manipulating these structures in the MP environment. Some implementations conflict on whether a Stream must first be frozen with **freezestr(9)** or not. *OpenSS7* recommends that the Stream be frozen across a call to **strqset(9)**, but it is not required.
- unfreezestr(9)** Thaw the state of a stream queue. **unfreezestr(9)** was provided in the MP environment to behave in the same fashion as **splx(9)** did in the UP environment.

### 1.1.4 DDI/DKI Functions

Traditionally, SVR 4 provided some DDI/DKI (Device Driver Interface/Driver Kernel Interface) functions for use by device drivers, including STREAMS device drivers. Many of these functions have survived into kernel/driver interfaces today in one form or another. Some implementations (particularly Solaris<sup>®</sup>) provide a wide array of additional DDI/DKI functions. Additional functions are supported by Compatibility Modules, and the base SVR 4 functions are provided by the base OpenSS7 package.

#### **kmem\_alloc(9)**

Allocate kernel memory.

#### **kmem\_free(9)**

Deallocates kernel memory.

#### **kmem\_zalloc(9)**

Allocate and zero kernel memory.

#### **cmn\_err(9)**

Print a kernel command error.

**bcopy(9)** Copy byte strings. This is the basic BSD-style function for copying bytes. Traditionally STREAMS has used the BSD-style function **bcopy(9)** instead of the SVR3-style **memcpy(9)**.<sup>3</sup>

**bzero(9)** Zero a byte string. This is the basic BSD-style function for zeroing bytes. Traditionally STREAMS has used the BSD-style function **bzero(9)** instead of the SVR3-style **memset(9)**.<sup>4</sup>

**copyin(9)** Copy user data in from user space to kernel space. In the UP environment, the top module put procedure was called in user context and it was possible to copy bytes directly from the user and block in this context. In the MP environment and with an MP STREAMS synchronization model, the top module put procedure could be called outside of the Stream head user context. Therefore, this function has little use under STREAMS.

**copyout(9)** Copy user data in from kernel space to user space. In the UP environment, the top module put procedure was called in user context and it was possible to copy bytes directly to the user and block in this context. In the MP environment and with an MP STREAMS synchronization model, the top module put procedure could be called outside of the Stream head user context. Therefore, this function has little use under STREAMS.

**delay(9)** Postpone the calling process for a number of clock ticks.

#### **drv\_getparm(9)**

Driver retrieve kernel parameter.

#### **drv\_hztomsec(9)**

Convert kernel tick time between microseconds or milliseconds.

#### **drv\_htztousec(9)**

Convert kernel tick time between microseconds or milliseconds.

<sup>3</sup> Perhaps this has something to do with STREAMS first being implemented on BSD 4.2.

<sup>4</sup> Perhaps this has something to do with STREAMS first being implemented on BSD 4.2.

- drv\_msectohz(9)** Convert kernel tick time between microseconds or milliseconds.
- drv\_priv(9)** Check if the current process is privileged.
- drv\_usectohz(9)** Convert kernel tick time between microseconds or milliseconds.
- drv\_usecwait(9)** Delay for a number of microseconds.
- min(9)** Determine the minimum of two integers.
- max(9)** Determine the maximum of two integers.
- getmajor(9)** Get the internal major device number for a device.
- getminor(9)** Get the extended minor device number for a device.
- makedevice(9)** Create a device from a major and minor device numbers.
- strlog(9)** Pass a message to the STREAMS logger.
- timeout(9)** Start a timer. Although general purpose in nature, the **timeout(9)** and **untimeout(9)** utilities were most often used for STREAMS modules and drivers. Some implementations only support these functions for STREAMS.
- untimeout(9)** Stop a timer. Although general purpose in nature, the **timeout(9)** and **untimeout(9)** utilities were most often used for STREAMS modules and drivers. Some implementations only support these functions for STREAMS.
- mknod(9)** Make block or character special files.
- mount(9)** Mount and unmount file systems.
- umount(9)** Mount and unmount file systems.
- unlink(9)** Remove a file.

### 1.1.5 Some Common Extension Functions

One of the most common extension functions is the ability to put a control message with two bytes as parameters. At some point the **M\_ERROR(9)** message was extended to include a separate error code for the Stream head write and read side. Also, at some point the **M\_FLUSH(9)** message was extended to include a band number as well as a flag byte. **putctl2(9)** and **putnextctl2(9)** were provided to accept and generate two arguments instead of one as their **putctl1(9)** and **putnextctl1(9)** counterparts provide. *OpenSS7* supports these functions as part of the base package.

Another common extension of *OSF/1* or *Mentat* derived STREAMS implementations is the ability to weld two queues together in pipe- or FIFO-like arrangements while maintaining queue synchronization. The two utilities **weldq(9)** and **unweldq(9)** were often included to provide this facility. *OpenSS7* supports these functions as part of the base package.

- linkmsg(9)** Link a message block to a STREAMS message.

- putctl2(9)** Put a two byte control message on a STREAMS message queue.
- putnextctl2(9)**  
Put a two byte control message on the downstream STREAMS message queue.
- weldq(9)** Weld two (or four) queues together.
- unweldq(9)**  
Unweld two (or four) queues.

### 1.1.6 Some Internal Functions

*OpenSS7* exposes some internal STREAMS functions that are exposed by many STREAMS implementations but which are not documented as available to the STREAMS module and driver writer. These functions are exposed for the purpose of compatibility with other implementations as well as providing some functions that are necessary to implement enhanced Stream heads, specialized drivers or modules such as the **clone(4)** driver or **conmld(4)** module.

Following are some of the exposed functions that are typically exposed by other STREAMS implementations as well:

- allocq(9)** Allocate a STREAMS queue pair.
- bcanget(9)** Test for message arrival on a band on a stream.
- canget(9)** Test for message arrival on a stream.
- freeq(9)** Deallocate a STREAMS queue pair.
- qattach(9)** Attach a module onto a STREAMS file.
- qclose(9)** Close a STREAMS module or driver.
- qdetach(9)** Detach a module from a STREAMS file.
- qopen(9)** Call a STREAMS module or driver open routine.
- setq(9)** Set sizes and procedures associated with a STREAMS message queue.

### 1.1.7 Some Oddball Functions

- appq(9)** Append one STREAMS message after another.
- esbbcall(9)**  
Install a buffer callback for an extended STREAMS message block.
- isdatablk(9)**  
Test a STREAMS data block for data type.
- isdatamsg(9)**  
Test a STREAMS data block for data type.
- kmem\_zalloc\_node(9)**  
Allocate and zero a NUMA memory extent.
- msgsize(9)** Calculate the size of the message blocks in a STREAMS message.
- qcountstrm(9)**  
Add all counts on all STREAMS message queues in a stream.
- xmsgsize(9)**  
Calculate the size of message blocks in a STREAMS message.

## 1.2 Porting from SVR 3.2

Detailed portability information for porting STREAMS modules and drivers from *SVR 3.2* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the `svr3compat(9)` manual page. The *STREAMS Compatibility Modules* package also provides some *SVR 3.2* specific compatibility functions.

This section captures portability information for *SVR 3.2* based systems. If the operating system from which you are porting more closely fits one of the other portability sections, please see that section.

For the most part, porting from *SVR 3.2* to *OpenSS7* is not much different than porting forward from *SVR 3.2* to *SVR 4.2 MP*. If you wish to be able to access some backward compatible *SVR 3.2* functions, use the *SVR 3 Compatibility Module* from the `strcompat` package.

Therefore, it is recommended that STREAMS modules and drivers for *SVR 3.2* be ported forward to *SVR 4.2 MP* before being ported to *OpenSS7*.

### 1.2.1 Differences from SVR 3.2

The most significant difference in *SVR 3.2* and *SVR 4* was the declaration of the queue open and close routine entry points. Some STREAMS implementations still support both *SVR 3.2* entry point declarations as well as *SVR 4* entry point declarations. *OpenSS7* only supports the *SVR 4* style entry points.

*SVR 3.2* was not MP-safe. *OpenSS7* is MP-safe.

