Tru64 UNIX

Asynchronous Transfer Mode

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This manual is for experienced UNIX kernel programmers responsible for writing Asynchronous Transfer Mode (ATM) device drivers and kernel modules. It describes the HP Tru64 UNIX ATM subsystem, how to configure the subsystem, and how to use the ATM kernel interfaces.

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About This Manual

This manual describes the Tru64 UNIX Asynchronous Transfer Mode (ATM) subsystem and how to use the ATM kernel interfaces. This document does not describe the application programming interface (API) that user-level applications would use to access the ATM subsystem. Also, this manual is not an ATM networking tutorial.

After reading this manual, you should be able to:

- Understand the ATM subsystem architecture
- Understand how the different kernel interfaces operate
- Write a kernel module

Audience

This manual is for experienced UNIX kernel programmers responsible for writing device drivers and kernel modules. These programmers should be familiar with the following:

- ATM technology
- ATM Forum User-Network Interface (UNI) Version 3.0 specification
- C language programming

The secondary audience is system administrators responsible for configuring network software. These system administrators should be familiar with the following:

- ATM technology
- C language
- Programming interfaces for UNIX operating systems

New and Changed Features

This manual has been revised, and includes the following changes:

- *Appendix A* has been revised to include a new routine for unregistering device driver modules.

Organization

This manual is organized into nine chapters and three appendixes.

Chapter 1	Provides an overview of the Tru64 UNIX Asynchronous Transfer Mode (ATM) architecture and its kernel interfaces.
Chapter 2	Describes the ATM header files, generic data structures, macros, and return codes that ATM modules use.
Chapter 3	Describes the ATM device driver interface, its tasks and routines, and associated data structures.
Chapter 4	Describes the ATM signaling module interface, its tasks and routines, and associated data structures.
Chapter 5	Describes the ATM convergence module interface, its tasks and routines, and associated data structures.
Chapter 6	Describes how ATM connections are initiated and terminated, and includes some code fragments that show how these tasks are implemented in software.
Chapter 7	Describes the ATM Module Management Interface (MMI).
Chapter 8	Describes queuing information that kernel module writers require.
Chapter 9	Describes the flow control in the ATM subsystem.
Appendix A	Describes the ATM CMM routines in reference-page format.
Appendix B	Contains programming code fragments that show certain connection-related tasks.
Appendix C	Contains ATM cause and diagnostic codes, their message strings, and brief descriptions.

Related Documents

For information about Tru64 UNIX device driver programming, refer to the following manuals that are part of the Device Driver Documentation kit:

- *Writing Device Drivers*
- *Reference Pages, Section 9r, Device Drivers (Volume 1)*
- *Reference Pages, Section 9s, 9u, and 9v, Device Drivers (Volume 2)*
- *Writing Network Device Drivers*
- *Writing TURBOchannel Device Drivers*
- *Writing EISA and ISA Bus Device Drivers*
- *Writing VMEbus Device Drivers*
- *Writing PCI Bus Device Drivers*
- *Writing Device Drivers for the SCSI/CAM Architecture Interfaces*

For information on kernel module programming, refer to the *Writing Kernel Modules* manual.

For additional information about ATM, refer to the *ATM User-Network Interface Specification, Version 3.0* ISBN 0-13-225863-3 and the *ATM User-Network Interface Specification, Version 3.1* ISBN 0-13-393828-X, both published by Prentice Hall.

For information on installing a HP ATM adapter and its device driver, see the documentation that comes with the adapter.

For information about administering networking interfaces, refer to the *System Administration* manual and the *Network Administration: Connections* manual. For information on configuring the ATM subsystem, see the *Network Administration: Connections* manual.

Icons on Tru64 UNIX Printed Manuals

The printed version of the Tru64 UNIX documentation uses letter icons on the spines of the manuals to help specific audiences quickly find the manuals that meet their needs. (You can order the printed documentation from HP.) The following list describes this convention:

G	Manuals for general users
S	Manuals for system and network administrators
P	Manuals for programmers
R	Manuals for reference page users

Some manuals in the documentation help meet the needs of several audiences. For example, the information in some system manuals is also used by programmers. Keep this in mind when searching for information on specific topics.

The *Documentation Overview* provides information on all of the manuals in the Tru64 UNIX documentation set.

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- The section numbers and page numbers of the information on which you are commenting.
- The version of Tru64 UNIX that you are using.
- If known, the type of processor that is running the Tru64 UNIX software.

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Conventions

This document uses the following typographic conventions:

%	
$	A percent sign represents the C shell system prompt. A dollar sign represents the system prompt for the Bourne, Korn, and POSIX shells.
#	A number sign represents the superuser prompt.
% **cat**	Boldface type in interactive examples indicates typed user input.
file	Italic (slanted) type indicates variable values, placeholders, and function argument names.
[|]	
{ | }	In syntax definitions, brackets indicate items that are optional and braces indicate items that are required. Vertical bars separating items inside brackets or braces indicate that you choose one item from among those listed.
. . .	In syntax definitions, a horizontal ellipsis indicates that the preceding item can be repeated one or more times.

`cat`(1)	A cross-reference to a reference page includes the appropriate section number in parentheses. For example, `cat`(1) indicates that you can find information on the `cat` command in Section 1 of the reference pages.
Return	In an example, a key name enclosed in a box indicates that you press that key.
Ctrl/*x*	This symbol indicates that you hold down the first named key while pressing the key or mouse button that follows the slash. In examples, this key combination is enclosed in a box (for example, Ctrl/C).

1

Overview of ATM Architecture

Asynchronous Transfer Mode (ATM) networks promise to become the dominant network interconnect because they provide the following capabilities:

- Speeds from 25 M/bps to up to 622 M/bps or greater through cell-switching.
- Multiple qualities of service.
- Connection-oriented interconnection with resource reservation for individual connections. These connections might be for conversations between two applications or for a connection over which many conversations between many applications and protocols are multiplexed.

Presently, interest in implementing ATM networks, particularly in the local area, comes from applications that need the high speed and the low latency (switched, full duplex network infrastructure) that ATM networks provide.

1.1 ATM Subsystem

The ATM subsystem is a separately configurable kernel subsystem with the following characteristics:

- Provides a set of ATM-related services to kernel and user applications. These applications, in turn, must provide their own interface to ATM.
- Provides a well-defined set of interfaces for using these services. Chapter 2 through Chapter 9 describe the interfaces and services.
- Is optimized for ATM functions; does not provide support for a specific set of user protocols.
- Is flexible and easy to expand and adapt to changing requirements.
- Provides an open interface for ATM hardware designers and for software developers to interface new or existing protocols to ATM.

The ATM subsystem consists of the following parts:

- Connection Management Module (CMM)

  This module handles all communications between the various elements of the ATM subsystem as well as managing all virtual circuits (VCs) and communications with protocol stacks that use ATM.

- One or more ATM hardware adapter device drivers

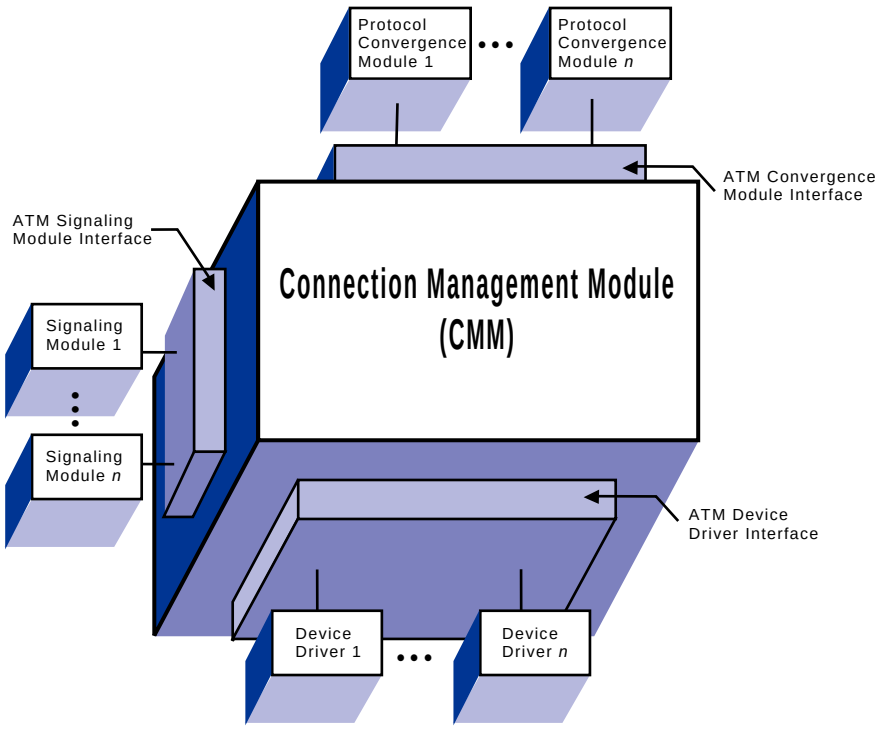
  These device drivers handle the hardware-specific details for controlling specific adapters.

- One or more signaling protocol modules

  These modules implement specific protocols for communicating connection management information between the end system and the switch. In this implementation, UNI 3.0/3.1 is the default signaling protocol module that the ATM subsystem uses.

Figure 1–1 illustrates the ATM subsystem.

Figure 1–1: ATM Subsystem



The ATM subsystem supports any number of ATM device drivers and signaling protocol modules as long as the actions of these modules do not interfere with each other. ATM modules should communicate only with the CMM as the CMM coordinates all communications between ATM modules. ATM modules should never bypass the CMM and communicate with each other directly.

The three elements of the ATM subsystem provide only raw ATM services. They do not implement any specific protocol for carrying data over the ATM

network. That is, the ATM subsystem is entirely protocol independent. If a specific protocol wants to use the ATM network to transport data, the protocol must provide an interface into the ATM subsystem.

The programs that provide the interface between the ATM subsystem and specific protocols are called convergence modules. These modules, using the ATM subsystem interface Kernel Programming Interface (KPI), control the creation and use of ATM virtual circuits (VCs) in a manner appropriate for the protocol. Since different protocols have different requirements, the ATM subsystem leaves the adaptation of the protocol to use ATM entirely up to the protocol implementor. The ATM subsystem does not provide any protocol-specific services.

1.1.1 Connection Management Module

The CMM is the central module in the ATM subsystem and has the following duties:

- Manages all activities of the ATM subsystem, including subsystem configuration. All data to and from the ATM networks must pass through the CMM to get properly routed to the correct destination.
- Handles all circuit connection requests from protocol modules (convergence modules) and manages all VCs from the time they are created until they are torn down.
- Provides interface points for other elements of the ATM subsystem, as well as the interfaces for accessing the ATM subsystem from kernel protocol stacks. These interfaces permit the modular addition of drivers, signaling modules, management modules, and protocol stack interfaces without having to make changes to the CMM.
- Provides the only interface into the ATM subsystem from the kernel. ATM modules are accessed only through the CMM.

1.1.2 CMM Interfaces

The CMM provides the following interfaces:

- ATM device driver interface

  ATM adapter device drivers use this interface to access the ATM subsystem. See Chapter 3 for more information.

- Signaling module interface

  Modules that implement ATM signaling protocols use this interface. This interface allows multiple signaling modules to provide services to protocol stacks on a per-VC basis, as long the signaling modules do not conflict on the ATM network. See Chapter 4 for more information.

- Convergence module interface

  Kernel protocol stacks use this external interface to the ATM subsystem to gain access to the ATM subsystem services. See Chapter 5 for more information.

These interfaces are registration-type interfaces. Each makes calls to the CMM to inform the CMM of its presence. The CMM places no limit on the number of each type of module that may register, the total number being limited only by system resources.

1.2 ATM Subsystem Configuration

Before you communicate on the ATM network, you must install a HP ATM adapter and configure the ATM software. See the installation and service documentation shipped with the adapter for information on installing the ATM adapter, and the *Network Administration: Connections* manual for information on configuring the ATM software.

2

ATM Subsystem General Features

This chapter describes the following ATM features that writers of ATM device drivers, signaling modules, and protocol convergence modules can use:

- Header files
- Module configuration management
- Error codes
- Data formats
- Physical point of attachment
- Memory allocation
- ATM locking macros
- Types of circuits
- Global data structures

2.1 Header Files

When building kernel modules to interface with the ATM subsystem, your application must include the following header files (located in the `/usr/include/io/atm/sys` directory):

- `atm.h` — Common ATM subsystem structures, function prototypes, and ATM error codes (required by all ATM kernel modules)
- `atm_adi.h` — Device driver interface function prototypes and structures (required by all ATM device drivers)
- `atm_smi.h` — Signaling protocol module interface function prototypes and structure definitions (required by all signaling protocol modules)
- `atm_cmi.h` — Protocol convergence module interface function prototypes and structure definitions (required by all protocol convergence modules)
- `atm_osf.h` — Macros and constants for services that ATM subsystem modules use

In addition, the protocol convergence module code must include any signaling protocol-specific module header files that define structures used by protocol convergence modules.

The atm.h header file defines all the global data structures as well as the revision level of these structures. The ATM_REVISION constant, which is defined in this file, is passed to the CMM by device drivers, signaling modules, and convergence modules during their registration process. The CMM uses this constant to determine which version of global structures the modules use; it should not be changed.

2.2 ATM Module Configuration

All ATM modules should use the standard configuration management routine for initializing and configuring modules. This routine also provides the sysconfig utility, which allows you to tune ATM modules without having to use a data file or recompile code. See the *Writing Kernel Modules* and sysconfig(8) for information on the configuration routine and sysconfig utility, respectively. See sys_attrs_atm(5) for information on tuning the ATM subsystem.

2.3 Error Codes

The /usr/sys/include/io/atm/sys/atm.h header file contains ATM-specific error codes that are returned by all modules within the ATM subsystem to indicate the result of an operation. These codes consist of standard User-Network Interface (UNI) 3.0/3.1 error numbers and error numbers specific to this operating system.

When a function call is completed with no errors, the function must return the value ATM_CAUSE_GOOD. Unsuccessful completion is indicated by the return of some other value. Only the values listed in the atm.h header file can be returned. Routines returning error codes to system calls or management routines must return standard error codes as defined in the sys/errno.h file.

All ATM subsystem routines use type atm_error_t to indicate the outcome of an operation and all ATM subsystem modules must also do so. An atm_error_t can take on one of the values listed in atm.h. The ATM signaling modules are responsible for translating values to external network representations when necessary.

2.4 Data Formats

The type of data transmitted and received on a virtual circuit (VC) depends on the type of ATM Adaption Layer (AAL) protocol the convergence module specifies when setting up the VC.

The type of data a convergence module and the CMM exchange depends on the Segmentation and Reassembly (SAR) capabilities of the underlying device driver and hardware adapter. Convergence modules must be prepared

either to handle drivers of differing capabilities or to recognize a driver that does not support the capabilities required by the convergence module. The convergence module interfaces provide a mechanism for convergence modules to obtain a driver's capabilities for making this determination.

Some device drivers or adapters implement some SAR functions in hardware or in a combination of hardware and software. This makes sending and receiving specific types of data more efficient. For example, TURBOchannel and Peripheral Component Interconnect (PCI) ATM adapters implement AAL5 in hardware. Other hardware may implement AAL3/4 or may be able to handle only raw ATM cells. Since the ATM subsystem is designed to accommodate a wide variety of drivers, it provides mechanisms for dealing with drivers of varying capabilities. It is the convergence module's responsibility to use the capabilities of a driver or an ATM interface in the best way possible for the protocol it is implementing.

The ATM subsystem can handle the following types of ATM data:

- Raw ATM cells (full ATM cells, including cell headers)
- Cooked packet Protocol Data Units (PDUs)

2.4.1 Raw ATM Cells

If a convergence module needs to transmit raw ATM cells, it should first determine if the underlying driver supports this service (some drivers may support only cooked data). If the driver cannot handle raw cells, the convergence module should not make or accept connections over the interface controlled by the driver. The convergence module should use the driver only if the driver provides compatible capabilities.

2.4.2 Cooked Data

If a convergence module needs to transmit cooked data (data packets, such as AAL5, rather than individual cells), it should first determine if the underlying driver supports this service (some drivers may support only raw data or may not cook the data in the needed AAL format). The convergence module should use the driver if the driver provides compatible capabilities. If a driver does not support the required capabilities, but does support raw cells, the convergence module can perform the SAR functions internally and then send and receive raw cells. Otherwise, the convergence module should not accept or make connections over the interface controlled by the driver.

2.4.3 How the Data Is Carried

Both cell and packet data in the ATM subsystem are carried in a chain of mbufs. The routines for allocating and manipulating the mbufs are the same as those the networking subsystem uses. The data representation within

the mbuf chain depends on the type of data (raw or cooked) being carried by the mbufs. When an mbuf chain contains raw cells, each mbuf in the chain contains exactly one ATM cell, a full 53-byte cell with Generic Flow Control (GFC) and Payload Type Indicator (PTI) bits set.

An mbuf chain can contain one or more ATM cells, each in its own mbuf. When an mbuf chain is carrying packet Protocol Data Units (PDUs) (AAL3/4 or AAL5 PDUs), the mbuf chain will contain exactly one packet PDU. On outgoing packets, the number of bytes in the packet must be less than or equal to the maximum transmission unit (MTU) of the VC on which the packet is transmitted. The mbuf chain must contain the appropriate headers and trailers (the AAL3/4 or AAL5 Convergence Sublayer Protocol Data Unit (CS-PDU) headers and trailers). If the device driver or adapter adds headers and trailers, the driver must strip off this extra information on outgoing packets. The drivers must include the CS-PDU headers and trailers on received packets.

2.4.4 Time-Stamping

When a driver receives raw ATM cells, the driver must be capable of optionally time-stamping the incoming cells to assist convergence modules or other protocol modules in determining intercell intervals; this might be required when processing constant bit rate (CBR) or variable bit rate (VBR) traffic. If a convergence module enables time-stamping of incoming data, the device driver must add an 8-byte time-stamp immediately after the cell bytes in the mbuf, increasing the mbuf length to 61 bytes.

On Tru64 UNIX systems, the time-stamp is the value read from the free-running system clock at the time the packet was received by the driver. This value has a 10-nanosecond resolution, but the value is accurate to only a few microseconds. This is because the time-stamp is not generated by the hardware when the packet arrives, but by the driver during its receive interrupt processing.

The driver can also optionally indicate lost or corrupted cells in the data stream. Cell loss can be due to hardware errors, the failure of cyclical redundancy checks (CRC), or insufficient resources to hold the incoming cell. The actual cause of local cell loss can vary between drivers. To indicate a lost cell in the data stream, the driver should insert a 0 length mbuf in the data stream where the cell was lost. Only one of these needs to be inserted if multiple sequential cells are lost. If time-stamping is enabled, the lost cell indicator will be an 8-byte mbuf with the time-stamp indicating the temporal position of the lost cell. The protocol convergence module can use this information for clock recovery, if necessary.

2.5 Physical Point of Attachment

The physical point of attachment (PPA) is a network services endpoint. It is the point at which the network services are provided and to which network services users attach to the network services. Each PPA represents a unique addressable entity on the network, identifying a provider of network services on both the local system and the network. When a call is placed on an ATM network, only the PPA is addressed; the PPA's address is registered with the ATM switch.

Although the network can address the PPA through the PPA address, the network cannot use the same address to address individual network services users attached to the PPA. For this, the ATM network uses ATM End System Addresses (AESAs). An AESA uniquely identifies both the network services endpoint and a specific network services user attached to that endpoint.

UNI 3.0/3.1 AESA-format ATM addresses consist of the following parts:

- A prefix — Assigned by the switch
- End system identifier (ESI) — Assigned by the local host
- A selector byte — Used by the network services provider on the end system to route a call to a specific network services user attached to a PPA

The first two parts together are registered with the ATM switch and network, and uniquely identify a PPA to which network services users may attach. Both the host and the switch must combine these two pieces of information to form complete addresses. This is done through the Integrated Local Management Interface (ILMI) protocol when new addresses are added or deleted. The CMM, in cooperation with signaling modules, keeps track of these two parts so that all addresses associated with either a prefix or an ESI are properly managed. Since the prefix is assigned by the switch, the CMM leaves the management of the prefixes up to the address registration and management portion of the signaling module.

ESI values have the following sources:

- The ESIs configured in the ATM adapter's read-only memory (ROM)
- ESIs configured by the system or network administrator, who uses the `atmconfig` command
- ESIs configured by convergence modules that need to create their own ATM addresses

The first two ESIs are considered global or public ESIs. All PPAs created from global ESIs are available to all convergence modules. Only the system or network administrator can delete global ESIs. ESIs that convergence modules create are considered private. All PPAs created from private ESIs

are available only to the convergence module that configured the ESI on the system. These ESIs can be deleted by either the system or network administrator or by the creating convergence module. The CMM keeps track of ESI sources (in the `atm_esi` structure) to assure that only the correct entity can remove an ESI (and all associated PPAs and the VCs associated with those PPAs).

Since ATM permits an arbitrary number of ESIs and prefixes to be registered for a specific connection to the network, an end system can have an arbitrary number of PPAs. Users of the ATM network services (convergence modules) can attach their service to any combination of PPAs to make their service available on the network. The process of attaching a service to a PPA is called binding, and creates a full AESA that uniquely identifies a specific instance of a service on the network. In the Tru64 UNIX ATM architecture, all calls must be placed and received through bind points that represent valid AESAs.

In the ATM subsystem, PPAs are created whenever an address is successfully registered with the local network switch. When a PPA comes into existence, convergence modules are notified and may bind their services to the PPAs. Each PPA contains three pieces of information that uniquely identify it among the different networks to which the host may be attached. Associated with each PPA is a device driver (representing the physical connection to a network), a signaling module (representing the protocol that controls the administration of the PPA), and the PPA's address on the network to which it is attached. This permits PPAs on separate, disjoint networks to have the same logical address, but to still be unique on the local system.

The ATM subsystem has two types of PPAs:

- Permanent virtual circuit (PVC) PPAs, which manage PVCs
- Switched virtual circuit (SVC) PPAs, which manage SVCs

You can specify as many services for PVC connections as for SVC connections.

2.5.1 Permanent Virtual Circuit PPAs

When an interface becomes active on a network, the CMM automatically creates a special PPA for use in connecting PVCs to network services users. A PVC PPA is a special PPA that has no network address and no associated signaling module. It represents a path between the network and a network services user. There is exactly one PVC PPA for each interface that is operational. PVC PPAs are destroyed only when a driver is taken down or unregistered with the CMM. PVC PPAs remain in place throughout network disruptions.

Since PVC PPAs have no associated address, you must decide how to bind a specific network services user to a PPA and how to uniquely identify the

user on that PPA. Since PVCs are created locally either with the `atmconfig` administration command or by convergence modules, and do not have any identifying characteristic that is unique on the network, you can assign an arbitrary addressing scheme to PPA bindings. The only requirements are that each network services user be uniquely identifiable and that there be a large enough address space to accommodate as many services as all the SVC PPAs can bind. See `atmconfig`(8) for more information.

In the ATM subsystem, a PVC bind point is identified not by an AESA, but by values unique to each network services user (convergence module) that binds to a PVC PPA. These values are the convergence module's name (provided when the convergence module registers with the CMM) and a selector value used to specify a specific instance of a service on the convergence module. Thus, a PVC network services user is identified by a driver/convergence/selector tuple that identifies a specific instance of a specific service on a specific network. The selector space for PVC bind points is 31-bits wide and is local to each convergence module; each convergence module has complete control over the selector values used to access instances of its service. This provides a large enough bind space to enable convergence modules to create a PVC binding for every SVC binding and to accommodate both PVC and SVC access to its services.

2.5.2 Switched Virtual Circuit PPAs

When an ATM network interface is brought up, the signaling protocol that uses the interface must contact the local switch to register the end system with the network. For UNI 3.0/3.1, this involves exchanging addressing information with the switch to create full ATM addresses, minus the selector values. Each ATM address comprises a prefix value, which is assigned by the network, and an ESI, which identifies the end system. ATM permits the switch to assign an arbitrary number of prefixes and the end system to provide an arbitrary number of ESIs, within reason and subject to implementation-specific limitation. Each combination of prefix and ESI forms an ATM address, or a network services endpoint (PPA).

When an address is registered with a switch, the registering signaling module informs the CMM that a new network services endpoint exists. The CMM then creates a PPA for the new address and notifies each convergence module or the network services users of the new PPA so that they can create AESA bindings, if necessary. Calls to remote systems are given the calling party number of the bind point and PPA through which the call is placed. Incoming calls are routed to bind points based on the called party's AESA address. Therefore, all SVC activity must use a bind point as the local endpoint object. Calls received for an unbound AESA are rejected, and no calls can be placed without first creating a bind point and calling party's AESA.

The bind space for SVC PPAs is 8 bits long, the size of an AESA selector. If a convergence module needs a larger binding space, it can create more PPAs to which it can bind additional instances of its services. A convergence module can create an SVC PPA for its private use by defining a new ESI to the system. By defining a new ESI, one or more new PPAs are created with the new ESI and the current prefixes provided by the switch. The ATM subsystem recognizes PPAs made with ESIs created by a convergence module and makes the new PPAs available only to the module that created the ESI. This allows convergence modules to create their own address space on the ATM network.

ESIs taken from an adapter's ROM and ESIs created by using the `atmconfig` command are considered global. All resulting PPAs are not restricted to specific convergence modules. All other ESIs and their resulting PPAs are considered private.

When a driver is taken down or a connection to the network is lost, the CMM destroys all SVC PPAs, along with any bind points and VCs associated with the PPAs. If the connection to the network is reestablished, the signaling module must reregister all the ESIs; only the creator of the ESI or the system administrator, using the `atmconfig` command, can remove ESIs. The PPAs are then recreated. The convergence modules must bind to the new PPAs.

2.6 Memory Allocation

All modules that allocate memory for use in the ATM subsystems should use the same allocation mechanism. This enables the system to keep track of memory allocated for use by ATM and provides a consistent programming model. The following macros for allocating and freeing memory can be safely called in any context:

```
ATM_MALLOC(pointer,cast,size)
ATM_MALLOCW(pointer,cast,size)
ATM_MALLOC_VAR(pointer,cast,size)
ATM_MALLOCW_VAR(pointer,cast,size)
ATM_FREE(pointer)
```

The `ATM_MALLOC` and `ATM_MALLOCW` macros allocate memory of at least `size` bytes. They place the address of the allocated memory into `pointer`, casting it with the type of `cast`. The allocated memory is correctly aligned for any operation. You should use these macros if the size of the allocation is determined at compile time, as they are optimized for that purpose.

The `ATM_MALLOC_VAR` and `ATM_MALLOCW_VAR` macros perform the same function as `ATM_MALLOC` and `ATM_MALLOCW`. You should use these macros when the allocation size is computed at run time.

The ATM_MALLOC and ATM_MALLOC_VAR macros do not block if the requested memory is not available, but return NULL. You should use these macros in the majority of cases since any routine called by the ATM Subsystem is not allowed to block (except Module Management Interface (MMI) calls).

The ATM_MALLOCW and ATM_MALLOCW_VAR macros block until the requested memory is available. However, they can still return NULL if an error occurs during the allocation processing. Use these macros only in contexts that can block (system calls and private kernel threads). All memory allocated by these macros is mapped in kernel virtual memory and can be passed to any kernel function.

The ATM_FREE macro frees memory allocated previously by any ATM_MALLOC macro. The value of pointer must be identical to that returned from the ATM_MALLOC macro. Once memory is freed, do not reference it again.

The macros return NULL if no memory is available. All modules must check the return value before dereferencing them to assure that memory was successfully allocated. Modules should also be prepared to handle situations where memory is not available; this should not be a fatal error.

The following code fragment shows how to use these macros:

```
struct my_struct *msp;

ATM_MALLOC(msp,struct my_struct *,sizeof(struct my_struct));
if(msp == NULL)
{
     /* allocation failed */
     return ATM_CAUSE_NOMEM;
}
/* use memory referenced by msp */
ATM_FREE(msp);
```

2.7 ATM Locking Macros

The base ATM subsystem is symmetric multiprocessing (SMP) and realtime (RT) safe. The CMM is highly parallelized and supports fine-grain concurrency in all attached modules. ATM modules that are included with the base ATM subsystem are either parallelized or funnel to the master processor. Therefore, any user-created ATM module must be both SMP and RT safe. The module must at least use funneling to force the module to run on the master processor. The module can also use fine-grain concurrency and locking.

The following section provides a brief overview of locking as it applies to ATM modules. See the *Writing Kernel Modules* manual for a complete description of locking within the kernel.

2.7.1 Locking Guidelines

Because of the way in which the ATM subsystem operates, you should write all routines of any ATM module that is called by the CMM to execute on an interrupt stack. Many ATM functions execute either off a device interrupt, the system soft clock, or an internal ATM thread. This means that no ATM routine that the CMM calls can block (with the exception of the `xxx_mmi` routine described in Appendix A). Therefore, all locks must be nonblocking simple locks. You can use blocking locks only from within a module's private thread, or when in a system call context.

No ATM module should hold a simple lock when calling outside the module (in general, simple locks should be held the minimum amount of time). Thus, when calling any CMM routine or any other kernel routine, no locks should be held. When the CMM calls any module's routine, no CMM locks are held across the call.

Finally, before taking a simple lock, raise the processor priority to `splimp` so that interrupts are blocked if the locking thread happens to be running on the master processor.

2.7.2 Types of Locking Methods

Modules that do not implement high levels of parallelism can implement one of the following locking methods (in increasing order of preference):

- Coarse-grain locking
- Funneling
- Using threads

Coarse-grain locking uses one lock (or perhaps a few) to lock a large code path or an entire module. Avoid this type of locking because it requires that a simple lock be held for long periods of time, possibly causing all other processors to block while waiting on the lock. Also, if the lock is held through function calls outside the module, locking hierarchy violations or deadlocks could result.

Funneling forces the module's thread of execution onto a single CPU. Since the module runs only on the master, it is effectively running in a uniprocessor environment. Once funneled, all calls outside the module also run on the master processor even though the called routine may be parallelized. Funneling causes severe context switch overhead that adversely affects module, ATM, and system performance. This is because the module's thread is suspended on the slave and then placed in the master processor's scheduling queue.

To funnel a thread, place the `unix_master()` function call at the start of and the `unix_release()` function call at the end of the code block to be

funneled. There must be a corresponding `unix_release()` call for every `unix_master()` call. You must account for this when designing error paths through a code block.

Creating a thread for the module and then queuing work to the thread is the preferred option. All the module's work is performed in the thread that can run on only one processor (any processor in a multiprocessor environment). Thus, within the thread's code path no locks are required. Only the queuing mechanism, which enqueues and dequeues requests to the thread, requires locking.

Using this strategy, all module routines that can be called from outside the module would allocate some queue structure, take the arguments to the routine along with some identifier to identify the routine that has been called, place them in this structure, and then enqueue the structure to a service queue (locking service queue access). Once the structure is enqueued, the module's thread would be scheduled through one of the thread-management calls. Then, when the thread is run, it would dequeue a request from the service queue (again, locking the service queue) and process the request in the thread's context. The thread would run until there were no more requests on the service queue. This does incur the overhead of a context switch on a uniprocessor system, but on a multiprocessor system the enqueuing could take place on one processor at the same time the thread is being run on another.

2.7.3 Order of Locking Macros

The ATM locking functions are actually macros that invoke other macros, and are defined in the `atm_osf.h` file. The following sequence of steps lists the locking macros and the order in which you call them in your module:

1. Declare and initialize the lock information structure.

   atm_lock_info(, *lock_info_name*);

   This declares the lock information structure and allocates storage for it. Lock information structures are declared as globals, so this macro should appear outside all functions. When creating a lock for structures that are dynamically allocated, you need only a single lock information structure that can be applied to all instances of the structure.

2. Declare a lock.

   atm_lock_decl(*lock_name*)

   Note

   Do not put a semicolon at the end of the declaration.

This declares the lock and allocates storage for it. You can use the macro within a structure declaration or by itself in a global context.

3. Initialize the lock.

   atm_lock_setup(&*lock_name*,&*lock_info_name*);

   Be sure to pass the address of the lock and lock information structures in this macro.

4. Take the lock.

   atm_lock(&*lock_name*);

   Be sure to raise the processor priority immediately before taking the lock.

5. Release the lock.

   atm_unlock(&*lock_name*);

   Be sure to lower the processor priority immediately after releasing the lock. Do not lower the processor priority while the lock is held.

6. If the lock is no longer needed, (for example, when storage for a structure with an embedded lock is being released), terminate the lock.

   atm_lock_terminate(&*lock_name*);

   Once terminated, you can no longer use the lock unless you reinitialize it.

The following code fragment shows the sequence of calls in creating and using a lock:

```
atm_lock_decl(some_lock)
atm_lock_info(,some_lock_info);
int oldpri;

/* initialize the lock */
atm_lock_setup(&some_lock,&some_lock_info);

/* take the lock */
oldpri = splimp();
atm_lock(&some_lock);

/* release lock */
atm_lock(&some_lock);
splx(oldpri);

/* terminate the lock when it will no longer be used */
atm_lock_terminate(&some_lock);
```

2.7.4 Creation of ATM Threads

ATM modules can create kernel threads for the following reasons:

- To schedule work in the module to be performed in a context that is private to that module. For example, a module may process incoming data from a thread rather than on the interrupt stack (incoming data is passed to convergence modules on the driver's interrupt stack).
- To perform functions that have to occur at periodic intervals such as protocol timeouts or garbage collection.

The operating system's kernel provides many kernel thread primitives that modules are free to call directly. These are described in greater detail in the *Writing Kernel Modules* manual. However, to create a thread for use by an ATM module, the ATM subsystem provides the `atm_cmm_new_thread` function. This function combines many of the operating system's thread primitives to provide an easier interface for ATM modules. See Appendix A for a description and format of this function.

2.8 Types of Circuits

The ATM subsystem supports the following circuits:

- Unspecified bit rate (UBR)
- Constant bit rate (CBR)

  A circuit in which both end systems and the network dedicate the resources necessary to handle transmission and reception of the circuit's traffic at the specified bit rate. CBR circuits requiring end-to-end timing are not supported because the drivers and adapters do not support the AAL1 capability.
- Pacing

  A circuit that allows convergence modules to specify that the local driver perform cell pacing on non-CBR circuits. The sending system ensures that traffic is injected onto the network at a rate no greater than the specified bit rate. A pacing circuit has local significance only. To the network and target system, the pacing circuit is a best-effort UBR connection. You can use pacing circuits, for example, to limit the local host's transmission rate without having both end systems and the network treat the circuit as CBR.

The default best-effort UBR connections and pacing connections do not require the end systems to dedicate resources (such as bandwidth) to the connections. However, CBR connections require the end systems to dedicate resources to those connections. These resources can either be allocated transparently at the time the connection is made or received, or they can be reserved in advance by the sending or receiving convergence module and

later applied to a connection setup or incoming call. See Section 6.1 and Section 6.2 for information on reserving resources for connections.

2.9 Global Data Structures

The following data structures are visible to all modules of the ATM subsystem and to the protocol convergence module:

- `atm_vc`
- `atm_addr`
- `atm_vc_services`
- `atm_uni_call_ie`
- `atm_ppa`
- `atm_esi`
- `atm_cause_info`

The ATM subsystem uses these structures to keep track of information for each VC, such as VC service parameters, connection endpoint addresses, VC numbers, and traffic statistics. When a module other than the CMM must allocate memory for a structure, the CMM provides a function call or macro to allocate structure memory in a consistent manner, to properly initialize the structures, and to allocate the correct version of the structure. Module writers must not use any routines other than those that the CMM supplies to allocate structure memory. The following sections describe these data structures.

2.9.1 The atm_vc Structure

The ATM subsystem uses the `atm_vc` structure to reference a VC. A VC is the object on which data is sent and received. VCs are associated with one or more local endpoints and one or more remote endpoints. An action performed on a VC usually affects all the endpoints associated with the VC. For example, transmitting data on a VC sends the data to all endpoints currently connected to the VC.

The `atm_vc` structure has the following characteristics:

- Only the CMM allocates and frees the structure.
- The CMM and other ATM modules use the structure for keeping track of an active VC. The CMM also uses it to maintain all per-VC state information.
- Some structure members are reserved for use by the various modules in the ATM subsystem. This enables all ATM modules to use a common

reference for a specific VC. All modules use the pointer to this structure as the handle for a specific VC.

- Each module of the ATM subsystem can write only those members of the structure that are assigned for its use. All other structure members should be considered read-only.
- The structure's size and members might change in the future, but the arrangement of the per-module structure members should not change.
- No locking is required for access to this data structure. Since each module is permitted to modify only those fields assigned to it, there is no need to coordinate access to the entire structure with other modules. Access within a module may be locked if necessary.
- You use a pointer of type `atm_vc_p` to reference the structure.

When a module is first informed of the presence of a new connection, it receives a reference to an `atm_addr` structure for the connection endpoint. The `atm_addr` structure references the `atm_vc` structure for the connection. At this point, the module can use its private structure members in the `atm_vc` structure to hold information necessary to keep track of the VC and can use its private pointer structure members to store any information it requires.

When the VC is torn down and local resources are deallocated, the CMM calls each module to deallocate any resources associated with the VC. At this time, the module must zero out its `atm_vc` structure private members to signify that it no longer has any reference to the defunct VC.

Table 2–1 lists those member names of the `atm_vc` structure, with their associated data types, that modules might reference.

Table 2–1: The atm_vc Structure Members

Member Name	Data Type
`conv_pp1`	`void *`
`conv_pp2`	`void *`
`sig_pp1`	`void *`
`sig_pp2`	`void *`
`drv_pp1`	`void *`
`drv_pp2`	`void *`
`vcs`	`atm_vc_services_p`
`call_reference`	`long`
`errno`	`atm_error_t`
`vci`	`int`

Table 2–1: The atm_vc Structure Members (cont.)

Member Name	Data Type
vpi	int
ppa	atm_ppa_p
selector	int
direction	atm_direction_t

2.9.1.1 The conv_pp1 and conv_pp2 Members

The conv_pp1 and conv_pp2 members are pointers reserved for the use by convergence modules only; no other ATM module is permitted to use these structure members. Typically, a convergence module uses these members to reference local structures and resources associated with the connection that the atm_vc structure controls. However, convergence modules may use these fields in other ways.

2.9.1.2 The sig_pp1, sig_pp2, drv_pp1, and drv_pp2 Members

The sig_pp1, sig_pp2, drv_pp1, and drv_pp2 members have corresponding meanings for ATM signaling protocol modules and ATM device drivers, respectively.

2.9.1.3 The vcs Member

The vcs member is a pointer to an atm_vc_services structure that contains all the service parameters for the VC. The CMM sets this pointer.

Note

This member and any member of the structure that it references should never be written by any module other than the CMM.

2.9.1.4 The call_reference Member

The call_reference member is a unique call identifier assigned to the VC. This value is assigned only by the CMM and signaling protocol modules and must not be modified by any other module.

2.9.1.5 The errno Member

The errno member contains the last error number that was reported on the VC.

2.9.1.6 The vci and vpi Members

The `vci` and `vpi` members contain the virtual circuit's virtual path identifier (VPI) and virtual channel identifier (VCI) values. These are assigned by the CMM in cooperation with the signaling protocol module that set up the connection.

2.9.1.7 The ppa Member

The `ppa` member indicates the PPA to which the VC belongs.

2.9.1.8 The selector Member

The `selector` member is the selector value assigned to the bind point to which the VC is attached. This value combined with the address information in the PPA form the full AESA address.

2.9.1.9 The direction Member

The `direction` member provides information about the direction of the call. The CMM sets this member to one of the following:

- ATM_DIRECTION_PVC, if the VC structure references a PVC
- ATM_DIRECTION_CALLING, if the VC structure references a call placed by the local system
- ATM_DIRECTION_CALLED, if the VC structure references a call received by the local system.

This structure member is set only by the CMM and must not be modified by any other module.

2.9.2 The atm_addr Structure

The ATM subsystem uses the `atm_addr` structure to reference a connection endpoint. One `atm_addr` structure exists for every connection to every endpoint. Multiple endpoints and multiple address structures can be associated with a single VC (for example, point-to-multipoint connections). A pointer to this structure is the handle that the ATM subsystem uses to reference a specific connection endpoint.

