



Wide-Area Networking Overview

Cisco IOS software provides a range of wide-area networking capabilities to fit almost every network environment need. Cisco offers cell relay via the Switched Multimegabit Data Service (SMDS), circuit switching via ISDN, packet switching via Frame Relay, and the benefits of both circuit and packet switching via ATM. LAN emulation (LANE) provides connectivity between ATM and other LAN types. Refer to the *Cisco IOS Dial Services Configuration Guide: Network Services* for further information on configuring ISDN. Refer to the *Cisco IOS Switching Services Configuration Guide* for information on configuring LANE.

Document Objectives

The *Cisco IOS Wide-Area Networking Configuration Guide* presents a set of general guidelines for configuring the following software components:

- ATM
- Frame Relay
- Frame Relay-ATM Internetworking
- SMDS
- Link Access Procedure, Balanced and X.25

This overview chapter gives a high-level description of each technology. For specific configuration information, see the appropriate chapter in this document.

Document Organization

This document includes the following chapters:

- Configuring ATM
- Configuring Frame Relay
- Configuring Frame Relay-ATM Interworking
- Configuring SMDS
- Configuring X.25 and LAPB

ATM

The following sections provide an overview of ATM and how Cisco supports ATM:

- ATM Environment
- Cisco's ATM Interface Processor, Port Adapters, and Network Modules
- Cisco ATM Features
- ATM Interface Types
- Virtual Circuits
- Classical IP and ARP
- AIP Microcode
- Supported MIBs

ATM Environment

ATM is a cell-switching and multiplexing technology designed to combine the benefits of circuit switching (constant transmission delay and guaranteed capacity) with those of packet switching (flexibility and efficiency for intermittent traffic).

ATM is a connection-oriented environment. All traffic to or from an ATM network is prefaced with a VPI and VCI. A VPI-VCI pair is considered a single virtual circuit. Each virtual circuit is a private connection to another node on the ATM network. Each virtual circuit is treated as a point-to-point mechanism to another router or host and is capable of supporting bidirectional traffic.

Each ATM node is required to establish a separate connection to every other node in the ATM network that it needs to communicate with. All such connections are established by means of a PVC or a switched virtual circuit (SVC) with an ATM signalling mechanism. This signalling is based on the ATM Forum User-Network Interface (UNI) Specification V3.0.

Each virtual circuit is considered a complete and separate link to a destination node. Users can encapsulate data as needed across the connection. The ATM network disregards the contents of the data. The only requirement is that data be sent to the ATM processor card of the router in a manner that follows the specific ATM adaptation layer (AAL) format.

An AAL defines the conversion of user information into cells. An AAL segments upper-layer information into cells at the transmitter and reassembles the cells at the receiver. AAL1 and AAL2 handle isochronous traffic, such as voice and video, and are not relevant to the router. AAL3/4 and AAL5 support data communications; that is, they segment and reassemble packets.

An ATM connection is simply used to transfer raw bits of information to a destination router or host. The ATM router takes the common part convergence sublayer (CPCS) frame, carves it up into 53-byte cells, and sends these cells to the destination router or host for reassembly. In AAL5 format, 48 bytes of each cell are used for the CPCS data; the remaining 5 bytes are used for cell routing. The 5-byte cell header contains the destination VPI-VCI pair, payload type, cell loss priority (CLP), and header error control (HEC).

The ATM network is considered a LAN with high bandwidth availability. Each end node in the ATM network is a host on a specific subnet. All end nodes needing to communicate with one another must be within the same subnet in the network.

Unlike a LAN, which is connectionless, ATM requires certain features to provide a LAN environment to the users. One such feature is broadcast capability. Protocols wishing to broadcast packets to all stations in a subnet must be allowed to do so with a single call to Layer 2. To support broadcasting, the

router allows the user to specify particular virtual circuits as broadcast virtual circuits. When the protocol passes a packet with a broadcast address to the drivers, the packet is duplicated and sent to each virtual circuit marked as a broadcast virtual circuit. This method is known as *pseudobroadcasting*.