A significant number of utilities were implemented in *SVR 3.2* as architecture dependent macros. In *SVR 4* these became architecture independent function calls.

In general, *OpenSS7* is different from *SVR 3.2* in any way that *SVR 3.2* is different from *SVR 4.2 MP*.

### 1.2.2 Commonalities with SVR 3.2

In general, most of the STREAMS utility functions that were present in *SVR 3.2* also made it into *SVR 4* (with few exceptions). *SVR 3.2* did not yet have the concept of a DDI/DKI, but the STREAMS functions present in *SVR 3.2* appear in the *SVR 4.2 MP* DDI/DKI.

### 1.2.3 Compatibility functions for SVR 3.2

#### `alloc_proto(9)`

Allocate control and data message blocks.

`emajor(9)` Get the external (real) major device number from the device number.

`eminor(9)` Get the external extended minor device number from the device number.

### 1.2.4 Configuration ala SVR 3.2

I have never seen a description of *SVR 3.2* STREAMS configuration. I can only assume that it involved relinking the kernel in some fashion.

## 1.3 Porting from SVR 4.2 MP

Detailed portability information for porting STREAMS modules and drivers from *SVR 4.2 MP* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the `svr4compat(9)` manual page. The *STREAMS Compatibility Modules* package also provides some *SVR 4.2 MP* specific compatibility functions.

This section captures portability information for SVR 4.2 MP based systems. If the operating system from which you are porting more closely fits one of the other portability sections, please see that section.

### 1.3.1 Differences from SVR 4.2 MP

*OpenSS7* has very few differences from *SVR 4.2 MP*. Not all *SVR 4.2 MP* functions are implemented in the base *OpenSS7* kernel modules. Some functions are included in the *SVR 4.2 MP* Compatibility Module (`streams_svr4compat.ko`) from the `strcompat` package.

#### 1.3.1.1 Priority Levels

**Linux** has a different concept of priority levels than *SVR 4.2 MP*. **Linux** has basically 4 priority levels as follows:

1. Preemptive

At this priority level, software and hardware interrupts are enabled and the kernel is executing with preemption enabled. This means that the currently executing kernel thread could preempt and sleep in favour of another thread of kernel execution.

This priority level only exists on preemptive (mostly 2.6 and 3.x) kernels.

2. Non-Preemptive

At this priority level, software and hardware interrupts are enabled and the kernel is executing with preemption disabled. This means that the currently executing kernel thread will only be interrupted by software or hardware interrupts.

This priority level exists in all kernels.

3. Software Interrupts Disabled

At this priority level, software interrupts are disabled and the kernel is executing with preemption disabled. This means that the currently executing kernel thread will only be interrupted by hardware interrupts.

This is the case when the executing thread is processing a software interrupt, or when the currently executing thread has disabled software interrupts.

This priority level exists in all kernels.

4. Interrupt Service Routines Disabled

At this priority level, hardware interrupts are disabled and the kernel is executing with preemption disabled. This means that the currently executing kernel thread will not be interrupted.

This is the case when the executing thread is processing a hardware interrupt, or when the currently executing thread has disabled hardware interrupts.

This priority level exists in all kernels.

### 1.3.2 Commonalities with SVR 4.2 MP

### 1.3.3 Compatibility functions for SVR 4.2 MP

### 1.3.3.1 STREAMS Locks

STREAMS locks are those that are mentioned in the *SVR 4 Programmer's Guide – STREAMS*. These locks lock a queue or Stream head for exclusive access. *OpenSS7* implements queue and Stream head locks as read-write locks, so these locks translate to taking a write lock on the queue or Stream head. These locks are not normally used by STREAMS modules and drivers and are therefore left in the *SVR 4.2 MP Compatibility Module*, `streams_svr4compat.ko`, from the STREAMS Compatibility Modules package, `strcompat`.

#### **MPSTR\_QLOCK(9)**

Release a queue from exclusive access.

#### **MPSTR\_QRELE(9)**

Acquire a queue for exclusive access.

#### **MPSTR\_STPLOCK(9)**

Acquire a stream head for exclusive access.

#### **MPSTR\_STPRELE(9)**

Release a stream head from exclusive access.

### 1.3.3.2 Basic Locks

Basic locks are similar to *Linux* spin locks and can be used as an ABI replacement for *Linux* spin locks. It is rather typical for *OpenSS7 Project* STREAMS modules and drivers to use *Linux* spin locks directly instead of via these functions. Therefore these locks are left in the *SVR 4.2 MP Compatibility Module*, `streams_svr4compat.ko`, from the STREAMS Compatibility Modules package, `strcompat`.

**LOCK(9)** Lock a basic lock.

#### **LOCK\_ALLOC(9)**

Allocate a basic lock.

#### **LOCK\_DEALLOC(9)**

Deallocate a basic lock.

#### **LOCK\_OWNED(9)**

Determine whether a basic lock is held by the caller.

#### **TRYLOCK(9)**

Try to lock a basic lock.

#### **UNLOCK(9)**

Unlock a basic lock.

### 1.3.3.3 Read-Write Locks

Read-write locks are similar to *Linux* read-write locks and can be used as an ABI replacement for *Linux* read-write locks.

#### **RW\_ALLOC(9)**

Allocate and initialize a read/write lock.

#### **RW\_DEALLOC(9)**

Deallocate a read/write lock.

#### **RW\_RDLOCK(9)**

Acquire a read/write lock in read mode.

**RW\_TRYRDLOCK(9)**

Attempt to acquire a read/write lock in read mode.

**RW\_TRYWRLOCK(9)**

Attempt to acquire a read/write lock in write mode.

**RW\_UNLOCK(9)**

Release a read/write lock.

**RW\_WRLOCK(9)**

Acquire a read/write lock in write mode.

**1.3.3.4 Sleep Locks**

Sleep locks are similar to *Linux* semaphores or mutexes.

**SLEEP\_ALLOC(9)**

Allocate a sleep lock.

**SLEEP\_DEALLOC(9)**

Deallocate a sleep lock.

**SLEEP\_LOCK(9)**

Acquire a sleep lock.

**SLEEP\_LOCKAVAIL(9)**

Determine whether a sleep lock is available.

**SLEEP\_LOCKOWNED(9)**

Determine whether a sleep lock is held by the caller.

**SLEEP\_LOCK\_SIG(9)**

Acquire a sleep lock.

**SLEEP\_TRYLOCK(9)**

Attempt to acquire a sleep lock.

**SLEEP\_UNLOCK(9)**

Release a sleep lock.

**1.3.3.5 Synchronization Variables**

Synchronization variables are similar to *Linux* wait queues.

**SV\_ALLOC(9)**

Allocate a basic condition variable.

**SV\_BROADCAST(9)**

Broadcast a basic condition variable.

**SV\_DEALLOC(9)**

Deallocate a basic condition variable.

**SV\_SIGNAL(9)**

Signal a basic condition variable.

**SV\_WAIT(9)**

Wait on a basic condition variable.

**SV\_WAIT\_SIG(9)**

Interruptible wait on a basic condition variable.

### 1.3.3.6 Atomic Integers

Atomic Integers are similar to *Linux* atomic integers.

**ATOMIC\_INT\_ADD(9)**

Add an integer value to an atomic integer.

**ATOMIC\_INT\_ALLOC(9)**

Allocate and initialize an atomic integer.

**ATOMIC\_INT\_DEALLOC(9)**

Deallocate an atomic integer.

**ATOMIC\_INT\_DECR(9)**

Decrement and test an atomic integer.

**ATOMIC\_INT\_INCR(9)**

Increment an atomic integer.

**ATOMIC\_INT\_INIT(9)**

Initialize an atomic integer.

**ATOMIC\_INT\_READ(9)**

Read an atomic integer.

**ATOMIC\_INT\_SUB(9)**

Subtract an integer value from an atomic integer.

**ATOMIC\_INT\_WRITE(9)**

Write an integer value to an atomic integer.

### 1.3.3.7 Set Processor Level

Processor levels are similar to *Linux* local irq or soft irq suppression.