The `atm_addr` structure has the following characteristics:

- The structure stores all address- and state-related information for a connection endpoint. This structure contains only endpoint information, not information about the connection to the endpoint. The connection information is maintained in the `atm_vc` structure that is referenced in the `atm_addr` structure. Except at structure initialization time, all address structures are associated with a VC.

- All function calls that perform an action related to a specific endpoint use a pointer to this structure.
- The structure maintains local address information since the local address is also a connection endpoint.

The structure may contain additional members for the internal use of the CMM. ATM modules should make no assumption about the actual length of the structure. Table 2–2 lists those members of the `atm_addr` structure, with their associated data types, that modules might reference.

Table 2–2: The atm_addr Structure Members

Member Name	Data Type
vc	atm_vc_p
address[20]	unsigned char
ton	unsigned char
anpi	unsigned char
subaddress[20]	unsigned char
subaddress_type	unsigned char
eprtype	unsigned char
endpoint	unsigned short
state	unsigned char
atm_error	atm_error_t
setup	void *
connect	void *
location	unsigned char
cause	atm_err_t
diag_length	unsigned char
diagnostic[27]	unsigned char
endstate	unsigned char
conv_p1	void *
conv_p2	void *
sig_p1	void *
sig_p2	void *

2.9.2.1 The vc Member

The `vc` member references the `atm_vc` structure of the VC to which this endpoint belongs.

2.9.2.2 The address Member

The `address` member is an array that contains the 20-byte ATM address of the endpoint.

2.9.2.3 The ton Member

The `ton` member is a value that specifies the endpoint's address type. These bits are identical to the type of number field in the Called Party Number information element (IE) (right justified).

2.9.2.4 The anpi Member

The `anpi` member is the address or numbering plan identification information for the address. These bits are identical to those in the corresponding field of the Called Party Number IE.

2.9.2.5 The subaddress Member

The `subaddress` member is an array that contains the subaddress of the endpoint. If the endpoint has no subaddress, the Authority and Format Indicator (AFI) byte of the subaddress array must be 0.

2.9.2.6 The subaddress_type Member

The `subaddress_type` member is a numeric value that specifies the type of subaddress that the endpoint uses. These bits are identical to those in the Type of subaddress field of the Called Party Subaddress IE (right justified).

2.9.2.7 The eprtype Member

The `eprtype` member is the endpoint reference type of the endpoint referenced by the structure. Signaling modules fill in this information, indicating the type of endpoint contained in the endpoint structure member.

2.9.2.8 The endpoint Member

The `endpoint` member is the endpoint reference value that the ATM subsystem uses to reference an endpoint in a point-to-multipoint connection. The CMM assigns this value when processing point-to-multipoint connection requests.

2.9.2.9 The state Member

The `state` member is the call state value or global interface state value field from the last Call State IE received for the connection. Only the signaling module fills in this member.

2.9.2.10 The atm_error Member

The `atm_error` member contains the error number for the last error reported on the endpoint.

2.9.2.11 The setup Member

The `setup` member is a pointer to a signaling protocol-specific structure that contains the parameters sent or received in the call setup phase of connection creation. These parameters indicate the call parameters set by the calling party of a connection. On incoming calls (the local host is the called party), the signaling protocol module sets this member. On outgoing calls (the local host is the calling party), the protocol convergence module that initiates the call sets this member.

The protocol convergence module and the signaling module must agree on the format of the object referenced by this member. The protocol convergence module can free storage for the objects referenced only when the associated connection is torn down.

2.9.2.12 The connect Member

The `connect` member is a pointer to a signaling protocol-specific structure that contains the parameters sent or received in the connection phase of connection creation. These parameters indicate the actual parameters the ATM subsystem uses to establish the service between the endpoints. These could differ from the setup parameters in cases where parameter negotiation took place. Both sets of parameters are maintained so that any differences between requested and negotiated parameters can be easily determined.

The protocol convergence module and the signaling module must agree on the format of the object referenced by this member. The protocol convergence module can free storage for the objects referenced only when the associated connection is torn down.

2.9.2.13 The location, cause, diag_length, and diagnostic Members

The `location`, `cause`, `diag_length`, and `diagnostic` members are filled in by the CMM from the Cause IE received for the connection. Convergence modules can use this information to determine the reason for a call failure. The diagnostic array contains `diag_length` valid bytes taken from the Cause IE length field.

2.9.2.14 The endstate Member

Only the signaling module fills in the `endstate` member as part of the enquiry processing.

2.9.2.15 The conv_p1 and conv_p2 Members

The `conv_p1` and `conv_p2` members are reserved for use by convergence modules only; no other module may access these members. Typically, these members store state information associated with the endpoint.

2.9.2.16 The sig_p1 and sig_p2 Members

The `sig_p1` and `sig_p2` members are reserved for use by signaling modules only; no other module may access these members. Typically, these members store state information associated with the endpoint.

No locking is required for access to this data structure. Since each module is permitted to modify only those fields assigned to it, there is no need to coordinate access to the entire structure with other modules. Access within a module may be locked if necessary.

2.9.2.17 Allocating the atm_addr Structure

One `atm_addr` structure is allocated by a protocol convergence module for each endpoint it calls and by signaling modules for each endpoint that calls the local host. Convergence and signaling modules use the `atm_cmm_alloc_addr` function call to allocate memory for the structure. The `atm_cmm_alloc_addr` call returns a valid pointer, if memory was successfully allocated and initialized; a NULL, if an error occurred. This is the only valid means to allocate memory for the structure.

Usually, the CMM frees all ATM address structures associated with a VC when the VC is destroyed. However, under some error conditions (such as when a convergence module is allocating a series of structures and one allocation fails), it may be necessary for the allocating module to free memory it has allocated. In these cases, modules can call the `atm_cmm_free_addr` function call with the value returned from `atm_cmm_alloc_addr` to free memory. Once the CMM accepts a connection request (either incoming or outgoing), only the CMM can free storage for this structure. See Appendix A for a description of the two routines.

2.9.3 The atm_vc_services Structure

Every connection on the system is allocated some amount of network resources (a portion of the network bandwidth). When a new connection is requested, the requester tells the ATM subsystem the type of physical

resources required by the connection. The CMM ensures those resources are available and allocates them to the connection.

The CMM uses the `atm_vc_services` structure to keep track of connection resources and to inform the device drivers of the resources that must be allocated for a connection. The `atm_vc_services` structure has the following characteristics:

- One structure must be allocated and the members set to valid values for each new connection by the entity that creates the connection (convergence protocol module on outgoing calls or signaling protocol module on incoming calls). Once the connection service parameters are set you cannot change them.
- The CMM keeps track of these structures on a per-VC basis and frees them when the connection is torn down.
- The structure defines those services the CMM and driver manage. Every signaling and convergence module must properly set up the structure regardless of the signaling protocol used to actually set up the connection.
- Signaling protocol modules may use the structure to obtain information needed to create various signaling protocol messages used in call management (available to all modules).
- The structure is also used to track resource reservations. A convergence module can reserve resources for allocation to incoming or outgoing calls at a later time. You use this structure to define what resources are to be reserved and to track the reserved resources. See Section 6.1 for more complete information on the use of this structure in resource reservation.
- This structure defines parameters relative to the local system, independent of the actual call direction. The term *forward* means the sending side of the connection on the local system; the term *backward* means the receiving side of the connection on the local system. This is different from the ATM Forum UNI specification, which defines parameters based on the call direction.

  The signaling module must perform any conversions between the `atm_vc_services` structure members and the appropriate information elements (IEs) in the signaling message. This might require interchanging forward and backward fields, depending on the direction of the call.
- The structure is always referenced as a pointer of type `atm_vc_services_p`.

Table 2–3 lists those member names of the `atm_vc_services` structure, with their associated data types, that modules might reference.

Table 2–3: The atm_vc_services Structure Members

Member Name	Data Type
vc	atm_vc_p
fqos	atmqos_t
bqos	atmqos_t
fmtu	unsigned int
bmtu	unsigned int
valid_rates	unsigned int
fpeakcr[2]	unsigned int
bpeakcr[2]	unsigned int
fsustcr[2]	unsigned int
bsustcr[2]	unsigned int
fburstcr[2]	unsigned int
bburstcr[2]	unsigned int
flags	unsigned int
aal	atmaal_t
queue	unsigned int
bearer_class	unsigned int
lerrstat	enum atm_lerr_t
nerrstat	unsigned int
cmm_drv_handle	atm_drv_handle_t
drv_resource	void *
converge_handle	void *

2.9.3.1 The vc Member

The vc member is a pointer to the VC structure for the connection.

2.9.3.2 The fqos and bqos Members

The fqos and bqos members are the forward and backward quality of services (QoS) types, respectively. These indicate the QoS the caller is requesting for the connection. The following table lists the values and meanings for fqos and bqos:

Value	Meaning
ATM_QOS_CLASSA	Connection-oriented, constant bit rate (CBR) traffic with source or destination timing relationships.
ATM_QOS_CLASSB	Connection-oriented, variable bit rate (VBR) traffic with source or destination timing relationships.
ATM_QOS_CLASSC	Connection-oriented, variable bit rate (VBR) traffic with no timing relationships.
ATM_QOS_CLASSD	Connectionless, variable bit rate (VBR) traffic with no timing relationships.
ATM_QOS_CLASSX	Undefined bit rate traffic.
ATM_QOS_CLASSY	Unspecified bit rate (UBR) traffic.
ATM_QOS_NONE	No specified quality of service.

2.9.3.3 The fmtu and bmtu Members

The `fmtu` and `bmtu` members are the forward and backward maximum transmission unit (MTU) size (in bytes), respectively. These indicate the maximum packet size that can be transmitted and received on the connection when the connection carries AAL3/4 or AAL5 data.

Only device driver modules use the `fmtu` and `bmtu` members to allocate resources for a connection; the signaling module does not use them to store MTU-related information elements (IEs). If a protocol requires explicit signaling of MTU information, the convergence module must use the `atm_uni_call_ie` structure to supply the IEs. See Section 2.9.4 for more information about the structure and its members. See Chapter 6 for information on making outgoing connections and accepting connections.

2.9.3.4 The valid_rates Member

The `valid_rates` member is a bit mask that indicates which line rates have been specified and which have been left unspecified. The following table lists the values and meanings for `valid_rates`:

Value	Meaning
ATM_VCRV_FPEAK0	Forward peak cell rate for CLP=0
ATM_VCRV_FPEAK1	Forward peak cell rate for CLP=1
ATM_VCRV_BPEAK0	Backward peak cell rate for CLP=0
ATM_VCRV_BPEAK1	Backward peak cell rate for CLP=1
ATM_VCRV_FSUST0	Forward sustainable cell rate for CLP=0
ATM_VCRV_FSUST1	Forward sustainable cell rate for CLP=1

Value	Meaning
ATM_VCRV_BSUST0	Backward sustainable cell rate for CLP=0
ATM_VCRV_BSUST1	Backward sustainable cell rate for CLP=1
ATM_VCRV_FBURST0	Forward burst cell rate for CLP=0
ATM_VCRV_FBURST1	Forward burst cell rate for CLP=1
ATM_VCRV_BBURST0	Backward burst cell rate for CLP=0
ATM_VCRV_BBURST1	Backward burst cell rate for CLP=1

2.9.3.5 The fpeakcr, bpeakcr, fsustcr, bsustcr, fburstcr, and bburstcr Members

The fpeakcr, bpeakcr, fsustcr, bsustcr, fburstcr, and bburstcr members are the arrays that contain the forward and backward peak, forward and backward sustainable, and forward and backward burst cell rates, respectively. These indicate the network bandwidth requested by the caller. The first element of each array specifies the value for cells that have the Cell Loss Priority (CLP) bit clear (CLP=0). The second element of each array specifies the value for cells that have the CLP bit set (CLP=1). Only certain combinations of these rates may be valid for a given signaling protocol or for a specific QoS type. Those rates that are explicitly specified are designated by setting the appropriate bit in the valid_rates member.

Note

To set a cell rate of 0, set the appropriate cell rate and mark it as valid; do not leave the cell rate unspecified.

2.9.3.6 The flags Member

The flags member contains a bit that specifies additional services required for the connection. The following table lists the values and meanings for flags:

Value	Meaning
ATM_SERVICES_BEI	Indicates that the connection should use the best effort service.
ATM_SERVICES_BTAG	Indicates that the network should enable tagging in the backward direction.

Value	Meaning
ATM_SERVICES_CBR	Indicates that the local ATM interface should pace cells out to the network and that the circuit should be set up so that the requested bandwidth is guaranteed for the VC. This flag causes both local cell pacing to be enabled and the circuit to be signaled as a CBR circuit. CBR can be enabled only on hardware that supports this feature.
ATM_SERVICES_CLIPPING	Indicates that the network should enable clipping of cells on this circuit.
ATM_SERVICES_FTAG	Indicates that the network should enable tagging in the forward direction.
ATM_SERVICES_NOTIMING	Indicates that the circuit has no end-to-end timing requirements. If neither this flag nor the ATM_SERVICES_TIMING flag are set, the circuit is signaled as having unspecified timing requirements.
ATM_SERVICES_PACING	Indicates that the local ATM interface should pace cells out to the network as if the circuit were a CBR circuit. This flag has local significance only and does not affect any of the signaling messages used in creating the connection. This flag is used mainly when a convergence module needs to limit the rate at which cells can be transmitting on a specific VC. Pacing can be enabled only on hardware that supports this feature.
ATM_SERVICES_PTM	Indicates that the connection is a point-to-multipoint connection.
ATM_SERVICES_TIMING	Indicates that this circuit has some end-to-end timing requirements. When set, the circuit is signaled as having timing requirements. Also, the local system may enable features to facilitate the delivery of data with timing constraints.
ATM_SERVICES_VBR	Indicates that the local ATM interface and the network should treat this circuit as a variable bit rate circuit. This flag both enables VBR cell processing on the local adapter and causes the circuit to be signaled as a VBR circuit. VBR can be enabled only on hardware that supports this feature.

2.9.3.7 The aal Member

The aal member specifies the AAL type for the connection and can have one of the following values: ATM_AAL1, ATM_AAL2, ATM_AAL3/4, or ATM_AAL5.

2.9.3.8 The queue Member

The queue member specifies the driver send queue to use for the VC (for drivers that support multiple send queues). The CMM sets this value; it must not be set by any other module.

2.9.3.9 The bearer_class Member

The bearer_class member specifies the bearer class information to be used when signaling the call or that was signaled by the caller. For UNI signaling, this must be set to one of the following values: ATM_BBEARER_BCOB_A, ATM_BBEARER_BCOB_C, or ATM_BBEARER_BCOB_X.

2.9.3.10 The lerrstat Member

The lerrstat member contains error indications that result from the CMM checking the validity of the structure contents. The following table lists the values and meanings for lerrstat:

Value	Meaning
ATM_LERR_GOOD	Indicates that no errors were found in the structure contents.
ATM_LERR_PEAKMISSING	Indicates that the peak cell rate for CLP0+1 has not been specified. A peak cell rate must be specified on all circuits (though the rates may be specified as 0).
ATM_LERR_PEAKTOOBIG	The specified CLP0+1 rate exceeds the rate that is permitted by the hardware or the system configuration.
ATM_LERR_NOBWAVAIL	The specified peak CLP0+1 bandwidth exceeds the available bandwidth on the interface.
ATM_LERR_BADPEAKCR0	The specified CLP0 peak cell rate exceeds the specified CLP0+1 peak cell rate. The CLP0 cell rate must be less than or equal to the CLP0+1 cell rate, depending on the connection type.
ATM_LERR_BADBURSTCR0	The CLP0 burst cell rate exceeds the CLP0+1 burst cell rate.
ATM_LERR_BURSTTOOBIG	The specified CLP0 or CLP0+1 burst cell rate exceeds the specified peak CLP0+1 cell rate.
ATM_LERR_BADSUSTCR0	The specified CLP0 sustained cell rate exceeds the specified CLP0+1 sustained cell rate.
ATM_LERR_SUSTTOOBIG	The specified CLP0 or CLP0+1 sustained cell rate exceeds the specified CLP0+1 peak cell rate.

Value	Meaning
ATM_LERR_RATETOOSMALL	The specified peak cell rate is smaller than the minimum rate the local hardware can allocate. A peak cell rate of 0 is always allowed.
ATM_LERR_BADTRAFFTYPE	Invalid traffic flags specified. This error occurs when neither the CBR or PACING flags are set, but the circuit is being configured as a CBR circuit. It can also occur when non-negotiable traffic flags are modified through the xxx_connect routine.
ATM_LERR_BADDRVHANDLE	When applying a reserved resource, the driver on which the resources were reserved does not match the driver on which the VC is being created.
ATM_LERR_RESNOTALLOC	When applying a reserved resource, the atm_vc_services structure is not backed by allocated resources. This indicates that an atm_vc_services structure that does not reference previously reserved resources is being applied in a context where reserved resources are required.
ATM_LERR_RESALREADY	When reserving resources, the atm_vc_services structure already references reserved resources. This indicates that an atm_vc_services structure that has already been used to reserve resources is being reused to reserve the same or different resources.
ATM_LERR_RATESCHANGED	When applying reserved resources, the information specified in the atm_vc_services structure has been changed since the resources referenced by the structure were originally reserved. Once resources are reserved, convergence modules are not allowed to change any of the entries in the atm_vc_services structure.
ATM_LERR_RATESINCOMPAT	When applying a reserved resource, the rates specified in the atm_vc_services structure are incompatible with the rates requested in an incoming call.
ATM_LERR_VCALREADY	When applying a reserved resource, the VC to which the resource is being applied already has a previously applied resource. Resources can be applied only once, and each VC can be assigned resources only once.

2.9.3.11 The nerrstat Member

Signaling modules use the `nerrstat` member to report signaling protocol-specific validity checking errors on the contents of the `atm_vc_services` structure. The values of this member depend on the signaling module. This structure is currently always set to zero (0).

2.9.3.12 The cmm_drv_handle Member

The `cmm_drv_handle` member contains the driver handle of the driver for which resources have been reserved (CBR circuits only). This may be compared to the driver handle information in the `atm_ppa` structure if a convergence module needs to determine whether reserved resources can be applied to a specific VC. This member is set by the CMM and must not be modified by any other module.

2.9.3.13 The drv_resource Member

Device drivers use the `drv_resource` member to store private information necessary to track reserved resources. The contents of this member have meaning only to the specific device driver on which resources have been reserved, and are not examined by the CMM. Only the driver on which the resources have been reserved can modify this member.

2.9.3.14 The converge_handle Member

Convergence modules use the `converge_handle` member to help track reserved resources. The contents of this member have meaning only to the specific convergence module that requested the reservations of resources, and are not examined by the CMM. Only the convergence module that reserved resources can modify this member.

2.9.3.15 Allocating the atm_vc_services Structure

To allocate the `atm_vc_services` structure, use the `atm_cmm_alloc_services` function call. This call allocates memory for the structure and initializes its members to default values for best-effort unspecified bit rate (UBR) service. Once allocated, other ATM modules can change the members of this structure as needed.

Typically, the CMM frees the `atm_vc_services` structure associated with a VC when the VC is destroyed. However, under some error conditions (such as when a convergence module is allocating a series of structures and one allocation fails), the allocating module might need to free memory it has allocated. In these cases, modules call the `atm_cmm_free_services` routine with the value returned from `atm_cmm_alloc_services` to free memory.

See Appendix A for syntax and a description of the two routines.

2.9.4 The atm_uni_call_ie Structure

The CMM uses the `atm_uni_call_ie` structure to store optional information elements (IEs) when the UNI 3.0/3.1 signaling protocol module sets up a VC. Since UNI 3.0/3.1 is the default signaling protocol that the ATM subsystem uses, the structure is described in this section. The `atm_uni_call_ie` structure has the following characteristics:

- The structure communicates only connection setup information between convergence protocol modules and the UNI 3.0/3.1 signaling protocol module.
- The CMM does not access or modify this structure.
- The information specified in this structure is taken directly from the various optional IEs used in the SETUP and CONNECT signaling messages. Mandatory IEs necessary for connection setup are built by the UNI 3.0/3.1 signaling protocol from information taken from the `atm_addr` and the `atm_vc_services` structures. See Section 2.9.2 and Section 2.9.3, respectively, for more information.
- The structure contains a union of all IEs that a convergence module can specify.
- Each instance of this structure specifies exactly one IE. To specify multiple IEs, you must define multiple instances of this structure. Convergence modules can specify as many IEs as are needed to place the call.
- The structure defines the terms forward and backward using the ATM Forum UNI specification definitions. Forward is the direction from the caller to the callee and backward is the direction from the callee to the caller. This is in contrast to the definitions used in the `atm_vc_services` struction. See Section 2.9.3 for more information.

Example 2–1 shows the `atm_uni_call_ie` structure definition.

Example 2–1: The atm_uni_call_ie Structure Definition

```
struct atm_uni_call_ie {
     atm_ie_types_t  ie_type;
     char            last;
     union {
          union {
               struct {
                     unsigned short  subtype;
                     unsigned short  cbr_rate;
                     unsigned short  multiplier;
                     unsigned short  crt;
```

Example 2–1: The atm_uni_call_ie Structure Definition (cont.)

```
                    unsigned short  err_corr;
                    unsigned short  sdt;
                    unsigned short  pfc;
               } aal1;
               struct {
                    unsigned int    fsdu;
                    unsigned int    bsdu;
                    unsigned int    mid;
                    unsigned short  mode;
                    unsigned short  sscs;
               } aal34;
               struct {
                    unsigned int    fsdu;
                    unsigned int    bsdu;
                    unsigned short  mode;
                    unsigned short  sscs;
               } aal5;
                    unsigned short user_aal[4];
          } aal_params;
          struct {
                unsigned short  hlit;
                unsigned short  hlisz;
                unsigned short  hli[8];
          } bb_high_layer;
          struct {
                unsigned short  layer2proto;
                unsigned short  mode2;
                unsigned short  q933;
                unsigned short  window_size;
                unsigned short  user2proto;
                unsigned short  layer3proto;
                unsigned short  mode3;
                unsigned short  dpsize;
                unsigned short  pktwindow;
                unsigned short  user3proto;
                unsigned int    ipi;
                unsigned short  snapid;
                unsigned short  oui[3];
                unsigned short  pid[2];
          } bb_low_layer;
          struct {
                unsigned short  bbri;
          } bbrepeat;
          unsigned short  bytes[28];
     } ie;
};
```

2.9.4.1 The ie_type Member

The `ie_type` member indicates the type of IE specified in the current instance of the structure. You must specify exactly one IE type per structure instance.

2.9.4.2 The last Member

The `last` member indicates the last element of the IE array. This member must have a nonzero value for the last element of the array and a value of 0 for all other elements. The last element of the array does not need to be the last physical element of the array. This indicates the last logical element so that a module reading the array can determine where the last valid element is located. To declare an element between the start of the array and the last element as unused, set the element's type to `ATM_IET_NONE`.

2.9.4.3 The aal_params Member

The `aal_params` member is a union that contains the data to be placed in (or read from the SETUP message) the AAL Parameters IE in the SETUP and CONNECT signaling messages. The way the system interprets this union depends on the value of the `ie_type` member. The meaning of each member of each structure in the `aal_params` union corresponds to a data field in the AAL Parameters IE. See the UNI 3.0/3.1 specification for details on the meaning and use of these IE fields.

2.9.4.4 The bb_high_layer and bb_low_layer Members

The `bb_high_layer` and `bb_low_layer` members are structures that specify information from their corresponding IE. Data in these structures is stored in machine native form, not just as a series of bytes from the network. Information in each structure is set either as numeric values or from constants as defined in the `atm/sys/atm.h` file. Also, the IE headers (the first 5 bytes of each IE that identifies the IE type and length) are not stored.

Note

Do not use the `bbbc` structure any more.

2.9.4.5 Allocating the atm_uni_call_ie Structure

A convergence module can allocate as many instances of the structure as are needed. The only valid way to allocate storage for and initialize the `atm_uni_call_ie` structure from a convergence module is to use the `atm_cmm_alloc_ie` function call.

IE structures are allocated in contiguous virtual memory so that convergence and signaling modules can access them as an array of structures. Each IE structure in the array can be accessed as an index from the value returned from this call. For example, the following code fragment shows how to access the *n*th structure in the array:

```
atm_uni_call_ie_p upp, pp;
register int i;

          /* Allocate 3 IE's */
upp = atm_cmm_alloc_ei(3);
          /* Make the first IE a repeat indicator */
p = upp;
p->ie_type = ATM_IET_REPEAT;
ATM_IE_SETVAL(p->ie.bbrepeat.bbri,2);
          /* make the next two BLLI */
p = upp+1;
p->ie_type = ATM_IET_BLLI;
ATM_IE_SETVAL(p->ie.bb_low_layer,layer2proto,...);
          /* fill in structure */
p = upp+2;
p->ie_type = ATM_IET_BLLI;
ATM_IE_SETVAL(p->ie.bb_low_layer.layer2proto,...);
          /* fill in structure */
```

If you are using non-UNI signaling protocols, the convergence modules that use these protocols might not be able to use this structure directly, but must still allocate memory for passing call setup information between the signaling and convergence modules. To do this, use the `atm_cmm_alloc_ie` routine to allocate memory and assist the CMM in properly freeing the memory when the connection is destroyed. The allocating module is free to use memory returned from this call, with the following restrictions:

- Memory is allocated in multiples of the structure size so the minimum number of `atm_uni_call_ie` structures that provide enough storage must be allocated.
- The only address that convergence and signaling modules are permitted to use to reference this memory is the address returned from the `atm_cmm_alloc_ie` call.

To allocate some arbitrary amount of memory for use in call setup, use the following algorithm:

```
register char *p;
register int size;

size = (bytes_to_alloc + (sizeof(struct atm_uni_call_ie)-1)) /
       sizeof(struct atm_uni_call_ie);
p = (char *)atm_cmm_alloc_ie(size);
```

Typically, the convergence protocol module frees all UNI signaling structures associated with a VC when the VC is destroyed. However, under some error conditions (such as when a convergence module is allocating a series of structures and one allocation fails) the allocating module (either the convergence or signaling module) might have to free memory it has allocated. Convergence modules should not free memory for this structure if the `atm_cmm_connect` or related call succeeds because the CMM will free the memory.

If the `connect` or related call fails, the CMM does not free the memory for structures passed in as arguments since it permits the calling routine to retain the memory for future tries. In this case, the convergence module must free the memory for these structures if they will not be retained for future call attempts. Modules can call the `atm_cmm_free_ie` function call with the value returned from `atm_cmm_alloc_ie` to free memory.

2.9.4.6 Setting Fields in the atm__uni_call_ie Structure

When a protocol convergence module needs to create a new connection, the module allocates and fills in an `atm_call_ie` structure array and passes this array to the CMM as part of the `atm_cmm_connect` function call. The convergence module must completely set all information in each IE that it creates; there are no default values. All IEs must be allocated using the routines described in Section 2.9.4.5 and must be referenced as an array of structures. Only the value returned from the `atm_cmm_alloc_ie` routine can be used to pass references to the IE array to the CMM. Never pass a pointer to an arbitrary element within the array to the CMM.

Since many of the IE fields are optional, each field explicitly set by a convergence module or by an incoming SETUP message must be explicitly flagged. Table 2–4 describes macros that provide the only valid means to read and write values to and from the `atm_uni_call_ie` structure.

Table 2–4: Information Element Macros

Macro	Meaning
`ATM_IE_SETVAL(Field,Value)`	Sets a value in an IE field. This sets the field to the specified value and marks the field as valid; any previous field value in the field is destroyed. The `Field` argument is a C statement that references the field to be written, and `Value` is the value to write to the field.
`ATM_IE_ISVALID(Field)`	Determines if the referenced field holds valid data (was explicitly specified by the entity that created the IE).

Table 2–4: Information Element Macros (cont.)

Macro	Meaning
ATM_IE_GETVAL(Field)	Reads values from an IE field. This returns 0 if the field does not contain valid data. To distinguish between a valid value of 0 and an unspecified field, use the ATM_IE_ISVALID( ) macro to determine the field's state.
ATM_IE_CLRVAL(Field)	Deletes valid information from an IE field. This deletes the data in the field and marks the field as invalid. This is the only way to remove (unset) a value from a field.

2.9.5 The atm_ppa Structure

The ATM subsystem uses the atm_ppa structure to identify a unique address/interface/signaling triple in the ATM subsystem. The PPA specifies the calling party address on outgoing calls and specifies the called party addresses to which the ATM subsystem will respond on incoming calls. The atm_ppa structure has the following characteristics:

- The CMM maintains exactly one PPA structure for each address or driver combination configured on the system.
- Only the CMM can change the contents of the PPA structure.
- Convergence modules can hold references to the PPA structures until they receive a notification that the PPA has been deleted.
- The structure is always referenced as type atm_ppa_p.

Table 2–5 lists those members of the atm_ppa structure, with their associated data types, that modules might reference.

Table 2–5: The atm_ppa Structure Members

Member Name	Data Type
driver	atm_drv_handle_t
sig	atm_sig_handle_t
ppas_id	void *
ton	unsigned char
anpi	unsigned char
addrlen	unsigned char
address[ATM_PPA_MAX_ADDR]	unsigned char
uni	atm_uni_type_t

Table 2–5: The atm_ppa Structure Members (cont.)

Member Name	Data Type
type	atm_ppa_type_t
esi_arg	void *

2.9.5.1 The driver Member

The driver member indicates the driver or physical interface to which this PPA belongs. Since each interface can have any number of PPAs (one for each registered address plus one PVC PPA), this member identifies the underlying device. This value is significant only to the ATM subsystem, but it can be used by convergence modules to determine if two PPAs are associated with the same physical interface.

2.9.5.2 The sig Member

The sig member indicates the signaling module to which the PPA belongs; the signaling module handles connection management for that PPA.

2.9.5.3 The ppas_id Member

The ppas_id member is a value provided by the signaling module that created the PPA for it to use in identifying or managing the PPA. The signaling module provides this value when registering the PPA with the CMM. The CMM does not use or modify this value.

2.9.5.4 The ton Member

The ton member is a value that specifies the endpoint's address type. These bits are identical to the type of number field in the Called Party Number IE (right justified).

2.9.5.5 The anpi Member

The anpi member is the address or numbering plan identification information for the address. These bits are identical to those in the corresponding field of the Called Party Number IE.

2.9.5.6 The addrlen Member

The addrlen member contains the length (in bytes) of the endpoint address in the address array.

2.9.5.7 The address Member

The `address` member is an array that contains one complete ATM address for the PPA. This is the fully registered address that contains either a valid E.164 address or a valid AESA (with both network and ESI parts).

2.9.5.8 The uni Member

The `uni` member identifies the type of UNI interface to which this PPA belongs. The types of UNI interface are as follows:

- `ATM_UNI_PRIVATE` — A private UNI interface
- `ATM_UNI_PUBLIC` — A public UNI interface

All ATM interfaces are private UNI interfaces.

2.9.5.9 The type Member

The `type` member identifies the PPA type. The PPA types are as follows:

- `ATM_PPA_PUBLIC` — Global PPAs that all convergence modules share.
- `ATM_PPA_PRIVATE` — PPAs that are private to a specific convergence module. The PPA was created using an ESI provided by that convergence module.

2.9.5.10 The esi_arg Member

The `esi_arg` member stores the convergence module private argument passed to the CMM when a private ESI is registered. Convergence modules use this information to track which PPAs are created from specific ESIs. This member is valid only for private PPAs, but contains NULL in public ESIs.

2.9.6 The atm_esi Structure

The `atm_esi` structure accommodates non-UNI ESI or equivalent address information for signaling modules that have similar requirements in forming full network addresses. Only the signaling module cares about the actual structure of the address since it is the entity that interprets this information for registration with the network. Of course, any entity that creates an ESI must make the ESI conform to the format that the signaling module uses. In addition, the `atm_esi` structure has the following additional characteristics:

- The pointer to the structure is maintained as the system-wide reference to the structure.
- Only the CMM allocates and frees the structure. Only the CMM may modify the nonprivate structure members.

- Non-UNI signaling protocols are free to use the ESI data in any way that is appropriate for the protocol, including setting full addresses from the `atm_esi` structure.

Table 2–6 lists those members of the `atm_esi` structure, with their associated data types, that modules might reference.

Table 2–6: The atm_esi Structure Members

Member Name	Data Type
`esi[ATM_MAX_ESI]`	`unsigned char`
`esilen`	`unsigned int`
`driver`	`atm_drv_handle_t`
`sigp1`	`void *`
`sigp2`	`void *`

2.9.6.1 The esi and esilen Members

The `esi` member is an array that holds `esilen` bytes of the ESI. The length of the ESI must be less than ATM_MAX_ESI. For UNI signaling, the ESI length must be 6 bytes.

2.9.6.2 The driver Member

The `driver` member is the driver handle for the interface on which the ESI is configured. Each ESI is associated with exactly one interface. However, different interfaces can have the same ESI values, but they must be in separate ESI structures.

2.9.6.3 The sigp1 and sigp2 Members

The `sigp1` and `sigp2` members are for the private use of signaling modules to keep internal information about the ESI. The CMM does not modify these members.

2.9.7 The atm_cause_info Structure

The `atm_cause_info` structure enables the CMM to keep track of all errors that occur on a VC or endpoint as well as record information that may be used to log activity on a VC or endpoint. The structure stores the following types of information:

- Cause information

  This can be any VC and endpoint errors that are made visible to the network and to the other end of the connection through a Cause IE. Cause

information also contains information of local significance only (such as text describing the error), but must contain a valid ATM cause code.

- Logging information

  This can be any VC and endpoint activity information that is simply logged on the local system and not converted to Cause IE. Logging information provides information about VC or endpoint activity that a system or network administrator can view on the local system by using ATM administration tools.

The `atm_cause_info` structure has the following additional characteristics:

- All ATM modules use this structure to read cause and logging information from a VC or endpoint.
- Only the CMM allocates the structure.
- All cause and logging information retrieval functions return a pointer to this structure.
- The structure is not used for setting cause and logging information.
- The CMM writes cause and logging information when logging routines are called. The structure contents are not directly modified.

Table 2–7 lists those members of the `atm_cause_info` structure, with their associated data types, that modules might reference.

Table 2–7: The atm_cause_info Structure Members

Member Name	Data Type
`cause`	`atm_error_t`
`location`	`atm_location_t`
`module_name`	`char *`
`reason`	`char *`
`diag_length`	`unsigned char`
`diag[ATM_DIAGNOSTIC_LENGTH]`	`unsigned char`

2.9.7.1 The cause Member

The `cause` member specifies the type of ATM error that occurred.

2.9.7.2 The location Member

The `location` member specifies the ATM location code indicating where the error occurred (that is, user and network).

2.9.7.3 The module_name Member

The `module_name` member specifies the ATM module in which the error occurred.

2.9.7.4 The reason Member

The `reason` member is a string that describes the error.

2.9.7.5 The diag_length Member

The `diag_length` member specifies the length of the diagnostic information.

2.9.7.6 The diag Member

The `diag` member contains diagnostic information from the diagnostic field in the Cause IE.

3

Device Driver Interface

The ATM device driver interface enables ATM device drivers to communicate with the ATM subsystem. It is a registration-based interface that dynamically configures itself at system boot time. The ATM device drivers resemble other operating system device drivers, with the following exceptions:

- The interface to the ATM subsystem is different than the current character, block, or networking device driver interfaces.
- ATM drivers must register with the ATM Connection Management Module (CMM).
- ATM drivers provide no `read`, `write`, `ioctl`, or `select` routine since all these functions are handled through the CMM.
- ATM drivers must provide a probe and attach routine for the operating system to call to determine if the device is present and to attach the device to the operating system.
- ATM drivers must provide an unattach routine, if the driver is to unregister with the operating system.

Like networking drivers, ATM device drivers do not require an entry in the system's `cdevsw` table.

The ATM device driver interface enables device drivers to:

- Register the device driver
- Receive data packets and cells
- Report errors
- Unregister the device driver

This chapter describes each of these tasks, the function calls involved, and the relevant data structures that device driver writers can use. Appendix A contains a reference page for each device driver interface routine.

3.1 Registering the Device Driver

When the operating system is booted, it calls each device driver's probe routine to determine if the device that the device driver controls is present on the system and is functional. If the probe routine finds a device, it uses

the return value to indicate this to the kernel. The kernel then calls the device's attach routine to attach itself to the system.

When a device driver's attach routine is called, it calls the `atm_cmm_register_dd` routine before returning from the attach. This registers the device driver with the CMM.

3.2 Receiving Data Packets and Cells

When an ATM device driver receives data packets and cells from the ATM network, it calls the `atm_cmm_receive` routine to pass the data to the CMM. When the CMM receives the data, it immediately passes the data to the convergence module that owns the virtual circuit (VC). The CMM does not queue the data. That way, the convergence modules receive the data at their input functions in the interrupt context; the driver should do all receive processing in interrupt context for efficiency.

After passing data to the CMM, the driver must not reference any mbufs in the mbuf chain again. If the driver must allocate private storage for data (rather than allocating from the system mbuf pool), the driver must provide an appropriate free routine and set the `m_ext` structure in the mbuf appropriately. The data mbuf chain is deallocated only when the protocol stack has finished referencing the data.

When an ATM device driver receives operations and maintenance (OAM) cells (nondata cells) from the ATM network, it calls the `atm_cmm_oam_receive` routine to pass the cells to the CMM for processing. Device drivers should pass all OAM cells to the CMM.

3.3 Reporting Errors

When an ATM device driver detects errors on VCs or other interface failures, it calls the `atm_cmm_error` routine to report the error to the CMM. When the CMM receives the error report, it recovers or shuts down the VC in error. The driver does not need to perform any other actions. If the VC must be destroyed, the CMM calls the driver through the driver management interface to deactivate or destroy the VC. If the error indicates an interface failure, the CMM tears down VCs on the interface.

3.4 Unregistering the Device Driver

When a device driver needs to unregister from the CMM, the driver calls its unattach routine. The routine should put the driver in the DOWN state, then call the `atm_cmm_unregister_dd` routine. The CMM then checks that no resources are still assigned to the driver and, if true, removes the driver instance from the list of active drivers registered with CMM. See the *Writing Network Device Drivers* manual and other device driver

documentation for information on writing network device drivers and the driver framework interface.

3.5 Using ATM Device Driver Interface Structures

The ATM device driver interface uses the following structures exclusively:

- `atm_drv_params` — The device parameters and statistics structure
- `atm_queue_param` — The queue parameter structure

3.5.1 The atm_drv_params Structure

The CMM and convergence modules need to know the capabilities of each physical interface. Since this information is maintained by the driver for each interface, the system uses the `atm_drv_params` structure to communicate interface parameters and statistics between modules. The CMM typically queries this information from device drivers and then passes it to other ATM modules on request. The CMM and convergence modules can request this information at any time, and there is no limit on the number of times the information can be queried. To allow for future expansion of the `atm_drv_params` structure, the device driver should call the `bzero` command to insert nulls into the entire structure before filling in the known fields.

Table 3–1 lists those members of the `atm_drv_params` structure, with their associated data types, that device drivers might reference.

Table 3–1: The atm_drv_params Structure Members

Member Name	Data Type
`name`	`char *`
`unit`	`unsigned int`
`type`	`atm_interface_t`
`num_vc`	`unsigned int`
`max_vcib`	`unsigned int`
`max_vpib`	`unsigned int`
`max_vci`	`unsigned int`
`max_vpi`	`unsigned int`
`sent`	`unsigned long`
`received`	`unsigned long`
`dropped`	`unsigned long`
`num_vci`	`unsigned int`

Table 3–1: The atm_drv_params Structure Members (cont.)

Member Name	Data Type
num_vpi	unsigned int
hard_mtu	unsigned int
nqueue	unsigned int
flowcontrol	unsigned int
rates	atm_vc_services_t
capabilities	unsigned int
numid	unsigned char
ids[6][1]	unsigned char

3.5.1.1 The name member

The name member specifies a character string that represents the name by which the device is known to the system. Management programs use this string when displaying information about the device. Do not include the character representation of the unit number in this name (for example, specify ATM rather than ATM0).

3.5.1.2 The unit Member

The unit member specifies a unit number for the device for those instances where the driver controls more than one device. The unit numbers start at 0.

3.5.1.3 The type Member

The type member specifies the type of interface that the device uses.

3.5.1.4 The num_vc Member

The num_vc member specifies the maximum number of VCs the driver can have open simultaneously.