**Note**

Effective with Cisco IOS Release 11.0, point-to-multipoint signalling allows pseudobroadcasting to be eliminated. On routers with point-to-multipoint signalling, the router can set up calls between itself and multiple destinations; drivers no longer need to duplicate broadcast packets. A single packet can be sent to the ATM switch, which replicates it to multiple ATM hosts.

Cisco's ATM Interface Processor, Port Adapters, and Network Modules

Cisco provides ATM access in the following ways, depending on the hardware available in the router:

- ATM Interface Processor (AIP), in supported routers
- ATM Port Adapter, Enhanced Port Adapter, and ATM-CES Port Adapter, in supported routers
- Network Processor Module (NPM), in supported routers
- 1-Port ATM-25 Network Module, in supported routers
- ATM OC-3 Network Module, in supported routers
- Multiport T1/E1 ATM Network Module with Inverse Multiplexing over ATM, in supported routers
- ATM Access over a Serial Interface

ATM Interface Processor (AIP)

On the Cisco 7500 series routers, network interfaces reside on modular interface processors, which provide a direct connection between the high-speed Cisco Extended Bus (CxBus) and the external networks. Each AIP provides a single ATM network interface; the maximum number of AIPs that the Cisco 7500 series supports depends on the bandwidth configured. The total bandwidth through all the AIPs in the system should be limited to 200 Mbps full-duplex (two Transparent Asynchronous Transmitter/Receiver Interfaces (TAXIs), or one SONET and one E3, or one SONET and one lightly used SONET, five E3s, or four T3s). For a complete description of the Cisco 7500 series routers and AIP, refer to the *Hardware Installation and Maintenance* publication for your specific router.

**Note**

Beginning in Cisco IOS Release 11.3, all commands supported on the Cisco 7500 series routers are also supported on Cisco 7000 series routers equipped with RSP7000.

ATM Port Adapter, Enhanced Port Adapter, and ATM-CES Port Adapter

The ATM port adapter and enhanced ATM port adapter are available on Cisco 7200 series routers and on the second-generation Versatile Interface Processor (VIP2) in Cisco 7500 series routers. The ATM-CES port adapter is available on the Cisco 7200 series routers only. For a complete description of these ATM port adapters, refer to the *PA-A1 ATM Port Adapter Installation and Configuration*, *PA-A3 Enhanced ATM Port Adapter Installation and Configuration*, and *PA-A2 ATM-CES Port Adapter Installation and Configuration* publications, respectively.

Network Processor Module (NPM)

Cisco 4500 and Cisco 4700 routers support one OC-3c NPM or up to two slower E3/DS3 NPMs. Physical layer interface modules (PLIMs) that support SONET/Synchronous Digital Hierarchy (SDH/SONET) 155 Mbps are available for both single-mode and multimode fiber. For a complete description of the Cisco 4500 and Cisco 4700 routers and the NPM, refer to the *Cisco 4000 Hardware Installation and Maintenance* manual. For information about installing the NPM, see the “Installing Network Processing Modules in the Cisco 4000 Series” section of the online document titled *Cisco 4000 Series Configuration Notes*.

1-Port ATM-25 Network Module

The 1-port ATM-25 network module is available on the Cisco 2600 series and Cisco 3600 series routers. For complete information about installing this network module, refer to “*Connecting ATM Network Modules to a Network*” at [http://www.cisco.com/univercd/cc/td/doc/product/access](http://www.cisco.com/univercd/cc/td/doc/product/accesshttp://www.cisco.com/univercd/cc/td/doc/product/access).