**spl0(9)** Set priority level 0.

**spl1(9)** Set priority level 1.

**spl2(9)** Set priority level 2.

**spl3(9)** Set priority level 3.

**spl4(9)** Set priority level 4.

**spl5(9)** Set priority level 5.

**spl6(9)** Set priority level 6.

**spl7(9)** Set priority level 7.

**spl(9)** Set priority level.

**splx(9)** Set priority level x.

### 1.3.3.8 Additional Compatibility Functions

**itimeout(9)**

Perform a timeout at an interrupt level.

**lbolt(9)**

Time in ticks since reboot.

**major(9)** Get the internal major number of a device.

**makedev(9)**

Make a device number from internal major and minor device numbers.

**minor(9)** Get the internal minor number of a device.

**sleep(9)** Put a process to sleep.

**vtop(9)** Convert virtual to physical address.

**wakeup(9)** Wake a process.

#### **1.3.4 Configuration ala SVR 4.2 MP**

## 1.4 Porting from AIX 5L Version 5.1

Detailed portability information for porting STREAMS modules and drivers from *AIX* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the `aixcompat(9)` manual page. The *STREAMS Compatibility Modules* package also provides some *AIX* specific compatibility functions.

Most of the STREAMS functions and DDI/DKI functions provided by *AIX*<sup>®</sup> are also provided by the *OpenSS7* base package. Some utilities, however, are provided by the *AIX* Compatibility Module (`streams_aixcompat.ko`) from the *STREAMS Compatibility Module* package (`strcompat`).

### 1.4.1 Differences from AIX 5L Version 5.1

### 1.4.2 Commonalities with AIX 5L Version 5.1

### 1.4.3 Compatibility Functions for AIX 5L Version 5.1

The compatibility functions described below are described in the STREAMS module and driver documentation for *AIX*. Some of these functions are provided also with other implementations (such as *OSF/1* or *Mentat*).

The following functions are typically also provided by *most* STREAMS implementations:

**putctl2(9)** Put a 2 byte control message on a STREAMS.

**splstr(9)** Set processor level for STREAMS.

**splx(9)** Set or restore processor level.

**unweldq(9)**  
Unweld two pairs of streams queues.

**weldq(9)** Weld together two pairs of streams queues.

The following functions are really just *Mentat Portable STREAMS* functions that made their way into *AIX*: (Portability considerations for *Mentat Portable STREAMS* functions is described in.)

**mi\_bufcall(9)**  
Reliable alternative to **bufcall(9)**. This is really just a *Mentat Portable STREAMS* function that made its way into *AIX*.

**mi\_close\_comm(9)**  
STREAMS common minor device close utility. This is really just a *Mentat Portable STREAMS* function that made its way into *AIX*.

**mi\_next\_ptr(9)**  
STREAMS minor device list traversal. This is really just a *Mentat Portable STREAMS* function that made its way into *AIX*.

**mi\_open\_comm(9)**  
STREAMS common minor device open utility. This is really just a *Mentat Portable STREAMS* function that made its way into *AIX*.

**mi\_prev\_ptr(9)**  
STREAMS minor device list traversal. This is really just a *Mentat Portable STREAMS* function that made its way into *AIX*.

The following functions are unique to *AIX*:

In particular, the **wantio(9)** and **wantmsg(9)** facilities are incredibly convoluted and complex and only documented by *AIX*. Although *OpenSS7* implements these functions (in the *AIX* Compatibility Module, **streams\_aixcompat.ko**, from the STREAMS Compatibility Module package, **strcompat**) as faithfully as possible, their use should be completely avoided by portable programs.

**wantio(9)** Perform direct I/O from a STREAMS driver.

**wantmsg(9)**  
Provide a filter of wanted messages from a STREAMS module.

#### 1.4.4 Configuration ala *AIX* 5L Version 5.1

##### **str\_install(9)**

Install a STREAMS module or driver. Each implementation has a different mechanism for registration and deregistration of STREAMS modules and drivers. This is the mechanism used by *AIX*. It should be avoided by programs that are not being ported from *AIX*. *AIX*-style STREAMS registration and deregistration is implemented in the *AIX* Compatibility Module, **streams\_aixcompat.ko**, from the STREAMS Compatibility Module package, **strcompat**.

## 1.5 Porting from HP-UX 11.0i v2

Detailed portability information for porting STREAMS modules and drivers from *HP-UX* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the `hpuxcompat(9)` manual page. The *STREAMS Compatibility Modules* package also provides some *HP-UX* specific compatibility functions.

### 1.5.1 Differences from HP-UX 11.0i v2

*HP-UX* stubs out the `qprocson(9)`, `qprocsoff(9)`, `freezestr(9)` and `unfreezestr(9)` utility functions. *HP-UX* expects that the appropriate level of synchronization be used instead.<sup>1</sup> Because of this, it is recommended that *HP-UX* drivers and modules port directly to the *OpenSS7* environment, not be run at synchronization level `SQLVL_NOP`. See `str_install_HPUX(9)`.

### 1.5.2 Commonalities with HP-UX 11.0i v2

#### 1.5.3 Compatibility Functions for HP-UX 11.0i v2

The following compatibility functions are typical extensions and are also provided by the *OpenSS7* base package:

`putctl2(9)` put a 2 byte control message on a STREAMS message queue

`putnextctl2(9)`  
put a 2 byte control message on the downstream STREAMS message queue

`unweldq(9)`  
unweld two pairs of streams queues

`weldq(9)` weld together two pairs of streams queues

The following compatibility functions are peculiar to *HP-UX*<sup>2</sup> and are only part of the *HP-UX* compatibility module, `streams_hpuxcompat.ko`, from the *STREAMS Compatibility Modules*, `strcompat`, package:

`get_sleep_lock(9)`  
Provide access to the global sleep lock.

`streams_get_sleep_lock(9)`  
Provide access to the global sleep lock.

`streams_mpsleep(9)`  
Put a process to sleep.

`streams_put(9)`  
Invoke the put procedure for a STREAMS module or driver with a STREAMS message.

### 1.5.4 Configuration ala HP-UX 11.0i v2

Installation, registration and deregistration of STREAMS modules and drivers is one of the least standardized mechanisms across the various STREAMS implementations. Each implementation has its own mechanism and *HP-UX* is no different. The following compatibility functions provide the *HP-UX* specific STREAMS driver installation, registration and deregistration style:

<sup>1</sup> *STREAMS/UX for the HP 9000 Reference Manual*, 1995, (Palo Alto, California), Hewlett-Package Company, HP. <http://docs.hp.com/>

<sup>2</sup> *STREAMS/UX for the HP 9000 Reference Manual*, 1995, (Palo Alto, California), Hewlett-Package Company, HP. <http://docs.hp.com/>

## Chapter 1: Porting

### **str\_install(9)**

Install a STREAMS module or driver.

### **str\_uninstall(9)**

Uninstall a STREAMS module or driver.

## 1.6 Porting from OSF/1 1.2/Digital UNIX

Detailed portability information for porting STREAMS modules and drivers from *OSF/1* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the `osfcompat(9)` manual page. The *STREAMS Compatibility Modules* package also provides some *OSF/1* specific compatibility functions.

### 1.6.1 Differences from OSF/1 1.2/Digital UNIX

### 1.6.2 Commonalities with OSF/1 1.2/Digital UNIX

### 1.6.3 Compatibility Functions for OSF/1 1.2/Digital UNIX

#### `unweldq(9)`

Unweld two pairs of streams queues.

`weldq(9)` Weld together two pairs of streams queues.

`lbolt(9)` Time in ticks since reboot.

`puthere(9)` Invoke the put procedure for a STREAMS module or driver with a STREAMS message.

#### `streams_close_comm(9)`

Common minor device close utility.

#### `streams_open_comm(9)`

Common minor device open utility.

#### `streams_open_ocomm(9)`

Common minor device open utility.

`time(9)` (undoc)

### 1.6.4 Configuration ala OSF/1 1.2/Digital UNIX

#### `strmod_add(9)`

Add a STREAMS module.

#### `strmod_del(9)`

Delete a STREAMS module or driver from the kernel.