3.5.1.5 The max_vcib and max_vpib Members

The max_vcib and max_vpib members specify the largest value the driver permits for VCI and VPI values, respectively.

3.5.1.6 The max_vci and max_vpi Members

The max_vci and max_vpi members specify the maximum number of VCIs per VPI and the maximum number of VPIs, respectively, that the driver can support.

3.5.1.7 The sent Member

The `sent` member is a counter of the total number of cells sent by the driver since it was last brought on line.

3.5.1.8 The received Member

The `received` member specifies the total number of cells received by the driver since it was last brought on line.

3.5.1.9 The dropped Member

The `dropped` member specifies the total number of cells dropped by the driver since it was last brought on line.

3.5.1.10 The num_vci and num_vpi Members

The `num_vci` member specifies the number of VCs currently available for use. It is equivalent to the value of `num_vc` minus the number of VCs currently in use.

The `num_vpi` member specifies the number of non-zero virtual paths (VPs) available for use. It is equivalent to the value of `max_vpi` minus the number of VPs currently in use.

3.5.1.11 The hard_mtu Member

The `hard_mtu` member specifies the maximum packet size (in bytes) the driver can accommodate when processing cooked packets (for AAL3/4 and AAL5 only).

3.5.1.12 The nqueue Member

The `nqueue` member specifies the total number of queues that the interface supports. If the driver supports more than one queue, the CMM assumes the driver is capable of permanently associating VCs to queues for the lifetime of the VC.

3.5.1.13 The flowcontrol Member

The `flowcontrol` member specifies the types of flow control the driver supports. Valid values are `ATM_FLOW_NONE`, `ATM_FLOW_STD`, and `ATM_FLOW_VENDOR`. The CMM uses this information to assign VCs to multiple queues based on connection service parameters to achieve the best performance and fairness in cell transmission.

3.5.1.14 The rates Member

The `rates` member specifies an `atm_vc_services` structure that the driver has set to indicate the maximum cell rates that the interface supports for each cell rate class. These values include any amount the driver can overcommit for the interface. The CMM uses these values to determine if a connection can be granted its requested bandwidth. The other members of the `atm_vc_services` structure are unused in this context.

3.5.1.15 The capabilities Member

The `capabilities` member specifies miscellaneous driver capabilities. It is a bit mask that the driver uses to specify functions that the driver can or cannot perform.

The CMM currently uses the following capabilities:

Capability	Description
`ATM_DC_DOESPTI`	Indicates whether the driver keeps track of the Payload Type Indicator (PTI) bits across all cells of cooked packets (when the driver or hardware reassembles the packets from ATM cells). This capability keeps track of the congestion indication bit in the PTI field of the ATM cell header. If this bit is set, the CMM expects the PTI information provided to the `atm_cmm_receive` call to be valid. If this bit is clear, the CMM ignores the PTI information on received packets.
`ATM_DC_DOESGFC`	Indicates whether the device driver supports passing Generic Flow Control (GFC) bits to the CMM and to convergence layers through the CMM. The use of the GFC bits is not finalized. Therefore, the CMM ignores any GFC bits.
`ATM_DC_DOES_AAL5`	Indicates that the driver or adapter directly implements AAL5. The driver or adapter adds the AAL5 trailer to outgoing packets (including cyclical redundancy check (CRC) generation) and splits the packets into cells. The driver or adapter will reassemble incoming cells into an AAL5 packet and check the AAL5 trailer CRC. If this bit is set, convergence modules can send or receive packets and do not have to implement the AAL5 SAR functions. If this bit is not set, convergence modules must implement all AAL5 SAR functions and send or receive full ATM cells, if they want to send and receive AAL5 cells.

Capability	Description
ATM_DC_DOES_AAL3	Indicates that the driver or adapter directly supports AAL3/4. The driver or adapter adds the AAL3/4 headers and trailers (including CRC) and splits the packets into cells. The driver or adapter reassembles incoming cells into an AAL3/4 packet and checks the CRC. If this bit is set, convergence modules can send or receive packets and do not have to implement the AAL3/4 SAR functions. If this bit is not set, convergence modules must implement all AAL3/4 SAR functions and send or receive full ATM cells, if they want to send and receive AAL3/4 cells.
ATM_DC_DOES_RAW	Indicates that the driver or adapter is capable of sending and receiving raw ATM cells. The driver or adapter accepts raw ATM cells (full 53-byte cells) for transmission and passes incoming cells to the CMM as received. A driver can support both raw and AAL5 or AAL3/4 handling simultaneously. If a driver does not support raw cells, convergence modules cannot send arbitrary cells through the interface controlled by the driver. Since most drivers do not support AAL1, AAL2, or AAL3/4 directly, these must be handled by convergence modules as raw cells; the convergence modules must perform any needed SAR functions.

3.5.1.16 The numid Member

The numid member specifies the number of 48-bit Media Access Control (MAC) addresses configured on the device's address read-only memory (ROM). The driver must allocate an atm_drv_params structure large enough to hold all the 48-bit MAC addresses by allocating space as follows:

```
sizeof(struct atm_drv_params) + numid*6 bytes
```

3.5.1.17 The ids Member

The ids member specifies an array that holds the 48-bit MAC addresses. Each address appears in the array sequentially starting at ids[6*n], where *n* is the address number. The CMM uses these addresses as the end system identifiers (ESI) when registering with the switch.

3.5.2 The atm_queue_param Structure

The atm_queue_param structure is an argument to the ATM_DRVMGMT_RAW-PARAM ATM management command. See the description for the atm_cmm_register_dd routine in Appendix A for more information.

Table 3–2 lists those members of the atm_queue_param structure, with their associated data types, that device drivers might reference.

Table 3–2: The atm_queue_param Structure Members

Member Name	Data Type
vc	atm_vc_p
qlength	unsigned int
qtime	unsigned int
flags	unsigned int

3.5.2.1 The vc Member

The vc member specifies the VC for which the parameters are being set.

3.5.2.2 The qlength Member

The qlength member specifies the number of cells to be queued for passing in a single mbuf chain. The driver waits until this number of cells has been received before passing the cells to the CMM. Larger values reduce the per-cell overhead, but increase latency and the amount of memory consumed to buffer the cells.

3.5.2.3 The qtime Member

The qtime member specifies the maximum interval between cells (in 10-millisecond intervals) before queued cells are passed to the CMM. This value enables the driver to control latency. A value of 0 specifies an infinite amount of time between cells. The interaction between the qlength and qtime values is similar to that in the TTY subsystem. Basically, the driver accumulates cells until qlength cells are received or until there has been more than qtime ticks since the last cell was received.

3.5.2.4 The flags Member

The flags member specifies one of the following behaviors from the driver:

Behavior	Definition
ATM_QP_STAMP	Instructs the driver to time-stamp all incoming cells and place the time-stamp immediately after the cell data in the mbuf. The time is a 64-bit value taken from the systems free-running clock and has a resolution of 10 nanoseconds. These values are useful only for determining the approximate cell interarrival time, by subtracting the time-stamp of cell *n* from the time-stamp of cell *n*+1. The time-stamp length is included in the mbuf length (time-stamped cells have an mbuf length of 61 rather than 53). See Section 2.4 for more information on data formats.
ATM_QP_EFLAG	Instructs the driver to insert 0-length mbufs to indicate that a cell was dropped due to an error or insufficient resources. If time-stamping is also enabled, the mbuf contains only a 64-bit time-stamp (the mbuf length is 8 bytes). Only cells lost in a manner detectable by the driver are flagged. Cells lost on the network are not tagged. Protocols using constant bit rate (CBR) can determine if a cell was lost on the network or at the sending station by a gap in the cell interarrival time. See Section 2.4 for more information on data formats.

4

Signaling Module Interface

The ATM subsystem signaling module interface enables signaling protocol modules to communicate with the ATM subsystem for connection management only. The primary signaling module provided with the base system is the UNI 3.0/3.1-compliant signaling module. However, you can add new signaling modules if the modules do not conflict with each other (such as in the use of well-known virtual circuits (VCs)). Once configured, any convergence module can use a signaling module on a per-call basis.

Note

New signaling modules should make no assumptions about which convergence modules use them, though the convergence modules may need to know about specific signaling modules.

The signaling module interface does not provide functions that allow the signaling module to exchange data with an ATM switch. To exchange data, signaling modules must also register as convergence modules for purposes of creating signaling VCs, usually permanent virtual circuits (PVCs), and of exchanging signaling data with the network.

The ATM signaling module interface enables signaling modules to:

- Register the signaling module
- Receive, reply to, activate, release, and delete connections
- Restart a VC
- Drop endpoints
- Add and delete physical points of attachment (PPA)
- Report a connection failure, a completed restart, a completed status enquiry, and Management Information Base (MIB) access
- Request VC and endpoint status

This chapter describes each task, the function calls involved, and the relevant data structures that signaling module writers can use. Appendix A contains a reference page for each signaling module interface routine.

4.1 Registering the Signaling Module

When a signaling module is initialized, the module must use the `atm_cmm_register_sig` function call to register with the Connection Management Module (CMM). Once registered, the CMM can use the signaling module and make it available to convergence modules.

Signaling modules should register as both signaling and convergence modules. When registering as a convergence module, a signaling module must set up its signaling VCs to send and receive signaling messages. The CMM does not provide special facilities for signaling VCs, but treats them like any other VC. See Section 6.6 for a description of signaling VC initialization.

4.2 Receiving a New Call

When a signaling module receives a new call, it uses the `atm_cmm_new_call` function call to notify the CMM of the new call. The CMM determines whether the call should be accepted. This CMM function call is nonblocking and returns with an indication about the disposition of the call.

4.3 Reporting a VC Activation

When a signaling module receives notification from the switch that a new connection has been completed and a new VC activated, the signaling protocol module uses the `atm_cmm_reply` function call to notify the CMM. The CMM passes the notification to the device driver and protocol convergence module.

This call notifies the CMM of both the activation of point-to-point connections and of the addition of endpoints in point-to-multipoint connections.

4.4 Activating a Connection

When a signaling module receives the necessary indication from the network that the circuit is connected, the signaling module uses the `atm_cmm_activate_con` function call to inform the CMM that the connection is ready to carry data. The CMM enables the VC locally.

Note

Do not make this call before circuit connection.

4.5 Reporting a Connection Failure

When the CMM makes a connection request to a signaling module, the call to the remote system might fail for some reason. Since call creation is an asynchronous operation, the signaling module might encounter errors during call processing after the `xxx_setup` call has returned. In these cases, the signaling module uses the `atm_cmm_con_failed` function call to notify the CMM of the call failure and the reason for the failure.

4.6 Releasing a Connection

When a signaling module receives a request to tear down a connection from the network or endpoint, the module uses the `atm_cmm_con_release` function call to notify the CMM that the connection will be released. The CMM makes the connection unavailable for transmission, initiates the teardown of the referenced connection and all associated endpoints, and awaits notification that the VC has been torn down.

4.7 Dropping an Endpoint

When a signaling module receives a request to drop an endpoint from a connection, the module uses the `atm_cmm_ep_dropped` function call to notify the CMM that the endpoint must be dropped. The CMM then notifies the convergence module that owns the endpoint's VC that the endpoint has been dropped and deletes the endpoint. If the last endpoint associated with a VC is dropped, the CMM initiates the release of the VC.

4.8 Deleting a Connection

When a signaling module receives confirmation of a connection's release from the switch, the module uses the `atm_cmm_con_deleted` function call to notify the CMM that the connection no longer exists. The CMM holds the resources associated with the connection for a brief period of time, then releases them, giving all incoming queues time to clear. The CMM also notifies convergence modules that the connection has been released.

4.9 Restarting a Virtual Circuit

When a signaling module receives a RESTART request, the module uses the `atm_cmm_restart` function call to pass all the appropriate information to the CMM. The CMM then initiates a restart of the indicated VC(s) before returning to the signaling module.

4.10 Reporting a Completed Restart

After the CMM requests a restart, the signaling module uses the `atm_cmm_restart_ack` function call to notify the CMM when the restart has completed. Once notified, the CMM returns the indicated VCs to the NULL state and frees their resources.

4.11 Reporting a Completed Status Enquiry

After the CMM requests a status enquiry of a VC, the signaling module uses the `atm_cmm_status_done` function call to notify the CMM when the enquiry has completed. Once notified, the CMM either examines the enquiry data itself or passes it to the convergence module that requested the enquiry.

4.12 Requesting Endpoint Information

Since signaling modules can receive messages for existing VCs at any time, the modules use the `atm_cmm_findaddr` function call to request endpoint and VC information from the CMM. The CMM maintains all state information about each VC and calls (endpoints) associated with the VC.

Signaling modules can call this routine at any time to resolve a reference to a connection endpoint. Once the reference is resolved, the signaling module can access and modify structures as necessary as long as locking conventions are followed.

4.13 Adding a PPA

Signaling protocols usually perform some protocol registration-specific registration with the switch, including registering local addresses. When a signaling module creates a new address (creating a new PPA), the module uses the `atm_cmm_new_ppa` function call to inform the CMM that this new PPA exists. A convergence module can use the PPA to make and receive calls.

For example, when a UNI 3.0/3.1 signaling module is informed of a new address prefix, through the Integrated Local Management Interface (ILMI), that has been created on the switch, the module combines the new prefix with existing end system identifiers (ESIs) to form a new set of addresses for the new prefix. Then, the signaling module tells the CMM about each of these new addresses.

4.14 Deleting a PPA

When a signaling protocol, in cooperation with a switch, deletes an address from the list of recognized addresses on an interface, it uses the `atm_cmm_del_ppa` function call to inform the CMM that the deleted PPA associated with the address is no longer valid. The CMM then informs

convergence modules bound to the PPA that the address is no longer valid and initiates a teardown of all VCs associated with the address.

All PPAs, except for the PVC PPAs, are owned by a signaling module. That is, a signaling module is always responsible for the creation and deletion of a PPA. This is required since the registration of addresses with a switch is handled entirely by signaling protocols. Also, PPAs can be deleted because of actions on the network that are completely unrelated to the local system. Because of this, the CMM does not automatically delete PPAs when an interface is taken down or loses its connection to the switch. The CMM responds to an interface shutdown by deleting the PVC PPA. Signaling modules will delete PPAs when it is appropriate for their protocols to do so (such as when they lose communications with the switch).

See Section 2.5.1 for more information on PVC PPAs.

4.15 Requesting VC Status

When a signaling module needs to access status information about a VC that is currently in service, based on the virtual path identifier (VPI) and virtual channel identifier (VCI), it calls the `atm_cmm_vc_get` function call. The call returns a reference to a VC.

4.16 Using the atm_sig_params Structure

The CMM needs to know the capabilities and entry points of each signaling module. Signaling modules use the `atm_sig_params` structure to pass this information to the CMM as part of the `atm_cmm_register_sig` function call. To allow for future expansion of the `atm_sig_params` structure, the signaling module should call the `bzero` command to insert nulls into the entire structure before filling in the known fields.

Example 4–1 shows the `atm_sig_params` structure definition.

Example 4–1: The atm_sig_params Structure Definition

```
struct atm_sig_params {
        atm_error_t (*sig_setup)(atm_addr_p addr,
                unsigned long *refptr);
        atm_error_t (*sig_release)(atm_addr_p addr);
        atm_error_t (*sig_add)(atm_addr_p addr);
        atm_error_t (*sig_drop)(atm_addr_p addr);
        atm_error_t (*sig_enquery)(atm_addr_p addr);
        atm_error_t (*sig_restart)(void *handle,
                unsigned int class,
                unsigned int vpi,
                unsigned int vci);
        atm_error_t (*sig_exception)(void *sig_handle,
                unsigned int exception,
                void *arg);
        int (*sig_mmi)(void *sig_handle,
                int command,
                void *arg,
                int *retval,
                struct ucred *cred);
        atm_error_t (*sig_mib)(void *sig_handle,
                atm_ppa_p ppa,
                atm_mib_request_t command,
                atm_mib_var_p request);
        void *reserved1;
        void *reserved2;
        void *reserved3;
};
```

4.16.1 The sig_setup Member

The `sig_setup` member specifies a pointer to a routine that the CMM calls to request the creation of a new connection (make a call).

4.16.2 The sig_release Member

The `sig_release` member specifies a pointer to a routine that the CMM calls to request the deletion of a connection (a hangup).

4.16.3 The sig_add Member

The `sig_add` member specifies a pointer to a routine that the CMM calls to request the addition of an endpoint to a point-to-multipoint connection.

4.16.4 The sig_drop Member

The `sig_drop` member specifies a pointer to a routine that the CMM calls to request the dropping of an endpoint to a point-to-multipoint connection.

4.16.5 The sig_enquery Member

The `sig_enquery` member specifies a pointer to a routine that the CMM calls to request status for an endpoint.

4.16.6 The sig_restart Member

The `sig_restart` member specifies a pointer to a routine that the CMM calls to request a RESTART message be sent.

4.16.7 The sig_exception Member

The `sig_exception` member specifies a pointer to a routine that CMM uses to notify the signaling module of errors and exception conditions.

4.16.8 The sig_mmi Member

The `sig_mmi` member specifies a pointer to a routine that CMM uses to manage the signaling module through the ATM Module Management Interface (MMI). A signaling module must supply an `xxx_mmi` routine if it is to be managed through the MMI.

4.16.9 The sig_mib Member

The `sig_mib` member is reserved, and must be initialized to zero.

4.16.10 The reserved1, reserved2, and reserved3 Members

The `reserved1`, `reserved2`, and `reserved3`members are reserved for future use, and should be specified as NULL.

5

Convergence Module Interface

The ATM convergence module interface enables all kernel-level protocol convergence modules (convergence modules, for short) to interface kernel networking protocol stacks to the ATM subsystem. The ATM convergence module interface is a registration-based interface that provides a set of ATM primitives that convergence modules can use to manage virtual circuits (VCs) and transfer data.

The ATM convergence module interface enables convergence modules to:

- Register and unregister the convergence module
- Receive connection, data, and exception notification from the CMM
- Connect to the ATM Module Management Interface (MMI)
- Request interface parameters, endpoint connection state information, and VC statistics
- Add an endpoint to and drop an endpoint from a connection
- Transmit data on an established VC
- Modify VC parameters
- Request a connection to a remote system and a connection teardown
- Bind to and unbind from a PPA
- Accept and reject an incoming call
- Add and delete ATM addresses

This chapter describes each task, the function calls involved, and the relevant data structures that convergence module writers can use. Appendix A contains a reference page for each convergence module interface routine.

5.1 Registering a Convergence Module

Before a protocol convergence module can interact with the ATM subsystem, it must use the `atm_cmm_register_cvg` function call to register itself with the Connection Management Module (CMM). The CMM then passes interface configuration information (for example, currently configured PPAs) to the convergence module, using the module's `xxx_except` routine, before the registration call returns.

Once a convergence module is registered, the CMM knows where to deliver connection notifications and various exception notifications (for example, changes in system configuration). Convergence modules can register at any time.

5.2 Receiving Data

When the CMM receives data on a VC that the convergence module owns, the CMM calls the `xxx_receive` routine to pass incoming data to the convergence module. This routine is declared within the convergence module.

If the convergence module uses point-to-multipoint VCs, the module can declare either a `xxx_receive` or `xxx_endpt_receive` routine. If a `xxx_receive` routine is declared, the CMM calls it once for each unit of data received on the VC. The convergence module must duplicate the data, if needed, for each endpoint. If a `xxx_endpt_receive` routine is declared, for each unit of data received the CMM calls it once for each endpoint. An `atm_addr_t` parameter to the routine identifies the endpoint. The CMM provides a duplicate mbuf chain for each endpoint; the data might or might not be physically duplicated.

When designing receive functions, you should remember that all data is delivered to the convergence module in an interrupt context with the processor running at the `splimp` level. The convergence module must implement a queuing policy appropriate for the convergence module's protocol. In general, convergence modules for protocols that can tolerate unspecified latency should queue the incoming data and return immediately to the CMM. Convergence modules for protocols that require bounded latencies (such as video or voice protocols) might want to perform some processing before queuing the data and returning to the CMM. In either case, the receive function must not block.

5.2.1 Receiving Exception Notifications

When an exception condition occurs on a VC, the CMM notifies the convergence module through its exception interface, `xxx_except`. This function is declared within the convergence module and is used to report exceptions, errors, and system configuration changes to the convergence modules.

Exception notifications have the following characteristics:

- Convergence modules can expect them at any time.
- They are delivered in an interrupt context.

- Exception processing must not block. If a convergence module needs to defer processing an exception notification, it must arrange for a kernel thread to be run at a later time and return immediately to the CMM.

5.2.2 Connecting to the ATM Module Management Interface

When the CMM connects a convergence module to the ATM Module Management Interface (MMI), the CMM uses the `xxx_mmi` interface. This function is declared within the convergence module. System management programs use the CMM's management interface to pass management and configuration requests directly to convergence modules, without requiring a new `/dev` entry or other kernel modifications normally associated with creating new management and configuration interfaces. If a module does not require any external management or configuration capabilities, it does not have to register a management function with the CMM.

The MMI follows the standard `ioctl` call with the following exceptions:

- The device major and minor number argument is replaced by the *`handle`* argument.
- No user credential information is passed. Only users with root access can use the management interface.

5.3 Unregistering a Convergence Module

If a convergence module is finished receiving or making connections, it can use the `atm_cmm_unregister_cvg` function call to unregister itself from the CMM. This might be necessary in environments where protocol stacks are dynamically configured and deconfigured from the system.

Before unregistering, a convergence module must close all existing connections and unbind from all PPAs. If all connections are not closed or if PPA bindings still exist, the CMM unregisters only the convergence module's `xxx_connect` routine. The CMM will continue to call the convergence module with incoming data and exception notifications. Once the convergence module is unregistered, the CMM will not call any of its routines.

5.4 Requesting Interface Parameters

When a convergence module must access current information about an interface's physical capabilities (such as its bit rates) and the amount of specific resources left available on an interface (the remaining nonreserved sustainable bit rate), it uses the `atm_cmm_ppa_info` and `atm_cmm_bind_info` function calls to query the CMM. The CMM and device drivers keep track of this information.

Since convergence modules normally deal with either PPAs or AESA bindings, the CMM allows convergence modules to query the information from the underlying interface by specifying either the PPA or bind directly. Thus, the convergence module requires no specific knowledge of any device driver or device driver-related structures.

5.5 Reserving Resources for CBR Circuits

If a convergence module needs to reserve resources (such as bandwidth) either prior to making an outgoing connection for a constant bit rate (CBR) circuit or prior to receiving a CBR connection, it uses the `atm_cmm_reserve_resources` function call to notify the CMM. The convergence module must apply these reserved resources within the system-specified amount of time either to an outgoing CBR connection by using the `atm_cmm_connect` function call or to an incoming CBR call by using the `atm_cmm_accept` function call.

Note

Reserved resources can be applied to point-to-point connections only.

If the resources are not applied in time, the CMM revokes the reservation and sends an `ATM_CME_RESV_EXPIRE` exception notification to the convergence module. The convergence module should remove knowledge of the reserved resources `atm_vc_services` structure that is being revoked, but should not free the `atm_vc_services` structure; the CMM frees the structure and releases the underlying resources upon return from the exception notification. In addition, the convergence module cannot apply the resources to a connection as part of handling the exception notification.

Once a reserved resource is successfully applied to a connection, the CMM transparently frees the underlying resources when the connection is torn down. No special action by the convergence module is required.

5.6 Releasing Reserved Resources

When a convergence module no longer needs to apply reserved resources to a VC and wants to release resources that it previously reserved, it uses the `atm_cmm_free_services` function call with a pointer to the `atm_vc_services` structure. This frees the `atm_vc_services` memory and releases its underlying resources.

5.7 Requesting a Connection to a Remote System

When a convergence module needs a connection to a remote system, it uses the `atm_cmm_connect` function call to make a connection request to the CMM. This initiates the exchanges between the network and the remote host to create a new connection. The convergence module must specify all connection parameters to the CMM; these parameters are required to create the new connection.

By requesting a connection to a remote host, the convergence module owns the VC; the VC's ownership cannot be changed. The convergence module is notified of all incoming data and exceptions on the VC. Also, the convergence module is the only module that can transmit data on the VC.

5.8 Adding an Endpoint to a Connection

When a convergence module must create a point-to-multipoint connection, it first uses the `atm_cmm_connect` function call to establish a call to the first party of the multipoint connection. This creates a VC and establishes the connection to the first endpoint. Then you can use the `atm_cmm_add` function call at any time to add new endpoints to the connection. You can add endpoints only to connections that were created with the `ATM_CT_PTM` flag set.

See Chapter 6 for more information on connections.

5.9 Requesting a Connection Be Torn Down

When a convergence module no longer requires a connection to a remote host, it uses the `atm_cmm_release` function call to request that the CMM tear down the connection. This initiates the release negotiation with the remote host, and will eventually lead to the connection being torn down and all resources released.

A convergence module can either request that a specific endpoint be disconnected (referenced by an `atm_addr` structure) or that a VC be disconnected. These operations are equivalent on point-to-point connections; disconnecting only the endpoint results in the VC being torn down. If a convergence module requests that a point-to-multipoint VC be disconnected, the CMM first disconnects all endpoints associated with the VC. This function simplifies the task of disconnecting multipoint VCs and permanent virtual circuits (PVCs).

5.10 Dropping an Endpoint from a Connection

When a convergence module must drop a connection to an endpoint, the module calls the `atm_cmm_drop` function. The endpoint can be associated

with either a point-to-point connection or a point-to-multipoint connection. When the last endpoint associated with a VC is dropped, the VC is torn down. You use this function to manage multipoint VCs, but you can also use it to initiate the teardown of point-to-point VCs.

5.11 Transmitting Data on an Established VC

When a convergence module must transmit data on an established VC, the module calls the `atm_cmm_send` function call. The CMM then passes the data to the appropriate device driver. Although the CMM does not queue outgoing data, the device driver might. Therefore, the successful return from this function call does not imply that the data was actually transmitted. In fact, the data could be discarded in the driver or on the network. The convergence module is not notified if the data is dropped locally.

5.12 Modifying VC Parameters

After VCs are created, convergence modules can use the `atm_cmm_vc_control` function call to modify some VC parameters to make the transfer of data more efficient or to control VC aging. You cannot modify the quality of service (QoS) and circuit bandwidth parameters.

5.13 Requesting Endpoint Connection State Information

When a convergence module needs the connection state information for an endpoint updated, the module calls the `atm_cmm_enquery` function call. This initiates a connection enquiry to the endpoint that results in the ATM address structure for the endpoint being updated with the latest status information. This function may be called any time a connection is active.

5.14 Binding to a PPA

When a convergence module must make outgoing calls or receive incoming calls being made to one of the configured local ATM addresses, the module calls the `atm_cmm_ppa_bind` function. This call informs the CMM that it will function as a network services user for a specific address and selector value.

Convergence modules are notified when a PPA is configured on the system (when an address is registered with a switch and is made known to the ATM network). Convergence modules can then bind to the PPA to create a network service user endpoint, which uniquely identifies the convergence module on the network. Once bound, there is a unique ATM End System Address (AESA) associated with the bound convergence module. The AESA and the bind point identify the service on the network and local system. Convergence modules will be informed only of incoming calls on PPAs to

which they have bound and can place calls only through a bind point. The CMM handles calls only to AESAs. If the AESA specified by the called party address of an incoming call does not exist, the CMM rejects the call. See Section 2.5 for more information on PPAs and AESAs.

By binding to a PPA, a convergence module is creating an AESA and uniquely identifying its service on the network. Once this is done, incoming calls can be routed to the convergence module, and the convergence module can make outgoing calls. All call activity is directed at a bind point and thus to a specific convergence module.

When binding to a PPA, a convergence module can either specify a selector value to use in creating the AESA address, or it may allow the CMM to assign it a selector value. In both cases, the selector value must specify a unique endpoint on the PPA.

Note that a convergence module can bind up to 256 times to a PPA (as long as all its selector values are unique), and may bind to as many PPAs as is necessary to provide its service.

5.15 Receiving a Connection Notification

When a connection request arrives on the system, a signaling protocol module notifies the CMM. The CMM uses the `xxx_connect` interface to call the convergence module that is bound to the selector specified in the called party address. Only one convergence module can accept a connection. The called convergence module then examines all the connection data (the information in the `atm_addr` structure as well as any information elements (IEs) or other signaling information passed in) to determine if it is willing to accept the call.

If the convergence module accepts the call, the CMM and signaling module proceed with call setup. The VC is not active at this point. The connection and VC is owned by the accepting convergence module until the connection is destroyed; you cannot change the VC's ownership. The convergence module VC is notified of all incoming data and exceptions on the VC. Also, the convergence module is the only module that can transmit data on the VC.

Connections are not shared between convergence modules at the bind point. If convergence modules must share connections, one module must own the connection and coordinate access to the connection with another module. Alternatively, you can layer modules on top of a multiplexor that assumes ownership of the connection.

If the convergence module rejects the call, the CMM and signaling module release the VC and notify the calling party that the call was rejected. The CMM never accepts a call without the explicit consent of a convergence module.

5.16 Unbinding from a PPA

If a convergence module must not accept an incoming connection (while awaiting a call from a specific caller) or make outgoing calls, it uses the `atm_cmm_ppa_unbind` function call to unbind its service from the PPA. Typically, convergence modules should unbind a PPA if their service is no longer available, and must unbind before unregistering with the CMM.

5.17 Accepting an Incoming Call

When a convergence module defers action on an incoming call (by returning `ATM_CAUSE_DEFER` from its `xxx_connect` routine), the module notifies the CMM as soon as it determines the disposition of the call. Typically, this is done within a set period of time, as defined by the signaling protocol, before the calling party times out on the call request.

If the convergence module determines that the call should be accepted, the module uses the `atm_cmm_accept` function call to inform the CMM that the call should be accepted and set the circuit resource parameters.

5.18 Rejecting an Incoming Call

When a convergence module defers action on an incoming call (by returning `ATM_CAUSE_DEFER` from its `xxx_connect` routine), the module notifies the CMM as soon as it determines the disposition of the call. Typically, this is done within a set period of time, as defined by the signaling protocol, before the calling party times out on the call request.

If the convergence module determines that the call should be rejected, the module uses the `atm_cmm_reject` function call to inform the CMM.

5.19 Adding a New ATM Address

When a convergence module must register a new address with the network, the module uses the `atm_cmm_new_esi` function call to supply the ESI (or other signaling protocol equivalent) portion of the address and a driver reference to the CMM. The CMM then performs all the necessary functions needed to register the address with the network and to activate it.

When a convergence module supplies a new ESI, the signaling modules apply the ESI in a signaling protocol-specific way. Depending on the signaling protocol, the addition of a single ESI to the system could create many PPAs. All convergence modules are notified of every new PPA that is created as the result of configuring a new ESI.

Once a convergence module creates an address, only the creating convergence module, the CMM (through the system `atmconfig` program),

or the network can delete the address. Other convergence modules cannot delete the address. The creating convergence module must issue the `atm_cmm_ppa_bind` call once it receives notification that the PPA(s) have been configured. If the convergence module unregisters with the CMM, all its created addresses are destroyed.

5.20 Deleting an ATM Address

When a convergence module is finished using a new address it has created, it can use the `atm_cmm_del_esi` function call to delete it. Deleting a PPA causes all VCs associated with that PPA to be closed by the CMM (both ends of the connection receive proper notification). Thus, convergence modules should delete addresses only when there are no active VCs associated with the address' PPAs.

5.21 Requesting VC Statistics

When a convergence module must retrieve current VC information from the CMM, it calls the `atm_cmm_vc_stats` function. The CMM returns the information in the `atm_vc_stats` structure.

The CMM keeps track of VC usage on a per-VC basis. This is done as part of the CMM's VC management and cannot be disabled.

5.22 Using ATM Convergence Module Interface Structures

The ATM device driver interface uses the following structures exclusively:

- `atm_vc_stats` — The virtual circuit statistics structure
- `atm_cmi_addr` — The called party address union
- `atm_cvg_params` — The convergence parameters structure

5.22.1 The atm_vc_stats Structure

The `atm_vc_stats` structure contains information on successful return from the `atm_cmm_vc_stats` function. Table 5–1 lists those members of the `atm_vc_stats` structure, with their associated data types, that convergence modules might reference.

Table 5–1: The atm_vc_stats Structure Members

Member Name	Data Type
`bytes_in`	`unsigned long`
`bytes_out`	`unsigned long`
`packets_in`	`unsigned int`

Table 5–1: The atm_vc_stats Structure Members (cont.)

Member Name	Data Type
packets_out	unsigned int
opened	struct timeval
last_out	struct timeval
last_in	struct timeval

The bytes_in member contains a count of the number of bytes received on the VC. This includes any ATM Adaptation Layer (AAL) protocol headers/trailers passed back by the driver.

The bytes_out member contains a count of the number of bytes transmitted on the VC. This does not include the AAL header/trailer bytes unless these are supplied by the convergence module.

The packets_in and packets_out members contain counts of the number of packets (or cells for raw cell VCs) received and sent, respectively.

The opened member contains the time-stamp of the time the VC was established. If you subtract this from the current time, the result is the time the VC has been in service.

The last_out and last_in members contain the time-stamps of the time the last data was received and sent, respectively. If you subtract either of these times from the current time, the result is the amount of time the VC has been idle in either direction.

5.22.2 The atm_cmi_addr Union

Convergence modules use the atm_cmi_addr union to pass a called party (destination) address to the CMM as part of the atm_cmm_connect function call. The format of this union is as follows:

```
union atm_cmi_addr {
     atm_addr_p     addr;
     struct {
          unsigned int     vci;
          unsigned int     vpi;
     } vcn
};
```

5.22.2.1 The addr Member

The addr member contains a pointer to an atm_addr structure, which is allocated by the convergence module (atm_cmm_alloc_addr), for creating a new switched virtual circuit (SVC).

5.22.2.2 The vcn Member

The vcn member is a structure that specifies the virtual channel identifier (VCI) and virtual path identifier (VPI) for creating a new PVC. See Appendix A for a description of the atm_cmm_connect function call.

5.22.3 The atm_cvg_params Structure

The CMM needs to know the capabilities and entry points of each convergence module. Convergence modules use the atm_cvg_params structure to pass this information to the CMM as part of the atm_cmm_register_cvg function call. To allow for future expansion of the atm_cvg_params structure, the convergence module should call the bzero command to insert nulls into the entire structure before filling in the known fields.

Example 5–1 shows the atm_cvg_params structure definition.

Example 5–1: The atm_cvg_params Structure Definition

```
struct atm_cvg_params {
        void (*receive)(atm_vc_p vc,
                        struct mbuf *mbp,
                        int length,
                        struct mbuf *trailer,
                        char      pti,
                        char gfc);
        atm_error_t (*exception)(void *cvg_handle,
                        int command,
                        void *arg);
        int (*mmi_manage)(void *cvg_handle,
                        int cmd,
                        void *arg,
                        int *retval,
                        struct ucred *cred);
        void (*endpt_receive)(atm_vc_p vc,
                        struct mbuf *mbp,
                        int length,
                        struct mbuf *trailer,
                        char      pti,
                        char gfc,
                        atm_addr_p addr);
        void *reserved1;
        void *reserved2;
        void *reserved3;
};
```

5.22.3.1 The receive Member

The `receive` member specifies a pointer to a routine that the CMM calls to to notify the convergence module of incoming data. The receive routine receives one copy of VC data, independent of how many local endpoints are added to the VC.

A convergence module must supply either a `xxx_receive` routine or an `xxx_endpt_receive` routine.

5.22.3.2 The exception Member

The `exception` member specifies a pointer to a routine that CMM uses to notify the convergence module of new connections and exception conditions. A convergence module must supply an exception routine.

5.22.3.3 The mmi_manage Member

The `mmi_manage` member specifies a pointer to a routine that CMM uses to manage the convergence module through the ATM Module Management Interface (MMI). A convergence module must supply an `xxx_mmi` routine if it is to be managed through the MMI.

5.22.3.4 The endpt_receive Member

The `endpt_receive` member specifies a pointer to a routine that CMM uses to notify the cnvergence module of incoming data. For a given unit of incoming data, the CMM calls the `xxx_endpt_receive` routine once for each local endpoint. The CMM provides a unique mbuf chain on each call, which references the received data.

A convergence module must supply either a `xxx_receive` routine or an `xxx_endpt_receive` routine.

5.22.3.5 The reserved1, reserved2, and reserved3 Members

The `reserved1`, `reserved2`, and `reserved3`members are reserved for future use, and should be specified as NULL.

6

Connections

This chapter describes the following connection tasks and the procedures for accomplishing these tasks:

- Making outgoing connections
- Accepting connections
- Controlling the aging of connections
- Releasing connections
- Creating permanent virtual circuits
- Creating signaling virtual circuits

These procedures illustrate the use of the ATM interfaces described in previous chapters.

6.1 Making Outgoing Connections

Making outgoing connections consists of the following tasks:

- Making the call (for both point-to-point and point-to-multipoint connections)
- Adding parties to an existing connection (point-to-multipoint connections only)

6.1.1 Making the Call

Making the call for point-to-point and point-to-multipoint connections is identical except for one argument. When writing convergence modules, make sure the module performs the following tasks when making a call:

1. Chooses a bind point for the outgoing call.
2. Calls the `atm_cmm_alloc_addr` function to allocate an `atm_addr` structure that identifies the called party.
3. Sets all the address information associated with the called endpoint in the `atm_addr` structure.
4. Calls `atm_cmm_alloc_ie` to allocate the `atm_uni_call_ie` structure that the module uses to make the call. If you use another signaling protocol, allocate the structure needed by that protocol instead.

5. Sets all the needed information in the atm_uni_call_ie structure or other signaling protocol call parameters structure. If the module is to pass MTU values to the signaling module or to the other end of the connection, the module sets the values in this structure.
6. Allocates an atm_vc_services_t structure by calling atm_cmm_alloc_services.
7. Sets all the structure members in the atm_vc_services_t structure. For constant bit rate (CBR) circuits, set the ATM_SERVICES_CBR flag. For pacing circuits, set the ATM_SERVICES_PACING flag. For both CBR and pacing circuits, you must set the peak bit rates.

   Also, set the fmtu and bmtu structure members with the largest MTU value that the module will use. The device driver uses this information to allocate resources for the VC.
8. If you want to reserve resources for CBR circuits, call the atm_cmm_reserve_resources routine, passing it a pointer to the atm_vc_services_t structure.

   Note

   You can apply reserved resources to point-to-point connections only.
9. If the reserve resources call returns ATM_CAUSE_DEFER, the atm_vc_services structure is considered a reserved resource reservation. The convergence module must wait for an ATM_CME_RESV_AVAIL exception notification before proceeding; this exception indicates that the atm_vc_services structure is backed by resources. If the convergence module does not wait for the reservation to become available, it terminates the resource reservation request (and frees the atm_vc_services_t memory) by calling atm_cmm_free_services.

   If the reserve resources call returns ATM_CAUSE_GOOD, the atm_vc_services_t structure is considered to be backed by resources, which can be applied to a call.

   If the reserve resources call returns any other error code, the convergence module should examine the lerrstat structure member of the atm_vc_services_t structure for additional error information. If the convergence module does not continue, it must free the memory allocated in the previous steps.
10. Calls atm_cmm_connect with the appropriate arguments. For point-to-point connections, uses the ATM_CT_PTP argument. For point-to-multipoint connections, uses the ATM_CT_PTM argument.

Once the connect call is made, all subsequent activity on the VC is reported through the exception interface (`xxx_except`). Receive data can also begin to arrive.

Note

If the module has reserved resources and they are not applied in time, they are revoked by an `ATM_CME_RESV_EXPIRE` exception notification.

11. If the connect call returns an error code, the convergence module frees the memory allocated in the previous steps. An error might be caused by the Connection Management Module (CMM) or other modules being unable to initiate a call request.

    For CBR connections that do not use resource reservation, there might be a failure to allocate the necessary resources. If the failure is due to an incorrectly set `atm_vc_services_t` structure, the `lerrstat` structure member contains local error information.

12. If the connect call returns `ATM_CAUSE_GOOD`, the call is proceeding and the convergence module can make a reference to the new `atm_vc` structure for the connection.

Section B.1 contains a sample routine that shows how to make a call for point-to-point connections and how to make the first call for point-to-multipoint connections.

After the call is initiated, the convergence module can receive the following notifications:

`ATM_CME_CALL_FAILED`

An error occurred in processing the call or the called party rejected the call.