ATM OC-3 Network Module

The ATM OC-3 network module is available on the Cisco 3600 series routers. For complete information about installing this network module, refer to “*Connecting ATM Network Modules to a Network*” at [http://www.cisco.com/univercd/cc/td/doc/product/access](http://www.cisco.com/univercd/cc/td/doc/product/accesshttp://www.cisco.com/univercd/cc/td/doc/product/access).

Multiport T1/E1 ATM Network Module with Inverse Multiplexing over ATM

The multiport T1/E1 ATM network modules with inverse multiplexing over ATM are available on the Cisco 2600 series and Cisco 3600 series routers. For complete information about installing this network module, refer to “*Connecting T1/E1 IMA Network Modules to a Network*” at http://www.cisco.com/univercd/cc/td/doc/product/access/acs_mod/cis2600/net_mod2/conntima.htm.

ATM Access over a Serial Interface

In routers that do not support the hardware described in the sections above, a serial interface can be configured for multiprotocol encapsulation over the ATM-Data Exchange Interface (ATM-DXI), as specified by RFC 1483. This standard describes two methods for transporting multiprotocol connectionless network interconnect traffic over an ATM network. One method allows multiplexing of multiple protocols over a single permanent virtual circuit (PVC). The other method uses different virtual circuits to carry different protocols. Our implementation supports transport of AppleTalk, Banyan VINES, IP, and Novell Internetwork Packet Exchange (IPX) protocol traffic.

If you configure ATM access over a serial interface, an ATM data service unit (ADSU) is required in order to do the following:

- Provide the ATM interface to the network
- Compute the DXI Frame Address (DFA) from the virtual path identifier (VPI) and virtual channel identifier (VCI) values defined for the protocol or protocols carried on the PVC
- Convert outgoing packets into ATM cells
- Reassemble incoming ATM cells into packets

Cisco ATM Features

This section provides an overview of the ATM features available on the AIP, ATM port adapter, Enhanced ATM port adapter, ATM-CES port adapter, NPM, 1-port ATM-25 network module, ATM OC-3 network module, and multiport T1/E1 ATM network module. These features are available on all of these interface cards, unless otherwise indicated.

The Cisco IOS software for ATM supports the following features:

- Multiple rate queues. (Not available on the ATM port adapter, ATM-CES port adapter, enhanced ATM port adapter, and 1-port ATM-25 network module.)
- Segmentation and reassembly (SAR) of up to 512 buffers for the AIP, reassembly of up to 512 buffers for the NPM, SAR of up to 200 buffers for the ATM port adapter, and SAR of up to 400 buffers for the ATM-CES port adapter. Each buffer represents a packet.
- Per-virtual-circuit counters, which improve the accuracy of the statistics shown in the output of **show** commands by ensuring that autonomously switched packets are counted, as well as fast-switched and process-switched packets.
- Support for up to 2048 virtual circuits on the AIP and ATM port adapter.
- Support for up to 2047 virtual circuits on the ATM-CES port adapter.
- Support for up to 4096 virtual circuits on the enhanced ATM port adapter.
- Support for up to 1023 virtual circuits on the NPM.
- Support for up to 2048 virtual circuits on the 1-port ATM-25 network module.
- Support for up to 1024 virtual circuits on the ATM OC-3 network module.
- Support for up to 256 virtual circuits on each interface of the multiport T1/E1 ATM network modules with inverse multiplexing over ATM.
- Support for three permanent virtual path connections (PVPs).
- Support for both AAL3/4 and AAL5. (AAL3/4 is not available on the ATM port adapter, enhanced ATM port adapter, ATM-CES port adapter, 1-port ATM-25 network module, multiport T1/E1 ATM network modules with inverse multiplexing over ATM, ATM OC-3 network module, and multiport T1/E1 ATM network module.)

An AAL defines the conversion of user information into cells by segmenting upper-layer information into cells at the transmitter and reassembling them at the receiver. AAL1 and AAL2 handle isochronous traffic, such as voice and video, and are not relevant to the router. AAL3/4 and AAL5 support data communications by segmenting and reassembling packets. On the Cisco 4500 and 4700 routers, Cisco supports both AAL3/4 (except at OC-3 rates) and AAL5.