## 1.7 Porting from UnixWare 7.1.3 (OpenUnix 8)

Detailed portability information for porting STREAMS modules and drivers from *UnixWare* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the `uw7compat(9)` manual page. The *STREAMS Compatibility Modules* package also provides some *UnixWare* specific compatibility functions.

### 1.7.1 Differences from UnixWare 7.1.3 (OpenUnix 8)

### 1.7.2 Commonalities with UnixWare 7.1.3 (OpenUnix 8)

### 1.7.3 Compatibility Functions for UnixWare 7.1.3 (OpenUnix 8)

The following compatibility functions are in addition to all SVR 4.2 compatibility functions.

**allocb\_physreq(9)**

Allocate a STREAMS message and data block.

**emajor(9)** Get the external (real) major device number from the device number.

**eminor(9)** Get the external extended minor device number from the device number.

**etoimajor(9)**

Convert an external major device number to an internal major device number.

**getemajor(9)**

Get the external (real) major device number.

**geteminor(9)**

Get the external minor device number.

**itoemajor(9)**

Convert an internal major device number to an external major device number.

**msgphysreq(9)**

Cause a message block to meet physical requirements.

**msgpullup\_physreq(9)**

Pull up bytes in a STREAMS message.

**msgscgth(9)**

(undoc)

**striocall(9)**

(undoc)

### 1.7.4 Configuration ala UnixWare 7.1.3 (OpenUnix 8)

## 1.8 Porting from Solaris 9/SunOS 5.9

Detailed portability information for porting STREAMS modules and drivers from *Solaris* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the [suncompat\(9\)](#) manual page. The *STREAMS Compatibility Modules* package also provides some *Solaris* specific compatibility functions.

### 1.8.1 Differences from Solaris 9/SunOS 5.9

### 1.8.2 Commonalities with Solaris 9/SunOS 5.9

### 1.8.3 Compatibility Functions for Solaris 9/SunOS 5.9

#### **ddi\_create\_minor\_node(9)**

Create a minor node for this device.

#### **ddi\_driver\_major(9)**

Find the major device number associated with a driver.

#### **ddi\_driver\_name(9)**

Return normalized driver name.

#### **ddi\_get\_cred(9)**

Get a reference to the credentials of the current user.

#### **ddi\_getiminor(9)**

#### **ddi\_get\_instance(9)**

Get device instance number.

#### **ddi\_get\_lbolt(9)**

Get the current value of the system tick clock.

#### **ddi\_get\_pid(9)**

#### **ddi\_get\_soft\_state(9)**

#### **ddi\_get\_time(9)**

Get the current time in seconds since the epoch.

#### **ddi\_remove\_minor\_node(9)**

Remove a minor node for a device.

#### **ddi\_removing\_power(9)**

#### **ddi\_soft\_state(9)**

#### **ddi\_soft\_state\_fini(9)**

#### **ddi\_soft\_state\_free(9)**

#### **ddi\_soft\_state\_init(9)**

#### **ddi\_soft\_state\_zalloc(9)**

#### **ddi\_umem\_alloc(9)**

Allocate page aligned kernel memory.

#### **ddi\_umem\_free(9)**

**power(9)** Power a device attached to the system.

#### **probe(9)**

**qbufcall(9)** Install a buffer callback.

**qtimeout(9)** Start a timer associated with a queue.

**queclass(9)**

**qunbufcall(9)**

**quntimeout(9)**

**qwait(9)** Wait for a queue message.

**qwait\_sig(9)**

Wait for a queue message or signal.

**qwriter(9)**

#### 1.8.4 Configuration ala Solaris 9/SunOS 5.9

**\_fini(9)**

**\_info(9)**

**\_init(9)**

**attach(9)** Attach a device to the system or resume a suspended device.

**detach(9)** Detach a device from the system or suspend a device.

**getinfo(9)**

**identify(9)** Determine if a driver is associated with a device.

**install\_driver(9)**

Install a device driver.

**mod\_info(9)**

Provides information on a loadable kernel module to the STREAMS executive.

**mod\_install(9)**

Installs a loadable kernel module in the STREAMS executive.

**mod\_remove(9)**

Removes a loadable module from the STREAMS executive.

## 1.9 Porting from SUPER-UX

Detailed portability information for porting STREAMS modules and drivers from *SUPER-UX* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the `suxcompat(9)` manual page. The *STREAMS Compatibility Modules* package also provides some *SUPER-UX* specific compatibility functions.

### 1.9.1 Differences from SUPER-UX

### 1.9.2 Commonalities with SUPER-UX

### 1.9.3 Compatibility Functions for SUPER-UX

`lbolt(9)` Time in ticks since reboot.

### 1.9.4 Configuration ala SUPER-UX

## 1.10 Porting from UXP/V

Detailed portability information for porting STREAMS modules and drivers from *UXP/V* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the `uxpcompat(9)` manual page. The *STREAMS Compatibility Modules* package also provides some *UXP/V* specific compatibility functions.

### 1.10.1 Differences from UXP/V

### 1.10.2 Commonalities with UXP/V

### 1.10.3 Compatibility Functions for UXP/V

### 1.10.4 Configuration ala UXP/V

## 1.11 Porting from Mac Open Transport

Detailed portability information for porting STREAMS modules and drivers from *Mac Open Transport* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the `maccompat(9)` manual page. The *STREAMS Compatibility Modules* package also provides some *Mac Open Transport* specific compatibility functions.

### 1.11.1 Differences from Mac Open Transport

### 1.11.2 Commonalities with Mac Open Transport

### 1.11.3 Compatibility Functions for Mac Open Transport

### 1.11.4 Configuration ala Mac Open Transport

## 1.12 Porting from Mentat Portable STREAMS

Detailed portability information for porting STREAMS modules and drivers from *Mentat Portable STREAMS* to *OpenSS7* is contained in the *STREAMS Compatibility Modules* package, `strcompat`, under the `mppscompat(9)` manual page. The *STREAMS Compatibility Modules* package also provides some *Mentat Portable STREAMS* specific compatibility functions.

### 1.12.1 Differences from Mentat Portable STREAMS

### 1.12.2 Commonalities with Mentat Portable STREAMS

### 1.12.3 Compatibility Functions for Mentat Portable STREAMS

#### `mi_alloc(9)`

Allocate and free kernel memory without later regard to size.

#### `mi_allocq(9)`

`allocq(9)` replacement.

#### `mi_alloc_sleep(9)`

`kmem_alloc(9)` replacement.

#### `mi_attach(9)`

Associate instance data with a STREAMS queue.

#### `mi_bcmp(9)`

`bcmp(9)` replacement.

#### `mi_bufcall(9)`

Reliable alternative to `bufcall(9)`.

#### `mi_close_comm(9)`

STREAMS common minor device close utility.

#### `mi_close_detached(9)`

Release instance data from the STREAMS queue and perform close cleanup.

#### `mi_close_free(9)`

Free a STREAMS driver or module instance on close.

#### `mi_copy_done(9)`

`ioctl(2s)` complete.

#### `mi_copyin(9)`

Copy data to a user buffer.

#### `mi_copyin_n(9)`

Copy data to a user buffer.

#### `mi_copyout(9)`

Copy data from a user buffer.

#### `mi_copyout_alloc(9)`

Allocate a buffer to be copied out using `mi_copyout(9)`.

#### `mi_copy_set_rval(9)`

Set return value for input-output control.