The convergence module should extract the cause information from the endpoint's `atm_addr` structure and decide how to handle the error based on this information. The module should then delete all references to the `atm_addr` structure and the VC, but should not deallocate the structure memory. The CMM does this after removing all references to the call. Once the convergence module returns from the exception notification routine, it can no longer access any nonprivate structures associated with the call.

`ATM_CME_EP_ACTIVE`

The call is successful; the circuit to the endpoint is complete and it could receive incoming data at any time (incoming data could arrive ahead of the connection activation notification because of race

conditions). The convergence module should not send any data until it receives the connection activation notification.

The call recipient could signal new MTU values. Therefore, the convergence module should examine the `atm_uni_call_ie` structure for the MTU sizes. The convergence module, however, does not have to change the `fmtu` or `bmtu` values in the `atm_vc_services` structure.

When a connection is activated, the convergence module may check the `atm_vc_services` structure referenced in the `atm_vc` structure to determine if any of its connection service parameters were changed by the called party through negotiation.

6.1.2 Adding Parties to an Existing Connection

For point-to-multipoint connections, after the call to the first party is successful, you can add parties to the VC associated with the first call and drop parties at any time. Note that since call placement is multithreaded, you can initiate calls to multiple endpoints sequentially. Convergence modules receive individual notifications for each endpoint that is connected. Thus, multiple connections can be in progress at any given time without the convergence module needing to handle synchronization issues.

The convergence module can receive exception notifications for exceptions affecting all parties on the VC or for single endpoints (an exception with a single party in the multipoint call). When writing a convergence module, you must ensure that the module can handle these exceptions properly so that it does not associate an endpoint exception affecting a specific party with all parties on a VC.

Section B.2 contains a code fragment that shows one method of adding parties to a point-to-multipoint connection.

6.2 Accepting Connections

When a remote host places a call to the local host, the following events occur on the local host:

1. The signaling protocol module on the local host receives a call request (a UNI 3.0/3.1 SETUP message or its equivalent).
2. The signaling protocol module uses the information in the signaling protocol message to construct an `atm_addr` structure and an `atm_vc_services` structure. These structures contain information about the calling endpoint and the services requested by the endpoint, respectively.

3. The signaling module uses the `atm_cmm_new_call` function call to pass the structures, the handle of the device driver on which the new VC will be attached, and a unique call reference value to the CMM.
4. The CMM examines the `atm_vc_services` structure parameters to determine if the available system resources can meet the level of service requested by the calling party. If so, the resources are reserved. If not, only available resources are reserved. The CMM calls the convergence module (using the `xxx_connect` routine) that has bound to the called party's ATM End System Address (AESA).
5. When called, the convergence module should inspect the ATM address information and the signaling protocol information (referenced by the `setup` member of the `atm_addr` structure) to determine if the call is for the convergence module's protocol. If the call does not belong to the convergence module, it should return an error indication to the CMM. If the call belongs to the convergence module, it continues with step 6.
6. The convergence module must set the `fmtu` and `bmtu` fields in the `atm_vc_services` structure. This is how the convergence module notifies the device driver of the MTU to use for the call.
7. The convergence module should check the service parameters arguments to determine if the service parameters are acceptable. For all calls, if the service parameters are insufficient for the type of service the module is providing, it can reject the call with the appropriate cause. The convergence module cannot modify the service parameters.

   For Constant Bit Rate (CBR) calls, the following should occur:

   - If the CMM has allocated the resources needed to meet the requested level of service, the convergence module should return `ATM_CAUSE_GOOD` to the CMM to accept the call.
   - If the CMM indicates that it cannot allocate the bandwidth and the convergence module does not have a reserved resource to apply to the incoming call, the convergence module should return an error indication to the CMM to reject the call.
   - If the CMM indicates that it cannot allocate the bandwidth and the convergence module has a reserved resource to apply to the incoming call, the convergence module should replace the `atm_vc_services` structure argument with the address of the reserved resource to apply to the call. If the reserved resource cannot be applied to the call, The CMM tears the new VC down, frees the supplied `atm_vc_services` structure and its underlying resources, and sends an `ATM_CME_EP_DEAD` exception notification to the convergence module. The VC's cause log contains the reason why the connection was torn down.

For Unspecified Bit Rate (UBR) calls, if the CMM indicates that it cannot allocate the bandwidth and the convergence module has a reserved resource to apply to the incoming call, the convergence module should replace the `atm_vc_services` structure argument with the address of with the address of an `atm_vc_services` structure that has the `flags` member set to ATM_SERVICES_PACING.

Section B.3 contains a sample code fragment that shows how a convergence module processes an incoming call.

8. If a convergence module accepts a call, the following should occur:
   - The convergence module should use the convergence module private fields in the `atm_addr` and `atm_vc` structures to create its internal references to the new VC and endpoint.
   - Once the connection notification call (`xxx_connect`) returns with `ATM_CAUSE_GOOD`, the convergence module owns the call and owns and controls the VC. From this point, all notifications associated with the VC go to the accepting convergence module.
   - The convergence module should consider the VC valid but not active. However, data can start arriving at any time since the path the activation notification takes could be longer than the data path.
   - The convergence module should not attempt to transmit data until it receives a notification that the VC is active.
   - The CMM returns `ATM_CAUSE_GOOD` to the signaling module, indicating that the signaling module should reply to the calling party in whatever way is appropriate to accept the call.
   - The signaling module must not deallocate any memory used for structures passed to the CMM.
9. If the call is not accepted, the signaling module replies to the caller in an appropriate way to reject the call. In this case, the signaling module must deallocate all memory use for structures passed to the CMM.

6.3 Controlling the Aging of Connections

This section applies to switched virtual circuits (SVCs) only; permanent virtual circuits (PVCs) do not age. The ATM subsystem provides for automatic detection and elimination of unused VCs when available resources are low. This prevents a hung protocol from continuing to hold resources and ensures that system resources are allocated fairly.

When a circuit is created, convergence modules specify an initial aging algorithm in an argument to the `atm_cmm_connect` routine. The CMM then performs all connection aging based on usage statistics it collects during the lifetime of a connection. If necessary, convergence modules can use the

atm_cmm_vc_control routine to change the aging algorithm applied by the CMM at any time. When a connection has aged, the CMM uses the convergence module's xxx_except routine to notify the convergence module that a connection has aged and is about to be removed from the system. This gives the convergence module a chance to prevent the connection's removal.

If the convergence module does not prevent the connection's removal, the CMM uses the normal connection release mechanism to remove the connection; the signaling module sees the release request as coming from the convergence module and the convergence module sees the request as coming from the remote endpoint. See Section 6.4 for information on releasing a connection.

Table 6–1 contains values you can use for the aging parameters in the atm_cmm_connect and atm_cmm_vc_control routines.

Table 6–1: Aging Parameter Values

Value	Meaning
ATM_AGE_DEFAULT	Uses the system's default aging algorithm. The default is to remove all VCs that have been inactive for the longest period of time, that have the lowest utilization (compared to the expected utilization), and whose reconnection time is expected to be less than 5 percent of the idle time.
ATM_AGE_LOW	Removes this VC when the system is low on free circuit identifiers and ignores its idle time and utilization.
ATM_AGE_FOREVER	Specifies that the circuit is not eligible for aging.
28-bit unsigned value	Specifies how long (in minutes) the circuit should be allowed to live. After the circuit is active for the specified number of minutes, it is aged from the system.
28-bit unsigned value bitwise ORed with ATM_AGE_IDLE	Ages the circuit when it has been inactive the specified number of minutes.

These circuit-aging algorithms provide sufficient flexibility so that individual convergence modules should not have to perform their own circuit aging. Also, centralizing circuit aging in the CMM allows aging algorithms to take affect only when the CMM detects that an interface is low on free VCs.

6.4 Releasing a Connection

Either convergence modules or the network or an endpoint can release connections. The following sections describe what happens in either case.

6.4.1 Release by a Convergence Module

When a convergence module no longer requires a connection to an endpoint, it should release the connection to free system resources. To release a connection, a convergence module calls either the `atm_cmm_release` or `atm_cmm_drop` function. The former releases a VC and all associated endpoints; the latter disconnects only a single endpoint, releasing the VC only if all endpoints have been dropped.

The convergence module can provide a cause value and diagnostic information for the release by calling `atm_cmm_set_cause` before calling `atm_cmm_release` or `atm_cmm_drop`. For UNI-based signaling, this information is supplied to the network in a Cause IE.

When a convergence module calls `atm_cmm_release`, the CMM initiates a disconnect of all endpoints associated with the VC.

For point-to-point VCs, this initiates a release operation on the VC. The convergence module receives an `ATM_CME_EP_DEAD` notification. This informs the convergence module that the release operation is in progress on the network and that no more data will be sent on the VC.

For multipoint VCs, this initiates the dropping of all endpoints and the release of the VC. As each endpoint is dropped, the convergence module receives an `ATM_CME_EP_DEAD` notification. The convergence module must delete all references to the endpoint. Once all endpoints associated with a VC have been dropped, the VC is released. The CMM handles conditions where endpoints are in various stages of set or release when it receives this request.

When the `ATM_CME_EP_DEAD` notification is received for the last endpoint on the VC, convergence modules should delete all references to the VC. To accomplish this, the module should maintain a use count for any VC references it maintains.

When a VC is released, the CMM notifies the device driver to which the VC is attached so that the device driver can free any resources it has allocated to the VC.

6.4.2 Release by Network or Endpoint

When the network or an endpoint initiates a connection release, the signaling protocol module receives either a release or a drop message. At that point, the signaling module calls either the `atm_cmm_con_release` or `atm_cmm_ep_dropped` function.

When a signaling module calls the `atm_cmm_con_release` function, the CMM does the following:

1. Initiates connection releases to all endpoints associated with the VC, if the VC being released is a multipoint VC.
2. Calls the device driver to which the VC is attached and passes an `ATM_DRVMGMT_DELVC` notification. The driver should delete all references to the VC and release all resources associated with the VC.
3. Calls the convergence module that owns the VC and passes an `ATM_CME_EP_DEAD` notification for each endpoint associated with the VC.
4. Frees all structures associated with the VC and returns to the signaling module.

When the signaling module calls the `atm_cmm_ep_dropped` function, the CMM calls the convergence module that owns the endpoint's VC and passes an `ATM_CME_EP_DEAD` notification. If this is the last endpoint associated with the VC, it initiates a release of the VC.

6.5 Creating Permanent Virtual Circuits

Although the ATM subsystem is designed primarily to use SVCs, you can also use PVCs. Before you create PVCs locally, the PVCs must already be set up on the network. You can use either of the following methods for setting up PVCs:

- The `atmconfig` program (see `atmconfig`(8) for more information)
- Allow convergence modules to directly create PVCs just as they create SVCs

Either method creates a local reference to the PVC and allocates the resources necessary for the VC to function on the system. In either case, the convergence module's connection routine for the bind point to which the PVC is attached is called.

Note

You can create PVCs only on the PVC PPA. You cannot create a PVC on an SVC PPA.

When a convergence module sets up a PVC, the following events occur:

- A local reference to the VC is set up in the CMM.
- The ownership of the PVC is given to the convergence module.
- The VC is created and enabled in the device driver.

Once set up, the PVC remains in existence until explicitly torn down by the convergence module.

The ATM subsystem treats a PVC like an SVC, except that there is no signaling protocol associated with the PVC, and PVCs do not age. When a convergence module requests a PVC, it must specify all the VC service parameters as it does for an SVC. If the PVC is created successfully, this does not necessarily mean that the PVC exists. Even though a local reference for the PVC has been created, modules cannot check (due to the nature of PVCs) to determine if the PVC exists on the network.

Note

If you create a PVC before it is configured on the network, no invalid VCI errors are reported to the convergence module.

To release PVCs, use the `atm_cmm_release` function call. However, since PVCs require no signaling protocol exchange with the network, PVC release is synchronous. The return value from the release function call indicates success or failure of the teardown. The convergence module receives no other notifications.

6.6 Creating Signaling Virtual Circuits

Signaling VCs are well-known PVCs that signaling protocols use to communicate with the switches on the network. The switches and the end systems on an ATM network automatically set up signaling VCs. The ATM subsystem treats signaling VCs as ordinary PVCs and does not provide any special mechanisms for them. The signaling protocol module is responsible for managing the signaling VCs.

When signaling modules are initialized, they register with the CMM as both a signaling module and as a convergence module. The signaling modules use the signaling module interface to field connection management requests from the CMM; they use the convergence module interface to send and receive signaling protocol packets on the network. Once registered as a convergence module, signaling modules must create all VCs required by their signaling protocol.

Once the signaling VCs are created, the CMM treats them like any other PVC. Like other convergence modules, the signaling module receives no notification whether a PVC exists on the network. Signaling modules receive notification of interfaces being brought up and interfaces going down. When an interface goes down, all signaling VCs on that interface are destroyed.

7

Module Management Interface

The Connection Management Module (CMM) provides an interface that allows any ATM module to exchange configuration and management information with application processes without the usual need for kernel modifications and new `/dev` nodes. The Module Management Interface (MMI) is the standard operating system `ioctl` interface, but it allows applications to communicate with specific ATM modules directly through the CMM. See `ioctl`(2) for more information.

To exchange information with any ATM module, applications must open the `/dev/atm_cmm` device and issue `ioctl` system calls. The `ioctl` commands are executed either by the CMM directly or passed to a selected ATM module. The ATM module transfers all data associated with the `ioctl` commands to and from user space; the MMI always has a user context since it is executed as part of a system call.

New ATM modules can define their own `ioctl` commands independently since commands are routed only to a module selected by using an `ioctl` call. Modules can also define their own structures and protocols for exchanging data with applications since interpretation of the `ioctl` data argument is done by agreement between the module and its application, not by the CMM.

Applications cannot send the CMM any commands other than those commands for establishing MMI paths. Only applications that HP has written to manage the ATM subsystem can select the CMM as the target for commands. Also, a module can restrict the establishment of an MMI path through the use of key values that are known only to the module and applications that are allowed to communicate with it. This prevents applications from illegally communicating with ATM modules.

This chapter describes the following:

- How to create an MMI command path
- How to verify the version of the `ioctl` commands
- How to define new MMI `ioctl` commands
- The MMI calling conventions
- Device driver, signaling, and convergence module interfaces

7.1 Creating an MMI Path

To send `ioctl` commands to an ATM module, you must create a path through the CMM to the module. The following code fragment shows a routine that creates an MMI path:

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

make_mmi_path(char *name)
{
     int atm_fd;
     struct atm_mmi_path path;  [1]

     atm_fd = open("/dev/atm_cmm",O_RDWR); [2]
     if(atm_fd == -1)
     {
          perror("open of /dev/atm_cmm");
          exit(errno);
     }
     path.name = name;
     path.length = strlen(name);
     path.key = 0x123456789abcdef;
     if(ioctl(atm_fd,GIOC_MMI_PATH,&path) == -1) [3]
     {
          perror("GIOC_MMI_PATH");
          exit(errno);
     }

     return atm_fd;
}
```

[1] Declares the `atm_mmi_path` structure.

[2] Opens the `/dev/atm_cmm` device.

[3] Issues the `ioctl` call with the `GIOC_MMI_PATH` command. The argument to the `GIOC_MMI_PATH` command is the name of the module to which the path is to be established; each module must register with a unique name.

After the path is created, all subsequent `ioctl` commands not understood by the CMM are sent to the selected module.

The `/dev/atm_cmm` device has the following restrictions:

- You can use this device only for the management and administration of ATM modules, not for transferring data across the network.
- Only one application can have the device opened at any time. Multiple accesses to this interface are not permitted.
- Only applications with root permissions can open the device.

Since all ATM modules, including the CMM, share a common interface, an application can inadvertently or deliberately issue an incorrect or damaging `ioctl` call. To prevent this from occurring, applications can identify themselves to ATM modules when the MMI path is created so their privilege to contact the module can be confirmed. You are not required to implement this in your module, but you should for added safety.

The application performs extra validation by passing a 64-bit key to the ATM module when the MMI path is created. The ATM module checks this key to verify that it is valid. Since only applications written specifically to communicate with certain modules know the key the module expects, it is more difficult for another module to create the MMI path to the ATM module.

Table 7–1 lists member names of the `atm_mmi_path` structure, with their associated data types, that modules might reference.

Table 7–1: The atm_mmi_path Structure Members

Member Name	Data Type
`*name`	`char`
`length`	`int`
`key`	`long`

The `name` member is a pointer to the name of the ATM module to which the MMI path is to be established. This name is a standard NULL-terminated ASCII string that must exactly match the string the module used when it registered with the CMM.

The `length` member is the length (in bytes) of the string pointed to by the name member. This length does not include the NULL termination.

The `key` member is a value that the application and the target ATM module agree to use to identify the application to the ATM module. Only target ATM modules use this member.

7.2 Verifying the ioctl Version

To verify that the application and the ATM module agree on the `ioctl` definitions in use, you can use the global `GIOC_MMI_GETVERSION` command in the application. This allows the application to provide backward compatibility when changes in its `ioctl` interface are needed. The following code fragment shows how to query a module for its version.

```
#define VERSION_1       1
#define VERSION_CURRENT 2

get_mmi_version(int atm_fd)
{
```

```
        struct atm_mmi_version v; [1]

        if(ioctl(atm_fd, GIOC_MMI_GETVERSION, &v) == -1) { [2]
                perror("GIOC_MMI_GETVERSION);
                return;
        }

        switch(v.version) {

        case VERSION_1:
                 /* Talk to module using old ioctls */
                 .
                 .
                 .
                 break;

        case VERSION_CURRENT:
                 /* Talk to module using current ioctls */
                 .
                 .
                 .
                 break;
        }
}
```

[1] Declares an `atm_mmi_version` structure. The structure contains only a `version` member of the data type `int`. The values used for MMI versions are agreed upon between the module and its application. The CMM does not look at the values passed in this structure.

[2] Queries the module for its version. `atm_fd` is associated with an open MMI path that was created in Section 7.1.

7.3 Defining New MMI ioctl Commands

All MMI `ioctl` commands are in the "g" `ioctl` group and are named `GIOC_`*`command_name`*. Each `ioctl` command group can contain up to 256 commands; each `ioctl` command encodes the group, the command within the group, the data transfer direction, and the size of the data to transfer. The GIOC group is divided into CMM-specific commands (with a range of 0 to 127, inclusive) and module commands (with a range of 128 to 255, inclusive). The CMM does not interpret commands in the module command range. Also, modules are not passed commands in the CMM command range.

As a rule, the module and application program must agree on the command number and the format of the command data passed as the third argument to the ATM `ioctl` system calls for a module. You do this with a module-specific header file in which the commands and structures are defined. This header file should include `sys/ioctl.h`, which contains the macros used to define `ioctl` commands.

To define a new `ioctl` command, you need the following pieces of information:

- The direction of any data transfer between the application and the ATM module (input from the application, output to the application, or both). This determines which macro to use for command definition (_IOR, _IOW, or _IORW).
- The definition of the data structures to be passed between the application and the ATM module as the argument to the command. This, along with the transfer direction information, controls how much data the kernel will move between user space and the kernel when the `ioctl` is processed.
- The number of the command (between 128 and 255).

Once you know this information, you can define a new `ioctl` command. For example, suppose an application needs to pass information contained in a single longword and receive information from the ATM module in the same word. You would define the command as follows:

```
#define GIOC_NEW_CMD  _IOWR('g',128,sizeof(long))
```

Note that the "g" must be in lowercase.

Using this example, the application executes the following call to send the new command to the ATM module:

```
long arg = some_value;
int atm_fd;

atm_fd = make_mmi_path("module name");
if(ioctl(atm_fd, GIOC_NEW_CMD, &arg) == -1)
{
     perror("GIOC_NEW_CMD");
     exit(errno);
}

printf("GIOC_NEW_CMD returned %ld0", arg);
```

An `ioctl` system call can copy only fixed-size data directly addressed by the argument. If a command requires the exchange of variable size data, the argument to the `ioctl` system call must be a fixed size structure that contains pointers to and lengths of variable size data in the application's memory space. The ATM module is responsible for copying data from or to this memory when processing the command; the kernel `ioctl` call copies the contents of the structure.

7.4 Using MMI Calling Conventions

All modules that provide an MMI routine must adhere to the following rules when handling arguments from the CMM:

- All MMI routines are called while in a system call context with no external locks held. This means that the MMI routines can block, if necessary, provided they do not hold simple locks while blocking.
- All MMI routines must return `ESUCCESS` to indicate successful completion of the operation or a error number to indicate the type of error that occurred.
- MMI modules can use the *`retval`* pointer to provide a nonzero return value to the calling program. This value is the return value from the `ioctl` when the MMI function returns `ESUCCESS` to the CMM. This follows the normal Tru64 UNIX `ioctl` processing conventions.
- MMI routines are required to process only their own commands and one global command: the `GIOC_MMI_PATH` command. This command instructs the MMI function to verify that it is willing to accept the establishment of an MMI path from the CMM as requested by an application program. The argument to this command is a pointer to an `atm_mmi_path` structure that the MMI function will evaluate.

  Convergence modules can optionally process the `GIOC_MMI_GETVERSION` global command. This enables the application to verify that it and the ATM module implement the same `ioctl` interface.
- The MMI routine should verify that the key provided in the `atm_mmi_path` structure is correct, but might also verify the specified module name. This is redundant since the CMM already verifies the module name. If the key or module name provided is acceptable, the MMI function returns `ESUCCESS`, otherwise, it returns `ENXIO`.
- The MMI function is informed only when MMI paths are established, not when they are destroyed.

See Appendix A for information on the `xxx_mmi` function.

7.5 Using the Device Driver MMI

When an ATM device driver registers with the CMM, it provides the CMM with the address of the following management functions:

- The internal management function that the CMM uses to manage driver resources and VCs. Only the CMM uses this interface; it is not available through the MMI. This function is not allowed to block at any time.
- The `xxx_mmi` function. This function receives only MMI commands through the `ioctl` system call from an application that has been written specifically to manage the device driver.

  The standard ATM interface defines no generic driver management through the MMI. If a device driver does not need to process MMI

commands, it should set this argument in the `atm_cmm_register_dd` routine to NULL.

The device driver's MMI function is passed the following arguments when called:

- The device driver's module handle, which the device driver module provided the CMM at registration time
- The `ioctl` command and data value

The MMI function is permitted to block, if necessary, at any time and has access to the user context of the calling application.

7.6 Using the Signaling Module MMI

The signaling module MMI is similar to the convergence module and device driver MMIs. The signaling module is passed the following arguments when called:

- The signaling module handle, which the signaling module provided the CMM at registration time. The signaling module can use this value in any way it chooses. The CMM does not modify this value.
- The `ioctl` command and data value.

7.7 Using the Convergence Module MMI

When a convergence module registers with the CMM, it can supply the address of an MMI function to be called when an application creates an MMI path to the convergence module. If a convergence module does not provide an MMI management function, the module writer should register an address of NULL for the MMI management function when the convergence module registers with the CMM.

The convergence module MMI function is passed the following arguments when called:

- The convergence module's internal handle, which the convergence module provided to the CMM at registration time. This value is internal to the convergence module; the CMM does not modify this value.
- The `ioctl` command and data value.

8

Queuing Guidelines

The Connection Management Module (CMM) is essentially a switch that connects the various components of the ATM subsystem. The CMM provides no queuing mechanisms in either the transmit or receive data paths. This means that each component is free to implement a queuing policy that is appropriate for its protocol or hardware. This chapter discusses guidelines for ATM component developers to consider when designing queuing policies for a component.

8.1 Queuing in Device Drivers

Device driver writers must implement a queuing policy on the transmit path and might implement a queuing policy on the receive path. The following sections describe the characteristics of each.

8.1.1 Device Driver Transmit Queuing

Device drivers must do all queuing of outgoing data. Under normal conditions, convergence modules pass data to the device drivers as the data comes down from the protocol stacks. The device driver must either queue the data or reject it, but should not drop it unless an error occurs after the driver has accepted the data for transmission. There is no mechanism other than the flow-control mechanism for a driver to request more data from a convergence module.

Most ATM devices provide at least one hardware queue or ring in which a small number of packets or raw cells can be queued to the hardware. The size of this queue is usually limited by the hardware. Some adapters might be able to schedule the processing of cells from these queues based on quality of service (QoS) parameters associated with each queue to provide QoS-based servicing of virtual circuits (VCs). Simpler hardware generally implements only a single first-in, first-out (FIFO) queue. Because of the limited size of these queues, the drivers should provide a software queue that provides some buffering of data from the CMM to the hardware queues. The software queues permit the driver to better handle bursts of data without having to use flow-control techniques on the sender.

Device drivers can completely hide their queuing mechanisms and policies or advertise some or all of them to the CMM. For example, a device driver could implement the following queuing policies:

- A device driver with multiple hardware queues advertises only a single software queue to the CMM and decides how to queue each packet it receives from the CMM.
- A driver advertises all its hardware queues to the CMM and lets the CMM make the decisions about what VC is associated with each queue.
- A combination of the first two policies.

Regardless of the method implemented, device drivers should always provide a software queuing mechanism to handle conditions when the hardware queue is full in order to delay using flow-control techniques on the sender.

The driver advertises virtual queues, which can be implemented in any number of ways internally, to the CMM. The CMM handles only the virtual queues, viewing each queue as being able to support a single QoS and being serviced by the driver based on the QoS parameters that the CMM set.

In addition to its no-queuing policy, the CMM does not enqueue data to the driver. When the CMM has data to transmit, it calls the driver's transmit routine. This routine must place the data passed to it on the correct queue. Thus, the transmit queuing policy is contained entirely within the device driver. This applies to both drivers that advertise single queues and those that advertise multiple queues.

The CMM assists drivers with multiple queues by assigning the VCs to the queues. In this case, the queue to which the CMM has assigned the VC is contained in the `atm_vc_services` structure referenced by the `atm_vc` structure. The driver uses this information to determine how to queue each packet of data.

If a device driver advertises only a single queue when it registers with the CMM, the CMM expects the device driver to provide its own internal scheduling of packet transmission.

If a device driver advertises more than one queue, the CMM tries to assign VCs to each queue in an effort to achieve the QoS requested for each VC. The CMM informs the driver of its intention to send data to a specific queue so the driver need not schedule the queue for servicing until notified by the CMM that the queue will be used. The CMM selects one queue for queuing best-effort available bit rate (ABR) traffic as VCs with this QoS are created. All ABR traffic is assigned to this queue. Queues for VCs that require other than an ABR QoS are chosen by the CMM as the VCs are created.

When the CMM needs to use a previously unused queue, it sends the driver an `ATM_DRVMGMT_SETQ` command through the driver's management interface. The argument to this command is a pointer to an `atm_vc_services` structure that contains all the information about the various QoS parameters for the queue. The driver might maintain a

reference to this structure as long as the queue is in use by the CMM. The driver uses the information in this structure to schedule its servicing of its active queues. The driver must schedule the services of the queues so that the QoSs specified for all queues are met. The CMM also uses this command to change a queue's parameters; for example, when another VC is attached to the queue and the aggregate reserved bandwidth for the queue must be increased.

When the CMM closes the last VC associated with a queue, it notifies the device driver that the queue is no longer in use by sending it the `ATM_DRVMGMT_CLEARQ` command through the driver's management interface. The argument to this command is the number of the queue to clear; queues are numbered from 0 to the maximum number the driver supports minus 1. When the driver receives this command, it can stop servicing the queue because the CMM will not send any more data to that queue.

8.1.2 Device Driver Receive Queuing

Device drivers might supply a small amount of queuing on the receive path to reduce interrupt overhead, batching up several receive packets for processing on a single interrupt. However, driver writers should be careful not to introduce significant latency on incoming data unless they are capable of scheduling receive processing in a way that gives priority to constant bit rate (CBR) types of traffic.

8.2 Queuing in Convergence Modules

Like device drivers, convergence modules can implement any queuing mechanism on both the transmit and receive data paths. You can tailor the queuing mechanism implemented to the protocol's needs and the QoS requirements of the convergence module. Convergence modules are not required to queue in any direction, but doing so might improve performance by reducing data losses when there is congestion on the outgoing line.

8.2.1 Convergence Module Transmit Queuing

Since device driver writers must implement some sort of queuing on the transmit path, you can write convergence modules to leave all queuing of transmit data to device drivers. However, if a device driver queue becomes full, convergence modules are responsible for deciding the disposition of any data that cannot be queued to the driver. If a driver cannot accept more data for transmission because of a full queue, the transmitting convergence module can simply elect to discard the data and try again later. However, this approach is not appropriate for all protocols, and may even cause performance problems for protocols that permit the arbitrary dropping of data. In such cases, the convergence modules must provide some queuing

mechanism to hold the outgoing data until the driver is ready to accept more data for transmission (see Chapter 9 for an explanation of flow control in the ATM subsystem).

Since device driver queues are not visible to convergence modules, convergence modules must queue on a per-VC basis. At the convergence module interface, all flow control takes place on a per-VC basis, so convergence modules have to handle queuing for each VC (and can even elect to provide queuing on only certain connections and discard data on others). When a convergence module receives an `ATM_CAUSE_QWARN` or `ATM_CAUSE_QFULL` return from the `atm_cmm_send` call, this means that the driver's queue is almost full or full, respectively, and it cannot accept the data. At this point, the VC is considered *flow controlled*. The convergence module must either queue subsequent transmit data or discard the data until it receives a flow-control notification from the CMM.

The convergence module's implementation must determine the size of the module's per-VC queues. This implementation depends on the amount of data expected to flow on the VC and the ability of the protocol to retransmit data. When the device driver is ready to accept more data for transmission, it notifies the CMM, which in turn notifies the convergence module. When the convergence module receives the notification, it can start sending queued data until its queue is either drained or until it receives another indication from the CMM that the driver's queue is full. Once the queue has been cleared, all further data can be sent directly to the CMM for transmission, avoiding the overhead of queuing and dequeuing.

8.2.2 Convergence Module Receive Queuing

Convergence modules are generally passed incoming data while the processor is still running off the device driver's interrupt stack (from the receive interrupt). This means the convergence module receive routines are running at a high priority and should process the data and return to the CMM as quickly as possible. Processing of receive data in this fashion is allowed so that the CMM receive path introduces no additional latency that may be unacceptable for CBR traffic.

The ATM subsystem attempts to deliver the data from the adapter to the convergence module as quickly as possible, with a minimum of extra processing and no additional latency. That way, convergence modules that handle CBR traffic are passed the incoming data as quickly as possible without interference from the ATM infrastructure or from the scheduling latencies of the operating system. Therefore, convergence modules must implement a receive queuing mechanism that is both appropriate to their protocol and QoS needs and that makes the modules cooperate in a multiprotocol, multi-QoS environment. For example, a convergence module that handles ABR traffic should not hold the processor for longer than

necessary just because it can and the module writer might want that module to perform well at the expense of other protocols.

In general, convergence modules should queue incoming data as soon as they can and schedule a kernel thread to process the data at a later time. Of course, modules that process CBR traffic should not queue data, but should do as much processing as is appropriate. Too much processing on the interrupt stack, however, could lead to live lock conditions on the processor.

Convergence modules cannot use flow control on device drivers. The only methods available to enforce flow control on the sender is either protocol-specific flow control or ATM flow control. Device drivers will use ATM flow control when they start running out of receive buffer space.

9

Flow Control

The ATM subsystem uses the following types of flow control:

- Hardware flow control — The ATM network uses this to manage congestion.
- Software flow control — The ATM subsystem uses this to control the movement of data between modules.

Although these methods of flow control are different, they do interact, especially in the transmission of data on the network. You must design and implement each device driver and convergence module to use flow control properly, thus ensuring the proper operation of the entire subsystem.

9.1 Hardware Flow Control

The ATM network and adapter use hardware flow control to control congestion within the network. This allows the network to prevent the sender from transmitting more data than the network can handle. In the UNI 3.0/3.1 environment, there is no standard for ATM flow control, although many vendors implement their own methods of flow control. Since these flow-control methods are confined to the ATM adapter and since the ATM subsystem accommodates as many types of adapters as possible, all methods of flow control are accommodated as long as they are isolated to the adapter and its device driver. The ATM subsystem also supports the use of both proprietary and standard methods of hardware flow control.

To enable hardware flow control, you must send a device driver the `ATM_DRVMGMT_FC` command through the driver's management function. The argument to this command indicates whether to enable flow control (and the type to enable) or to disable all flow control. Drivers must be initialized with flow control disabled. Currently, the CMM recognizes the following types of hardware flow control:

- Vendor-specific flow control

  Requires that the adapter and the switch implement the same type of hardware flow control. This command is sent as the result of the `atmconfig +vfc` command being issued by an operator (the system is unable to determine which types of vendor-specific protocols are usable since this requires knowledge of the protocols that both the adapter and the switch implement).

- ATM Forum standard flow control

  Currently not supported. Generally, the CMM uses the fields in the switch and driver Management Information Bases (MIBs) to detect flow control, and turns on this flow control without any user interaction. However, system administrators can also enable this form of flow control by running the `atmconfig +sfc` command.

To disable flow control, a system administrator uses either the `atmconfig -sfc` or `atmconfig -vfc` command, depending on the type of flow control currently enabled.

9.2 Software Flow Control

If you do not use hardware flow control, the driver might be passed data from convergence modules faster than it can transmit the data on the interface. In this case, the driver must be able to inform the sending convergence modules that its queues are full and that no data should be sent until further notification. Rather than having the driver perform an explicit notification (which involves extra function call overhead) to do this, the driver must return a value from its transmit function indicating that its queue is full (or is filling). The driver should then consider the queue flow controlled and must send a notification to the CMM when the queue is ready to accept more data.

In its implementation, the CMM records most information associated with flow control. Since the driver does all software flow control on a per-queue basis, the CMM must translate this into information that can be used on a per-VC basis. The CMM maintains a list of which VCs are assigned to which driver queues; the CMM converts driver queue enable notifications to per-VC enable notifications for convergence modules.

Drivers must maintain the following values on their queues: a high-water mark and a low-water mark. Drivers use these marks to control the value returned by the transmit function and the sending of flow-control notifications to the CMM.

9.2.1 High-Water Mark

The high-water mark controls when the driver starts returning warnings (`ATM_CAUSE_QWARN`) from the transmit call. These warnings are used by convergence modules that might try to start queuing before the driver can no longer accept data. The use of warnings also allows convergence modules the chance to use flow control on the upper-layer protocol modules, if possible, before the driver actually starts rejecting data. The driver should start returning the queue warning when the number of queued messages passes

its high-water mark. The driver writer must choose a high-water mark that is appropriate for the driver's queuing policy and adapter characteristics.

When a driver returns a queue warning, it must have accepted the data for transmission and queued the data. The warning returned does not indicate that the driver cannot accept the data, only that the queue is close to being full.

When a driver's queue is full, the driver must not discard data passed in the transmit function. Instead, the driver must return `ATM_CAUSE_QFULL` from the transmit function so the convergence module can decide if the data is to be dropped or queued within the convergence module. The queue full return indicates that the driver cannot accept the data for transmission because its queue is full, not for any other reason, such as insufficient memory. Drivers can continue to receive and reject packets for transmission even after the queue fill return, since more than one convergence module could be queuing to the queue.

9.2.2 Low-Water Mark

When the number of messages on a driver's transmit queue drops below the low-water mark, the driver sends an `ATM_DE_STARTQ` notification to the CMM. The driver must send this notice if it has returned any queue warning or full conditions from its transmit function since the last restart notification was sent. This implies that drivers maintain state information about previous returns and notifications. Driver writers can provide extra restart notifications (the CMM properly handles redundant notification), but should not provide too few notifications. The driver notifies restarts per queue only. The CMM converts these to per-VC restarts and sends those notifications to convergence modules. Therefore, drivers need to maintain only the per-queue state, not the per-VC state, for flow control.

9.3 Convergence Module Flow Control

Convergence modules are not required to maintain any type of transmit queue since ATM device drivers must provide some amount of output queuing. However, convergence modules should provide transmit queues if data not accepted for transmission by a driver is to be saved for retransmission. If it is acceptable to discard data, convergence modules can ignore queuing and flow-control features all together.

Device drivers generate flow control on a per-queue basis; convergence modules handle flow control on a per-VC basis. The reasons for this are as follows:

- Information concerning driver queuing policies and CMM assignment of VCs to driver queues is not available to convergence modules.

- The CMM uses flow control on the sender synchronously so that only those VCs trying to send data to a flow-controlled queue actually receive flow-control indications. Those VCs that do not send any data to the affected queue while the flow-control condition exists never receive a flow-control indication and are unaffected by the flow-control condition.
- Only those VCs that have been flow controlled are notified when they can resume transmission of data.

If a convergence module implements transmit queuing, it must be prepared to handle software flow control from the CMM. Convergence modules are given flow-control information in the return from the CMM send routine and by an exception notification. The convergence module should use this information to control its queuing and sending of data.

Convergence modules can bypass internal queues for efficiency as long as data is flowing freely to the CMM. A convergence module needs to use transmit queues only when it is informed that the device driver's queue is filling up or is full. Once the queues have drained, the queues can be bypassed again. This type of implementation requires some extra state to be maintained in the convergence module. However, this implementation could increase the speed of the nonqueued transmit path.

When a convergence module calls `atm_cmm_send`, it receives an `atm_err_t` return value, indicating the disposition of the data by the CMM and device driver. If the device driver accepts the data for transmission, `atm_cmm_send` returns `ATM_CAUSE_GOOD`. In this case, the driver has queued the data for transmission and the convergence module must destroy any references to the data; the driver frees the mbufs associated with the data.

When a device driver's transmit queue fills up beyond the high-water mark, the driver starts returning `ATM_CAUSE_QWARN` to the CMM, which returns this value to the convergence module. When a convergence module gets an `ATM_CAUSE_QWARN` back from `atm_cmm_send`, this means that the data was accepted and queued by the driver, but that the convergence module should not send any more data. The driver's queue could fill up and it would have to start rejecting data. In this case, the convergence module should either start queuing outgoing data or start dropping subsequent packets until it receives notification that the driver can accept data again.

The convergence module might also notify the upper-layer protocols (if the flow can be controlled) and continue to send data to the driver until the upper layers stop sending. A queue warning might not be returned before a queue is completely full and the driver can no longer accept data. This is true in cases in which multiple VCs are feeding a single queue. The queue warning is intended to give the convergence module warning of an impending queue full condition so that it can take any appropriate action *before* the driver stops accepting data.

If a device driver's queue becomes completely full and the driver is unable to queue any additional data, ATM_CAUSE_QFULL is returned from atm_cmm_send. In this case, the driver did not accept and queue the data and the convergence module must consider the VC blocked and unable to transmit any more data. The module must either queue the data internally or discard it. Any further attempts to transmit will probably return a queue full condition.

For those cases where multiple VCs feed a single queue and the convergence module can control the upper-layer protocols, the convergence module should implement a small transmit queue to handle any data that is sent by the upper layers between the flow-control notification and the actual cessation of data transmission. A small transmit queue ensures sufficient storage space to prevent data loss if a driver queue suddenly becomes full due to the accumulation of data from another VC.

When a queue warning or a queue full condition is reported to a convergence module, the VC that received the condition is considered flow controlled; no more data should be sent on the VC. When the driver queue drains below its low-water mark, the driver notifies the CMM that it is ready to start accepting data on that queue. The CMM then sends an ATM_CME_START_VC notification to each convergence module, specifying that the affected VCs can resume data transmission. One notification is sent for every VC that receives a flow-control indication from one or more atm_cmm_send calls.

When a convergence module receives the ATM_CME_START_VC exception, it should arrange to start sending data from its queues down to the driver and to remove flow control from the upper-layer protocols, if necessary. Note that convergence modules should not drain their queues as part of the exception function call on which the ATM_CME_START_VC exception is received as this could be on an interrupt stack. Instead, convergence modules should schedule a kernel thread or timeout to run and process the queued data.

A

CMM Routines

This appendix contains a description of each of the routines described in this guide, in reference-page format. The routines are in alphabetical order.

atm_cmm_accept

NAME

atm_cmm_accept – Accepts a previously deferred call and informs the CMM that the call should be accepted

SYNOPSIS