- Support for fast-switched transparent bridging over ATM.

Fast-switched transparent bridging over ATM supports AAL5-SNAP encapsulated packets only. All bridged AAL5-SNAP encapsulated packets are fast switched. Fast-switched transparent bridging supports Ethernet, FDDI, and Token Ring packets sent in AAL5-Subnetwork Access Protocol (SNAP) encapsulation over ATM. You can enable fast-switched bridging for AAL5-SNAP as described later in this chapter.

- Exception queue, which is used for event reporting. Events such as cyclic redundancy check (CRC) errors are reported to the exception queue. (Available only on the AIP.)
- Support for sending operation, administration, and maintenance (OAM) F5 loopback cells. OAM F5 cells must be echoed back on receipt by the remote host, thus demonstrating connectivity on the PVC between the router and the remote host.

- Raw queue, which is used for all raw traffic over the ATM network. Raw traffic includes OAM cells and Interim Local Management Interface (ILMI) cells. ATM signalling cells are not considered raw. (Available only on the AIP.)
- Up to 256 transmit buffers for simultaneous fragmentation on the ATM port adapter.
- Fast switching of IP and IPX.
- Cross-connect CES—structured and unstructured. (Available only on the ATM-CES port adapter.)
- Prioritization of ATM transport, including the following traffic classes:
 - Real-time and non-real-time variable bit rate (VBR) connection-oriented service suitable for video and voice
 - Available bit rate (ABR) connection-oriented service for traffic, such as LAN interconnections and TCP/IP connectivity that work well with variable delays
 - Unspecified bit rate (UBR), as recognized by the ATM Forum, without resource allocation or quality of service (QoS) specifications
- ATM Interim Local Management Interface (ILMI) as specified by the ATM Forum for incorporating network-management capabilities
- Automatic and dynamic removal of failed links or those not performing according to delay standards—along with automatic and dynamic restoration when the links are up or when delays are acceptable
- Cell-based inverse multiplexing that allows operation, administration, and maintenance (OAM) cells to provide management and monitoring, which performs across the imuxed (inverse multiplexed) links. In this fashion, a Cisco 2600 or 3600 router with ATM IMA functionality can exchange monitoring information, such as connectivity, alarm indication signals (AIS), and loopback.
- The ATM IMA T1 and E1 network modules interoperate with the Cisco 3810 multiservice access concentrator, but only when the Cisco MC3810 is in UNI mode, and only when the T1 or E1 links operate as individual links—not as IMA groups.

ATM Interface Types

This section describes the following interface types that are available for ATM:

- AIP Interface Types
- ATM Port Adapter Interface Types
- Enhanced ATM Port Adapter Interface Types
- ATM-CES Port Adapter Interface Types
- NPM Interface Types
- 1-Port ATM-25 Network Module Interface Types
- ATM OC-3 Network Module Interface Types
- Multiport T1/E1 ATM Network Modules with Inverse Multiplexing over ATM Interface Types

AIP Interface Types

All ATM interfaces are full duplex. You must use the appropriate ATM interface cable to connect the AIP with an external ATM network. Refer to the chapter “ATM Interface Processor” in the *Cisco Interface Processor Installation and Configuration Guide* for descriptions of ATM connectors.

The AIP provides an interface to ATM switching fabrics for sending and receiving data at rates of up to 155 Mbps bidirectionally; the actual rate is determined by the physical layer interface module (PLIM). The PLIM contains the interface to the ATM cable. The AIP can support PLIMs that connect to the following physical layers:

- TAXI 4byte/5byte 100-Mbps multimode fiber-optic cable
- SDH/SONET 155-Mbps multimode fiber-optic cable—STS-3C or STM-1
- SDH/SONET 155-Mbps single-mode fiber-optic cable—STS-3C or STM-1
- E3 34-Mbps coaxial cable

For wide-area networking, ATM is currently being standardized for use in Broadband Integrated Services Digital Networks (BISDNs) by the International Telecommunication Union Telecommunication Standardization Sector (ITU-T) and the American National Standards Institute (ANSI). BISDN supports rates from E3 (34 Mbps) to multiple gigabits per second (Gbps).