- mi\_copy\_state(9)**  
Current state of the input-output control process.
- mi\_detach(9)**  
Disassociate instance data from the STREAMS queue.
- mi\_first\_dev\_ptr(9)**  
Obtain first device instance pointer.
- mi\_first\_ptr(9)**  
Obtain first instance pointer.
- mi\_free(9)** **kmem\_free(9)** replacement.
- mi\_freeq(9)**  
**freeq(9)** replacement.
- mi\_mprintf(9)**  
Print a formatted string to a message buffer.
- mi\_mprintf\_nr(9)**  
Continue to print a formatted string to a message buffer.
- mi\_next\_dev\_ptr(9)**  
Obtain next device instance pointer.
- mi\_next\_ptr(9)**  
STREAMS minor device list traversal.
- mi\_offset\_param(9)**  
Obtain parameter location within STREAMS message block.
- mi\_offset\_paramc(9)**  
Obtain parameter location within STREAMS message block chain.
- mi\_open\_alloc(9)**  
Allocate a STREAMS module or driver instance.
- mi\_open\_alloc\_sleep(9)**  
Allocate a STREAMS module or driver instance (may sleep).
- mi\_open\_comm(9)**  
STREAMS common minor device open utility.
- mi\_open\_detached(9)**  
STREAMS create detached instance data.
- mi\_open\_link(9)**  
Link a STREAMS driver or module instance on open.
- mi\_prev\_ptr(9)**  
STREAMS minor list traversal.
- mi\_timer\_q\_switch(9)**  
Switch STREAMS queues for a timer message.
- mi\_reallocb(9)**  
Reallocated a STREAMS message block.

- mi\_reuse\_proto(9)**  
Reuse a STREAMS protocol message block.
- mi\_set\_sth\_copyopt(9)**  
Set the STREAMS Stream head copy options.
- mi\_set\_sth\_hiwat(9)**  
Set the STREAMS Stream head high water mark.
- mi\_set\_sth\_lowat(9)**  
Set the STREAMS Stream head low water mark.
- mi\_set\_sth\_maxblk(9)**  
Set the STREAMS Stream head maximum block size.
- mi\_set\_sth\_wroff(9)**  
Set the STREAMS Stream head write offset.
- mi\_sprintf(9)**  
**sprintf(9)** replacement.
- mi\_sprintf\_putc(9)**  
Put a character in a sprintf buffer.
- mi\_strcmp(9)**  
**strcmp(9)** replacement.
- mi\_strlen(9)**  
**strlen(9)** replacement.
- mi\_strlog(9)**  
**strlog(9)** replacement.
- mi\_strtol(9)**  
**strtol(9)** replacement.
- mi\_timer(9)**  
Process a STREAMS timer.
- mi\_timer\_alloc(9)**  
Allocate a STREAMS timer.
- mi\_timer\_cancel(9)**  
Cancel a STREAMS timer.
- mi\_timer\_free(9)**  
Free a STREAMS timer.
- mi\_timer\_move(9)**  
Move a STREAMS timer.
- mi\_timer\_q\_switch(9)**  
Switch queues for a STREAMS timer.
- mi\_timer\_stop(9)**  
Stop a STREAMS timer.
- mi\_timer\_valid(9)**  
Check a STREAMS timer.

- mi\_zalloc(9)**  
    **kmem\_zalloc(9)** replacement.
- mi\_zalloc\_sleep(9)**  
    **kmem\_zalloc(9)** replacement.
- mi\_tpi\_ack\_alloc(9)**  
    Allocate a **T\_OK\_ACK(7)** or **T\_ERROR\_ACK(7)** primitive.
- mi\_tpi\_conn\_con(9)**  
    Generate a **T\_CONN\_CON(7)** primitive.
- mi\_tpi\_conn\_ind(9)**  
    Generate a **T\_CONN\_IND(7)** primitive.
- mi\_tpi\_conn\_req(9)**  
    Generate a **T\_CONN\_REQ(7)** primitive.
- mi\_tpi\_data\_ind(9)**  
    Generate a **T\_DATA\_IND(7)** primitive.
- mi\_tpi\_data\_req(9)**  
    Generate a **T\_DATA\_REQ(7)** primitive.
- mi\_tpi\_discon\_ind(9)**  
    Generate a **T\_DISCON\_IND(7)** primitive.
- mi\_tpi\_discon\_req(9)**  
    Generate a **T\_DISCON\_REQ(7)** primitive.
- mi\_tpi\_err\_ack\_alloc(9)**  
    Generate a **T\_ERROR\_ACK(7)** primitive.
- mi\_tpi\_exdata\_ind(9)**  
    Generate a **T\_EXDATA\_IND(7)** primitive.
- mi\_tpi\_exdata\_req(9)**  
    Generate a **T\_EXDATA\_REQ(7)** primitive.
- mi\_tpi\_info\_req(9)**  
    Generate a **T\_INFO\_REQ(7)** primitive.
- mi\_tpi\_ok\_ack\_alloc(9)**  
    Generate a **T\_OK\_ACK(7)** primitive.
- mi\_tpi\_ordrel\_ind(9)**  
    Generate a **T\_ORDREL\_IND(7)** primitive.
- mi\_tpi\_ordrel\_req(9)**  
    Generate a **T\_ORDREL\_REQ(7)** primitive.
- mi\_tpi\_uderror\_ind(9)**  
    Generate a **T\_UDERROR\_IND(7)** primitive.
- mi\_tpi\_unitdata\_ind(9)**  
    Generate a **T\_UNITDATA\_IND(7)** primitive.
- mi\_tpi\_unitdata\_req(9)**  
    Generate a **T\_UNITDATA\_REQ(7)** primitive.

#### 1.12.4 Configuration ala Mentat Portable STREAMS



## 2 Development

### 2.1 Portable STREAMS Drivers and Modules

In the process of creating the **Linux Fast-STREAMS** subsystem in such a way so as to facilitate portability of STREAMS drivers and modules from a wide range of *UNIX* operating system variants, a number of guidelines for the development of portable STREAMS drivers and modules have been developed. These guidelines, when adhered to, will allow the resulting driver or module to be ported to another STREAMS implementation with minimal effort. These portability guidelines are collected here.

#### 2.1.1 Memory Allocation

Portable STREAMS modules and drivers will always allocate memory using the SVR4 memory allocators/deallocators: **kmem\_alloc(9)**, **kmem\_zalloc(9)** and **kmem\_free(9)**.

Additional eligible allocators are:

**rmallocmap(9)** **rmfreemap(9)** **rmalloc(9)** **rmalloc\_wait(9)** **rmfree(9)** **rminit(9)** **rmsetwant(9)** **rmwanted(9)**

Unfortunately, these resource map allocators are not available on *AIX* so, if portability to the *AIX PSE* is important, then do not use these allocators.

Additional eligible allocators are:

**kmem\_fast\_alloc(9)** **kmem\_fast\_free(9)**

#### 2.1.2 Alignment of Message Buffers

#### 2.1.3 Disabling and Enabling Queue Procedures

Portable STREAMS modules and drivers will always call **qprocson(9)** before returning from its queue open procedure (see **qopen(9)**).

Portable STREAMS modules and drivers will always call **qprocoff(9)** upon entering its queue close procedure (see **qclose(9)**).

#### 2.1.4 Freezing and Unfreezing Streams

#### 2.1.5 Passing Messages from Interrupt Service Routines

#### 2.1.6 Timeout Call Back and Link Identifiers

Although buffer callbacks identifiers (see **bufcall(9)**), timeout identifiers (see **timeout(9)**), and multiplexing driver link identifiers (see *L\_LINK* and *L\_PLINK* under **streamio(2)**), are often illustrated as small integer numbers, with some STREAMS implementations, including **Linux Fast-STREAMS**, these identifiers are kernel addresses (pointers) and are never small integer values like 1, 2, or 3.

Also, there is no guarantee that the identifier will be positive. It is guaranteed that the returned identifier will not be zero (0). Zero is used by these function as a return value to indicate an error.

Portable STREAMS drivers and modules will not depend upon the returned identifier from **bufcall(9)**, **timeout(9)** or **streamio(2)** as being any specific range of value. Portable drivers and modules will save any returned identifiers in data types that will not lose the precision of the identifier.

#### 2.1.7 Synchronization with Timeouts and Callback Functions

### 2.1.8 Synchronization with Callout Functions

### 2.1.9 Synchronization of Drivers and Modules

### 2.1.10 Special STREAMS Message Types

### 2.1.11 Use of Message Allocation Priorities

### 2.1.12 Registration/Deregistration and Device Numbering

#### UNIX Device Numbering

In versions of *UNIX System V* previous to *Release 4*, the major and minor device numbers were each 8 bit, and they were packed into a 16 bit word (usually a C Language *short* variable). Under *UNIX System V Release 4*, the device numbers are held in a `'dev_t'` variable, which is often implemented as a 32 bit integer. The minor device number is held as 14 bits, and a further 8 bits are used for the major device number. `'dev_t'` is often referred to as the "expanded device type", since it allows many more minor devices than before.