```
atm_error_t atm_cmm_accept(
          atm_addr_p addr,
          atm_vc_services_t give);
```

ARGUMENTS

addr Specifies a pointer to the atm_addr structure for the call being accepted. This is the same pointer passed into the convergence module's xxx_connect routine when the call first came in.

give This argument is not currently used.

DESCRIPTION

The atm_cmm_accept routine is a convergence module interface that accepts a previously deferred incoming call, notifies the CMM, and sets the circuit resource parameters. The incoming call was deferred when a convergence module returned ATM_CAUSE_DEFER from its xxx_connect routine.

Typically, the determination is done within a set period of time, as defined by the signaling protocol, before the calling party times out on the call request.

The connection is not established and ready for use until the convergence module receives the appropriate exception notifications.

RETURN VALUES

If connection setup is proceeding, atm_cmm_accept returns ATM_CAUSE_GOOD; otherwise, it returns an ATM error number that indicates the reason the call failed. If the call fails, the convergence module should remove any reference to the call.

RELATED INFORMATION

xxx_connect

Section 6.2 for information on accepting connections

NAME

atm_cmm_activate_con – Informs the CMM that a connection is ready to carry data

SYNOPSIS

```
atm_error_t atm_cmm_activate_con(
         atm_sig_handle_t sm,
         atm_addr_t *addr);
```

ARGUMENTS

sm Specifies the signaling module handle that the CMM returned in the registration call.

addr Specifies a pointer to an atm_addr structure that contains all the parameters of the call. This pointer must point to the same atm_addr structure that was passed in either the atm_cmm_new_call function call or in the xxx_setup and xxx_add function calls since this pointer is the handle that refers to the specific connection.

DESCRIPTION

The atm_cmm_activate_con routine is a signaling module interface. Signaling modules call this routine when they receive an indication from the network that the circuit is connected. The routine notifies the CMM that the connection is ready to carry data. The CMM enables the VC locally, and passes the notification to the device driver and protocol convergence modules.

Note

Do not make this call before circuit connection.

RETURN VALUES

If the indicated connection is found on the system no matter what the result of the operation, atm_cmm_activate_con returns ATM_CAUSE_GOOD. If the indicated connection is not found, an error value is returned indicating

that the signaling module should release the connection since the CMM has no reference to it.

RELATED INFORMATION

`atm_cmm_con_release`, `xxx_setup`, `xxx_add`

Section 6.4 for information on releasing connections

NAME

atm_cmm_add – Adds an endpoint to an existing point-to-multipoint connection

SYNOPSIS

```
atm_err_t atm_cmm_add(
          atm_cvg_handle_t cm,
          atm_addr_t *addr,
          atm_uni_call_ie_p ei,
          atm_vc_t *vc);
```

ARGUMENTS

cm Specifies a value returned to the convergence module by the registration function call. This uniquely identifies the convergence module making the request.

addr Specifies a pointer to a properly set atm_addr structure that specifies the address of the endpoint to be added to the connection.

ei Specifies a pointer to an array of atm_uni_call_ie structures that has been initialized with information to be used in placing the additional call. This argument must be NULL if no optional IEs are specified.

vc Specifies a pointer to the atm_vc structure of the VC to which the endpoint is to be added. The VC must have been created with the ATM_CT_PTM flag set.

DESCRIPTION

The atm_cmm_add routine is a convergence module interface that adds endpoints to an existing point-to-multipoint connection. You can add endpoints at any time only to connections that were created with the ATM_CT_PTM flag set.

EXAMPLE

See Example B–2 for a code example of the atm_cmm_add routine.

RETURN VALUES

If the endpoint add is proceeding, atm_cmm_add returns ATM_CAUSE_GOOD. The convergence module receives the ATM_CME_CALL_FAILED or the ATM_CME_EP_ACTIVE exception indications to report the progress of the call. ATM_CME_EP_ACTIVE indicates that the call completed and the connection to the endpoint is active and can transport data. These indications do not reflect the state of any other endpoint associated with the VC. If the endpoint add cannot proceed, an ATM error number is returned.

RELATED INFORMATION

atm_cmm_drop

Chapter 6 for information on connections

NAME

`atm_cmm_adi_set_cause` – Logs a network-visible VC or endpoint condition

SYNOPSIS

```
atm_err_t atm_cmm_adi_set_cause(
          atm_drv_handle_t driver,
          atm_vc_p vp,
          atm_addr_p addr,
          char *reason,
          atm_error_t cause,
          atm_location_t location,
          unsigned char diag_length,
          unsigned char *diag);
```

ARGUMENTS

driver	Specifies the interface on which the condition occurred. This is the driver handle that the CMM assigned at driver registration time.
vp	Specifies a pointer to the VC on which the condition occurred. If the error applies to one endpoint, set the value to NULL and set the *addr* value to non-NULL.
addr	Specifies a pointer to the `atm_addr` structure for the endpoint on which the error occurred. If the error applies to all endpoints on the VC (global), set the value to NULL and set the *vp* value to non-NULL.
reason	Specifies a NULL-terminated character string that contains descriptive text for the error.
cause	Specifies the `atm_error_t` value that describes the condition.
location	Specifies an `atm_location_t` value that indicates the location in the network where the error occurred.

diag_length	Specifies the length (in bytes) of the data in the *diag* argument.
diag	Specifies a string of bytes that contains diagnostic information about the error. This data might be passed to the network in the diag field of a Cause IE.

DESCRIPTION

The atm_cmm_adi_set_cause routine is a device driver interface that records an error or normal condition associated with a VC or endpoint. The condition is stored as an atm_cause_info structure together with the VC. Convergence and signaling modules can retrieve this information by using the atm_cmm_next_cause routine. Users can display this information by using the atmconfig utility.

Errors or events stored with the atm_cmm_adi_set_cause routine are visible to the network and to the other end of the connection. When a signaling module releases a connection or drops an endpoint, the module extracts the most recent cause from a VC or endpoint and creates a Cause IE.

RETURN VALUES

If the cause is recorded successfully, atm_cmm_adi_set_cause returns ATM_CAUSE_GOOD. If the driver handle, *vp* argument, or *addr* argument is invalid, atm_cmm_adi_set_cause returns ATM_CAUSE_BARG.

RELATED INFORMATION

atm_cmm_adi_set_log, atm_cmm_next_cause, atm_cmm_set_cause, atm_cmm_smi_set_cause

Section 2.9.7 for information on cause information

NAME

atm_cmm_adi_set_log – Logs a VC or endpoint condition

SYNOPSIS

```
atm_err_t atm_cmm_adi_set_log(
          atm_drv_handle_t driver,
          atm_vc_p vp,
          atm_addr_p addr,
          char *reason,
          atm_error_t cause,
          atm_location_t location,
          unsigned char diag_length,
          unsigned char *diag);
```

ARGUMENTS

driver	Specifies the interface on which the condition occurred. This is the driver handle that the CMM assigned at driver registration time.
vp	Specifies a pointer to the VC on which the condition occurred. If the error applies to one endpoint, set the value to NULL and set the *addr* value to non-NULL.
addr	Specifies a pointer to the atm_addr structure for the endpoint on which the error occurred. If the error applies to all endpoints on the VC (global), set the value to NULL and set the *vp* value to non-NULL.
reason	Specifies a NULL-terminated character string that contains descriptive text for the error.
cause	Specifies the atm_error_t value that describes the condition.
location	Specifies the location in the network where the error occurred.
diag_length	Specifies the length (in bytes) of the data in the *diag* argument.

diag	Specifies a string of bytes that contains diagnostic information about the error. This data might be passed to the network in the diag field of a Cause IE.

DESCRIPTION

The atm_cmm_adi_set_log routine is a device driver interface that records an error or normal condition associated with a VC or endpoint. The condition is stored as an atm_cause_info structure together with the VC. Users can display this information by using the atmconfig utility.

Errors or events stored with the atm_cmm_adi_set_log routine are logged on the local system only, and are not available when a signaling module generates a Cause IE. Logging provides information about VC or endpoint activity for a system or network administrator to view on the local system.

RETURN VALUES

If the cause is recorded successfully, atm_cmm_adi_set_log returns ATM_CAUSE_GOOD. If the driver handle, *vp* argument, or *addr* argument is invalid, the routine returns ATM_CAUSE_BARG.

RELATED INFORMATION

atm_cmm_adi_set_cause, atm_cmm_next_cause, atm_cmm_set_log, atm_cmm_smi_set_log

Section 2.9.7 for information on cause information

NAME

atm_cmm_alloc_addr – Allocates memory for and initializes the atm_addr structure

SYNOPSIS

```
atm_addr_p atm_cmm_alloc_addr( void );
```

DESCRIPTION

The atm_cmm_alloc_addr routine is a signaling and convergence module interface that allocates memory for the atm_addr structure and initializes the structure members. One atm_addr structure is allocated by a convergence module for each endpoint it calls and by a signaling module for each endpoint that calls the local host.

Usually, the CMM frees all ATM address structures associated with a VC when the VC is destroyed. However, under some error conditions (such as when a convergence module is allocating a series of structures and one allocation fails), it may be necessary for the allocating module to free memory it has allocated. In these cases, modules can call the atm_cmm_free_addr routine with the value returned from atm_cmm_alloc_addr to free memory.

EXAMPLE

See Section B.1 for a code example of the atm_cmm_alloc_addr routine.

RETURN VALUES

If storage cannot be allocated, a NULL is returned; otherwise, a pointer to the allocated memory is returned.

RELATED INFORMATION

atm_cmm_free_addr

Section B.1 for information on connections

atm_cmm_alloc_ie

NAME

atm_cmm_alloc_ie – Allocates memory for and initializes the atm_uni_call_ie structure

SYNOPSIS

```
atm_uni_call_ie_p atm_cmm_alloc_ie(
          int num_ie);
```

ARGUMENTS

num_ie Specifies the number of IE structures to allocate.

DESCRIPTION

The atm_cmm_alloc_ie routine is a convergence module interface that allocates memory for the atm_uni_call_ie structure and initializes the structure members.

Typically, the convergence protocol module frees all UNI signaling structures associated with a VC when the VC is destroyed. However, under some error conditions (such as when a convergence module is allocating a series of structures and one allocation fails) the allocating module (either the convergence or signaling module) might have to free memory it has allocated. Convergence modules should not free memory for this structure if the atm_cmm_connect or related call succeeds because the CMM will free the memory.

EXAMPLE

See Section B.1, Section B.2, and Section B.3 for code examples of the atm_cmm_alloc_ie routine.

RETURN VALUES

If storage cannot be allocated, a NULL is returned; otherwise, a pointer to the allocated memory is returned.

RELATED INFORMATION

`atm_cmm_free_ie`

Chapter 6 for information on connections

atm_cmm_alloc_services

NAME

atm_cmm_alloc_services – Allocates memory for and initializes an atm_vc_services structure

SYNOPSIS

```
atm_vc_services_p atm_cmm_alloc_services( void );
```

DESCRIPTION

The atm_cmm_alloc_services routine is a signaling and convergence module interface that allocates memory for the atm_vc_services structure and initializes the structure members to default values for best-effort unspecified bit rate (UBR) service. Once allocated, other ATM modules can change the atm_vc_services structure as needed.

Typically, the CMM frees the atm_vc_services structure associated with a VC when the VC is destroyed. However, under some error conditions (such as when a convergence module is allocating a series of structures and one allocation fails), the allocating module might need to free memory it has allocated. In these cases, modules call the atm_cmm_free_services routine with the value returned from atm_cmm_alloc_services to free memory.

EXAMPLE

See Section B.1 for a code example of the atm_cmm_alloc_services routine.

RETURN VALUES

If storage cannot be allocated, a NULL is returned; otherwise, a pointer to the allocated memory is returned.

RELATED INFORMATION

atm_cmm_free_services

Chapter 6 for information on connections

NAME

atm_cmm_bind_info – Queries parameters from a bind

SYNOPSIS

```
unsigned long atm_cmm_bind_info(
        atm_bind_handle_t handle,
        atm_bind_info_t it);
```

ARGUMENTS

handle Specifies a pointer to a CMM bind handle of a currently active AESA binding. Information is retrieved from the PPA associated with the bind point.

it Specifies the type of information that is being queried. The value returned depends on the object type of the queried information. The following values may be used to query the indicated information:

Value	Meaning
ATM_BIND_INFO_HANDLE	Returns the convergence module's bind handle, which the convergence module supplied at the time it created the AESA bind point.
ATM_BIND_INFO_ID	Returns a unique global value for referencing the bind point. Each bind point gets assigned a unique ID (which is different from the bind handle). An application program can use this value when specifying a bind point (atmconfig uses these values to reference bind points). The returned value is 32-bits wide.
ATM_BIND_INFO_PPA	Returns a pointer to the PPA associated with the AESA bind point.
ATM_BIND_INFO_SELECTOR	Returns the selector value assigned to the bind point. Primarily, a convergence module uses this to request that the CMM assign an unused selector value to a bind point. The value returned is between 0 and 255 for SVC bindings, and is 31-bits wide for PVC bindings.
ATM_PPA_ALLOCGRANE	Returns a type of atm_bw_granularity_p, which reflects the underlying interface's units of bandwidth allocation, or its allocation granularity.
ATM_PPA_ALLOCLIMIT	Returns a type of atm_bw_granularity_p, which reflects the underlying interface's per-VC bit rate limits, expressed in allocation granularity units.

atm_cmm_bind_info

Value	Meaning
ATM_PPA_AVAILRES	Returns a type of atm_services_granes_p, which reflects the amount of bandwidth (in granularity units) currently available for new CBR circuits over the underlying interface.
ATM_PPA_BRESVLIM	Returns the user-configurable limit, expressed as a percentage of backward bandwidth, on CBR circuits.
ATM_PPA_ESI	Returns the ESI that the signaling module supplied when the PPA was created.
ATM_PPA_ESIID	Returns the unique ESI identifier associated with the PPA's ESI.
ATM_PPA_ESILEN	Returns the length of the ESI that the signaling module supplied when the PPA was created.
ATM_PPA_ESIPID	Returns the ESI identifier of the PPA's parent ESI.
ATM_PPA_FRESVLIM	Returns the user-configurable limit, expressed as a percentage of forward bandwidth, for CBR circuits.
ATM_PPA_INFO_BURST_AVAIL	Returns the available burst cell rate in cells-per-second. This is the amount of burst cell rate that is available to be reserved by a convergence module.
ATM_PPA_INFO_BURST_MAX	Returns the maximum burst cell rate supported by the interface in cells-per-second.
ATM_PPA_INFO_CAPABILITIES	Returns the driver's capabilities for that interface.
ATM_PPA_INFO_DID	Returns a unique global value that can be used to reference the driver for the underlying interface.
ATM_PPA_INFO_DNAME	Returns the name of the driver for the underlying interface.
ATM_PPA_INFO_DUNIT	Returns the driver's unit number for the underlying interface.
ATM_PPA_INFO_FC	Returns a nonzero value if hardware flow control is currently enabled on the interface.
ATM_PPA_INFO_HARD_MTU	Returns the largest PDU (in bytes) that the interface supports. This is valid only for interfaces that support AAL5 or AAL3/4 SAR functions in hardware.
ATM_PPA_INFO_HI_VCI	Returns the highest value that may be used for a VCI on the interface.
ATM_PPA_INFO_HI_VPI	Returns the highest value that may be used for a VPI on the interface.
ATM_PPA_INFO_ID	Returns a unique global value for referencing the PPA. Each PPA gets assigned a unique ID when it is created. An application program can use this value to specify a bind point (atmconfig uses these values to reference bind points). The returned value is 32-bits wide.

Value	Meaning
ATM_PPA_INFO_MAX_VCI	Returns the maximum number of VCIs that the interface supports.
ATM_PPA_INFO_MAX_VPI	Returns the maximum number of VPIs that the interface supports.
ATM_PPA_INFO_MEDIA	Returns a value that indicates the type of physical media to which the interface is connected. The return value is of the type atm_media_type_t.
ATM_PPA_INFO_PEAK_AVAIL	Returns the available peak cell rate (in cells-per-second). This is the amount of peak cell rate that is available to be reserved by a convergence module.
ATM_PPA_INFO_PEAK_MAX	Returns the maximum peak cell rate (in cells-per-second) that the interface supports.
ATM_PPA_INFO_QUEUES	Returns the number of scheduling queues that the driver has made visible to the CMM.
ATM_PPA_INFO_SNAME	Returns the name of the signaling module that created the PPA.
ATM_PPA_INFO_SUST_AVAIL	Returns the available sustainable cell rate (in cells-per-second). This is the amount of sustainable cell rate that is available for a convergence module to reserve.
ATM_PPA_INFO_SUST_MAX	Returns the maximum sustainable cell rate (in cells-per-second) that the interface supports.
ATM_PPA_INFO_TOTAL_VC	Returns the maximum number of VCs that can be opened on the interface at any given time.
ATM_PPA_INFO_TYPE	Returns a value that indicates the underlying interface type. The returned value is of the type atm_interface_t.
ATM_PPA_INFO_UNI	Returns the UNI type associated with the PPA, which the signaling module supplied at the time the PPA was created. The return value is of the type atm_uni_type_t.
ATM_PPA_INFO_VC_LEFT	Returns the number of unopened VCs on the interface at the time of the call. This is the total number of VCs (the value returned by ATM_PPA_INFO_TOTAL_VC) minus the number of VCs currently opened.
ATM_PPA_MAX_VC_BBW	Returns the user-configurable maximum per-VC backward (incoming) bit rate (in allocation granularity units) permitted over the underlying interface for CBR circuits.
ATM_PPA_MAX_VC_FBW	Returns the user-configurable maximum per-VC forward (outgoing) bit rate (in allocation granularity units) permitted over the underlying interface for CBR and pacing circuits.

Value	Meaning
ATM_PPA_MAXRES	Returns a type of atm_services_granes_p, which reflects the maximum bandwidths available for CBR circuits over the underlying interface. These bandwidths (expressed in granularity units) are a function of the interface limits and the user-configurable limits on the percentage of bandwidth available to CBR and pacing circuits.
ATM_PPA_NUM_VCI	Returns the current number of VCIs configured on the underlying interface.
ATM_PPA_NUM_VPI	Returns the current number of VPIs configured on the underlying interface.
ATM_PPA_PEAK_CELLRATE	Returns the peak PDU bit rate (in cells-per-second) for the underlying interface.
ATM_PPA_UNUSEDRES_BACK	Returns the amount of backward (incoming) bandwidth (in cells-per-second) currently reserved for, but not yet applied to, CBR circuits.
ATM_PPA_UNUSEDRES_FWD	Returns the amount of forward (outgoing) bandwidth (in cells-per-second) currently reserved for, but not yet applied to, CBR circuits.

DESCRIPTION

The atm_cmm_bind_info interface is a convergence module interface that queries the CMM for current information about an interface's physical capabilities (such as its bit rates) and the amount of specific resources left available on an interface (the remaining nonreserved sustainable bit rate). The CMM and device drivers keep track of this information.

Since convergence modules normally deal with either PPAs or AESA bindings, the CMM allows convergence modules to query the information from the underlying interface by specifying the bind directly. Thus, the convergence module requires no specific knowledge of any device driver or device driver-related structures.

RETURN VALUES

If an invalid query is made for an ATM_BIND_* object type, atm_cmm_bind_info returns a value of –1. If an invalid query is made for any other object type, the function returns a value of 0.

RELATED INFORMATION

`atm_cmm_del_ppa`, `atm_cmm_new_ppa`, `atm_cmm_ppa_bind`, `atm_cmm_ppa_info`

Section 3.5.1.15 for information on driver capabilities

atm_cmm_con_deleted

NAME

atm_cmm_con_deleted – Notifies the CMM that a connection does not exist

SYNOPSIS

```
atm_err_t atm_cmm_con_deleted(
          atm_sig_handle_t sm,
          atm_addr_p addr);
```

ARGUMENTS

sm Specifies the signaling module handle that the CMM returned in the registration call.

addr Specifies a pointer to an atm_addr structure that contains all the parameters of the call. This pointer must point to the same atm_addr structure that was passed in either the atm_cmm_new_call function call or in the xxx_setup and xxx_add function calls since this pointer is the handle that refers to the specific connection.

DESCRIPTION

The atm_cmm_con_deleted interface is a signaling module interface. A signaling module calls this routine when the module receives confirmation of a connection's release from the switch. The routine notifies the CMM that the connection no longer exists.

The CMM holds the resources associated with the connection for a brief period of time, then releases them, giving all incoming queues time to clear. The CMM also notifies convergence modules that the connection has been released.

This routine notifies the CMM of both the deletion of point-to-point connections and of the deletion of parties in point-to-multipoint connections.

RETURN VALUES

If the endpoint referenced is invalid, the atm_cmm_con_deleted routine returns ATM_CAUSE_EIR to indicate that it has no previous entry for the connection; otherwise, it returns ATM_CAUSE_GOOD.

RELATED INFORMATION

atm_cmm_activate_con, atm_cmm_con_release, xxx_add, xxx_setup

Section 6.4.2 for information on releasing connections

atm_cmm_con_failed

NAME

atm_cmm_con_failed – Notifies the CMM of a call failure

SYNOPSIS

```
atm_error_t atm_cmm_con_failed(
          atm_sig_handle_t sm,
          atm_addr_t *addr);
```

ARGUMENTS

sm Specifies the signaling module handle that the CMM returned in the registration call.

addr Specifies a pointer to an atm_addr structure that contains all the parameters of the call. This pointer must point to the same atm_addr structure that was passed in either the atm_cmm_new_call function call or in the xxx_setup and xxx_add function calls since this pointer is the handle that refers to the specific connection.

DESCRIPTION

The atm_cmm_con_failed routine is a signaling module interface. When the CMM makes a connection request to a signaling module, the call to the remote system might fail for some reason. Since call creation is an asynchronous operation, the signaling module might encounter errors during call processing after the xxx_setup call has returned. In these cases, the signaling module notifies the CMM of failures both of point-to-point connections and of additional endpoints in point-to-multipoint connections. In the case of the failure of endpoints in a point-to-multipoint connection, the addr pointer points to the atm_addr structure of the added endpoint.

RETURN VALUES

If the endpoint referenced is invalid, the atm_cmm_con_failed routine returns ATM_CAUSE_EIR to indicate that it has no previous entry for the connection; otherwise, it returns ATM_CAUSE_GOOD.

RELATED INFORMATION

Section 6.1 for information on setting up connections

atm_cmm_con_release

NAME

atm_cmm_con_release – Notifies the CMM that a connection will be released

SYNOPSIS

```
atm_error_t atm_cmm_con_release(
          atm_sig_handle_t sm,
          unsigned long reference,
          atm_ppa_p ppa);
```

ARGUMENTS

sm	Specifies the signaling module handle that the CMM returned in the registration call.
reference	Specifies the unique call reference value that identifies the connection to be released.
ppa	Specifies a pointer to the PPA to which the VC being released belongs.

DESCRIPTION

The atm_cmm_con_release routine is a signaling module interface. The signaling module calls this routine when the module receives a request to tear down a connection from the network or endpoint. This notifies the CMM to release a connection or virtual circuit, and not to drop a single endpoint from a connection. When this routine is called, the CMM makes the connection unavailable for transmission, initiates the teardown of the referenced connection and all associated endpoints, and awaits notification that the VC has been torn down.

RETURN VALUES

If the endpoint referenced is invalid, the atm_cmm_con_release routine returns ATM_CAUSE_EIR to indicate that it has no previous entry for the connection; otherwise, it returns ATM_CAUSE_GOOD.

RELATED INFORMATION

`atm_cmm_activate_con`, `atm_cmm_con_deleted`

Section 6.4 for information on releasing connections

atm_cmm_connect

NAME

atm_cmm_connect – Requests a connection to a remote system

SYNOPSIS

```
atm_error_t atm_cmm_connect(
          atm_cvg_handle_t cm,
          enum atm_ctype type,
          atm_bind_handle_t calling,
          union atm_cmi_addr called,
          atm_uni_call_ie_p ei,
          int aging,
          atm_vc_service_p params);
```

ARGUMENTS

cm

Specifies a value returned to the convergence module by the registration function call. This uniquely identifies the convergence module making the request.

type

Specifies the type of connection being requested. The following types are defined:

Connection	Meaning
ATM_CT_PTM	Specifies that the connection is the first connection in a point-to-multipoint connection. This sets the ATM_SERVICES_PTM flag in the atm_vc_services structure.
ATM_CT_PTP	Specifies that the connection is a point-to-point connection only.
ATM_CT_PVC	Specifies that the connection is a permanent virtual circuit.

calling

Specifies the calling party address information to be used when placing the call. This is the identifier returned from the bind operation when the convergence module is bound to a PPA. This specifies the fully qualified AESA that will be used as the calling party address, and is used to direct the call to the proper signaling module and device driver.

called Specifies the called party (destination) address for the connection. When requesting the creation of a new SVC, the atm_cmi_addr union contains a pointer to an atm_addr structure that the convergence module allocates (using the proper CMM routine) with all necessary structure members set to specify the intended destination of the call. The convergence module must not free the storage for this structure; the CMM performs the deallocation when the connection closes (the caller is responsible for deallocating this structure if this routine returns an error indication). When requesting the creation of a new PVC, this argument contains the VCI and VPI for the new VC. Interpretation of the information in this argument is based on the value of the *type* argument. See Section 5.22.2 for information on the atm_cmi_addr union.

ie Specifies a pointer to an array of atm_uni_call_ie structures that has been initialized with information to be used in placing the call. This argument must be NULL if no optional IEs are specified.

aging Specifies how the CMM is to age the connection. The CMM provides connection aging services to detect connections that are unused and to delete the resources associated with the connections. The CMM provides several aging algorithms. The convergence modules must specify an initial aging algorithm at the time the circuit is created, but can modify this setting at any time through the atm_cmm_vc_control routine.

params Specifies an atm_vc_services_p pointing to a properly set atm_vc_services structure that defines the circuit parameters. For CBR circuits, the *params* argument can be a resource reservation; that is, a services structure that is backed by reserved resources.

DESCRIPTION

The atm_cmm_connect routine is a convergence module interface that requests the CMM to create a connection to a remote system. This initiates the exchanges between the network and the remote host to create a new

connection. The convergence module must specify all connection parameters to the CMM; these parameters are required to create the new connection.

By requesting a connection to a remote host, the convergence module owns the VC; the VC's ownership cannot be changed. The convergence module is notified of all incoming data and exceptions on the VC. Also, the convergence module is the only module that can transmit data on the VC.

NOTES

To create a PVC, set the *type* argument to ATM_CT_PVC, set the *calling* argument to the bind handle returned by the CMM for a binding on the PVC PPA, set the *params* argument to the circuit parameters for the new PVC, and set the *called* argument to an atm_cmi_addr union that contains valid vci and vpi data; the *aging* arguments are ignored.

If the system cannot provide the level of service specified in the params argument, the appropriate error is returned. No parameter negotiation is done for PVCs.

EXAMPLE

See Section B.1 for a code example of the atm_cmm_connect routine.

RETURN VALUES

If the call is proceeding, the atm_cmm_connect routine returns ATM_CAUSE_GOOD; otherwise, it returns an ATM error number that indicates the reason the call cannot proceed.

If the call proceeds, the atm_vc_p information in the atm_addr structure is valid on return. However, this does not mean the VC is ready to carry data. It means only that the CMM has allocated an atm_vc structure with which it can keep track of the connection. The convergence module is notified through the xxx_except routine when the call has completed and when the VC can carry data.

RELATED INFORMATION

atm_cmm_vc_control

Section 5.22.2 for information on the atm_cmi_addr union

Section 6.3 for information on connection aging

Section 6.5 for information on PVC creation

atm_cmm_cr2grain

NAME

atm_cmm_cr2grain – Converts a cell rate to allocation granularity

SYNOPSIS

```
unsigned long atm_cmm_cr2grain(
        atm_ppa_p ppa,
        unsigned long cr,
        atm_direction_t direction);
```

ARGUMENTS

ppa	Specifies a pointer to the PPA for which the conversion is to be performed. This can be any valid PPA configured in the system.
cr	Specifies the cell rate, in cells per second, to be converted.
direction	Specifies the direction of the cell rate. A driver might have different allocation granularities for the forward and backward directions.

DESCRIPTION

The atm_cmm_cr2grain routine is a convergence module interface that converts a cell rate to an allocation granularity unit. Some ATM drivers do not support setting a virtual circuit's (VC) cell rate in 1 cell per second increments. You can also use the atmconfig command to set a driver's allocation granularity. Therefore, this routine enables a convergence module to determine the nearest actual cell rate that can be achived on the VC, allowing for the allocation granularity.

The atm_cmm_cr2grain routine converts a cell rate to the nearest number of allocation granularity units, rounding as necessary. In the forward direction, the return value is the number of allocation granularity units that comes closest to, but does not exceed, the cell rate, to avoid violating the network contract. In the backward direction, the return value is the number of allocation granularity units that are needed to handle the entire incoming cell rate to avoid violating the network contract.

RETURN VALUES

Returns the number of granularity units. Returns zero if the driver associated with the PPA does not support traffic shaping (for example, CBR and VBR).

RELATED INFORMATION

`atm_cmm_grain2cr`, `atm_cmm_ppa_info`

atm_cmm_del_esi

NAME

atm_cmm_del_esi – Deletes an ATM address

SYNOPSIS

```
atm_err_t atm_cmm_del_esi(
          atm_cvg_handle_t cvg_handle,
          atm_esi_handle_t esi);
```

ARGUMENTS

cvg_handle	Specifies the value returned to the convergence module by the registration request routine. This uniquely identifies the convergence module making the request.
esi	Specifies the value returned to the convergence module when the ESI was created.

DESCRIPTION

The atm_cmm_del_esi routine is a convergence module interface that deletes an ATM address. A convergence module uses this routine when it no longer needs a new address it has created. Only the convergence module that registered the address can unregister the address.

Deleting an ESI causes the signaling module to delete all PPAs created from the ESI.

Deleting a PPA causes all VCs associated with that PPA to be closed by the CMM (both ends of the connection receive proper notification). Thus, convergence modules should delete addresses only when there are no active VCs associated with the address's PPAs.

RETURN VALUES

None

RELATED INFORMATION

atm_cmm_new_esi

NAME

atm_cmm_del_ppa – Notifies the CMM that a deleted PPA is invalid

SYNOPSIS

```
atm_error_t atm_cmm_del_ppa(
          atm_sig_handle_t sm,
          atm_ppa_p ppa);
```

ARGUMENTS

sm Specifies the signaling module handle that the CMM returned in the registration call.

ppa Specifies the PPA pointer that was returned when the PPA was added to the system.

DESCRIPTION

The atm_cmm_del_ppa routine is a signaling module interface. When a signaling protocol, in cooperation with a switch, deletes an address from the list of recognized addresses on an interface, the signaling module calls this routine to notify the CMM that the deleted PPA associated with the address is no longer valid. The CMM then informs convergence modules bound to the PPA that the address is no longer valid and initiates a teardown of all VCs associated with the address.

All PPAs, except for the PVC PPAs, are owned by a signaling module. That is, a signaling module is always responsible for the creation and deletion of a PPA. This is required since the registration of addresses with a switch is handled entirely by signaling protocols. Also, PPAs may be deleted because of actions on the network that are completely unrelated to the local system. Because of this, the CMM does not automatically delete PPAs when an interface is taken down or loses its connection to the switch. The CMM responds to an interface shutdown by deleting the PVC PPA. Signaling modules will delete PPAs when it is appropriate for their protocols to do so (such as when they lose communications with the switch).

RETURN VALUES

Upon successful completion, the atm_cmm_del_ppa routine returns ATM_CAUSE_GOOD; otherwise, it returns an ATM error number.

RELATED INFORMATION

atm_cmm_new_ppa, atm_cmm_ppa_bind, atm_cmm_ppa_info

NAME

atm_cmm_drop – Drops a connection to an endpoint

SYNOPSIS

```
atm_err_t atm_cmm_drop(
          atm_cvg_handle_t cm,
          atm_addr_t *addr);
```

ARGUMENTS

cm Specifies a value that the registration function call returns to the convergence module. This uniquely identifies the convergence module making the request.

addr Specifies a pointer to the atm_addr structure of the endpoint to be dropped.

DESCRIPTION

The atm_cmm_drop routine is a convergence module interface that drops a connection to an endpoint. The endpoint can be associated with either a point-to-point connection or a point-to-multipoint connection. When the last endpoint associated with a VC is dropped, the VC is torn down. You use this routine to manage multipoint VCs; you can also use it to initiate the teardown of point-to-point VCs.

RETURN VALUES

If the endpoint teardown is proceeding, the atm_cmm_drop routine returns ATM_CAUSE_GOOD; otherwise, it returns an ATM error number. After the endpoint is torn down, the convergence module receives an ATM_CME_EP_DEAD exception notification. When the last endpoint associated with a VC has been disconnected, the VC is torn down.

RELATED INFORMATION

atm_cmm_add

atm_cmm_enquery

NAME

atm_cmm_enquery – Requests that connection state information for an endpoint be updated

SYNOPSIS

```
atm_err_t atm_cmm_enquery(
          atm_cvg_handle_t cm,
          atm_addr_t *ep);
```

ARGUMENTS

cm Specifies a value that the registration function call returns to the convergence module. This uniquely identifies the convergence module making the request.

ep Specifies the endpoint to be queried.

DESCRIPTION

The atm_cmm_enquery routine is a convergence module interface that requests that the connection state information for an endpoint be updated. This initiates a connection enquiry to the endpoint that results in the atm_addr structure for the endpoint being updated with the latest status information. This routine may be called any time a connection is active.

RETURN VALUES

If the enquiry is initiated, the atm_cmm_enquery routine returns ATM_CAUSE_GOOD; otherwise, it returns an ATM error number, indicating the reason the enquiry was not initiated. When the enquiry reply is received by the system, the convergence module is informed by an ATM_CME_ENQUERY_DONE exception notification. When the convergence module gets this notification, it may then examine the updated endpoint status information in the atm_addr structure.

RELATED INFORMATION

atm_cmm_add

NAME

atm_cmm_ep_add – Notifies the CMM to add an endpoint

SYNOPSIS

```
atm_err_t atm_cmm_ep_add(
          atm_sig_handle_t sm,
          atm_addr_t *addr,
          atm_uni_call_ie_p ie,
          atm_ppa_p ppap,
          unsigned long call_reference,
          unsigned long epreference);
```

ARGUMENTS

sm	Specifies the signaling module handle that the CMM returned in the registration call.
addr	Specifies a pointer to an atm_addr structure that contains all the information about the incoming endpoint. The signaling module writes the information into this structure.
ie	Specifies a pointer to an array of optional information elements received from the adding party. The signaling module converts data from the incoming signaling messages and fills in an array of information element structures.
ppap	Specifies the PPA on which the incoming add request was received.
call_reference	Specifies the unique call reference value associated with this call. The signaling module should have already delivered a call with this reference when the initial connection was received.
epreference	Specifies the unique endpoint reference value associated with the endpoint. This value identifies the endpoint during its entire lifetime on the system. The value is unique with respect to

call_reference, but might be duplicated across different calls. The value is opaque to the CMM, and can have special meaning to the signaling module.

DESCRIPTION

The atm_cmm_ep_add routine is a signaling module interface. A signaling module calls this routine when the module receives a request to add an endpoint to an existing call. This notifies the CMM of the new endpoint. The CMM determines whether to accept the endpoint.

This routine is nonblocking, and returns an indication about the disposition of the endpoint.

RETURN VALUES

If the CMM and the convergence module that owns the call agree to accept the endpoint, the atm_cmm_ep_add routine returns ATM_CAUSE_GOOD.

If the call is rejected, the routine returns an ATM error value that indicates the reason. The convergence module might supply additional information in the cause fields in the atm_addr structure. If the endpoint is rejected, the signaling module must deallocate the storage for the atm_addr structure and the information elements.

RELATED INFORMATION

xxx_except, atm_cmm_new_call

Section 6.1.2 for information on adding endpoints

NAME

atm_cmm_ep_dropped – Notifies the CMM to drop an endpoint

SYNOPSIS

```
atm_err_t atm_cmm_ep_dropped(
          atm_sig_handle_t sm,
          unsigned long reference,
          long epreference,
          atm_ppa_p ppa);
```

ARGUMENTS

sm	Specifies the signaling module handle that the CMM returned in the registration call.
reference	Specifies the unique call reference value that identifies the connection to be released.
epreference	Specifies the unique endpoint reference value that identifies the endpoint to be dropped.
ppa	Specifies a pointer to the PPA to which the VC being released belongs.

DESCRIPTION

The atm_cmm_ep_dropped routine is a signaling module interface. A signaling module calls this routine when the module receives a request to drop an endpoint from a connection. This notifies the CMM to drop endpoints in a multipoint connection. The endpoint must already exist on the system.

The CMM notifies the convergence module that owns the endpoint's VC that the endpoint has been dropped and deletes the endpoint. If the last endpoint associated with a VC is dropped, the CMM initiates the release of the VC.

RETURN VALUES

If the endpoint referenced is invalid, the atm_cmm_ep_dropped routine returns ATM_CAUSE_EIR to indicate that it has no previous entry for the connection; otherwise, it returns ATM_CAUSE_GOOD.

atm_cmm_ep_dropped

RELATED INFORMATION

atm_cmm_add, atm_cmm_drop

NAME

`atm_cmm_error` – Reports errors to the CMM

SYNOPSIS

```
void atm_cmm_error(
          atm_drv_handle_t driver,
          int error,
          atm_vc_t *vc);
```

ARGUMENTS

driver Specifies the interface on which the error has occurred. This is the handle assigned to the driver when the driver registers with the CMM.

error Specifies a numeric value that indicates one of the following error types:

Error	Meaning
ATM_DE_DOWN	The driver detected a fatal medium error. In response, the CMM initiates the destruction of all VCs belonging to the failed interface. Further, the CMM considers the interface unavailable and rejects any requests for new connections on the interface. The driver must inform the CMM when the media is functional again. The *vc* argument is ignored for this notification.
ATM_DE_UP	The driver detected that the medium is up and ready to transfer data. When the CMM receives this indication, it allows the processing of connection requests. The *vc* argument is ignored for this notification.

Error	Meaning
ATM_DE_STARTQ	A driver output queue whose flow was controlled is now able to accept additional data for transmission. The *vc* argument is the number of the queue that is being enabled (0<= vc < atm_drv_params.nqueue).
ATM_DE_VC_FATAL	A local, fatal error has occurred to the interface that causes one or more VCs to become inoperative. An example of this type of error might be an adapter memory error that destroys any information about the VC on the adapter. This indication reports errors from which the driver is unable to recover. The *vc* argument is a pointer to the failed VC.

vc Specifies a pointer to the VC on which the error occurred. If the error is not associated with a VC, this is NULL.

DESCRIPTION

The atm_cmm_error routine is a device driver interface. When an ATM device driver detects errors on VCs or other interface failures, the module calls this routine to report the error to the CMM.

When the CMM receives the error report, it recovers or shuts down the VC with the errors. The driver does not need to perform any other actions. If the VC must be destroyed, the CMM calls the driver through the driver management interface to deactivate or destroy the VC. If the error indicates an interface failure, the CMM tears down VCs on the interface.

RETURN VALUES

None

RELATED INFORMATION

Chapter 9 for information on flow control in the ATM subsystem

NAME

atm_cmm_findaddr – Requests endpoint and VC information from the CMM

SYNOPSIS

```
atm_addr_p atm_cmm_findaddr(
          long call_reference,
          long endpoint,
          atm_ppa_p ppa);
```

ARGUMENTS

call_reference	Specifies the unique call reference value assigned to the VC.
endpoint	Specifies the endpoint reference value for an endpoint in a point-to-multipoint connection. This argument is set to 0 for the root of point-to-multipoint connections and for point-to-point connections.
ppa	Specifies the interface associated with the endpoint to look up. Since call reference values are usually unique only per interface, you must specify this argument to differentiate between VCs with the same reference value but belonging to different interfaces.

DESCRIPTION

The atm_cmm_findaddr routine is a signaling module interface that signaling modules use to request endpoint and VC information from the CMM. The CMM maintains all state information about each VC and calls (endpoints) associated with the VC.

Signaling modules can call this routine at any time to resolve a reference to a connection endpoint. Once the reference is resolved, the signaling module can access and modify structures as necessary as long as you follow locking conventions. For example, if the signaling module needs to process a STATUS ENQUIRY request, all the information necessary to format the STATUS reply is in the atm_addr structure. This routine returns a

reference to the structure, enabling the signaling module to extract the data needed to format the reply.

RETURN VALUES

Upon successful completion, the `atm_cmm_findaddr` call returns a pointer to the `atm_addr` structure for the specified endpoint. Signaling modules can use this information to find the `atm_vc` structure, if necessary. If the specified endpoint is not found, the CMM returns NULL.

RELATED INFORMATION

`atm_cmm_add`

NAME

`atm_cmm_find_driver` – Determines whether a driver is registered with the CMM

SYNOPSIS