**Note**

The ITU-T carries out the functions of the former Consultative Committee for International Telegraph and Telephone (CCITT).

ATM Port Adapter Interface Types

The ATM port adapter provides a single SDH/SONET OC-3 full-duplex interface (either multimode or single-mode intermediate reach) and supports data rates of up to 155 Mbps bidirectionally. The ATM port adapter connects to a SDH/SONET multimode or SONET/STC-3C single-mode fiber-optic cable (STS-3C or STM-1 physical layer) to connect the router to an external DSU (an ATM network).

Enhanced ATM Port Adapter Interface Types

The enhanced ATM port adapters (PA-A3-T3, PA-A3-E3, PA-A3-OC3MM, PA-A3-OC3SMI, and PA-A3-OC3SML) are available on the Cisco 7200 and 7500 series routers. They include five hardware versions that support the following standards-based physical interfaces:

- DS3
- E3
- OC-3c/STM-1 multimode
- OC-3c/STM-1 single-mode intermediate reach
- OC-3c/STM-1 single-mode long reach

ATM-CES Port Adapter Interface Types

The ATM-CES port adapters (PA-A2-4T1C-OC3SM, PA-A2-4T1C-T3ATM, PA-A2-4E1XC- OC3SM, PA-A2-4E1XC-E3ATM, PA-A2-4E1YC-OC3SM, and PA-A2-4E1YC-E3ATM) are available on Cisco 7200 series routers. The ATM-CES has four T1 (1.544 Mbps) or four E1 (2.048 Mbps) ports (75- or 120-ohm) that can support both structured (N x 64 kbps) and unstructured ATM Forum-compliant CES, and one port that supports an OC-3 (155 Mbps) single-mode intermediate reach interface or a T3 (45 Mbps) or E3 (34 Mbps) standards-based ATM interface.

NPM Interface Types

All ATM interfaces are full duplex. You must use the appropriate ATM interface cable to connect the NPM with an external ATM network. Refer to the *Cisco 4000 Series Hardware Installation and Maintenance* and *Installing NPMs in the Cisco 4000 Series* publications for descriptions of ATM connectors.

The NPM provides an interface to ATM switching fabrics for sending and receiving data at rates of up to 155 Mbps bidirectionally; the actual rate is determined by the PLIM. The PLIM contains the interface to the ATM cable. The NPM can support PLIMs that connect to the following physical layers:

- SDH/SONET 155-Mbps multimode fiber-optic cable—STS-3C or STM-1
- SDH/SONET 155-Mbps single-mode fiber-optic cable—STS-3C or STM-1

1-Port ATM-25 Network Module Interface Types

The 1-port ATM-25 network module has a single RJ-45 connector with signals compliant with the ATM Forum recommendation for the 25.6 Mbps ATM physical layer.

ATM OC-3 Network Module Interface Types

The ATM OC-3 network module has a single SC connector with signals compliant with the ATM Forum recommendation for the 25.6 Mbps ATM physical layer.

Multiport T1/E1 ATM Network Modules with Inverse Multiplexing over ATM Interface Types

The Multiport T1/E1 ATM network modules with inverse multiplexing over ATM have RJ-45 connectors with signals compliant with the ATM Forum recommendation for the 25.6 Mbps ATM physical layer.