Many drivers were written for earlier releases, and may eventually be ported to *UNIX System V Release 4*. In earlier releases, some manufacturers got around the 256 minor device number limit by using multiple major device numbers for a device. Devices were created with different major device numbers (the external major device number) but they all mapped to the same device driver entry in the device switch tables (the internal device number). Even under this scheme, each major device could only support 256 minor devices, but the driver could support many more. This has been recognized in *UNIX System V Release 4*, and functions are provided to do this mapping; for example, the function `etoimajor()` and so on, give a machine independent interface to the device number mapping.<sup>1</sup>

#### Linux Device Numbering

Versions of the **Linux** kernel in the 2.4 kernel series and prior to 2.6 also provided an 8 bit major device number and an 8 bit minor device number grouped into a 16-bit combined device number. Linux 2.6 and 3.x kernels (and some patched 2.4 kernels) now have larger device numbers. These extended device numbers are 12 bits for major device number and 20 bits for minor device number, with 32 bits for the combined device number.

#### Linux Fast-STREAMS Device Numbering

**Linux Fast-STREAMS** began with extended device numbering. The `specfs` shadow special character device file system used by **Linux Fast-STREAMS** uses the `'inode'` number to hold the `'dev_t'` device number instead of the `'inode->i_rdev'`, which on older kernels is only a 16-bit *short*.

In earlier versions of **Linux Fast-STREAMS**, the internal device numbering is 16-bits for major device number and 16-bits for minor device number. This will soon be changed to 12-bits for major device number and 20-bits for minor device number to accommodate the newer **Linux** scheme.

On 2.6 and 3.x **Linux** kernels that support the newer extended device numbers, external device numbers and internal device numbers will be the same. On 2.4 **Linux** kernels with the older 16-bit

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<sup>1</sup> *The Magic Garden Explained*

device numbers, external device number and internal device numbers will differ. In some situations, an internal device number can exist with no corresponding external device number (accessed only via a clone device or direct access to the mounted `specfs` shadow special character device file system).

**etoimajor(9)**

change external to internal major device number

**getemajor(9)**

get external major device number

**geteminor(9)**

get external minor device number

**itoemajor(9)**

change internal to external major device number



## Appendix A Licenses

## A.1 GNU General Public License

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Version 3, 29 June 2007

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## Indices

## Concept Index

-	
<code>_fini(9)</code> .....	26
<code>_info(9)</code> .....	26
<code>_init(9)</code> .....	26
<code>_RD(9)</code> .....	8
<code>_WR(9)</code> .....	8
<b>A</b>	
<code>adjmsg(9)</code> .....	5
agencies .....	4
<code>aixcompat(9)</code> .....	19
<code>alloc_proto(9)</code> .....	13
<code>allocb(9)</code> .....	5, 6
<code>allocb_physreq(9)</code> .....	24
<code>allocq(9)</code> .....	12, 30
<code>appq(9)</code> .....	12
<code>ATOMIC_INT_ADD(9)</code> .....	17
<code>ATOMIC_INT_ALLOC(9)</code> .....	17
<code>ATOMIC_INT_DEALLOC(9)</code> .....	17
<code>ATOMIC_INT_DECR(9)</code> .....	17
<code>ATOMIC_INT_INCR(9)</code> .....	17
<code>ATOMIC_INT_INIT(9)</code> .....	17
<code>ATOMIC_INT_READ(9)</code> .....	17
<code>ATOMIC_INT_SUB(9)</code> .....	17
<code>ATOMIC_INT_WRITE(9)</code> .....	17
<code>attach(9)</code> .....	26
<b>B</b>	
<code>backq(9)</code> .....	7
Base Functions .....	5
<code>bcanget(9)</code> .....	12
<code>bcanput(9)</code> .....	7, 8
<code>bcanputnext(9)</code> .....	8
<code>bcmp(9)</code> .....	30
<code>bcopy(9)</code> .....	10
<code>bufcall(9)</code> .....	6, 30
<code>buffcall(9)</code> .....	19
<code>bzero(9)</code> .....	10
<b>C</b>	
<code>canenable(9)</code> .....	7
<code>canget(9)</code> .....	12
<code>canput(9)</code> .....	8
<code>canputnext(9)</code> .....	8
<code>clone(4)</code> .....	12
<code>cmn_err(9)</code> .....	10
commonalities with aix 5l version 5.1 .....	19
commonalities with hp-ux 11.0i v2 .....	21
commonalities with mac open transport .....	29
commonalities with mentat portable streams ...	30
commonalities with osf/1 1.2/digial unix .....	23
commonalities with solaris 9/sunos 5.9 .....	25
commonalities with super-ux .....	27
Commonalities with SVR 3.2 .....	13
commonalities with svr 4.2 mp .....	14
commonalities with unixware 7.1.3 (openunix 8) .....	24
commonalities with uxp/v .....	28
compatibility functions for aix 5l version 5.1 ...	19
compatibility functions for hp-ux 11.0i v2 .....	21
compatibility functions for mac open transport .....	29
compatibility functions for mentat portable streams .....	30
compatibility functions for osf/1 1.2/digial unix .....	23
compatibility functions for solaris 9/sunos 5.9 ..	25
compatibility functions for super-ux .....	27
Compatibility functions for SVR 3.2 .....	13
compatibility functions for svr 4.2 mp .....	14
compatibility functions for unixware 7.1.3 (openunix 8) .....	24
compatibility functions for uxp/v .....	28
configuration ala aix 5l version 5.1 .....	20
configuration ala hp-ux 11.0i v2 .....	21
configuration ala mac open transport .....	29
configuration ala mentat portable streams .....	33
configuration ala osf/1 1.2/digial unix .....	23
configuration ala solaris 9/sunos 5.9 .....	26
configuration ala super-ux .....	27
Configuration ala SVR 3.2 .....	13
configuration ala svr 4.2 mp .....	18
configuration ala unixware 7.1.3 (openunix 8) ..	24
configuration ala uxp/v .....	28
<code>conlld(4)</code> .....	12
contributors .....	1
<code>copyb(9)</code> .....	6
<code>copyin(9)</code> .....	10
<code>copymsg(9)</code> .....	6
<code>copyout(9)</code> .....	10
credits .....	1
<b>D</b>	
<code>datams(9)</code> .....	6
DDI/DKI functions .....	10
<code>ddi_create_minor_node(9)</code> .....	25
<code>ddi_driver_major(9)</code> .....	25
<code>ddi_driver_name(9)</code> .....	25
<code>ddi_get_cred(9)</code> .....	25
<code>ddi_get_instance(9)</code> .....	25
<code>ddi_get_lbolt(9)</code> .....	25
<code>ddi_get_pid(9)</code> .....	25

**ddi\_get\_soft\_state(9)** ..... 25  
**ddi\_get\_time(9)** ..... 25  
**ddi\_getiminor(9)** ..... 25  
**ddi\_remove\_minor\_node(9)** ..... 25  
**ddi\_removing\_power(9)** ..... 25  
**ddi\_soft\_state(9)** ..... 25  
**ddi\_soft\_state\_fini(9)** ..... 25  
**ddi\_soft\_state\_free(9)** ..... 25  
**ddi\_soft\_state\_init(9)** ..... 25  
**ddi\_soft\_state\_zalloc(9)** ..... 25  
**ddi\_umem\_alloc(9)** ..... 25  
**ddi\_umem\_free(9)** ..... 25  
**delay(9)** ..... 10  
**detach(9)** ..... 26  
 development ..... 35  
 differences from aix 5l version 5.1 ..... 19  
 differences from hp-ux 11.0i v2 ..... 21  
 differences from mac open transport ..... 29  
 differences from mentat portable streams ..... 30  
 differences from osf/1 1.2/digial unix ..... 23  
 differences from solaris 9/sunos 5.9 ..... 25  
 differences from super-ux ..... 27  
 Differences from SVR 3.2 ..... 13  
 differences from svr 4.2 mp ..... 14  
 differences from unixware 7.1.3 (openunix 8) ... 24  
 differences from uxp/v ..... 28  
**drv\_getparm(9)** ..... 10  
**drv\_hztousec(9)** ..... 10  
**drv\_hztomsec(9)** ..... 10  
**drv\_msectohz(9)** ..... 11  
**drv\_priv(9)** ..... 11  
**drv\_usectohz(9)** ..... 11  
**drv\_usecwait(9)** ..... 11  
**dupb(9)** ..... 6  
**dupmsg(9)** ..... 6  
  