```
atm_drv_handle_t atm_cmm_find_driver(
          char *name);
```

ARGUMENTS

name Specifies a NULL-terminated character string that identifies the driver.

DESCRIPTION

The `atm_cmm_find_driver` routine is a convergence and signaling module interface that enables the module to determine whether a specified driver is registered with the CMM.

If a convergence or signaling module provides MMI services, the module can use this routine to determine whether the driver over which it is requested to operate actually exists.

RETURN VALUES

Upon successful completion, the `atm_cmm_find_driver` call returns the handle (`atm_drv_handle_p`) that identifies the driver to the CMM. If the driver is not registered, the call returns NULL.

RELATED INFORMATION

`atm_cmm_register_dd`

atm_cmm_free_addr

NAME

atm_cmm_free_addr – Frees memory allocated to atm_addr structures

SYNOPSIS

```
void atm_cmm_free_addr(
         atm_addr_p addr);
```

ARGUMENTS

addr Specifies a pointer to the atm_addr structure to free. This is the same pointer passed into the atm_alloc_addr routine.

DESCRIPTION

The atm_cmm_free_addr routine is a convergence module interface that convergence modules use to free memory that they have allocated.

Usually, the CMM frees all ATM address structures associated with a VC when the VC is destroyed. However, under some error conditions (such as when a convergence module is allocating a series of structures and one allocation fails), it may be necessary for the allocating module to free memory it has allocated. In these cases, modules can call the atm_cmm_free_addr routine with the value returned from atm_cmm_alloc_addr to free memory.

RETURN VALUES

None

RELATED INFORMATION

atm_cmm_alloc_addr

NAME

atm_cmm_free_ie – Frees memory allocated to IE structures

SYNOPSIS

```
void atm_cmm_free_ie(
         atm_uni_call_ie_p u);
```

ARGUMENTS

u Specifies a pointer to the atm_call_ie structure to free. This is the same pointer returned from the atm_cmm_alloc_ie routine as a result of a successful storage allocation.

DESCRIPTION

The atm_cmm_free_ie routine is a convergence module interface that convergence modules use to free IE structure memory that they have allocated.

EXAMPLE

See Section B.1 for a code example of the atm_cmm_free_ie routine.

RETURN VALUES

None

RELATED INFORMATION

atm_cmm_alloc_ie

atm_cmm_free_services

NAME

atm_cmm_free_services – Frees memory allocated to atm_vc_services structures and releases reserved resources

SYNOPSIS

```
atm_error_t atm_cmm_free_services (
         atm_vc_services_p s);
```

ARGUMENTS

s Specifies a pointer to the atm_vc_services structure to free. This is the same pointer passed into the atm_alloc_services routine.

DESCRIPTION

The atm_cmm_free_services routine is a convergence module interface that convergence modules use to free memory that they have allocated. Typically, the CMM frees the atm_vc_services structure associated with a VC when the VC is destroyed. However, under some error conditions (such as when a convergence module is allocating a series of structures and one allocation fails), the allocating module might need to free memory it has allocated. In these cases, modules call the atm_cmm_free_services routine with the value returned from atm_cmm_alloc_services to free memory.

A convergence module can also use the atm_cmm_free_services call to free a resource reservation or to terminate a resource reservation request. (See Section 6.1 for more information.) The atm_cmm_free_services call frees the atm_vc_services_t memory and releases its reserved resources, if any.

RETURN VALUES

If the CMM is able to free the memory and any reserved resources, the atm_cmm_free_services call returns ATM_CAUSE_GOOD. If the services structure is associated with a resource that is in the process of being released, the call returns ATM_CAUSE_BUSY. If the convergence module inadvertently attempts to free an atm_vc_services_t that is attached to an active connection, ATM_CAUSE_BUSY is also returned.

RELATED INFORMATION

`atm_cmm_alloc_services`, `atm_cmm_reserve_resources`, `xxx_except`

Section 5.2.1 for information on convergence module exception handling

Section 6.1 for information on making outgoing connections and resource reservations

atm_cmm_grain2cr

NAME

atm_cmm_grain2cr – Converts an allocation granularity to a cell rate

SYNOPSIS

```
unsigned long atm_cmm_grain2cr(
         atm_ppa_p ppa,
         unsigned long nm,
         atm_direction_t direction);
```

ARGUMENTS

ppa	Specifies a pointer to the PPA for which the conversion is to be performed. This can be any valid PPA configured in the system.
hm	Specifies the granularity units to be converted.
direction	Specifies the direction of the cell rate. A driver might have different allocation granularities for the forward and backward directions.

DESCRIPTION

The atm_cmm_grain2cr routine is a convergence module interface that converts allocation granularity units to a cell rate. Some ATM drivers do not support setting a virtual circuit's (VC) cell rate in increments of 1 cell per second. You can also use the atmconfig command to set a driver's allocation granularity. Therefore, this routine enables a convergence module to determine the nearest actual cell rate that can be achived on the VC, allowing for the allocation granularity.

The atm_cmm_grain2cr routine converts number of allocation granularity units, for the given adapter and direction, to a cell rate (in cells per second).

RETURN VALUES

Returns the number of cells per second. Returns zero if the driver associated with the PPA does not support traffic shaping (for example, CBR and VBR).

RELATED INFORMATION

atm_cmm_cr2grain, atm_cmm_ppa_info

NAME

`atm_cmm_new_call` – Notifies CMM of a connection request

SYNOPSIS

```
atm_error_t atm_cmm_new_call(
          atm_sig_handle_t sm,
          atm_addr_t *addr,
          atm_uni_call_ie_p ie,
          atm_vc_services services,
          atm_ppa_p ppap,
          int selector,
          unsigned int vpi,
          unsigned int vci,
          long call_reference);
```

ARGUMENTS

sm	Specifies the signaling protocol module handle that was returned by the registration function.
addr	Specifies a pointer to an `atm_addr` structure that contains all the information about the incoming call. The signaling module writes the information into the structure.
ie	Specifies a pointer to an array of optional information elements received from the calling party. The signaling module converts data from the call setup message and fills in an array of information element structures.
services	Specifies a pointer to a properly set `atm_vc_services` structure. This indicates the type of service the calling party is requesting. The signaling protocol module must extract the required information from its signaling protocol messages. All members of this structure must be set. If a signaling protocol does not provide means by which some of the needed values can be specified, the signaling protocol module must supply some reasonable defaults. The CMM and driver

require this information to determine if there are sufficient local resources to handle the services the caller is requesting. The CMM modifies values in this structure to indicate that the value should be negotiated with the calling party. (This usually means that the signaling module simply returns the modified values in the reply to the calling party.)

ppap — Specifies the PPA on which the incoming call arrived.

selector — Specifies the selector value taken from the called party address information sent by the caller. This indicates the service on the PPA that is being called.

vpi — Specifies the VPI value for the new VC that the network has created for this call.

vci — Specifies the VCI value for the new VC that the network has created for this call.

call_reference — Specifies a unique value that the signaling module has assigned to this call. This is the value used to reference this call during the call's entire lifetime on the system. This value is opaque to the CMM and can have special meaning to the signaling protocol module.

DESCRIPTION

The `atm_cmm_new_call` routine is a signaling module interface that a signaling module calls when it receives a new call. This notifies the CMM of the new call. The CMM determines whether the call should be accepted. This CMM routine is nonblocking and returns with an indication about the disposition of the call.

RETURN VALUES

The CMM evaluates the call parameters and determines if the call should be accepted. If the call is accepted, the `atm_cmm_new_call` routine returns `ATM_CAUSE_GOOD`. If the CMM and convergence module cannot immediately

decide on the disposition of the call, ATM_CAUSE_DEFER is returned; the signaling module's exception routine is called when the disposition of the call is determined.

If the call is rejected, this routine returns an ATM error number indicating the reason. The convergence module may supply additional information in the cause fields in the atm_addr structure. If the call is rejected (a value other than ATM_CAUSE_GOOD or ATM_CAUSE_DEFER is returned), the signaling module must deallocate the storage for the atm_addr structure, the information elements, and the atm_vc_services structure.

RELATED INFORMATION

xxx_except

Section 6.2 for information on receiving connections

atm_cmm_new_esi

NAME

atm_cmm_new_esi – Registers an ATM address with the network

SYNOPSIS

```
atm_esi_handle_t atm_cmm_new_esi(
          atm_cvg_handle_t cvg_handle,
          unsigned char *esi,
          int esilen,
          atm_drv_handle_t driver,
          void *arg);
```

ARGUMENTS

cvg_handle	Specifies the convergence module handle returned to the convergence module when it registered with the CMM.
esi	Specifies a pointer to an array of the 6 bytes of ESI to be registered with the network.
esilen	Specifies the size (in bytes) of the ESI being added. This must be less than ATM_MAX_ESI. For UNI signaling, this is always 6.
driver	Specifies the driver handle of the interface on which the address is to be registered. This value is obtained from the PVC PPA for the driver on which the ESI is being registered.
arg	Specifies a value that the convergence module creating the ESI uses to identify any PPAs created from the ESI. The CMM does not modify the value of this argument.

DESCRIPTION

The atm_cmm_new_esi routine is a convergence module interface that registers an ATM address with the network. The module supplies the ESI (or other signaling protocol equivalent) portion of the address and a driver

reference to the CMM. The CMM then performs all the necessary functions needed to register the address with the network and to activate it.

When a convergence module supplies a new ESI, the signaling modules apply the ESI in a signaling protocol-specific way. Depending on the signaling protocol, the addition of a single ESI to the system could create many PPAs.

The calling convergence module is notified of the new PPA(s) when the registration is complete. Note that the addition of a new ESI does not cause the immediate creation of a new PPA in cases where there is no signaling protocol that accepts the ESI, or if the link to the switch is down. In these cases, new PPAs are created when new signaling modules are registered and accept the ESIs, or when links to the switch become functional.

Once a convergence module creates an address, only the creating convergence module, the CMM (through the system `atmconfig` program), or the network can delete the addresses; other convergence modules cannot delete the address. The creating convergence module must issue the `atm_cmm_ppa_bind` call once it receives notification that the PPA(s) have been configured. If the convergence module unregisters, all its created addresses are destroyed.

If an ESI is deleted, the calling convergence module receives an `ATM_CME_ESI_DEL` exception notification.

RETURN VALUES

If the registration process is proceeding, the `atm_cmm_new_esi` routine returns a handle for the new ESI; otherwise, it returns a NULL. If the requested ESI is already registered, the routine also returns NULL.

RELATED INFORMATION

`atm_cmm_del_esi`, `atm_cmm_ppa_bind`

NAME

atm_cmm_new_ppa – Notifies the CMM that a new PPA exists

SYNOPSIS

```
atm_ppa_p atm_cmm_new_ppa(
          atm_sig_handle_t sm,
          unsigned char *addr,
          unsigned int addrlen,
          unsigned char ton,
          unsigned char anpi,
          atm_drv_handle_t driver,
          atm_esi_p esi,
          void *ppas_id,
          atm_uni_type_t uni,
          void *sig_info);
```

ARGUMENTS

sm Specifies the signaling module handle that the registration function call returned.

addr Specifies a pointer to a series of bytes in memory that is the fully formed new address. The CMM copies this information and the signaling module can free these bytes on return if they are not needed for internal use.

addrlen Specifies the exact number of bytes in the address. This must be less than ATM_PPA_MAX_ADDR. For UNI signaling, the value of this argument is always 20.

ton Specifies the endpoint's address type. These bits are the same as the type of number field in the Called Party Number IE (right justified).

anpi Specifies the address or numbering plan identification information for the address. These bits are the same as those in the corresponding field of the Called Party Number IE.

driver Specifies the device driver handle for the interface on which the new address has been created. This value is taken from the PVC PPA over which the signaling module has created the new address.

esi Specifies which ESI was used in the creation of this address. This is the atm_esi structure pointer that gets passed in to the signaling module on the ATM_SIGE_NEWESI exception.

ppas_id Specifies an internal value that the signaling module can use to keep track of the PPA. The CMM does not use or modify the value of this argument, which gets placed in the atm_ppa structure for use by the signaling module.

uni Identifies the type of UNI (public or private) associated with the PPA.

sig_info Identifies a piece of data that the signaling module needs to associate with the PPA. For UNI signaling, set this value to the UNI version that is in use on the PPA. The version is specified as an atm_uni_vers_t constant.

DESCRIPTION

The atm_cmm_new_ppa routine is a signaling module interface. When a signaling module creates a new address (new PPA), the module calls this routine. This notifies the CMM that the new PPA exists. A convergence module can use the PPA to make and receive calls.

For example, when a UNI 3.0/3.1 signaling module is informed of a new address prefix, through the Interim Local Management Interface (ILMI), that has been created on the switch, the module combines the new prefix with existing end system identifiers (ESIs) to form a new set of addresses for the new prefix. Then, the signaling module tells the CMM about each of these new addresses.

RETURN VALUES

Upon successful completion, the atm_cmm_new_ppa routine returns a valid PPA pointer for the new PPA; otherwise, it returns NULL.

RELATED INFORMATION

atm_cmm_del_ppa, atm_cmm_ppa_bind, atm_cmm_ppa_info

atm_cmm_new_thread

NAME

atm_cmm_new_thread – Creates a kernel thread for use by an ATM module

SYNOPSIS

```
thread_t atm_cmm_new_thread(
         task_t task,
         void(*)(void * arg) *first,
         void *arg,
         int pri,
         int maxpri);
```

ARGUMENTS

task Specifies a pointer to a task structure used to uniquely identify the thread. The contents of this structure are filled in by this routine and should never be modified. This argument must reference a structure that will be valid for the life of the thread (generally a global structure).

first Specifies the address of the routine that serves as the thread's entry point. This is the first routine called in the new thread's context. Returning from this routine terminates the thread. This routine is passed a single argument whose use is entirely thread specific.

arg Specifies the argument that is passed as the only argument to the thread's entry point. The use and interpretation of this argument is entirely up to the module creating and using the thread.

pri Specifies the priority at which the thread runs when its entry point is called. This is also the priority at which the thread always runs unless you change the priority by using one of the kernel thread management functions.

maxpri Specifies the maximum priority at which the thread is allowed to run. You cannot set the thread priority higher than this value. Note that thread priorities range from 1 (the highest) to 63 (the lowest). Set the thread priority as follows:

maxpri <= *newpri* <= 63

DESCRIPTION

The atm_cmm_new_thread routine is a signaling, convergence, and device driver module interface. When an ATM module creates a new thread for use by any ATM module, the module calls this routine. This routine combines many of the operating system's thread primitives to provide an easier interface for ATM modules.

RETURN VALUES

Upon successful completion, the atm_cmm_new_thread routine returns a pointer to a thread structure that is used to reference the thread in all subsequent calls to kernel thread routines. If a thread could not be created, it returns NULL.

RELATED INFORMATION

Section 2.7.4 for a description of ATM thread creation

atm_cmm_next_cause

NAME

atm_cmm_next_cause – Retrieves logged VC or endpoint cause information

SYNOPSIS

```
atm_cause_info_p atm_cmm_next_cause(
          atm_vc_p vp,
          atm_addr_p addr,
          atm_cause_info_p cip);
```

ARGUMENTS

vp Specifies a pointer to the VC from which to retrieve cause information. If you want information for only one endpoint, set the value to NULL and set the *addr* value to non-NULL.

addr Specifies a pointer to the atm_addr structure for the endpoint from which to retrieve cause information. If the error applies to all endpoints on the VC (global), set the value to NULL and set the *vp* value to non-NULL.

cip Specifies the atm_cause_info_p value returned by the previous call to atm_cmm_next_cause. To retrieve the first cause entry for a VC or endpoint, set the value to NULL.

DESCRIPTION

The atm_cmm_next_cause routine is a convergence and signaling module interface that retrieves error or normal condition information logged by previous calls to atm_cmm_set_cause, atm_cmm_adi_set_cause, or atm_cmm_smi_set_cause.

To retrieve the first logged cause for a VC or endpoint, set the value of the *cip* parameter to NULL. To retrieve subsequent causes, set the value of the *cip* parameter to the value returned from the previous call to atm_cmm_next_cause.

RETURN VALUES

Upon successful completion, the atm_cmm_next_cause routine returns a pointer to the next atm_cmm_next_cause structure for the specified VC or endpoint. If both the VC (*vp*) and endpoint (*addr*) arguments are NULL,

or if there are no more causes for the specified VC or endpoint, the routine returns NULL.

RELATED INFORMATION

`atm_cmm_adi_set_cause`, `atm_cmm_set_cause`, `atm_cmm_smi_set_cause`

Section 2.9.7 for information on cause information

atm_cmm_oam_receive

NAME

atm_cmm_oam_receive – Passes OAM cells to the CMM

SYNOPSIS

```
void atm_cmm_oam_receive(
         atm_drv_handle_t driver,
         struct mbuf *mbp,
         atm_vc_t *vc);
```

ARGUMENTS

driver Specifies the interface on which the operations and maintenance (OAM) cell was received. This is the driver handle that the CMM assigned at driver registration time.

mbp Specifies a pointer to a single mbuf that contains the complete OAM cell (including the cell header). You can pass only one OAM cell to the CMM in a single call.

vc Specifies a pointer to the VC to which the OAM cell belongs. The CMM creates PVCs for VCs 3 and 4 for the receipt of F4 OAM flows.

DESCRIPTION

The atm_cmm_oam_receive routine is a device driver interface. When an ATM device driver receives data packets and cells from the ATM network, the driver calls this routine to pass the data to the CMM. Device drivers should pass all OAM cells to the CMM.

RETURN VALUES

None

RELATED INFORMATION

atm_cmm_receive

Section 2.4.3 for information on how data are carried

NAME

atm_cmm_ppa_bind – Binds a convergence module to a PPA

SYNOPSIS

```
atm_bind_handle_t atm_cmm_ppa_bind(
         atm_ppa_p ppa,
         atm_cvg_handle_t cvg_handle,
         int selector,
         void *const bind_handle,
         atm_error_t (*const xxx_connect)(void bind_handle,
                  atm_addr_p addr,
                  atm_bind_handle_t myaddr,
                  atm_vc_p vc,
                  atm_uni_call_ie_p *reply,
                  atm_vc_services_p requested,
                  atm_vc_services_p *avail));
```

ARGUMENTS

ppa
: Specifies a pointer to the atm_ppa structure of the PPA to which the convergence module is binding. This is the same pointer passed into the convergence module when it is notified of the existence of the new PPA.

cvg_handle
: Specifies the convergence module handle returned to the convergence module when it registered with the CMM. This argument must be valid for the bind to proceed.

selector
: Specifies the selector byte that the convergence module will use as its bind point. This value must not already be bound to an AESA. If this value is ATM_CMM_BIND_PICK, the CMM assigns the selector value. If the caller specifies the selector value to use, it must be in the range of 0 to 255 (for binding to SVC PPAs) and the high-order bit must be clear (for binding to PVC PPAs).

bind_handle
: Specifies a value that the CMM will pass back to the convergence module when it informs the convergence module of a new call. The convergence module can

use this value to identify any internal references to the bound PPA. This value has no meaning to the CMM and is not modified by the CMM.

xxx_connect — Specifies a pointer to a routine that the CMM is to call when a new connection is being processed. If a convergence module should not receive a connection through a bind point, the value of this argument must be NULL.

DESCRIPTION

The atm_cmm_ppa_bind routine is a convergence module interface that binds a convergence module to a PPA. A convergence module must call this routine if it wants to make outgoing calls or to receive incoming calls being made to one of the configured local ATM addresses. The routine informs the CMM that the convergence module will function as a network service user for a specific address and selector value.

Convergence modules are notified when a PPA is configured on the system (when an address is registered with a switch and is made known to the ATM network). Convergence modules can then bind to the PPA to create a network service user endpoint, which uniquely identifies the convergence module on the network. Once bound, there is a unique AESA associated with the bound convergence module. The AESA and the bind point identify the service on the network and local system. Convergence modules will be informed only of incoming calls on PPAs to which they have bound and can place calls only through a bind point. The CMM handles calls only to AESAs. If the AESA specified by the called party address of an incoming call does not exist, the CMM rejects the call.

By binding to a PPA, a convergence module is creating an AESA and uniquely identifying its service on the network. Once this is done, incoming calls can be routed to the convergence module, and the convergence module can make outgoing calls. All call activity is directed at a bind point, and thus, a specific convergence module.

When binding to a PPA, a convergence module can either specify a specific selector value it wants to use in creating the AESA address, or it may allow the CMM to assign it a selector value. In both cases, the selector value must specify a unique endpoint on the PPA.

Note that a convergence module can bind to up to 256 times to a PPA (as long as all its selector values are unique), and may bind to as many PPAs as is necessary to provide its service.

RETURN VALUES

Upon successful completion, the `atm_cmm_ppa_bind` routine returns a value that the convergence module uses to reference the bind point; otherwise, it returns a NULL. Typically, bind failure occurs for the following reasons: insufficient memory, the PPA is no longer valid, the selector value specified is in use, or there are no free selectors available.

RELATED INFORMATION

`atm_cmm_bind_info`, `atm_cmm_del_ppa`, `atm_cmm_new_ppa`, `atm_cmm_ppa_info`, `atm_cmm_ppa_unbind`, `xxx_connect`

Section 2.5 for information on PPAs and AESAs

atm_cmm_ppa_info

NAME

atm_cmm_ppa_info – Queries parameters from a PPA

SYNOPSIS

```
unsigned long atm_cmm_ppa_info(
        atm_ppa_p ppa,
        atm_bind_info_t it);
```

ARGUMENTS

ppa Specifies a pointer to the PPA for which information is to be retrieved. This can be any valid PPA currently configured on the system.

it Specifies the type of information that is being queried. The value returned depends on the object type of the queried information. You may use the following values to query the indicated information:

Value	Meaning
ATM_PPA_ALLOCGRANE	Returns a type of atm_bw_granularity_p, which reflects the underlying interface's units of bandwidth allocation or its allocation granularity.
ATM_PPA_ALLOCLIMIT	Returns a type of atm_bw_granularity_p, which reflects the underlying interface's per-VC bit rate limits, expressed in allocation granularity units.
ATM_PPA_AVAILRES	Returns a type of atm_services_granes_p, which reflects the amount of bandwidth (in granularity units) currently available for new CBR circuits over the underlying interface.
ATM_PPA_BRESVLIM	Returns the user-configurable limit, expressed as a percentage of backward bandwidth, on CBR circuits.
ATM_PPA_ESI	Returns the ESI that the signaling module supplied when the PPA was created.
ATM_PPA_ESIID	Returns the unique ESI identifier associated with the PPA's ESI.
ATM_PPA_ESILEN	Returns the length of the ESI that the signaling module supplied when the PPA was created.
ATM_PPA_ESIPID	Returns the ESI identifier of the PPA's parent ESI.

Value	Meaning
ATM_PPA_FRESVLIM	Returns the user-configurable limit, expressed as a percentage of forward bandwidth, on CBR circuits.
ATM_PPA_INFO_BURST_AVAIL	Returns the available burst cell rate (in cells-per-second). This is the amount of burst cell rate that is available for a convergence module to reserve.
ATM_PPA_INFO_BURST_MAX	Returns the maximum burst cell rate (in cells-per-second) that the interface supports.
ATM_PPA_INFO_CAPABILITIES	Returns the driver's capabilities for that interface.
ATM_PPA_INFO_DID	Returns a unique global value that can be used to reference the driver for the underlying interface.
ATM_PPA_INFO_DNAME	Returns a pointer to a character string that is the name of the driver for the underlying interface.
ATM_PPA_INFO_DUNIT	Returns the unit number of the driver for the underlying interface.
ATM_PPA_INFO_FC	Returns a nonzero value if hardware flow control is currently enabled on the interface.
ATM_PPA_INFO_HARD_MTU	Returns the largest PDU (in bytes) that the interface supports. This is valid only for interfaces that support AAL5 or AAL3/4 SAR functions in hardware.
ATM_PPA_INFO_HI_VCI	Returns the highest value that may be used for a VCI on the interface.
ATM_PPA_INFO_HI_VPI	Returns the highest value that may be used for a VPI on the interface.
ATM_PPA_INFO_ID	Returns a unique global value for referencing the PPA. Each PPA is assigned a unique ID when it is created. An application program can use this value when specifying a bind point (`atmconfig` uses these values to reference bind points). The returned value is 32-bits wide.
ATM_PPA_INFO_MAX_VCI	Returns the maximum number of VCIs that the interface supports.
ATM_PPA_INFO_MAX_VPI	Returns the maximum number of VPIs that the interface supports.
ATM_PPA_INFO_MEDIA	Returns a value that indicates the type of physical media to which the interface is connected. The return value is of the type `atm_media_type_t`.
ATM_PPA_INFO_PEAK_AVAIL	Returns the available peak cell rate (in cells-per-second). This is the amount of the interface's peak cell rate that is available to a convergence module.

atm_cmm_ppa_info

Value	Meaning
ATM_PPA_INFO_PEAK_MAX	Returns the maximum peak cell rate (in cells-per-second) that the interface supports.
ATM_PPA_INFO_QUEUES	Returns the number of scheduling queues that the driver has made visible to the CMM.
ATM_PPA_INFO_SNAME	Returns a pointer to a character string that contains the name of the signaling module that controls all SVCs created on the PPA. If the PPA is a PVC PPA, the returned value is NULL.
ATM_PPA_INFO_SUST_AVAIL	Returns the available sustainable cell rate (in cells-per-second). This is the amount of sustainable cell rate that is available for a convergence module to reserve.
ATM_PPA_INFO_SUST_MAX	Returns the maximum sustainable cell rate (in cells-per-second) that the interface supports.
ATM_PPA_INFO_TOTAL_VC	Returns the maximum number of VCs that can be opened on the interface at any given time.
ATM_PPA_INFO_TYPE	Returns a value that indicates the underlying interface type. The returned value is of the type atm_interface_t.
ATM_PPA_INFO_UNI	Returns the UNI type associated with the PPA, which the signaling module supplied at the time the PPA was created. The return value is of the type atm_uni_type_t.
ATM_PPA_INFO_VC_LEFT	Returns the number of unopened VCs on the interface at the time of the call. This is the total number of VCs (the value returned by ATM_PPA_INFO_TOTAL_VC) minus the number of VCs currently opened.
ATM_PPA_MAX_VC_BBW	Returns the user-configurable maximum per-VC backward (incoming) bit rate (in allocation granularity units) permitted over the underlying interface.
ATM_PPA_MAX_VC_FBW	Returns the user-configurable maximum per-VC forward (outgoing) bit rate (in allocation granularity units) permitted over the underlying interface for CBR and pacing circuits.
ATM_PPA_MAXRES	Returns a type of atm_services_granes_p, which reflects the maximum bandwidths available for CBR circuits over the underlying interface. These bandwidths (expressed in granularity units) are a function of the interface limits and the user-configurable limits on the percentage of bandwidth available to CBR circuits.
ATM_PPA_NUM_VCI	Returns the current number of VCIs configured on the underlying interface.

Value	Meaning
ATM_PPA_NUM_VPI	Returns the current number of VPIs configured on the underlying interface.
ATM_PPA_PEAK_CELLRATE	Returns the peak PDU bit rate (in cells-per-second) for the underlying interface.
ATM_PPA_UNUSEDRES_BACK	Returns the amount of backward (incoming) bandwidth (in cells-per-second) currently reserved for, but not yet applied to, CBR circuits.
ATM_PPA_UNUSEDRES_FWD	Returns the amount of forward (outgoing) bandwidth (in cells-per-second) currently reserved for, but not yet applied to, CBR circuits.

DESCRIPTION

The atm_cmm_ppa_info routine is a convergence module interface that queries the CMM for current information about an interface's physical capabilities (such as its bit rates) and the amount of specific resources left available on an interface (the remaining nonreserved sustainable bit rate). The CMM and device drivers keep track of this information.

Since convergence modules normally deal with either PPAs or AESA bindings, the CMM allows convergence modules to query the information from the underlying interface by specifying the PPA directly. Thus, the convergence module requires no specific knowledge of any device driver or device driver-related structures.

RETURN VALUES

None

RELATED INFORMATION

atm_cmm_bind_info, atm_cmm_del_ppa, atm_cmm_new_ppa, atm_cmm_ppa_bind, atm_cmm_ppa_unbind

Section 3.5.1.15 for a description of the capabilities member of the atm_drv_params structure

atm_cmm_ppa_unbind

NAME

atm_cmm_ppa_unbind – Unbinds convergence module service from a PPA

SYNOPSIS

```
atm_error_t atm_cmm_ppa_unbind(
         atm_bind_handle_t bind_handle);
```

ARGUMENTS

bind_handle	Specifies the binding to be removed. This is the handle that the atm_cmm_ppa_bind routine returns to the convergence module.

DESCRIPTION

The atm_cmm_ppa_unbind routine is a convergence module interface that unbinds a convergence module's service from a PPA. A convergence module uses this routine when it does not want to accept an incoming connection or to make outgoing calls, for example, a module awaiting a call from a specific caller. Typically, convergence modules should unbind a PPA if their service is no longer available, and must unbind before unregistering with the CMM.

Removing a binding releases all VCs associated with the bind point.

RETURN VALUES

Upon successful completion, the atm_cmm_ppa_unbind routine returns ATM_CAUSE_GOOD; otherwise, it returns an ATM error number.

RELATED INFORMATION

atm_cmm_bind_info, atm_cmm_del_ppa, atm_cmm_new_ppa, atm_cmm_ppa_bind, atm_cmm_ppa_info

NAME

atm_cmm_receive – Presents received data to the CMM

SYNOPSIS

```
void atm_cmm_receive(
        atm_drv_handle_t driver,
        const struct mbuf *const mbp,
        const int length,
        const struct mbuf *const trailer,
        atm_vc_t *vc,
        char pti,
        char gfc);
```

ARGUMENTS

driver Specifies the interface on which the data arrived. This is the driver handle that is given to the driver when it registers with the CMM.

mbp Specifies a pointer to a chain of mbufs that contain the data received.

length Specifies the total number of bytes received. For cooked data, this is the number of cells received multiplied by 48. For raw cells, this is the total number of data bytes in the mbuf chain, including the ATM cell headers but not including any time-stamps.

trailer Specifies a pointer to the last mbuf in the mbuf chain. This enables the CMM to quickly locate the cooked packet trailer in the incoming packet without having to traverse the mbuf chain (the driver already knows the address of this mbuf because it must fill in the mbuf length after the data is copied by the adapter using DMA). For raw data, this pointer simply references the last mbuf in the chain.

vc Specifies a pointer to the atm_vc structure of the VC on which the data was received.

pti Specifies the PTI field of the incoming cells. This is driver dependent since it is up to the hardware how it keeps track of the PTI fields of all the cells in a packet. The driver indicates its ability to keep track of these bits to the CMM in the `atm_drv_params` structure during the driver registration process. This field is valid only for cooked connections since complete cells are passed up when raw cells are received.

gfc Specifies flow-control information the driver passes up to the CMM. The use of this field is not currently defined. This argument is provided for future use when GFC bits are standardized.

DESCRIPTION

The `atm_cmm_receive` routine is a device driver interface. When an ATM device driver receives data packets and cells from the ATM network, the driver calls this routine to pass the data to the CMM.

When the CMM receives the data, it immediately passes the data to the convergence module that owns the VC. The CMM does not queue the data. That way, the convergence modules receive the data at their input functions in the interrupt context; the driver should do all receive processing in interrupt context for efficiency.

After passing data to the CMM, the driver must not reference any mbufs in the mbuf chain again. If the driver must allocate private storage for data (rather than allocating from the system mbuf pool), the driver must provide an appropriate free routine and set the `m_ext` structure in the mbuf appropriately. The data mbuf chain is deallocated only when the protocol stack has finished referencing the data.

Device drivers use this call to pass up only data packets and cells. Device drivers must use the `atm_cmm_oam_receive` routine to pass operations and maintenance (OAM) cells (nondata cells) to the CMM.

RETURN VALUES

None

RELATED INFORMATION

xxx_xmit

Section 2.4.3 for information on the mbuf chain

Section 3.2 for information on receiving cells

atm_cmm_register_cvg

NAME

atm_cmm_register_cvg – Registers a convergence module with the CMM

SYNOPSIS

```
void * atm_cmm_register_cvg(
          long version,
          char *const name,
          void *cvg_handle,
          atm_cvg_params_t *params,
          atm_cvg_handle_t *return_handle,
          void *reserved);
```

ARGUMENTS

version
: Specifies the version of the include files that were used when the convergence module driver was compiled. The value of this argument must match ATM_REVISION in the /usr/include/io/atm/sys/atm.h file when the convergence module was compiled. This tells the CMM which version of the global data structures the convergence module is using.

name
: Specifies a unique character string by which the convergence module is known to the system. Management programs use this string to display the name of the convergence module. This string must be unique; if the convergence module registers itself multiple times, it must use a different name for each registration.

cvg_handle
: Specifies a value that the convergence module can use to identify a specific registration to the CMM. This value is passed back to the convergence module for exception and management processing. The CMM does not modify this value, which is always passed back unchanged.

params
: Specifies a pointer to a atm_cvg_params structure that defines the entry points and capabilities of the convergence module. To allow for future expansion

of the structure, the convergence module should call the `bzero` command to insert nulls into the entire structure before filling in the fields. For the registration call, this pointer can reference private memory because the CMM copies the information into its local memory before returning.

return_handle — Specifies a pointer to a `atm_cvg_handle_t` variable that CMM fills in with a unique value to identify this instance of the convergence module. The convergence module must use this value on all subsequent calls to the CMM. This value is set before the CMM calls any of the convergence module's entry points, which can happen before the `atm_cmm_register_cvg` call returns.

reserved — This parameter is reserved for future use, and must be specified as NULL.

DESCRIPTION

The `atm_cmm_register_cvg` routine is a convergence module routine that registers a convergence module with the CMM. A protocol convergence module must register with the CMM before it can interact with the ATM subsystem. The CMM passes interface configuration information (for example, currently configured PPAs) to the convergence module, using the module's exception routine, before the registration call returns.

Once a convergence module is registered, the CMM knows where to deliver connection notifications and various exception notifications (for example, changes in system configuration). Convergence modules can register at any time.

RETURN VALUES

Upon successful registration, the `atm_cmm_register_cvg` routine returns a non-NULL value; otherwise, it returns NULL.

RELATED INFORMATION

`atm_cmm_unregister_cvg`, `xxx_except`, `xxx_mmi`, `xxx_receive`

atm_cmm_register_cvg

Section 5.22.3 for the `atm_cvg_params` structure definition

Chapter 7 for information on the MMI

NAME

atm_cmm_register_dd – Registers a device driver with the CMM

SYNOPSIS

```
atm_drv_handle_p atm_cmm_register_dd(
          long version,
          atm_drv_params_p params,
          atm_error_t (*const xxx_xmit)(int unit,
                    struct mbuf *data,
                    long length,
                    atm_vc_p vc,
                    unsigned char clp,
                    unsigned char gfc),
          atm_error_t (*const xxx_manage)(int unit,
                    unsigned int command,
                    void *arg),
          int (*const xxx_mmi)(int handle,
                    unsigned int command,
                    void *arg,
                    int *retval,
                    struct ucred *cred));
```

ARGUMENTS

version

Specifies the version of the include files that are used when the device driver is compiled. The value of this argument must match ATM_REVISION in the /usr/include/io/atm/sys/atm.h file when the device driver is compiled. This tells the CMM which version of the global data structures the driver is using.

params

Specifies a pointer to an atm_drv_params structure, which defines the basic capabilities of the interface. This structure must be completely initialized. To allow for future expansion of the structure, the convergence module should call the bzero command to insert nulls into the entire structure before filling in the fields. For the registration call, this pointer can reference private memory because the CMM copies the information into its local memory before returning.

xxx_xmit	Specifies the address of the routine for the CMM to call when it has data to transmit on the interface.
xxx_manage	Specifies the address of a routine that the CMM calls to perform various driver management functions. The management function definitions are in the `atm_adi.h` file in the `/usr/include/io/atm/sys` directory.
xxx_mmi	Specifies a pointer to a routine that the CMM calls to pass MMI commands from an application program. This routine is optional; you provide it only if the driver implements any MMI services.

DESCRIPTION

The `atm_cmm_register_dd` routine is a device driver interface that registers the device driver with the CMM. This is done during driver initialization, when a device driver's attach routine is called. The `atm_cmm_register_dd` routine is called before returning from the attach.

RETURN VALUES

Upon successful completion, `atm_cmm_register_dd` returns `atm_drv_handle_t`. The driver uses this handle in all subsequent calls to the CMM; otherwise, it returns NULL.

RELATED INFORMATION

`atm_cmm_unregister_dd`, `xxx_manage`, `xxx_mmi`, `xxx_xmit`

Section 2.4.3 for information on the mbuf chain

Chapter 3 for more information on the device driver interface and the `atm_queue_param` structure

Chapter 7 for more information on the MMI

NAME

`atm_cmm_register_sig` – Registers the signaling module with the CMM

SYNOPSIS

```
void * atm_cmm_register_sig(
          long version,
          char *const id,
          void *sig_handle,
          atm_sig_params_t *params,
          atm_sig_handle_t *return_handle,
          void * reserved1,
          void * reserved2,
          void * reserved3,
          void * reserved4,
          void * reserved5,
          void * reserved6,
          void * reserved7);
```

ARGUMENTS

version

Specifies the version of the include files that were used when the signaling module was compiled. The value of this argument must match `ATM_REVISION` in the `/usr/include/io/atm/sys/atm.h` file when the signaling module was compiled. This tells the CMM which version of the global data structures the signaling module is using.

id

Specifies a unique character string by which the protocol is known to the system. This string is used both by management programs to display the name of the switching module and by protocol convergence modules needing to use a specific protocol. For example, the UNI 3.0 switching protocol could use an ID of UNI 3.0 to identify itself. Each ID must be unique. The CMM performs signaling module lookup with case-insensitive searches, so the IDs cannot use case to differentiate themselves. Management programs display the ID strings as supplied by the signaling modules. Signaling modules that implement more than one protocol (or more than one version of the same protocol) must use multiple registration calls to register each protocol.

atm_cmm_register_sig

sig_handle	Specifies a value that the signaling module can use to identify a specific registration to the CMM. This value is passed back to the signaling module for exception and management processing. The CMM does not modify this value, which is always passed back unchanged.
params	Specifies a pointer to a `atm_sig_params` structure that defines the entry points and capabilities of the signaling module. To allow for future expansion of the structure, the convergence module should call the `bzero` command to insert nulls into the entire structure before filling in the fields. For the registration call, this pointer can reference private memory because the CMM copies the information into its local memory before returning.
return_handle	Specifies a pointer to a `atm_sig_handle_t` variable that CMM fills in with a unique value to identify this instance of the signaling module. The signaling module must use this value on all subsequent calls to the CMM. This value is set before the CMM calls any of the signaling module's entry points, which can happen before the `atm_cmm_register_sig` call returns.
reserved1	This parameter is reserved for future use, and must be specified as NULL.
reserved2	This parameter is reserved for future use, and must be specified as NULL.
reserved3	This parameter is reserved for future use, and must be specified as NULL.
reserved4	This parameter is reserved for future use, and must be specified as NULL.

reserved5	This parameter is reserved for future use, and must be specified as NULL.
reserved6	This parameter is reserved for future use, and must be specified as NULL.
reserved7	This parameter is reserved for future use, and must be specified as NULL.

DESCRIPTION

The atm_cmm_register_sig routine is a signaling module interface that registers a signaling module with the CMM. Registration must occur when the signaling module is initialized. Once registered, the CMM can use the signaling module and make it available to convergence modules.

Signaling modules should register as both signaling and convergence modules. When registering as a convergence module, a signaling module must set up its signaling VCs to send and receive signaling messages. The CMM does not provide special facilities for signaling VCs, but treats them like any other VC.

RETURN VALUES

Upon successful registration, the atm_cmm_register_sig routine returns a non-NULL value; otherwise, it returns NULL.

RELATED INFORMATION

xxx_add, xxx_drop, xxx_enquery, xxx_except, xxx_mmi, xxx_release, xxx_restart, xxx_setup

Section 4.16 for the atm_sig_params structure definition

Section 6.6 for a description of signaling VC initialization

Chapter 7 for a discussion of the MMI

atm_cmm_reject

NAME

atm_cmm_reject – Rejects an incoming call and notifies the CMM

SYNOPSIS