Virtual Circuits

A virtual circuit is a connection between remote hosts and routers. A virtual circuit is established for each ATM end node with which the router communicates. The characteristics of the virtual circuit that are established when the virtual circuit is created include the following:

- Traffic shaping (Not available on the ATM port adapter.)
- AAL mode—AAL3/4 and AAL5 (AAL3 /4 is not available on the ATM port adapter, ATM-CES port adapter, and enhanced ATM port adapter.)

- Encapsulation types:
 - Logical Link Control (LLC)/SNAP
 - MUX (one protocol per PVC)
 - NLPID (multiprotocol encapsulation consistent with RFC 1294 and RFC 1490)
 - QSAAL (encapsulation used on a signalling PVC that is used for setting up or tearing down SVCs)
 - SMDS (not available on the ATM port adapter, ATM-CES port adapter, or enhanced ATM port adapter)
 - PPP over ATM (Not available on the PA-A1 ATM port adapter)
- Protocol traffic to be carried—multiprotocol or single-protocol traffic
- Multiprotocol—AppleTalk, Connectionless Network Service (CLNS), DECnet, IP, IPX, Banyan VINES, and Xerox Network Systems (XNS)
- Peak and average transmission rates
- Point-to-point or point-to-multipoint

Each virtual circuit supports the following router functions:

- On routers with a serial interface configured for ATM, fast switching of IP, IPX, AppleTalk, and VINES packets; on the Cisco 7200 and 7500 series routers, fast switching of AppleTalk, CLNS, IP, IPX and VINES
- Pseudobroadcast support for multicast packets
- By default, fast switching is enabled on all AIP interfaces. These switching features can be turned off with interface configuration commands. By default, optimum switching is enabled on all ATM port adapter interfaces.
- Fast switching of IP, IPX, AppleTalk, and CLNS

Classical IP and ARP

Cisco implements classical IP and Address Resolution Protocol (ARP) over ATM as described in RFC 1577. RFC 1577 defines an application of classical IP and ARP in an ATM environment configured as a logical IP subnet (LIS). It also describes the functions of an ATM ARP server and ATM ARP clients in requesting and providing destination IP addresses and ATM addresses in situations when one or both are unknown. Our routers can be configured to act as an ARP client, or to act as a combined ARP client and ARP server.

The ATM ARP server functionality allows classical IP networks to be constructed with ATM as the connection medium. Without this functionality, you must configure both the IP network address and the ATM address of each end device with which the router needs to communicate. This static configuration task takes administrative time and makes moves and changes more difficult.

The Cisco implementation of the ATM ARP server functionality provides a robust environment in which network changes can be made more easily and more quickly than in a pure ATM environment. The Cisco ATM ARP client works with any ARP server that is fully compliant with RFC 1577.

AIP Microcode

The AIP microcode is a software image that provides card-specific software instructions. An onboard ROM component contains the default AIP microcode. The Cisco 7500 series supports downloadable microcode, which enables you to upgrade microcode versions by loading new microcode images onto the Route Processor (RP), storing them in Flash memory, and instructing the AIP to load an image from Flash memory instead of the default ROM image. You can store multiple images for an interface type and instruct the system to load any one of them or the default ROM image with a configuration command. All processor modules of the same type will load the same microcode image from either the default ROM image or from a single image stored in Flash memory.

Although multiple microcode versions for a specific interface type can be stored concurrently in Flash memory, only one image can load at startup. The **show controller cxbus** command displays the currently loaded and running microcode version for the Switch Processor (SP) and for each IP. The **show running-config** command shows the current system instructions for loading microcode at startup.

For a complete description of microcode and procedures for downloading microcode, refer to the chapter “ATM Interface Processor” in the *Cisco Interface Processor Installation and Configuration Guide* or the *Cisco IOS Configuration Fundamentals Configuration Guide*.

Supported MIBs

Cisco IOS ATM software supports a subset of the specification in *AToM MIB* (RFC 1695) for Cisco IOS Release 11.2 software or later. Cisco IOS Release 11.3 software or later releases support the proprietary *Cisco AAL5 MIB* that is an extension to RFC 1695.