**E**  
**emajor(9)** ..... 13, 24  
**eminor(9)** ..... 13, 24  
**enableok(9)** ..... 7  
**esballoc(9)** ..... 5, 6  
**esbcall(9)** ..... 12  
**etoimajor(9)** ..... 24, 37  
  
**F**  
**flushband(9)** ..... 7  
**flushq(9)** ..... 7  
**freeb(9)** ..... 6  
**freemsg(9)** ..... 6  
**freeq(9)** ..... 12, 31  
**freezestr(9)** ..... 7, 8, 9, 21

**G**

**get\_sleep\_lock(9)** ..... 21  
**getemajor(9)** ..... 24, 37  
**geteminor(9)** ..... 24, 37  
**getinfo(9)** ..... 26  
**getmajor(9)** ..... 11  
**getminor(9)** ..... 11  
**getq(9)** ..... 7

**H**

**hpuxcompat(9)** ..... 21

**I**

**identify(9)** ..... 26  
**insq(9)** ..... 7  
**install\_driver(9)** ..... 26  
**ioctl(2s)** ..... 30  
**isdatabl(9)** ..... 12  
**isdatamsg(9)** ..... 12  
**itimeout(9)** ..... 17  
**itoemajor(9)** ..... 24, 37

**K**

**kmem\_alloc(9)** ..... 5, 10, 30  
**kmem\_free(9)** ..... 10, 31  
**kmem\_zalloc(9)** ..... 10, 33  
**kmem\_zalloc\_node(9)** ..... 12

**L**

**lbolt(9)** ..... 17, 23, 27  
 license, FDL ..... 50  
 license, GNU Free Documentation License ..... 50  
 license, GNU General Public License ..... 40  
 license, GPL ..... 40  
 Licenses ..... 39  
**linkb(9)** ..... 6  
**linkmsg(9)** ..... 11  
**LOCK(9)** ..... 15  
**LOCK\_ALLOC(9)** ..... 15  
**LOCK\_DEALLOC(9)** ..... 15  
**LOCK\_OWNED(9)** ..... 15

**M**

**M\_ERROR(9)** ..... 11  
**M\_FLUSH(9)** ..... 11  
**maccompat(9)** ..... 29  
**major(9)** ..... 18  
**makedev(9)** ..... 18  
**makedevice(9)** ..... 11  
**max(9)** ..... 11  
**memcpy(9)** ..... 10

## Indices

<code>memset(9)</code> .....	10	<code>mi_tpi_ack_alloc(9)</code> .....	33
message functions .....	5	<code>mi_tpi_conn_con(9)</code> .....	33
<code>mi_alloc(9)</code> .....	30	<code>mi_tpi_conn_ind(9)</code> .....	33
<code>mi_alloc_sleep(9)</code> .....	30	<code>mi_tpi_conn_req(9)</code> .....	33
<code>mi_allocq(9)</code> .....	30	<code>mi_tpi_data_ind(9)</code> .....	33
<code>mi_attach(9)</code> .....	30	<code>mi_tpi_data_req(9)</code> .....	33
<code>mi_bcmp(9)</code> .....	30	<code>mi_tpi_discon_ind(9)</code> .....	33
<code>mi_bufcall(9)</code> .....	19, 30	<code>mi_tpi_discon_req(9)</code> .....	33
<code>mi_close_comm(9)</code> .....	19, 30	<code>mi_tpi_err_ack_alloc(9)</code> .....	33
<code>mi_close_detached(9)</code> .....	30	<code>mi_tpi_exdata_ind(9)</code> .....	33
<code>mi_close_free(9)</code> .....	30	<code>mi_tpi_exdata_req(9)</code> .....	33
<code>mi_copy_done(9)</code> .....	30	<code>mi_tpi_info_req(9)</code> .....	33
<code>mi_copy_set_rval(9)</code> .....	30	<code>mi_tpi_ok_ack_alloc(9)</code> .....	33
<code>mi_copy_state(9)</code> .....	31	<code>mi_tpi_ordrel_ind(9)</code> .....	33
<code>mi_copyin(9)</code> .....	30	<code>mi_tpi_ordrel_req(9)</code> .....	33
<code>mi_copyin_n(9)</code> .....	30	<code>mi_tpi_uderror_ind(9)</code> .....	33
<code>mi_copyout(9)</code> .....	30	<code>mi_tpi_unitdata_ind(9)</code> .....	33
<code>mi_copyout_alloc(9)</code> .....	30	<code>mi_tpi_unitdata_req(9)</code> .....	33
<code>mi_detach(9)</code> .....	31	<code>mi_zalloc(9)</code> .....	33
<code>mi_first_dev_ptr(9)</code> .....	31	<code>mi_zalloc_sleep(9)</code> .....	33
<code>mi_first_ptr(9)</code> .....	31	<code>min(9)</code> .....	11
<code>mi_free(9)</code> .....	31	<code>minor(9)</code> .....	18
<code>mi_freeq(9)</code> .....	31	<code>mknod(9)</code> .....	11
<code>mi_mpprintf(9)</code> .....	31	<code>mod_info(9)</code> .....	26
<code>mi_mpprintf_nr(9)</code> .....	31	<code>mod_install(9)</code> .....	26
<code>mi_next_dev_ptr(9)</code> .....	31	<code>mod_remove(9)</code> .....	26
<code>mi_next_ptr(9)</code> .....	19, 31	<code>mount(9)</code> .....	11
<code>mi_offset_param(9)</code> .....	31	MP queue functions .....	8
<code>mi_offset_paramc(9)</code> .....	31	<code>mpscompat(9)</code> .....	30
<code>mi_open_alloc(9)</code> .....	31	<code>MPSTR_QLOCK(9)</code> .....	15
<code>mi_open_alloc_sleep(9)</code> .....	31	<code>MPSTR_QRELE(9)</code> .....	15
<code>mi_open_comm(9)</code> .....	19, 31	<code>MPSTR_STPLOCK(9)</code> .....	15
<code>mi_open_detached(9)</code> .....	31	<code>MPSTR_STPRELE(9)</code> .....	15
<code>mi_open_link(9)</code> .....	31	<code>msgdsz(9)</code> .....	6
<code>mi_prev_ptr(9)</code> .....	19, 31	<code>msgphysreq(9)</code> .....	24
<code>mi_reallocb(9)</code> .....	31	<code>msgpullup(9)</code> .....	6
<code>mi_reuse_proto(9)</code> .....	32	<code>msgpullup_physreq(9)</code> .....	24
<code>mi_set_sth_copyopt(9)</code> .....	32	<code>msgscgth(9)</code> .....	24
<code>mi_set_sth_hiwat(9)</code> .....	32	<code>msgsize(9)</code> .....	12
<code>mi_set_sth_lowat(9)</code> .....	32		
<code>mi_set_sth_maxblk(9)</code> .....	32		
<code>mi_set_sth_wroff(9)</code> .....	32		
<code>mi_sprintf(9)</code> .....	32		
<code>mi_sprintf_putc(9)</code> .....	32		
<code>mi_strcmp(9)</code> .....	32		
<code>mi_strlen(9)</code> .....	32		
<code>mi_strlog(9)</code> .....	32		
<code>mi_strtol(9)</code> .....	32		
<code>mi_timer(9)</code> .....	32		
<code>mi_timer_alloc(9)</code> .....	32		
<code>mi_timer_cancel(9)</code> .....	32		
<code>mi_timer_free(9)</code> .....	32		
<code>mi_timer_move(9)</code> .....	32		
<code>mi_timer_q_switch(9)</code> .....	31, 32		
<code>mi_timer_stop(9)</code> .....	32		
<code>mi_timer_valid(9)</code> .....	32		
		<b>N</b>	
		<code>noenable(9)</code> .....	7
		<b>O</b>	
		<code>osfcompat(9)</code> .....	23
		<code>OTHERQ(9)</code> .....	7
		<b>P</b>	
		<code>pcmsg(9)</code> .....	6
		portable STREAMS drivers and modules .....	35
		porting .....	5
		Porting from AIX 5L Version 5.1 .....	19
		Porting from HP-UX 11.0i v2 .....	21