```
void atm_cmm_reject(
         atm_addr_p addr);
```

ARGUMENTS

addr Specifies a pointer to the atm_addr structure for the call being rejected. This is the same pointer passed into the convergence module's xxx_connect routine when the call first came in.

DESCRIPTION

The atm_cmm_reject routine is a convergence module interface that rejects a previously deferred incoming call and notifies the CMM. The incoming call was deferred when a convergence module returned ATM_CAUSE_DEFER from its xxx_connect routine.

When this call returns, the convergence module must destroy all references to the rejected call.

RETURN VALUES

None

RELATED INFORMATION

atm_cmm_accept, atm_cmm_new_call

NAME

atm_cmm_release – Requests that a VC be disconnected

SYNOPSIS

```
atm_err_t atm_cmm_release(
          atm_cvg_handle_t cm,
          atm_vc_t *vc);
```

ARGUMENTS

cm Specifies the value that the registration routine returns to the convergence module. This uniquely identifies the convergence module making the request.

vc Specifies a pointer to the VC to be torn down. This can be a point-to-point or a point-to-multipoint VC. In the case of a point-to-multipoint VC, connections to all endpoints in the multipoint connection are torn down.

DESCRIPTION

The atm_cmm_release routine is a convergence module routine that requests the CMM to delete a virtual circuit. A convergence module uses this routine when it no longer requires a connection to a remote host. After the routine is called, release negotiation with the remote host is initiated, which will eventually lead to the connection being torn down and all resources released.

A convergence module can either request that a specific endpoint be dropped using atm_cmm_drop or that a VC be disconnected. These operations are equivalent on point-to-point connections; disconnecting only the endpoint results in the VC being torn down. If a convergence module requests that a point-to-multipoint VC be disconnected, the CMM first disconnects all endpoints associated with the VC. This task simplifies the task of disconnecting multipoint VCs and for disconnecting PVCs.

RETURN VALUES

For an SVC, if the connection teardown is proceeding, the atm_cmm_release routine returns ATM_CAUSE_GOOD; otherwise, it returns an ATM error

number. As each endpoint is torn down, the convergence module receives an ATM_CME_EP_DEAD exception notification for that endpoint. When the last endpoint associated with a VC has been disconnected, the VC is torn down.

For a PVC, if the PVC has been destroyed on the local system, the atm_cmm_release routine returns ATM_CAUSE_GOOD and the PVC can still exist on the network; otherwise, it returns an ATM error number. No notifications are provided on the PVC release.

RELATED INFORMATION

atm_cmm_con_release

NAME

`atm_cmm_reply` – Notifies the CMM that an outgoing connection has been acknowledged

SYNOPSIS

```
atm_err_t atm_cmm_reply(
          atm_sig_handle_t sm,
          atm_addr_t *addr,
          atm_uni_call_ie_p ies,
          unsigned int vpi,
          unsigned int vci,
          unsigned long call_reference);
```

ARGUMENTS

sm
Specifies the signaling module's handle assigned to it when it registered with the CMM.

addr
Specifies a pointer to an `atm_addr` structure that contains all the parameters of the call. This pointer must point to the same `atm_addr` structure that was passed in the `xxx_setup` and `xxx_add` routines since this pointer is the handle used to refer to the specific connection.

ies
Specifies a pointer to an array of UNI signaling information elements (or any memory array in the case of non-UNI signaling protocols). The signaling module stores the contents of the information elements sent in the connection reply received from the called party in the array. The information element array contains only those elements that do not translate to values in the `atm_vc_services` structure.

vpi
Specifies the VPI value for the connection. The network should assign this before the routine is called.

vci	Specifies the VCI value for the connection. The network should assign this before the routine is called.
call_reference	Specifies the call reference value that the signaling module will use when referring to this call. This is placed in the atm_vc structure for future use in referencing the call.

DESCRIPTION

The atm_cmm_reply routine is a signaling module interface. Signaling modules use this routine to notify the CMM when they receive notification from the switch that an outgoing connection has been completed. The CMM receives signaling information elements returned by the called party in the connection reply. You use this call to notify the CMM of both the completion of point-to-point connections and of the addition of endpoints in point-to-multipoint connections.

If you are adding endpoints to a point-to-multipoint connection, the addr pointer will point to the atm_addr structure of the added endpoint.

The call to atm_cmm_reply is always followed by a call to atm_cmm_activate_con, which notifies the CMM that the connection is ready to carry data.

RETURN VALUES

Since the atm_cmm_reply routine is notifying the CMM that a previously created connection has completed, it can fail only if the connection referenced is invalid. In this case, it returns ATM_CAUSE_EIR to indicate it has no previous entry for the connection; otherwise, it returns ATM_CAUSE_GOOD. If the CMM or a convergence module needs to destroy the connection at this point it must follow the normal teardown procedure. If ATM_CAUSE_EIR is returned, the signaling module is expected to tear down the connection.

RELATED INFORMATION

atm_cmm_activate_con

NAME

atm_cmm_reserve_resources – Reserves resources for CBR services

SYNOPSIS

```
atm_err_t atm_cmm_reserve_resources(
          atm_ppa_p ppa,
          atm_cvg_handle_t cm,
          atm_vc_services_p s);
```

ARGUMENTS

ppa Specifies the underlying driver or adapter bandwidth pool from which to allocate the resources. The underlying driver or adapter must support CBR. These resources can be applied only to point-to-point connections set up over bind points associated with the same PPA.

cm Specifies the value returned to the convergence module by the registration request routine. This uniquely identifies the convergence module reserving the resources.

s Specifies an atm_vc_services_p pointing to a properly set atm_vc_services structure that defines the CBR circuit parameters.

DESCRIPTION

The atm_cmm_reserve_resources routine is a convergence module interface. Convergence modules use this routine to reserve bandwidth resources and to notify the CMM before making a call or accepting a connection. The CMM passes the notification to the device driver and protocol convergence module.

RETURN VALUES

The atm_cmm_reserve_resources routine returns ATM_CAUSE_GOOD, if the CMM was able to allocate and reserve the necessary resources.

This routine returns ATM_CAUSE_DEFER if the CMM was not able to allocate and reserve the necessary resources. In this case, the convergence

module must wait for the ATM_CME_RESV_AVAIL notification exception before making a call or accepting a connection. Until the convergence module receives an ATM_CME_RESV_AVAIL notification exception, the atm_vc_services structure is considered to be a resource reservation request.

If the resource reservation fails, the atm_cmm_reserve_resources routine returns an ATM error number that indicates the reason for the resource reservation failure. If the failure is due to an incorrectly set atm_vc_services structure, the lerrstat structure member contains local error information.

RELATED INFORMATION

atm_cmm_free_services

NAME

atm_cmm_restart – Notifies the CMM that a RESTART request was received

SYNOPSIS

```
atm_err_t atm_cmm_restart(
          atm_sig_handle_t sm,
          unsigned int class,
          unsigned int vpi,
          unsigned int vci);
```

ARGUMENTS

sm Specifies the signaling module's handle returned by the CMM when the signaling module registers.

class Specifies the type of restart that is being performed. The caller can set the value of this argument to either ATM_RESTART_VP (to restart all VCs on a VP) or ATM_RESTART_VC (to restart a specific VC).

vpi Specifies the VC(s) to be restarted. If *class* is set to ATM_RESTART_VP, *vpi* specifies the VP on which all VCs are to be restarted; the *vci* argument is ignored. If *class* is set to ATM_RESTART_VC, the *vpi* and *vci* arguments specify which VC is to be restarted.

vci Specifies the VC(s) to be restarted. If *class* is set to ATM_RESTART_VC, the *vpi* and *vci* arguments specify which VC is to be restarted.

DESCRIPTION

The atm_cmm_restart routine is a signaling module interface. When a signaling module receives a RESTART request, the module calls this routine to pass all of the appropriate information to the CMM. The CMM then initiates a restart of the indicated VC(s) before returning to the signaling module.

RETURN VALUES

If the restart is successfully initiated, the atm_cmm_restart routine returns ATM_CAUSE_GOOD; otherwise, it returns an appropriate ATM error number.

RELATED INFORMATION

atm_cmm_new_call, atm_cmm_restart_ack

NAME

atm_cmm_restart_ack – Notifies the CMM that a restart has completed

SYNOPSIS

```
void atm_cmm_restart_ack(
         void *handle,
         unsigned int class,
         unsigned int vpi,
         unsigned int vci);
```

ARGUMENTS

handle Specifies the handle that the CMM uses to identify the restart. This value has significance only to the CMM. This is the value that the CMM passed to the restart function call.

class Specifies the type of restart that is being performed. The caller can set the value of this argument to either ATM_RESTART_VP (to restart all VCs on a VP) or ATM_RESTART_VC (to restart a specific VC).

vpi Specifies the VC(s) to be restarted. If *class* is set to ATM_RESTART_VP, *vpi* specifies the VP on which all VCs are to be restarted; the *vci* argument is ignored. If *class* is set to ATM_RESTART_VC, the *vpi* and *vci* arguments specify which VC is to be restarted.

vci Specifies the VC(s) to be restarted. If *class* is set to ATM_RESTART_VC, the *vpi* and *vci* arguments specify which VC is to be restarted.

DESCRIPTION

The atm_cmm_restart_ack routine is a signaling module interface that signaling modules call to notify the CMM when a restart has been completed. Once notified, the CMM returns the indicated VCs to the NULL state and frees their resources.

atm_cmm_restart_ack

RETURN VALUES

None

RELATED INFORMATION

atm_cmm_restart

NAME

atm_cmm_send – Transmits data on an established VC

SYNOPSIS

```
atm_err_t atm_cmm_send(
          atm_cvg_handle_t cm,
          atm_vc_t *vc,
          const struct mbuf *const data,
          const long length,
          unsigned char clp,
          unsigned char gfc);
```

ARGUMENTS

cm Specifies the value returned to the convergence module by the registration function call. This uniquely identifies the convergence module making the request.

vc Specifies a pointer to the atm_vc structure of the VC on which the data is to be sent.

data Specifies a pointer to a chain of mbufs that contain the data to be transmitted.

length Specifies the total length of the data to be sent. For raw ATM cell transmission, this value must be a multiple of the ATM cell size. For cooked transmission, this value indicates the size of the PDU to be encapsulated and sent.

clp Specifies the congestion loss priority bits to be used when transmitting cooked data. When transmitting raw data, the convergence module sets these bits in each ATM cell.

gfc Specifies the value of the generic flow-control bits to be used when transmitting the cooked data. When transmitting raw data, the convergence module sets these bits in each ATM cell.

atm_cmm_send

DESCRIPTION

The atm_cmm_send routine is a convergence module interface that transmits data on an established virtual circuit. The CMM then hands the data to the appropriate device driver. Although the CMM does not queue outgoing data, the device driver might. Therefore, the successful return from this routine does not imply that the data was actually transmitted. In fact, the data could be discarded in the driver or on the network. The convergence module is not notified if the data is dropped locally.

RETURN VALUES

If the data is successfully passed to the driver and the driver accepts the data, the atm_cmm_send routine returns ATM_CAUSE_GOOD. This does not indicate that the data arrived at the destination or that it has even left the system. If the driver does not accept the data, an ATM error number is returned, indicating the reason the data was not accepted.

ATM_CAUSE_QFULL indicates that the driver cannot accept the data because its queue is full or it is out of some other resource. The convergence module can then decide if the data should be discarded or queued to send later.

RELATED INFORMATION

xxx_xmit

Section 2.4.3 for more information on the mbuf chain

Chapter 9 for information on flow control in the ATM subsystem

NAME

atm_cmm_set_cause – Logs a network-visible VC or endpoint condition

SYNOPSIS

```
atm_err_t atm_cmm_set_cause(
          atm_cvg_handle_t cm,
          atm_vc_p vp,
          atm_addr_p addr,
          char *reason,
          atm_error_t cause,
          atm_location_t location,
          unsigned char diag_length,
          unsigned char *diag);
```

ARGUMENTS

cm	Specifies the value the registration request function call returned to the convergence module. This uniquely identifies the convergence module making the request.
vp	Specifies a pointer to the VC on which the condition occurred. If the error applies to one endpoint, set the value to NULL and set the *addr* value to non-NULL.
addr	Specifies a pointer to the atm_addr structure for the endpoint on which the error occurred. If the error applies to all endpoints on the VC (global), set the value to NULL and set the *vp* value to non-NULL.
reason	Specifies a NULL-terminated character string that contains descriptive text for the error.
cause	Specifies the atm_error_t value that describes the condition.
location	Specifies an atm_location_t value that identifies the location in the network where the error occurred.

diag_length	Specifies the length (in bytes) of the data in the *diag* argument.
diag	Specifies a string of bytes that contains diagnostic information about the error. This data might be passed to the network in the `diag` field of a Cause IE.

DESCRIPTION

The `atm_cmm_set_cause` routine is a convergence module interface that records an error or normal condition associated with a VC or endpoint. The condition is stored as an `atm_cause_info` structure together with the VC. Convergence and signaling modules can retrieve this information by using the `atm_cmm_next_cause` routine. Users can display this information by using the `atmconfig` utility.

Errors or events stored with the `atm_cmm_set_cause` routine are visible to the network and to the other end of the connection. When a signaling module releases a connection or drops an endpoint, the module extracts the most recent cause from a VC or endpoint and creates a Cause IE.

RETURN VALUES

If the cause is recorded successfully, the `atm_cmm_set_cause` routine returns `ATM_CAUSE_GOOD`. If the driver handle, *vp* argument, or *addr* argument is invalid, the routine returns `ATM_CAUSE_BARG`.

RELATED INFORMATION

`atm_cmm_adi_set_cause`, `atm_cmm_next_cause`, `atm_cmm_set_log`, `atm_cmm_smi_set_cause`

Section 2.9.7 for information on cause information

NAME

atm_cmm_set_log – Logs a VC or endpoint condition

SYNOPSIS

```
atm_err_t atm_cmm_set_log(
          atm_cvg_handle_t cm,
          atm_vc_p vp,
          atm_addr_p addr,
          char *reason,
          atm_error_t cause,
          atm_location_t location,
          unsigned char diag_length,
          unsigned char *diag);
```

ARGUMENTS

cm	Specifies the value the registration request function call returned to the convergence module. This uniquely identifies the convergence module making the request.
vp	Specifies a pointer to the VC on which the condition occurred. If the error applies to one endpoint, set the value to NULL and set the *addr* value to non-NULL.
addr	Specifies a pointer to the atm_addr structure for the endpoint on which the error occurred. If the error applies to all endpoints on the VC (global), set the value to NULL and set the *vp* value to non-NULL.
reason	Specifies a NULL-terminated character string that contains descriptive text for the error.
cause	Specifies the atm_error_t value that describes the condition.
location	Specifies an atm_location_t value that identifies the location in the network where the error occurred.

diag_length	Specifies the length (in bytes) of the data in the *diag* argument.
diag	Specifies a string of bytes that contains diagnostic information about the error. This data might be passed to the network in the diag field of a Cause IE.

DESCRIPTION

The atm_cmm_set_log routine is a convergence module interface that records an error or normal condition associated with a VC or endpoint. The condition is stored as an atm_cause_info structure together with the VC. Users can display this information by using the atmconfig utility.

Errors or events stored with the atm_cmm_set_log routine are logged on the local system only, and are not available when a signaling module generates a Cause IE. Logging provides information about VC or endpoint activity for a system or network administrator to view on the local system.

RETURN VALUES

If the cause is recorded successfully, the atm_cmm_set_log routine returns ATM_CAUSE_GOOD. If the handle, *vp* argument, or *addr* argument is invalid, the routine returns ATM_CAUSE_BARG.

RELATED INFORMATION

atm_cmm_adi_set_log, atm_cmm_next_cause, atm_cmm_set_cause, atm_cmm_smi_set_log

Section 2.9.7 for information on cause information

NAME

`atm_cmm_smi_set_cause` – Logs a network-visible VC or endpoint condition

SYNOPSIS

```
atm_err_t atm_cmm_smi_set_cause(
          atm_sig_handle_t sm,
          atm_vc_p vp,
          atm_addr_p addr,
          char *reason,
          atm_error_t cause,
          atm_location_t location,
          unsigned char diag_length,
          unsigned char *diag);
```

ARGUMENTS

sm	Specifies the signaling module handle that the registration function call returned.
vp	Specifies a pointer to the VC on which the condition occurred. If the error applies to one endpoint, set the value to NULL and set the *addr* value to non-NULL.
addr	Specifies a pointer to the `atm_addr` structure for the endpoint on which the error occurred. If the error applies to all endpoints on the VC (global), set the value to NULL and set the *vp* value to non-NULL.
reason	Specifies a NULL-terminated character string that contains descriptive text for the error.
cause	Specifies the `atm_error_t` value that describes the condition.
location	Specifies an `atm_location_t` value that identifies the location in the network where the error occurred.
diag_length	Specifies the length (in bytes) of the data in the *diag* argument.

diag	Specifies a string of bytes that contains diagnostic information about the error. This data might be passed to the network in the diag field of a Cause IE.

DESCRIPTION

The atm_cmm_smi_set_cause routine is a signaling module interface that records an error or normal condition associated with a VC or endpoint. The condition is stored as an atm_cause_info structure together with the VC. Convergence and signaling modules can retrieve this information by using the atm_cmm_next_cause routine. Users can display this information by using the atmconfig utility.

Errors or events stored with the atm_cmm_smi_set_cause routine are visible to the network and to the other end of the connection. When a signaling module releases a connection or drops an endpoint, the module extracts the most recent cause from a VC or endpoint and creates a Cause IE.

RETURN VALUES

If the cause is recorded successfully, the atm_cmm_smi_set_cause routine returns ATM_CAUSE_GOOD. If the driver handle, *vp* argument, or *addr* argument is invalid, the routine returns ATM_CAUSE_BARG.

RELATED INFORMATION

atm_cmm_adi_set_cause, atm_cmm_smi_set_log, atm_cmm_next_cause, atm_cmm_set_cause

Section 2.9.7 for information on cause information

NAME

atm_cmm_smi_set_log – Logs a VC or endpoint condition

SYNOPSIS

```
atm_err_t atm_cmm_smi_set_log(
          atm_sig_handle_t sm,
          atm_vc_p vp,
          atm_addr_p addr,
          char *reason,
          atm_error_t cause,
          atm_location_t location,
          unsigned char diag_length,
          unsigned char *diag);
```

ARGUMENTS

sm	Specifies the signaling module handle that the registration function call returned.
vp	Specifies a pointer to the VC on which the condition occurred. If the error applies to one endpoint, set the value to NULL and set the *addr* value to non-NULL.
addr	Specifies a pointer to the atm_addr structure for the endpoint on which the error occurred. If the error applies to all endpoints on the VC (global), set the value to NULL and set the *vp* value to non-NULL.
reason	Specifies a NULL-terminated character string that contains descriptive text for the error.
cause	Specifies the atm_error_t value that describes the condition.
location	Specifies an atm_location_t value that identifies the location in the network where the error occurred.
diag_length	Specifies the length (in bytes) of the data in the *diag* argument.

diag	Specifies a string of bytes that contains diagnostic information about the error. This data might be passed to the network in the diag field of a Cause IE.

DESCRIPTION

The atm_cmm_smi_set_log routine is a signaling module interface that records an error or normal condition associated with a VC or endpoint. The condition is stored as an atm_cause_info structure together with the VC. Users can display this information by using the atmconfig utility.

Errors or events stored with the atm_cmm_smi_set_log routine are logged on the local system only, and are not available when a signaling module generates a Cause IE. Logging provides information about VC or endpoint activity for a system or network administrator to view on the local system.

RETURN VALUES

If the cause is recorded successfully, the atm_cmm_smi_set_log routine returns ATM_CAUSE_GOOD. If the handle, *vp* argument, or *addr* argument is invalid, the routine returns ATM_CAUSE_BARG.

RELATED INFORMATION

atm_cmm_adi_set_log, atm_cmm_next_cause, atm_cmm_set_log, atm_cmm_smi_set_cause

Section 2.9.7 for information on cause information

NAME

atm_cmm_status_done – Notifies the CMM that a status enquiry has completed

SYNOPSIS

```
void atm_cmm_status_done(
         atm_addr_p addr);
```

ARGUMENTS

addr Specifies a pointer to the atm_addr structure, indicating the endpoint from which the enquiry response was received. This should correspond to the endpoint provided to the signaling module's enquiry function call.

DESCRIPTION

The atm_cmm_status_done routine is a signaling module interface that signaling modules call to notify the CMM when a status enquiry has completed. Once notified, the CMM either examines the enquiry data itself or passes it to the convergence module that requested the enquiry.

RETURN VALUES

None

RELATED INFORMATION

atm_cmm_enquery

atm_cmm_unregister_cvg

NAME

atm_cmm_unregister_cvg – Unregisters a convergence module from the CMM

SYNOPSIS

```
atm_error_t atm_cmm_unregister_cvg(
         atm_cvg_handle_t cm);
```

ARGUMENTS

cm Specifies a value that identifies the convergence module. The atm_cmm_register_cvg call returns this value.

DESCRIPTION

The atm_cmm_unregister_cvg routine is a convergence module interface that unregisters a convergence module with the CMM. A convergence module unregisters with the CMM if it no longer needs to receive or make connections. This might be necessary in environments when protocol stacks are dynamically configured and unconfigured from the system.

Before unregistering, a convergence module must close all existing connections, delete any ESIs it created, and unbind from all PPAs. If all connections are not closed or if PPA bindings still exist, the CMM unregisters only the convergence module's connection routine. The CMM will continue to call the convergence module with incoming data and exception notifications. Once the convergence module is unregistered, the CMM does not call any of its routines.

RETURN VALUES

If the convergence module is completely unregistered and the CMM will make no more calls to its routines, the atm_cmm_unregister_cvg routine returns ATM_CAUSE_GOOD. If there are still connections associated with the convergence module, it returns ATM_CAUSE_BUSY. This means the module's xxx_connect routine is unregistered, but the CMM will continue to deliver data and exception notifications. Once the convergence module unregisters, the CMM will not accept any more connection requests from the module until it reregisters. The convergence module must repeat the unregister call until the routine returns ATM_CAUSE_GOOD. It might take up to several seconds for all connections to clear completely.

RELATED INFORMATION

atm_cmm_register_cvg

atm_cmm_unregister_dd

NAME

atm_cmm_unregister_dd – Unregisters a device driver module from the CMM

SYNOPSIS

```
atm_error_t atm_cmm_unregister_dd(
          atm_drv_handle_t drv_handle);
```

ARGUMENTS

drv_handle	Specifies a value that identifies the driver module. The atm_cmm_register_dd call returns this value.

DESCRIPTION

The atm_cmm_unregister_dd routine is a device driver module interface that unregisters a device driver module from the CMM. A device driver module unregisters with the CMM if it no longer needs to to be an active component of the ATM stack; for example, when dynamically loading and unloading a driver or performing hot swap of the hardware adapter.

Before unregistering, you must put the device driver into the DOWN state. The driver should also have no VC connections. Use the atmconfig down command to stop the driver. Call the atm_cmm_unregister_dd routine before returning from the driver's unattach routine.

RETURN VALUES

If the device driver is completely unregistered and the CMM will make no more calls to its routines, the atm_cmm_unregister_dd routine returns ATM_CAUSE_GOOD. If the driver state is still UP or if there are resources still assigned to the driver, the routine returns ATM_CAUSE_BUSY. The device driver must repeat the unregister call until the routine returns ATM_CAUSE_GOOD. It might take up to several seconds for all connection resources to clear completely.

RELATED INFORMATION

atm_cmm_register_dd

NAME

atm_cmm_vc_control – Modifies VC parameters

SYNOPSIS

```
atm_err_t atm_cmm_vc_control(
          atm_cvg_handle_t cm,
          atm_vc_t *vc,
          int operation,
          void *arg);
```

ARGUMENTS

cm — Specifies the value returned to the convergence module by the registration function call. This uniquely identifies the convergence module making the request.

vc — Specifies the VC to which the function call applies.

operation — Specifies the type of operation to be performed on the VC.

arg — Specifies further data for the operations. The type and use of this argument depend on the type of operation being performed. The following are valid operations:

Operation	Meaning
ATM_VCC_AGING	Changes the circuit-aging algorithm applied to the VC. For this operation, *arg* is a pointer to an unsigned int whose value is the new aging parameter (see Table 6–1 for a list of values).
ATM_VCC_QPARAM	Sets the queuing parameters for queuing raw cells in the driver. The argument to this operation is an atm_queue_param_p that points to a properly set atm_queue_param structure. This structure is referenced only within the context of the function call and may be a local variable in the calling function.

DESCRIPTION

The atm_cmm_vc_control routine is a convergence module interface that enables convergence modules to modify virtual circuit parameters, either to

make the transfer of data more efficient or to control the VC aging. The QoS and circuit bandwidth parameters cannot be modified.

RETURN VALUES

Upon successful completion, the `atm_cmm_vc_control` routine returns `ATM_CAUSE_GOOD`; otherwise, it returns an ATM error number.

RELATED INFORMATION

Section 3.5.2 for information on the `atm_queue_param` structure

Section 6.3 for information on connection aging

NAME

atm_cmm_vc_get – Requests status information from a VC

SYNOPSIS

```
atm_vc_p atm_cmm_vc_get(
         atm_drv_handle_t driver,
         unsigned int vpi,
         unsigned int vci);
```

ARGUMENTS

driver Specifies the device driver handle for the PPA to which the VC being queried is attached.

vpi Specifies the VPI values for the VC.

vci Specifies the VCI values for the VC.

DESCRIPTION

The atm_cmm_vc_get routine is a signaling module interface. When a signaling module needs to access status information about a VC that is currently in service, based on the VPI and VCI, the module calls this routine.

RETURN VALUES

If the VC is currently configured on the system, the atm_cmm_vc_get routine returns a pointer to that atm_vc structure; otherwise, it returns NULL.

RELATED INFORMATION

atm_cmm_status_done, atm_cmm_vc_stats

atm_cmm_vc_stats

NAME

atm_cmm_vc_stats – Retrieves current VC information from the CMM

SYNOPSIS

```
atm_error_t atm_cmm_vc_stats(
          atm_vc_p vc,
          atm_vc_stats_p stats);
```

ARGUMENTS

vc Specifies a pointer to the VC for which statistics are to be reported.

stats Specifies a pointer to an atm_vc_stats structure allocated by the caller into which the CMM can copy the statistics.

DESCRIPTION

The atm_cmm_vc_stats routine is a convergence module interface that retrieves VC statistics from the CMM. The CMM returns the information in the atm_vc_stats structure.

The CMM keeps track of VC usage on a per-VC basis. This is done as part of the CMM's VC management and cannot be disabled.

No entity can reset the VC counters. If a convergence module needs to collect statistics between two events, it must query the statistics at the first event and the second event and subtract the first event's statistics from the second event's statistics.

RETURN VALUES

Upon successful completion, the atm_cmm_vc_stats routine returns ATM_CAUSE_GOOD; otherwise, it returns an ATM error.

RELATED INFORMATION

atm_cmm_vc_control, atm_cmm_vc_get

NAME

xxx_add – Requests a signaling module to add an endpoint to a point-to-multipoint connection

SYNOPSIS

```
atm_error_t xxx_add(
          atm_addr_p addr);
```

ARGUMENTS

addr	Specifies a pointer to the atm_addr structure for the endpoint to be added.

DESCRIPTION

The xxx_add routine is a routine declared within a signaling module that the CMM calls when it needs to add an endpoint to a point-to-multipoint connection. The name of the routine (xxx_add) can be any valid C language function name. You pass the routine to the CMM by reference only.

The signaling module can obtain the information about the root's VC by following the addr->vc pointer. This routine is nonblocking. The CMM is notified when the connection has been added.

RETURN VALUES

The xxx_add routine must return ATM_CAUSE_GOOD if the signaling module is proceeding with the endpoint addition or an ATM error number if the call cannot proceed.

RELATED INFORMATION

atm_cmm_register_sig

NAME

xxx_connect – Notifies a convergence module of a connection request

SYNOPSIS

```
atm_error_t xxx_connect(
        void *bind_handle,
        atm_addr_p addr,
        atm_bind_handle_t myaddr,
        atm_vc_p vc,
        atm_uni_call_ie_p *reply,
        atm_vc_services_p requested,
        atm_vc_services_p *avail);
```

ARGUMENTS

bind_handle	Specifies the PPA binding being used. It is the value passed to the CMM when the convergence module requested a PPA bind on which the call is being processed.
addr	Specifies a pointer to the atm_addr structure, indicating the endpoint that is initiating the connection.
myaddr	Specifies the bind identifier for the bind point on which the call arrived. This is the value the CMM returns when the convergence module calls atm_cmm_ppa_bind.
vc	Specifies a pointer to the VC of the new connection.
reply	Specifies a pointer to an atm_uni_call_ie structure in which the convergence module writes the address of an information elements array to be used in composing the reply to the calling party. If no reply is necessary, the convergence module can ignore this argument.
requested	Specifies a pointer to an atm_vc_services structure that contains information to pass to the

convergence module about the network resources required to establish the new connection.

avail

Specifies a pointer to an atm_vc_services structure that contains information about the network resources available to be committed to the new connection.

If the *avail* argument is NULL, the convergence module cannot negotiate service structure parameters; it can only accept or reject the call. If the *avail* argument is not NULL, the convergence module must evaluate the structure's contents to obtain more information about the incoming call.

For non-CBR circuits, the *avail* argument is the same as the *requested* argument. The convergence module can change negotiable parameters by modifying the appropriate fields in the atm_vc_services structure referenced by *avail*. In UNI 3.1, no circuit parameters can be modified. Forward and backward MTU sizes may be negotiable through the atm_uni_call_ie structure. The convergence module can pace outbound traffic on the new UBR connection by setting *avail* to the address of an atm_vc_services structure that has the ATM_SERVICES_PACING flag set and the peak bit rates set to the rates you want.

For CBR circuits, the value of *avail* depends on whether or not the CMM was able to allocate the bandwidth resources necessary to establish a new CBR connection.

If *avail* is NULL, the CMM was not able to allocate bandwidth resources. The convergence module can use the information provided in the *requested* argument to determine the resources needed to establish the connection, and can apply reserved resources to the call. You do this by setting *avail* to the address of an atm_vc_services_t structure that has been backed by the appropriate resources. The supplied reserved resource bit rates need not

match the requested resource bit rates exactly. The forward (local system transmit) rate can be less than or equal to the requested rate (so as not to exceed the contract already established with the network). The backward (local system receive) rate can be greater than or equal to the requested rate (to ensure that the local system can receive at least as much as the sender contracted to send).

The convergence module can impose exact bit-rate matching, if necessary. The convergence module can change negotiable parameters by changing *avail*, as for non-CBR circuits. If the supplied reserved resource cannot be applied to the call, the convergence module receives an ATM_CME_EP_DEAD exception notification; the VC cause information indicates the reason for the failure.

For CBR circuits, if the *avail* argument is not NULL, the CMM was able to allocate the bandwidth resources necessary to establish a CBR connection. The convergence module can change negotiable parameters, as with non-CBR circuits. The convergence module also has the option of replacing the CMM-allocated resources with reserved resources held by the convergence module by setting *avail* to the address of the reserved resources services structure. Restrictions on bit-rate matching still apply.

DESCRIPTION

The xxx_connect routine is a function declared within a convergence module that the CMM calls to notify the convergence module of a connection request. The CMM calls the convergence module that is bound to the selector specified in the called party address.

The name of the routine (xxx_connect) can be any valid C language function name. The routine is passed to the CMM by reference only. Only one convergence module can accept a connection. The called convergence module then examines all the connection data (the information in the atm_addr structure as well as any IEs or other signaling information passed in) to determine if it is willing to accept the call.

If the convergence module accepts the call, the CMM and signaling module proceed with call setup. The VC is not active at this point. The connection and VC is owned by the accepting convergence module until the connection is destroyed; the VC's ownership cannot be changed. The convergence module VC is notified of all incoming data on the VC and exceptions on the VC. Also, the convergence module is the only module that can transmit data on the VC.

You use this routine for both point-to-point and point-to-multipoint connections.

Connections are not shared between convergence modules at the bind point. If convergence modules must share connections, one module must own the connection and coordinate access to the connection with another module. Alternatively, modules could be layered on top of a multiplexor that assumes ownership of the connection.

If the convergence module rejects the call, the CMM and signaling module release the VC and notify the calling party that the call was rejected. The CMM never accepts a call without the explicit consent of a convergence module.

NOTES

PVCs created by the `atmconfig` utility must have a convergence module specified since it is not possible for convergence modules to determine if they should accept a PVC call.

When the `atmconfig` utility creates a new PVC, the convergence module to which it belongs receives the connection notification. For PVCs, the *`myaddr`* argument points to the PVC PPA, the *`vc`* argument references the new `atm_vc` structure, and the `requested` argument references the new PVCs circuit parameters. The *`addr, reply`*, and *`avail`* arguments are NULL. Convergence modules cannot change or reject PVC circuit parameters; the system does not create the PVC unless it can provide the requested level of service as specified by the creator of the PVC.

When a convergence module accepts a connection, it can assume that the connection exists and that it will receive notifications if the connection is destroyed. It is free to use its private structure members in the `atm_vc` structure referenced in the `atm_addr` structure.

When a connection is accepted, it is not yet ready to carry data. The convergence module must not attempt to transmit data until it is notified

that the connection is active. However, it should be ready to receive data since data can arrive ahead of the activation notification.

EXAMPLE

See Section B.3 for a code example of the xxx_connect routine. In the example, new_connect is the name of the routine.

RETURN VALUES

If the convergence module accepts the connection, it should return ATM_CAUSE_GOOD. If the convergence module cannot immediately accept the connection (for example, if negotiation is needed with upper-level protocols or a user-level process), it must not block; it should return ATM_CAUSE_DEFER. Returning ATM_CAUSE_DEFER causes no immediate action to be taken on the connection since the ATM protocols allow some time for the called party to reply. When the convergence module makes a determination about the disposition of the call, it must communicate this to the CMM by using either the atm_cmm_accept or atm_cmm_reject calls. If the convergence module rejects the call, it must return an ATM error number other than ATM_CAUSE_GOOD or ATM_CAUSE_DEFER.

RELATED INFORMATION

atm_cmm_accept, atm_cmm_ppa_bind, atm_cmm_reject

NAME

xxx_drop – Requests a signaling module to drop an endpoint in a point-to-multipoint connection

SYNOPSIS

```
atm_error_t xxx_drop(
          atm_addr_p addr);
```

ARGUMENTS

addr	Specifies a pointer to the atm_addr structure for the endpoint to be dropped.

DESCRIPTION

The xxx_drop routine is a function declared within a signaling module that the CMM calls when it needs to drop an endpoint on a point-to-multipoint connection. The name of the routine (xxx_drop) can be any valid C language function name. The routine is passed to the CMM by reference only.

The signaling module can obtain the information about the root's VC by following the addr->vc pointer. This function call is nonblocking. The CMM is notified when the connection has been dropped.

RETURN VALUES

The xxx_drop routine must return ATM_CAUSE_GOOD if the signaling module is proceeding with the endpoint drop or an ATM error number if the call cannot proceed.

RELATED INFORMATION

atm_cmm_register_sig

xxx_endpt_receive

NAME

xxx_endpt_receive – Passes incoming data to a convergence module for each endpoint

SYNOPSIS

```
void xxx_endpt_receive(
          atm_vc_t *vc,
          struct mbuf *mbp,
          int length,
          struct mbuf *trailer,
          char pti,
          char gfc,
          atm_addr_p addr);
```

ARGUMENTS

vc Specifies a pointer to the atm_vc structure on which the data arrived. The module being called already owns the VC, so this is used as a handle for the module to identify on which (of many) VCs the data arrived. The convergence module may use its two private structure members in the atm_vc structure to place local information necessary for managing the connection.

mbp Specifies a pointer to a list of mbufs that contain the data received. A unique mbuf chain is provided for each endpoint. All chains might point a single physical copy of the data.

length Specifies a value that indicates the exact number of bytes received. For cooked packets, this is the size of the received packet or protocol data unit (PDU) plus the padding and AAL trailer. It is always a multiple of 48. For raw data, this value is a multiple of the number of cells received. It is a multiple of 53 bytes (time-stamp bytes are not included in the count).

trailer Specifies a pointer to the mbuf that contains the last byte of the received data. This permits the convergence module to easily and quickly locate the AAL trailer for obtaining the PDU length and other information (such as user-to-user indications). When receiving raw cells, this argument points to the mbuf that contains the last cell in the chain.

pti Specifies the accumulated PTI information of a received cooked packet. The availability of this information is dependent on the driver's ability to keep track of all the PTI fields in all the cells that compose a cooked packet. The convergence module can determine if this argument is valid by examining the `capabilities` structure member in the device driver's `atm_drv_params` structure. This argument has no meaning for raw data.

gfc Specifies the accumulated GFC information from the cells that make up a cooked packet. The availability of this information is dependent on the driver's ability to keep track of all the GFC fields in all the cells that compose a cooked packet. The convergence module can determine if this argument is valid by examining the `capabilities` structure member in the device driver's `atm_drv_params` structure. This argument has no meaning for raw data.

addr Specifies the endpoint on the specified VC for which this data is being delivered. The convergence module might use its two private structure members in the `atm_addr` structure to hold local information about the endpoint.

DESCRIPTION

The `xxx_endpt_receive` routine is a function declared within a convergence module that the CMM calls to pass data to a convergence module. The name of the routine (`xxx_endpt_receive`) can be any valid C language function name. You pass the routine to the CMM by reference only.

When designing receive routines, convergence module writers should remember that all data is delivered to the convergence module in an interrupt context with the processor running at the `splimp` level. The convergence module must implement a queuing policy appropriate for the convergence module's protocol. In general, convergence modules for protocols that can tolerate unspecified latency should queue the incoming data and return immediately to the CMM. Convergence modules for protocols that require bounded latencies (such as video or voice protocols) might need to do some processing before queuing the data and returning to the CMM. In either case, the receive routine must not block.

RETURN VALUES

None

RELATED INFORMATION

`atm_cmm_register_cvg`, `atm_cmm_receive`

Section 2.4 for a description of ATM data formats

Chapter 3 and Chapter 5 for information on device drivers and convergence modules, respectively

NAME

xxx_enquery – Requests a signaling module to obtain status for an endpoint

SYNOPSIS

```
atm_error_t xxx_enquery(
          atm_addr_p addr);
```

ARGUMENTS

addr Specifies a pointer to the atm_addr structure for the endpoint to be queried.

DESCRIPTION

The xxx_enquery routine is a function declared within a signaling module that the CMM calls when it needs status for an endpoint. The name of the routine (xxx_enquery) can be any valid C language function name. You pass the routine to the CMM by reference only.

This routine is nonblocking. When the query response arrives, the signaling module uses a function call to notify the CMM.

RETURN VALUES

The xxx_enquery routine must return ATM_CAUSE_GOOD if the signaling module is proceeding with the enquiry or an ATM error number if the call cannot proceed.

RELATED INFORMATION

atm_cmm_register_sig

NAME

xxx_except – Reports exceptions, errors, and system configuration changes to convergence and signaling modules

SYNOPSIS