Frame Relay

The Cisco Frame Relay implementation currently supports routing on IP, DECnet, AppleTalk, XNS, Novell IPX, CLNS, Banyan VINES, and transparent bridging.

Although Frame Relay access was originally restricted to leased lines, dialup access is now supported. For more information, see the “Configuring DDR over Frame Relay” section for dialer profiles or for legacy dial-on-demand routing (DDR) in the “Configuring DDR” chapter in the *Cisco IOS Dial Services Configuration Guide: Terminal Services*.

To install software on a new router or access server by downloading software from a central server over an interface that supports Frame Relay, see the “Loading Images and Configuration Files” chapter in the *Cisco IOS Configuration Fundamentals Configuration Guide*.

To configure access between Systems Network Architecture (SNA) devices over a Frame Relay network, see the “Configuring SNA Frame Relay Access Support” chapter in the *Cisco IOS Bridging and IBM Networking Configuration Guide*.

The Frame Relay software provides the following capabilities:

- Support for the three generally implemented specifications of Frame Relay Local Management Interfaces (LMIs):
 - The *Frame Relay Interface* joint specification produced by Northern Telecom, Digital Equipment Corporation, StrataCom, and Cisco Systems
 - The ANSI-adopted Frame Relay signal specification, T1.617 Annex D
 - The ITU-T-adopted Frame Relay signal specification, Q.933 Annex A

- Conformity to ITU-T I-series (ISDN) recommendation as I122, “Framework for Additional Packet Mode Bearer Services”:
 - The ANSI-adopted Frame Relay encapsulation specification, T1.618
 - The ITU-T-adopted Frame Relay encapsulation specification, Q.922 Annex A
- Conformity to Internet Engineering Task Force (IETF) encapsulation in accordance with RFC 2427, except bridging.
- Support for a keepalive mechanism, a multicast group, and a status message, as follows:
 - The keepalive mechanism provides an exchange of information between the network server and the switch to verify that data is flowing.
 - The multicast mechanism provides the network server with a local data-link connection identifier (DLCI) and a multicast DLCI. This feature is specific to our implementation of the Frame Relay joint specification.
 - The status mechanism provides an ongoing status report on the DLCIs known by the switch.
- Support for both PVCs and SVCs in the same sites and routers.

SVCs allow access through a Frame Relay network by setting up a path to the destination endpoints only when the need arises and tearing down the path when it is no longer needed.
- Support for Frame Relay Traffic Shaping beginning with Cisco IOS Release 11.2. Traffic shaping provides the following:
 - Rate enforcement for individual circuits—The peak rate for outbound traffic can be set to the committed information rate (CIR) or some other user-configurable rate.
 - Dynamic traffic throttling on a per-virtual-circuit basis—When backward explicit congestion notification (BECN) packets indicate congestion on the network, the outbound traffic rate is automatically stepped down; when congestion eases, the outbound traffic rate is stepped up again.
 - Enhanced queueing support on a per-virtual circuit basis—Custom queueing, priority queueing, and weighted fair queueing can be configured for individual virtual circuits.
- Transmission of congestion information from Frame Relay to DECnet Phase IV and CLNS. This mechanism promotes forward explicit congestion notification (FECN) bits from the Frame Relay layer to upper-layer protocols after checking for the FECN bit on the incoming DLCI. Use this Frame Relay congestion information to adjust the sending rates of end hosts. FECN-bit promotion is enabled by default on any interface using Frame Relay encapsulation. No configuration is required.
- Support for Frame Relay Inverse ARP as described in RFC 1293 for the AppleTalk, Banyan VINES, DECnet, IP, and IPX protocols, and for native hello packets for DECnet, CLNP, and Banyan VINES. It allows a router running Frame Relay to discover the protocol address of a device associated with the virtual circuit.
- Support for Frame Relay switching, whereby packets are switched based on the DLCI—a Frame Relay equivalent of a Media Access Control (MAC)-level address. Routers are configured as a hybrid DTE switch or pure Frame Relay DCE access node in the Frame Relay network. The Cisco implementation of Frame Relay switching allows the following configurations:
 - Switching over an IP tunnel
 - Network-to-Network Interface (NNI) to other Frame Relay switches
 - Local serial-to-serial switching