- Porting from Mac Open Transport ..... 29
- Porting from Mentat Portable STREAMS..... 30
- Porting from OSF/1 1.2/Digital UNIX..... 23
- Porting from Solaris 9/SunOS 5.9..... 25
- Porting from SUPER-UX..... 27
- Porting from SVR 3.2 ..... 13
- Porting from SVR 4.2 MP ..... 14
- Porting from UnixWare 7.1.3 (OpenUnix 8).... 24
- Porting from UXP/V..... 28
- power**(9) ..... 25
- priority levels..... 14
- probe**(9) ..... 25
- pullupmsg**(9) ..... 6
- put**(9) ..... 9
- putbq**(9) ..... 7
- putctl**(9) ..... 7, 9
- putctl1**(9) ..... 7, 9, 11
- putctl2**(9) ..... 11, 12, 19, 21
- puthere**(9) ..... 23
- putnext**(9) ..... 9
- putnextctl**(9) ..... 9
- putnextctl1**(9) ..... 9, 11
- putnextctl2**(9) ..... 11, 12, 21
- putq**(9) ..... 7
  
- Q**
- qattach**(9) ..... 12
- qbufcall**(9) ..... 25
- qclose**(9) ..... 12
- qcountstrm**(9) ..... 12
- qdetach**(9) ..... 12
- qenable**(9) ..... 8
- qopen**(9) ..... 12
- qprocsoff**(9) ..... 9, 21
- qprocson**(9) ..... 9, 21
- qreply**(9) ..... 8
- qsize**(9) ..... 8
- qtimeout**(9) ..... 26
- queclass**(9) ..... 26
- qunbufcall**(9) ..... 26
- quntimeout**(9) ..... 26
- qwait**(9) ..... 26
- qwait\_sig**(9) ..... 26
- qwriter**(9) ..... 26
  
- R**
- RD**(9) ..... 8
- rmvb**(9) ..... 6
- rmvq**(9) ..... 8
- RW\_ALLOC**(9) ..... 15
- RW\_DEALLOC**(9) ..... 15
- RW\_RDLOCK**(9) ..... 15
- RW\_TRYRDLOCK**(9) ..... 16
- RW\_TRYWRLOCK**(9) ..... 16
- RW\_UNLOCK**(9) ..... 16
- RW\_WRLOCK**(9) ..... 16
  
- S**
- SAMESTR**(9) ..... 8
- setq**(9) ..... 12
- sleep**(9) ..... 18
- SLEEP\_ALLOC**(9) ..... 16
- SLEEP\_DEALLOC**(9) ..... 16
- SLEEP\_LOCK**(9) ..... 16
- SLEEP\_LOCK\_SIG**(9) ..... 16
- SLEEP\_LOCKAVAIL**(9) ..... 16
- SLEEP\_LOCKOWNED**(9) ..... 16
- SLEEP\_TRYLOCK**(9) ..... 16
- SLEEP\_UNLOCK**(9) ..... 16
- some common extension functions..... 11
- some internal functions ..... 12
- some oddball functions ..... 12
- spl**(9) ..... 8, 17
- spl0**(9) ..... 17
- spl1**(9) ..... 17
- spl2**(9) ..... 17
- spl3**(9) ..... 17
- spl4**(9) ..... 17
- spl5**(9) ..... 17
- spl6**(9) ..... 17
- spl7**(9) ..... 17
- splstr**(9) ..... 19
- splx**(9) ..... 9, 17, 19
- sponsors ..... 1
- sprintf**(9) ..... 32
- str\_install**(9) ..... 20, 22
- str\_install\_HPUX**(9) ..... 21
- str\_uninstall**(9) ..... 22
- strcmp**(9) ..... 32
- streams\_close\_comm**(9) ..... 23
- streams\_get\_sleep\_lock**(9) ..... 21
- streams\_mpsleep**(9) ..... 21
- streams\_open\_comm**(9) ..... 23
- streams\_open\_ocomm**(9) ..... 23
- streams\_put**(9) ..... 21
- striocall**(9) ..... 24
- strlen**(9) ..... 32
- strlog**(9) ..... 11, 32
- strmod\_add**(9) ..... 23
- strmod\_del**(9) ..... 23
- strqget**(9) ..... 9
- strqset**(9) ..... 9
- strtol**(9) ..... 32
- suncompat**(9) ..... 25
- supporters ..... 1
- suxcompat**(9) ..... 27
- SV\_ALLOC**(9) ..... 16
- SV\_BROADCAST**(9) ..... 16
- SV\_DEALLOC**(9) ..... 16

## Indices

<b>SV_SIGNAL</b> (9) .....	16
<b>SV_WAIT</b> (9) .....	16
<b>SV_WAIT_SIG</b> (9) .....	16
<b>svr3compat</b> (9) .....	13
<b>svr4compat</b> (9) .....	14

## T

<b>T_CONN_CON</b> (7) .....	33
<b>T_CONN_IND</b> (7) .....	33
<b>T_CONN_REQ</b> (7) .....	33
<b>T_DATA_IND</b> (7) .....	33
<b>T_DATA_REQ</b> (7) .....	33
<b>T_DISCON_IND</b> (7) .....	33
<b>T_DISCON_REQ</b> (7) .....	33
<b>T_ERROR_ACK</b> (7) .....	33
<b>T_EXDATA_IND</b> (7) .....	33
<b>T_EXDATA_REQ</b> (7) .....	33
<b>T_INFO_REQ</b> (7) .....	33
<b>T_OK_ACK</b> (7) .....	33
<b>T_ORDREL_IND</b> (7) .....	33
<b>T_ORDREL_REQ</b> (7) .....	33
<b>T_UDERROR_IND</b> (7) .....	33
<b>T_UNITDATA_IND</b> (7) .....	33
<b>T_UNITDATA_REQ</b> (7) .....	33
<b>testb</b> (9) .....	6
<b>time</b> (9) .....	23
<b>timeout</b> (9) .....	11
<b>TRYLOCK</b> (9) .....	15

## U

<b>umount</b> (9) .....	11
<b>unbufcall</b> (9) .....	6
<b>unfreezestr</b> (9) .....	9, 21
<b>unlink</b> (9) .....	11
<b>unlinkb</b> (9) .....	6
<b>UNLOCK</b> (9) .....	15
<b>untimeout</b> (9) .....	11
<b>unweldq</b> (9) .....	11, 12, 19, 21, 23
UP queue functions .....	7
<b>uw7compat</b> (9) .....	24
<b>uxpcompat</b> (9) .....	28

## V

<b>vtop</b> (9) .....	18
-----------------------	----

## W

<b>wakeup</b> (9) .....	18
<b>wantio</b> (9) .....	20
<b>wantmsg</b> (9) .....	20
<b>weldq</b> (9) .....	11, 12, 19, 21, 23
<b>WR</b> (9) .....	8

## X

<b>xmsgsize</b> (9) .....	12
---------------------------	----

## Type Index

`dev_t` ..... 36

Indices

## Function and Macro Index

(Index is nonexistent)

## Variable and Constant Macro Index

I_LINK.....	35	I_PLINK.....	35
-------------	----	--------------	----

Indices

## Program and File Index

(Index is nonexistent)