```
int xxx_except(
          void *handle,
          unsigned int exception,
          void *arg);
```

ARGUMENTS

handle — Specifies an identifier that the module passed to the CMM when the module registered. For convergence and signaling modules, this is the internal handle the module registers with the CMM. This value is meaningful only to the called module.

exception — Specifies a value that identifies the type of exception that occurred. The following table contains a list of valid values:

Exception	Meaning
ATM_CME_BIND_DEL	Informs the convergence module that one of its bindings is being destroyed. The usual reason for this is that a PPA is being destroyed either because its address is no longer registered with the network or because the interface to the network has gone down. The argument to this exception is the value returned from the atm_cmm_ppa_bind call (atm_bind_handle_t); the convergence module uses this value to reference the bind point. The return value from this call is ignored.
ATM_CME_CALL_FAILED	Indicates that a call to an endpoint has failed. The argument is an atm_addr_p that specifies the endpoint to which the CMM was trying to connect. The cause information in the atm_addr structure is set to indicate the reason for the call failure, which can be the failure of both a point-to-point call and the failure of adding a leaf to a point-to-multipoint call. The convergence module must destroy all references to the endpoint when processing this notification. The convergence module receives one additional notification to destroy all its references to the endpoint's VC if this was the only endpoint associated with a VC.

Exception	Meaning
ATM_CME_DELPVC	Informs the convergence module that a PVC has been deleted from the system. Convergence modules receive one of these exceptions for each PVC that is deleted, even PVCs that they delete. The argument for this command is an atm_vc_p to the PVC being deleted. When this notification is received, convergence modules must destroy all references to the PVC and must not send any more data on it.
ATM_CME_DVR_DOWN	Informs the convergence module that a driver is down, and any unused reserved resource or outstanding reservation request is revoked. The convergence module should remove knowledge of the reserved resource or outstanding reservation request services structure indicated by the atm_vc_services_p argument. The convergence module should not free the atm_vc_services structure; the CMM does this upon return from the exception notification. If the convergence module attempts to free the structure, ATM_CAUSE_BUSY is returned.
ATM_CME_ENQUERY_DONE	Informs the convergence module that a requested connection state enquiry function on an endpoint has completed. The argument is an atm_addr_p for the endpoint that was queried. The state information in the atm_addr structure indicates if the enquiry succeeded and the current endpoint state.
ATM_CME_EP_ACTIVE	Informs the convergence module that an endpoint is now active and available for transferring data. This notification is usually the result of receiving a connection complete from the signaling module. When the convergence module requests a new connection or receives notification of a new connection, the connection is not yet ready to carry data. Only after the connection setup is complete (requiring several message exchanges between connection endpoints) will it be able to carry data. This command tells the convergence module that the connection is complete and ready to carry data. Use this notification for both point-to-point and point-to-multipoint notifications. The command argument is an atm_addr_p to the atm_addr structure of the endpoint that is now active.
ATM_CME_EP_DEAD	Informs the convergence module that the connection to an endpoint has been destroyed and that all resources allocated for the endpoint should be freed. This is the only notification the convergence module will receive. After receiving this notification, it is illegal for the convergence module to reference the endpoint. The command argument is an atm_addr_p to the atm_addr structure of the endpoint that is down. Use this notification for both point-to-point and point-to-multipoint connections. The convergence module receives exactly one of these notifications for each endpoint associated with a VC (that is, one notification for point-to-point VCs and one notification for each endpoint of a point-to-multipoint connection).

xxx_except

Exception	Meaning
ATM_CME_ESI_DEL	Informs the convergence module that an ESI it had created has been removed from the system. The CMM notifies the convergence module separately to destroy any PPAs created from the ESI. The argument is the value (*arg*) that the convergence module passed in to the atm_cmm_new_esi call. When this notification is received, convergence modules should destroy all references to the deleted ESI.
ATM_CME_PPA_ADD	Informs the convergence module that a new PPA has been configured and is available for connections. The argument is a pointer to the atm_ppa structure for the new PPA. If the convergence module needs to receive calls on this new PPA it must perform an atm_cmm_ppa_bind function call for the new PPA.
ATM_CME_PPA_DEL	Informs the convergence module that a PPA has been removed from the system. The CMM notifies the convergence module separately to destroy all VCs associated with the PPA. The argument for this command is a pointer to the atm_ppa structure for the PPA that is being deleted. When this notification is received, convergence modules should destroy all references to the deleted PPA.
ATM_CME_RESV_AVAIL	Informs the convergence module that an outstanding request for a reserved resource has been satisfied. The atm_vc_services structure indicated by the atm_vc_services_p argument is now a services structure that is backed by resources, or a reserved resource. The convergence module must apply this services structure to an outgoing or incoming call within the system-specified amount of time to avoid having the resources revoked by an ATM_CME_RESV_EXPIRE exception notification.
ATM_CME_RESV_EXPIRE	Informs the convergence module that a reserved resource has not been used in the system-specified amount of time and is revoked. The convergence module should remove knowledge of the reserved resource services structure indicated by the atm_vc_services_p argument. The convergence module should not free the atm_vc_services structure; the CMM does this upon return from the exception notification. If the convergence module attempts to free the structure, ATM_CAUSE_BUSY is returned.

Exception	Meaning
ATM_CME_RESVREQ_REL	Informs the convergence module that an outstanding request for a reserved resource has been canceled. This exception is generated by a change in configuration parameters that causes the contents of the atm_vc_services structure (which were valid at the time of the request) to no longer be valid. For example, this event could occur if the system administrator reduced the per-VC bandwidth limit to values below the rates specified in the reservation request. The convergence module should remove knowledge of the reservation request services structure indicated by the atm_vc_services_p argument. The convergence module should not free the services structure; the CMM does this upon return from the exception notification. If the convergence module attempts to free the structure, ATM_CAUSE_BUSY is returned.
ATM_CME_START_VC	Informs the convergence module that a VC on which flow was previously controlled may now resume transmission of data. The argument to this command is a pointer to the atm_vc structure of the VC that can resume data transmission.
ATM_CME_VC_OLD	Informs a convergence module that a VC has aged (been inactive for a long period of time) and that the CMM is about to delete it. In this situation, the convergence module is given the chance to stop the CMM from destroying the VC. When the VC is about to be destroyed because of inactivity, this notification is made to the convergence module. The argument is an atm_vc_p for the VC that has aged. The convergence module may return either ATM_AGER_OK to allow the CMM to delete the VC or ATM_AGER_RESET to restart the aging timer and not to delete the VC.
ATM_SIGE_ACCEPT	Specifies that an incoming call whose disposition was previously deferred has been accepted. The signaling modules should take appropriate action to accept the call and activate the connection. The argument to this exception is an atm_addr_p that references the call that is being accepted.
ATM_SIGE_DEL_ESI	Informs the signaling module of a user- or convergence module-initiated deletion of an ESI (or similar) part of an address. The signaling module then performs the deletion of every PPA associated with the ESI through protocol exchanges with the switch. As each PPA is deleted, the signaling module uses the atm_cmm_del_ppa function call to notify the CMM. The arguments and returns are the same as for the ATM_SIGE_NEW_ESI exception.

Exception	Meaning
ATM_SIGE_DEL_PPA	Informs the signaling module of a user-initiated deletion of a PPA. The signaling module then performs the deletion of the PPA through protocol exchanges with the switch. The argument for this exception is a pointer to the atm_ppa structure of the PPA being deleted. If the signaling module returns ATM_CAUSE_GOOD, the CMM considers the PPA deleted (even though the protocol exchange with the switch may not be complete). It then initiates the deletion of all VCs and bind points associated with the PPA.
ATM_SIGE_NEW_ESI	Informs the signaling module that a user- or convergence module-initiated creation of a new ESI (or similar address part) has been configured on the system. The argument for this exception is a pointer to an atm_esi structure for the new ESI. When a signaling module receives this exception, it should initiate creation of new PPAs based on the new ESI, notifying the CMM of each new PPA created. This exception should return ATM_CAUSE_GOOD if the new ESI is accepted by the signaling module. The signaling module does not need to create the new PPAs immediately (and probably cannot), so the CMM will not expect to have any new PPAs on return from this call. When a new driver is brought on line, the CMM notifies the signaling module of every ESI that the driver reports from its ROM. This enables the system to automatically configure addresses based on adapter ROM values (if any). Note that even though signaling modules have access to device driver's ROM ESI addresses from the driver's atm_drv_params structure, do not use those values. Use only an ESI set with this exception value in the creation of new PPAs.
ATM_SIGE_REJECT	Specifies that an incoming call whose disposition was previously deferred has been rejected. The signaling modules should take appropriate action to reject the call. The argument to this exception is an atm_addr_p that references the call that is being rejected.

arg Specifies an additional argument whose interpretation depends on the exception value.

DESCRIPTION

The xxx_except routine is a function declared within a convergence or signaling module that the CMM calls to report exceptions, errors, and system configuration changes on a VC.

The name of the routine (xxx_except) can be any valid C language function name. You pass the routine to the CMM by reference only.

Exception notifications have the following characteristics:

- Convergence and signaling modules can expect them at any time.
- They are delivered in an interrupt context.
- Exception processing must not block. If a convergence or signaling module needs to defer processing an exception notification, it must arrange for a kernel thread to be run at a later time and to return immediately to the CMM.

RETURN VALUES

If a command has no explicit return value specified, it always returns `ATM_CAUSE_GOOD`; otherwise, it returns one of the specified values.

RELATED INFORMATION

`atm_cmm_register_cvg`, `atm_cmm_register_sig`

Section 6.3 for information on connection aging

Chapter 9 for more information on flow control in the ATM subsystem

NAME

xxx_manage – Instructs a device driver to perform some driver management functions

SYNOPSIS

```
atm_error_t xxx_manage(
        int unit,
        unsigned int command,
        void *arg);
```

ARGUMENTS

unit Specifies the unit number to which the command applies.

command Specifies the type of management function to perform. The following management functions are defined:

Function	Definition
ATM_DRVMGMT_ADDVC	Instructs the driver to create a new VC. The *arg* argument is a pointer to the atm_vc structure for the new VC. This call cannot block. The driver allocates resources for the VC, but does not make the VC active. The driver uses the queue value to assign the VC to the indicated queue (the driver should make no queue assignments other than those indicated by the CMM). The value of the queue member is in the range of 0<= queue <= maxqueue, where maxqueue is the number of queues the driver told the CMM it supports. If the driver has insufficient resources to meet the QoS specified for the VC, it must return a value other than ATM_CAUSE_GOOD. Note that the VPI and VCI in the atm_vc_services structure are not necessarily valid at this time. They become valid when the VC is enabled. This call gives the driver a chance to allocate resources for a VC before the VC is set up on the network. The connection operation cannot proceed unless all the local resources needed for the new VC are allocated.
ATM_DRVMGMT_CLEARQ	Clears the QoS parameters from a driver queue. The CMM issues this command after the last VC has been detached from a queue to indicate to the driver that the queue no longer requires servicing.
ATM_DRVMGMT_DELVC	Instructs the driver to reclaim all resources associated with a VC and to destroy any references to the VC. This call cannot block. The *arg* argument is a pointer to the atm_vc structure for the VC to be deleted. The driver must free all local resources for the VC and set vc->drv_pp1 and vc->drvpp2 to 0 prior to returning.

Function	Definition
ATM_DRVMGMT_DOWN	Instructs the interface to shut down and to stop exchanging data with the switch. This call cannot block. This call need only start the driver shutdown procedure. When the shutdown is complete, the driver must notify the CMM by using the CMM driver error interface. The CMM takes care of VC deallocation; the driver can expect to be called to deallocate local resources for each open VC. Do not use the *arg* argument.
ATM_DRVMGMT_ENBVC	Instructs the driver to enable the VC for sending and receiving data. This call cannot block. The *arg* argument is a pointer to the atm_vc structure, which identifies the VPI and VCI values to be activated. This call is made only after a VC is set up on the network and becomes active and only after the ATM_DRVMGMT_ADDVC command, never before it.
ATM_DRVMGMT_FC	Enables the types of flow control that the driver uses. The following values are supported: ATM_FLOW_NONE (disables all flow control); ATM_FLOW_STD (enables ATM Forum standard flow control); and ATM_FLOW_VENDOR (enables vendor-specific flow control). ATM_FLOW_NONE is the default state for the driver. Flow control is enabled or disabled globally rather than on a per-VC basis.
ATM_DRVMGMT_MAXVCI	Specifies the maximum VCI value for any VC on the driver. The *arg* argument is the maximum VCI value (0<= VCI <= maxvci). This value must be less than the max_vci member of the atm_drv_params structure. The CMM uses this when it detects that the connect switch supports fewer VCIs than the driver.
ATM_DRVMGMT_MAXVPI	Specifies the maximum VPI value for any VC on the driver. The *arg* argument is the maximum VPI value (0<= VPI <= maxvpi). This value must be less than the max_vpi member of the atm_drv_params structure. The CMM uses this when it detects that the connect switch supports fewer VPIs than the driver.
ATM_DRVMGMT_QUERY	Queries the driver for its current available resources. This call cannot block. The *arg* argument is a pointer to an atm_drv_params structure in which to write the information. The driver does not write the num_id member or the ids array. The values written should be the maximum allowable values for each resource minus the resources currently in use. The CMM uses this call to synchronize its current driver state information with the driver's internal state. The driver's internal state is always assumed to be correct.
ATM_DRVMGMT_RAWPARAM	Controls queuing of raw cells (not used for cooked connections). This command sets parameters that the driver uses to queue incoming raw cells into one mbuf chain rather than passing each cell up to the CMM. This reduces the cell-processing overhead when receiving raw cells. The argument is a pointer to the atm_queue_param structure.

xxx_manage

Function	Definition
ATM_DRVMGMT_SETQ	Specifies QoS parameters of a driver's transmit queue. Only drivers that have informed the CMM that they implement multiple queues can expect this command. The CMM issues this command before any VCs are attached to a specific queue. The argument is a pointer to an atm_vc_services structure that holds the queue parameters. The CMM can issue this command at any time to change the parameters of a queue.
ATM_DRVMGMT_UP	Instructs the interface to initialize and come on line. This call cannot block. This call need only start a driver initialization function. When the initialization is complete and the driver is ready to create VCs, it must use the atm_cmm_error routine to notify the CMM.

arg Specifies any data needed to perform the function.

DESCRIPTION

The xxx_manage routine is a function declared within a device driver module that the CMM calls when it needs to perform some driver management task. The name of the routine (xxx_manage) can be any valid C language function name. You pass the routine to the CMM by reference only.

RETURN VALUES

If the xxx_manage routine is completed successfully, the driver returns ATM_CAUSE_GOOD; otherwise, the driver returns an ATM error number indicating the cause of the failure.

RELATED INFORMATION

atm_cmm_error, atm_cmm_register_dd

NAME

xxx_mmi – Connects a convergence, device driver, or signaling module to the MMI

SYNOPSIS

```
int xxx_mmi(
        void *handle,
        unsigned int command,
        void *arg,
        int *retval,
        struct ucred *cred);
```

ARGUMENTS

handle Specifies an identifier that the module passed to the CMM when the module registered. For device drivers, this is a unit number. For convergence and signaling modules, this is the internal handle that the module provides to the CMM. This value is meaningful only to the called module.

command Specifies what action the MMI routine is to perform. The format of the command is the same as that of ATM `ioctl` commands as defined in the `/usr/include/sys/atm.h` file. Commands for non-CMM ATM modules are defined using the IOW (I/O write) or equivalent macros. All commands have a type of "g" and a value of between 128 and 255 inclusive.

arg Specifies a command-specific argument that is interpreted by the management function based on the value of `cmd`. The format of the data referenced by this argument can be anything that is valid for `ioctl` calls.

retval Specifies a pointer to an integer into which the MMI routine writes a return value when returning `ESUCCESS` to the CMM. This argument is optional.

cred Specifies the credentials or access information passed by the system to the CMM in the `ioctl` call.

xxx_mmi

DESCRIPTION

The xxx_mmi routine is a function declared within a convergence, device driver, or signaling module that the CMM calls to pass management and configuration requests from applications through the CMM and the MMI interface.

The name of the routine (xxx_mmi) can be any valid C language function name. You pass the routine to the CMM by reference only.

The xxx_mmi routine is called from within a system call context with no external locks held. It has access to the per-process data structures and user address space of the calling process. If necessary, the xxx_mmi routine can block as long as it does not hold simple locks while blocking.

If a module does not require any external management or configuration capabilities, it does not have to register a management function with the CMM.

This interface follows the standard operating system ioctl call with the following exceptions:

- The device major and minor number argument is replaced by the *handle* argument.
- No user credential information is passed. Only users with root access can use the management interface.

RETURN VALUES

If the operation completes successfully, the xxx_mmi routine returns ESUCCESS; otherwise, it returns an error number as defined in sys/errno.h. In addition, for successful completions modules can use the *retval* pointer to pass the return value from the ioctl system call to the calling program.

RELATED INFORMATION

atm_cmm_register_cvg, atm_cmm_register_dd, atm_cmm_register_sig

Chapter 7 for information on MMI and ioctl calls

NAME

`xxx_receive` – Passes incoming data to a convergence module

SYNOPSIS

```
void xxx_receive(
          atm_vc_t *vc,
          struct mbuf *mbp,
          int length,
          struct mbuf *trailer,
          char pti,
          char gfc);
```

ARGUMENTS

vc Specifies a pointer to the `atm_vc` structure on which the data arrived. The module being called already owns the VC, so this is used as a handle for the module to identify on which (of many) VCs the data arrived. The convergence module may use its two private structure members in the `atm_vc` structure to place local information necessary for managing the connection.

mbp Specifies a pointer to a list of mbufs that contain the data received.

length Specifies a value that indicates the exact number of bytes received. For cooked packets, this is the size of the received packet or protocol data unit (PDU) plus the padding and AAL trailer. It is always a multiple of 48. For raw data, this value is a multiple of the number of cells received. It is a multiple of 53 bytes (time-stamp bytes are not included in the count).

trailer Specifies a pointer to the mbuf that contains the last byte of the received data. This permits the convergence module to easily and quickly locate the AAL trailer for obtaining the PDU length and other information (such as user-to-user indications). When receiving raw cells, this argument points to the mbuf that contains the last cell in the chain.

pti Specifies the accumulated PTI information of a received cooked packet. The availability of this information is dependent on

the driver's ability to keep track of all the PTI fields in all the cells that compose a cooked packet. The convergence module can determine if this argument is valid by examining the `capabilities` structure member in the device driver's `atm_drv_params` structure. This argument has no meaning for raw data.

gfc Specifies the accumulated GFC information from the cells that make up a cooked packet. The availability of this information is dependent on the driver's ability to keep track of all the GFC fields in all the cells that compose a cooked packet. The convergence module can determine if this argument is valid by examining the `capabilities` structure member in the device driver's `atm_drv_params` structure. This argument has no meaning for raw data.

DESCRIPTION

The `xxx_receive` routine is a function declared within a convergence module that the CMM calls to pass data to a convergence module. The name of the routine (`xxx_receive`) can be any valid C language function name. You pass the routine to the CMM by reference only.

When designing receive routines, convergence module writers should remember that all data is delivered to the convergence module in an interrupt context with the processor running at the `splimp` level. The convergence module must implement a queuing policy appropriate for the convergence module's protocol. In general, convergence modules for protocols that can tolerate unspecified latency should queue the incoming data and return immediately to the CMM. Convergence modules for protocols that require bounded latencies (such as video or voice protocols) might need to do some processing before queuing the data and returning to the CMM. In either case, the receive routine must not block.

RETURN VALUES

None

RELATED INFORMATION

`atm_cmm_register_cvg`, `xxx_endpt_receive`

Section 2.4 for a description of ATM data formats

Chapter 3 and Chapter 5 for information on device drivers and convergence modules, respectively

xxx_release

NAME

xxx_release – Requests a signaling module to tear down a connection

SYNOPSIS

```
atm_error_t xxx_release(
          atm_addr_p addr);
```

ARGUMENTS

addr Specifies the pointer to the atm_addr structure.

DESCRIPTION

The xxx_release routine is a function declared within a signaling module that the CMM calls when it needs a connection torn down (a hangup). The name of the routine (xxx_release) can be any valid C language function name. You pass the routine to the CMM by reference only.

When the CMM makes the call, the signaling protocol module should initiate a release of the connection to the specified endpoint. This routine is nonblocking, and is used only for releasing a point-to-point connection or the root of a point-to-multipoint connection (when all leaf connections have been released).

RETURN VALUES

The xxx_release routine must return ATM_CAUSE_GOOD if the circuit deletion is completed or an ATM error number if the circuit deletion fails.

RELATED INFORMATION

atm_cmm_register_sig

NAME

xxx_restart – Requests a signaling module to send a restart message

SYNOPSIS

```
atm_error_t xxx_restart(
         void *handle,
         unsigned int class,
         unsigned int vpi,
         unsigned int vci);
```

ARGUMENTS

handle Specifies a unique identifier that the CMM uses to identify the restart request. This has meaning only to the CMM and should not be modified by the signaling module.

class Specifies the type of restart that is being performed. Currently, only restarting of individual VCs or all VCs in a VP are supported. The caller sets the value of this argument to ATM_RESTART_VP to restart all VCs on a VP or ATM_RESTART_VC to restart a specific VC. These are the only two values permitted for this argument.

vpi Specifies which VC(s) are to be restarted. If class is set to ATM_RESTART_VP, vpi specifies the VP on which all VCs are to be restarted; the vci argument is ignored.

vci Specifies which VC(s) are to be restarted. If class is set to ATM_RESTART_VC, the vpi and vci arguments specify which VC is to be restarted.

DESCRIPTION

The xxx_restart routine is a function declared within a signaling module that the CMM calls to request a RESTART message be sent. The name of the routine (xxx_restart) can be any valid C language function name. You pass the routine to the CMM by reference only.

xxx_restart

RETURN VALUES

The xxx_restart routine must return ATM_CAUSE_GOOD if the signaling module is proceeding with the restart or an ATM error number if the call cannot proceed.

RELATED INFORMATION

atm_cmm_register_sig, atm_cmm_restart_ack

NAME

`xxx_setup` – Requests a signaling module to set up a new connection

SYNOPSIS

```
atm_error_t xxx_setup(
          atm_addr_p addr,
          unsigned long *refptr);
```

ARGUMENTS

addr Specifies the pointer to the `atm_addr` structure. The CMM will have initialized the `atm_addr` structure and will have set up the `atm_uni_call_ie` structure with parameters that the protocol convergence modules supplied.

refptr Specifies a unique call reference number for the call. If the signaling module creates a unique call reference number for the call, the module must assign this value.

DESCRIPTION

The `xxx_setup` routine is a function declared within a signaling module that the CMM calls to request the creation of a new connection (make a call). The name of the routine (`xxx_setup`) can be any valid C language function name. You pass the routine to the CMM by reference only.

When the CMM calls this routine, the signaling protocol module should initiate a call to the party specified in the `atm_addr` structure. This routine is nonblocking, and is used only to set up point-to-point connections or the first connection in a point-to-multipoint connection.

Note

The CMM uses the value returned in *refptr* to release a connection. The signaling module should set this up as soon as possible, and before a call to `atm_cmm_con_release`.

xxx_setup

RETURN VALUES

The xxx_setup routine returns ATM_CAUSE_GOOD if the setup is proceeding or an ATM error number if the call cannot proceed.

RELATED INFORMATION

atm_cmm_register_sig

NAME

`xxx_xmit` – Notifies a device driver that the CMM has data to transmit

SYNOPSIS

```
atm_error_t xxx_xmit(
        int unit,
        struct mbuf *data,
        long length,
        atm_vc_p vc,
        unsigned char clp,
        unsigned char gfc);
```

ARGUMENTS

unit Specifies the unit number on which to send the data.

data Specifies the data to be transmitted. This data is passed to the driver as a chain of mbufs. The driver determines the type of data being sent by examining `vc->vcs->aal`.

length Specifies to the driver the total number of bytes in the AAL5 PDU or the total number of bytes being sent. The use of this information depends on the driver implementation. The CMM uses this information to gather VC and interface usage statistics so the driver does not have to keep track of the total number of bytes transmitted.

vc Specifies the VC on which to send the data.

clp Specifies the CLP value for AAL5 PDUs. When sending raw cells, the convergence module must place this value in each cell header along with the *gfc* argument.

gfc Specifies the GFC bits for congestion control when sending AAL5 PDUs. When sending raw cells, the convergence module must place this value in each cell header along with the *clp* argument.

xxx_xmit

DESCRIPTION

The xxx_xmit routine is a function declared within a device driver module that the CMM calls when it has data to transmit on the interface. The name of the routine (xxx_xmit) can be any valid C language function name. You pass the routine to the CMM by reference only.

The xxx_xmit routine cannot block. The driver must either queue the data or, if the routine queue is full, return an error indication. If the data is queued, the driver must return ATM_CAUSE_GOOD.

If the data is not queued, the driver must return an ATM error number that indicates the reason the data was not queued (ATM_CAUSE_QFULL indicates a queue full condition). In addition, the driver must not discard the data. The CMM returns the error indication to the convergence module. It is up to the convergence module to implement a discard or retry policy.

RETURN VALUES

None

RELATED INFORMATION

atm_cmm_register_dd

B

Connection Programming Examples

This appendix contains programming code fragments for the following connection-related tasks:

- Making a call
- Adding more parties to a point-to-multipoint connection
- Processing an incoming call

B.1 Making a Call

Example B–1 shows one way to make a call for point-to-point connections and to make the first call for a point-to-multipoint connection.

Example B–1: Making a Call Code Fragment

```
make_call(unsigned char *called_party)
{
    register atm_uni_call_ie_p iep, ie;
    register union atm_cmi_addr ra;
    register atm_vc_services_p vcs;
    atm_error_t retval;
    int rv = ESUCCESS;
    extern atm_cvg_handle_t my_handle;
    extern atm_bind_handle_t my_bind;

    /* Get memory for setup IEs */
    iep = ie = atm_cmm_alloc_ie(3);
    if(ie == NULL)
    {
        rv =  ENOMEM;
        goto bad;
    }

    /* Get memory for services structure */
    vcs = atm_cmm_alloc_services();
    if(vcs == NULL)
    {
        atm_cmm_free_ie(iep);
        rv =  ENOMEM;
        goto bad;
    }
```

Example B–1: Making a Call Code Fragment (cont.)

```
/* Get the storage for the endpoint address */
ra.addr = atm_cmm_alloc_addr();
if(ra.addr == NULL)
{
    atm_cmm_free_ie(iep);
    atm_cmm_free_services(vcs);
    rv = ENOMEM;
    goto bad;
}

/* Set cell rate information for ABR traffic.
 * Cell rates - cells/sec. 1 cell = 53 bytes.
 */
 vcs->fpeakcr[ATM_CLP_1] = 0x800;
 vcs->bpeakcr[ATM_CLP_1] = 0x800;

 vcs->valid_rates =  ATM_VCRV_FPEAK1 |
   ATM_VCRV_BPEAK1;

 /* Best effort service class and enable tagging */
 vcs->flags = ATM_SERVICES_BEI;

/* Set the Qos */
vcs->fqos = ATM_QOS_CLASSA;
vcs->bqos = ATM_QOS_CLASSA;

/* Set the MTU in the services structure */
vcs->fmtu = 1500;
vcs->bmtu = 1500;

/* Set the BB bearer class in the services structure */
vcs->bearer_class = ATM_BBEARER_BCOB_X;

/* Fill out the AAL 5 IE */
ie->ie_type = ATM_IET_AAL5;
ATM_IE_SETVAL(ie->ie.aal_params.aal5.fsdu,1500);
ATM_IE_SETVAL(ie->ie.aal_params.aal5.bsdu,1500); 1
ATM_IE_SETVAL(ie->ie.aal_params.aal5.mode,
   ATM_AAL_MESG_MODE);
ATM_IE_SETVAL(ie->ie.aal_params.aal5.sscs,
   ATM_AAL_SSCS_NULL);

/* Fill out the BLLI IE */
ie++;
ie->last = 1;
ie->ie_type = ATM_IET_BBLOW;
```

Example B–1: Making a Call Code Fragment (cont.)

```
    ATM_IE_SETVAL(ie->ie.bb_low_layer.layer2proto,
       ATM_BLLI_UIL2_LAN_LLC_8022);


    bcopy(called_party,ra.addr->address,ATMADDR_LEN);
    ra.addr->ton = 0;
    ra.addr->anpi = 2;


    if((retval = atm_cmm_connect(my_handle,ATM_CT_PTP, 2
      my_bind,ra,iep,ATM_AGE_FOREVER,vcs)) !=
       ATM_CAUSE_GOOD)
    {
        atm_cmm_free_ie(iep);
        atm_cmm_free_services(vcs);
        atm_cmm_free_addr(ra.addr);
        ATM_FREE(ivc);
        rv =  EIO;
        goto bad;
    }

    /* The VC is valid if the call is proceeding! */
    ra.addr->vc->conv_pp1 =
    ra.addr->conv_p1 =
    ra.addr->conv_p2 =

    return rv;
}
```

1 For point-to-multipoint connections, set this parameter to zero (0).

2 For point-to-multipoint connections, use the ATM_CT_PTM argument in place of the ATM_CT_PTP argument.

B.2 Adding More Parties to a Point-to-Multipoint Connection

Example B–2 shows one way to add more parties to the VC associated with the first call in a point-to-multipoint connection.

Example B–2: Adding Parties to a Point-to-Multipoint Connection Code Fragment

```
add_leaf(atm_vc_p vc, unsigned char *new_leaf)
{
    register atm_uni_call_ie_p iep, ie;
    register struct atm_addr_p leaf;
    atm_error_t retval;
    int rv = ESUCCESS;
    extern atm_cvg_handle_t my_handle;
    extern atm_bind_handle_t my_bind;

    /* Get memory for setup IEs */
    iep = ie = atm_cmm_alloc_ie(3);
    if(ie == NULL)
    {
        rv =  ENOMEM;
        goto bad;
    }

    /* Get the storage for the endpoint address */
    leaf = atm_cmm_alloc_addr();
    if(leaf == NULL)
    {
        atm_cmm_free_ie(iep);
        atm_cmm_free_services(vcs);
        rv = ENOMEM;
        goto bad;
    }

    /* Fill out the AAL 5 IE */
    ie->ie_type = ATM_IET_AAL5;
    ATM_IE_SETVAL(ie->ie.aal_params.aal5.fsdu,1500);
    ATM_IE_SETVAL(ie->ie.aal_params.aal5.bsdu,1500); 1
    ATM_IE_SETVAL(ie->ie.aal_params.aal5.mode,
       ATM_AAL_MESG_MODE);
    ATM_IE_SETVAL(ie->ie.aal_params.aal5.sscs,
       ATM_AAL_SSCS_NULL);

    /* Fill out the BLLI IE */
    ie++;
    ie->last = 1;
    ie->ie_type = ATM_IET_BBLOW;
    ATM_IE_SETVAL(ie->ie.bb_low_layer.layer2proto,
       ATM_BLLI_UIL2_LAN_LLC_8022);


    bcopy(new_leaf,leaf->address,ATMADDR_LEN);
    leaf->ton = 0;
    leaf->anpi = 2;
```

Example B–2: Adding Parties to a Point-to-Multipoint Connection Code Fragment (cont.)

```
    if((retval = atm_cmm_add(my_handle,leaf,ie,vc)) !=
       ATM_CAUSE_GOOD)
    {
        atm_cmm_free_ie(iep);
        atm_cmm_free_addr(leaf);
        ATM_FREE(ivc);
        rv =  EIO;
        goto bad;
    }

    /* The VC is valid if the call is proceeding! */
    ra.addr->conv_p1 =
    ra.addr->conv_p2 =

    return rv;
}
```

1 For point-to-multipoint connections, set this parameter to zero (0).

B.3 Processing an Incoming Call

Example B–3 shows how a convergence module processes an incoming call.

Example B–3: Incoming Call Processing Code Fragment

```
atm_error_t
new_connect(void *bind_handle,
        atm_addr_p          addr,
        atm_bind_handle_t   bind,
        atm_vc_p            vc,
        atm_uni_call_ie_p   *reply,
        atm_vc_services_p   requested,
        atm_vc_services_p   *avail)
{
    register atm_uni_call_ie_p iep = NULL;
    atm_uni_call_ie_p rblli = NULL, raal = NULL;
    atm_uni_call_ie_p nblli;

    /* Verify IEs to make sure they are valid for our service */
    if(addr != NULL && (iep = addr->setup))
    {
        for(;; iep++)
        {
            switch(iep->ie_type)
            {
            /* Things we do not want to see */
            case ATM_IET_AAL1:
            case ATM_IET_AAL2:
```

Example B–3: Incoming Call Processing Code Fragment (cont.)

```
        case ATM_IET_AAL3:
        case ATM_IET_AALU:
            return ATM_CAUSE_APNS;

        /* Do not need to look at these */
        case ATM_IET_BBBC:
        case ATM_IET_BBHI:
            break;

        case ATM_IET_REPEAT:
            break;

        case ATM_IET_AAL5:
            /* Make sure the MTU is supported.  Accept
             * an MTU greater than 1500 and then
             * negotiate it down until larger MTUs are
             * supported.
             */
            if(ATM_IE_ISVALID(iep->ie.aal_params.aal5.fsdu))
            {
                if(ATM_IE_GETVAL(iep->ie.aal_params.aal5.fsdu) < 1500)
                     return ATM_CAUSE_APNS;
            }
            if(ATM_IE_ISVALID(iep->ie.aal_params.aal5.bsdu))
            {
                if(ATM_IE_GETVAL(iep->ie.aal_params.aal5.bsdu) < 1500)
                     return ATM_CAUSE_APNS;
            }
            raal = iep;
            break;

        case ATM_IET_BBLOW:
            /* Check for LLC encapsulation */
            if(ATM_IE_ISVALID(iep->ie.bb_low_layer.layer2proto))
            {
                if(ATM_IE_GETVAL(iep->ie.bb_low_layer.layer2proto) != 0x0C)
                     return ATM_CAUSE_BCNI;
                rblli = iep;
                break;
            }
            break;
        }
        if(iep->last)
            break;
    }

    /* Make sure the required info is present */
    if(rblli == NULL)    /* No required BLLI */
    {
        addr->diag_length = 2;
        addr->diagnostic[0] = 0x5;
        addr->diagnostic[1] = 0x5e;
        return ATM_CAUSE_CR;
    }
    if(raal == NULL)    /* No required AAL parameters */
    {
        addr->diag_length = 2;
        addr->diagnostic[0] = 0x5;
        addr->diagnostic[1] = 0x58;
        return ATM_CAUSE_CR;
    }
```

Example B–3: Incoming Call Processing Code Fragment (cont.)

```
        /* Check if point-to-point */
        if (addr->endpoint == 0) [1]
        {
            /* Set up reply values */
            iep = atm_cmm_alloc_ie(2);
            if(!iep)
                return ATM_CAUSE_RUU;
            bcopy(raal,iep,sizeof(atm_uni_call_ie_t));
            ATM_IE_SETVAL(iep->ie.aal_params.aal5.fsdu,1500);
            ATM_IE_SETVAL(iep->ie.aal_params.aal5.bsdu,1500);
            nblli = iep+1;
            bcopy(rblli,nblli,sizeof(atm_uni_call_ie_t));
            nblli->last = 1;
            *reply = iep;

            /* Now take care of the services stuff */
            if ( (avail) && (*avail) ) {
                (*avail)->fmtu = (*avail)->bmtu = 1500;
            }
        }
    }

    vc->conv_pp1 =
    vc->conv_pp2 =

    /* If there is no signalling protocol, then this is a PVC */
    if(vc->ppa->sig != NULL)
    {
        addr->conv_p1 =
        addr->conv_p2 =
    }

    return ATM_CAUSE_GOOD;
}
```

[1] For point-to-multipoint connections, the `addr->endpoint` value will be greater than zero. Therefore, you should not change the call's values. See the *ATM User-Network Interface Specification, Version 3.1*.

C

ATM Cause Codes

This appendix lists ATM cause and diagnostic codes, their message strings, and brief descriptions that are displayed by various parts of the ATM subsystem. These codes are returned when an ATM request is rejected or when a connection is released.

The User-Network Interface (UNI) cause codes are defined by ATM Forum specifications, and represent error information provided by the ATM network.

1: Unallocated number

The called party cannot be reached because the number (in valid format) is not currently assigned.

2: No route to network

The equipment that sent this cause has received a request to route the call through an unrecognized network. The equipment does not recognize the network either because the network does not exist or because the network exists, but does not serve the equipment that is sending this cause.

Support for this cause varies from network to network.

3: No route to destination

The called party cannot be reached because the network through which the call has been routed does not serve the destination.

Support for this cause varies from network to network.

10: VCI/VPI unacceptable (UNI 3.0 only)

The virtual channel most recently identified is not acceptable to the sending entity for use in this call.

16: Normal VC release

One of the users involved in the call has requested that the call be cleared. In normal situations, the network is not the source of this cause.

17: User busy

The called party is unable to accept another call because the user busy condition has been encountered. Either the called user or the network might generate this cause.

18: No user responding

The called party did not respond to a call establishment message with a connect indication within the prescribed period of time.

21: Call rejected

The equipment that is sending this cause does not want to accept this call. The equipment is neither busy or incompatible.

22: Number changed

The called party number indicated by the calling user is no longer assigned. The new called party number might be included in the diagnostic field. If a network does not support this capability, cause 1 (unallocated number) is used. This cause is returned to a calling party.

23: User rejects all calls with line identification restriction

The call is offered without calling party number information, and the called party requires this information.

27: Destination out of order

The destination by the user cannot be reached because the interface to the destination is not functioning correctly. This indicates that a signaling message could not be delivered to the remote user either because of a physical layer or SAAL failure at the remote user or because user equipment is off-line.

28: invalid number format

The called user cannot be reached because the called party number is not in a valid format or is not complete.

30: Response to ENQUERY

An entity is sending STATUS message in response to a STATUS ENQUERY message. The cause number is included in the STATUS message.

31: Normal release, unspecified cause

A normal event occurred for which no other cause applies.

35: Requested VC unavailable

The requested VPCI/VCI is not available.

36: VPCI/VCI assignment failure

The VPCI/VCI could not be assigned.

37: User cell rate unavail

The requested ATM Traffic Descriptor is unobtainable.

38: Network out of order

The network is not functioning properly. This condition might last a long period of time; any immediate call attempt is likely to fail.

41: Temporary failure

The network is not functioning properly. This condition is temporary; you can retry the call immediately.

43: Access info discarded

The network could not deliver access information (for example, ATM adaptation layer parameters, broadband low layer information, broadband high layer information, and sub-address) to the remote user as requested.

45: No VC available

There is no VC available to handle the call.

47: Resource unavailable

The requested resource is unavailable. No other cause is applicable.

49: QOS unavailable

The requested Quality of Service (QoS) cannot be provided.

51: User cell rate unavailable (UNI 3.0 only)

The requested ATM Traffic Descriptor is unobtainable.

57: Bearer capability not authorized

The user requested a bearer capability that is implemented in the equipment, but the user is not authorized to use.

58: Bearer capability not presently available

The user requested a bearer capability that is implemented in the equipment, but is unavailable at this time.

63: Option not available

The option is unavailable. No other cause applies.

65: Bearer capability not implemented

The equipment that sent this cause does not support the bearer capability requested.

73: Unsupported combination of traffic parameters

The combination of traffic parameters contained in the ATM traffic descriptor information element (IE) is not supported.

78: AAL parameters can not be supported

The equipment that sent this cause received a request to establish a call with ATM adaptation layer parameters that cannot be accommodated.

81: Invalid call reference value

The equipment that sent this cause received a message with a call reference that is not currently in use on the user-network interface (UNI).

82: Identified channel does not exist

The equipment that sent this cause received a request to use a channel that is not activated on the interface for a call.

88: Incompatible destination

The equipment that sent this cause received a request to establish a call that it cannot accommodate. Possible incompatibility reasons include broadband low layer information, broadband high layer information, or compatibility attributes.

89: Invalid endpoint reference

The equipment that sent this cause received a message with an endpoint reference that is not currently in use on the UNI.

91: Invalid transit network selection

A received transit network identification has an incorrect format.

92: Too many pending add party requests

The calling party sent an add party message, but the network is unable to accept another add party message because the network's queues are full. This is a temporary condition.

93: AAL parameters can not be supported (UNI 3.0 only)

The equipment that sent this cause received a request to establish a call that it cannot accommodate. The main reason is the ATM adaptation layer parameters.

96: Mandatory information element missing

The equipment that sent this cause received a message that is missing a required IE.

97: Message type non-existent or not implemented

The equipment that sent this cause received a message with an unrecognized message type. Possible reasons include the message type is undefined or the message is defined, but not implemented by the equipment.

99: IE non-existent or not implemented

The equipment that sent this cause received a message that includes an unrecognized IE or IEs. Possible reasons include the IE is undefined or the IE is defined, but not implemented by the equipment. The IE or IEs were discarded. However, the message was processed because the IE or IEs were not required.

100: Invalid IE contents

The equipment that sent this cause received a valid IE, but the implementation prevents it from understanding the format of one or more fields in the IE.

101: Message not compatible with call state
A received message is incompatible with the call state.

102: Recovery timer expired
A timer expired and an error handling procedure is initiated.

104: incorrect message length
An inconsistent message length occurred.

111: Protocol error unspecified
A protocol error event occurred. No other cause applies.

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