Frame Relay switching is used when all traffic arriving on one DLCI can be sent out on another DLCI to the same next hop address. In such cases, the Cisco IOS software need not examine the frames individually to discover the destination address, and, as a result, the processing load on the router decreases.

- Support for *subinterfaces* associated with a physical interface. The software groups one or more PVCs under separate subinterfaces, which in turn are located under a single physical interface. See the “Configuring Frame Relay Subinterfaces” and the “Subinterface Examples” sections in the “Configuring Frame Relay” chapter of this document.
- Support for fast-path transparent bridging, as described in RFC 1490, for Frame Relay encapsulated serial and High-Speed Serial Interfaces (HSSIs) on all platforms.
- Support of the Frame Relay DTE MIB specified in RFC 1315. However, the error table is not implemented. To use the Frame Relay MIB, refer to your MIB publications.

Frame Relay-ATM Internetworking

Frame Relay-ATM Interworking enables Frame Relay voice or data traffic to be encapsulated in ATM cells. There are two types of Frame Relay-ATM Interworking:

- FRF.5 Frame Relay-ATM Network Interworking
- FRF.8 Frame Relay-ATM Service Interworking



Note

FRF.5 and FRF.8 are only supported on the Cisco MC3810 multiservice access concentrator for Cisco IOS Release 12.1.

FRF.5 Frame Relay-ATM Network Interworking

FRF.5 transports Frame Relay traffic over an ATM cloud via a virtual interface within the Cisco MC3810. By using the encapsulation process, you can migrate from Frame Relay to ATM, or you can tunnel Frame Relay traffic across an ATM backbone to a second Cisco MC3810 or other Frame Relay device, and then extract the ATM traffic back to Frame Relay.

FRF.8 Frame Relay-ATM Service Interworking

FRF.8 connects a Frame Relay network to an ATM network while the networks function independently. Service Interworking allows bidirectional PVC protocol conversion functions and provides a standards-based solution for service providers, enterprises, and end users.

In Service Interworking translation mode, Frame Relay PVCs are mapped to ATM PVCs without the necessity for symmetric topologies—the paths can terminate on the ATM side. The ATM-connected Cisco MC3810 need not be directly linked to a Frame Relay network. Some network devices in a Frame Relay network can evolve to ATM without all network devices doing so.

FRF.8 supports two modes of operation of the IWF for upper-layer user protocol encapsulation, which differ in the following ways:

- Translation mode—maps between ATM and Frame Relay encapsulation. It also supports interworking of routed or bridged protocols.

- Transparent mode—does not map encapsulations but sends them unaltered. This mode is used when translation is impractical because encapsulation methods do not conform to the supported standards for Service Interworking.

FRF.8 works in translation mode like a protocol converter in the following ways:

- When Inverse Address Resolution Protocol (Inverse ARP) or static mapping is configured, addresses are resolved one-to-one between Frame Relay and ATM schemes.
- Header function mapping and multiprotocol data unit headers are converted between protocols.
- ATM adaptation layer 5 (AAL5) information assists in translating boundary information in both directions:
 - In the Frame Relay-to-ATM direction, a frame is mapped to an AAL5 protocol data unit (PDU).
 - In the ATM-to-Frame Relay direction, the AAL5 information delineates frame boundaries and inserts flags and other information that is stripped from frames in the opposite direction.
- Discard Eligibility (DE) and cell loss priority (CLP) can be mapped in both directions.
- Mapping can occur between the forward explicit congestion notification (FECN) and the ATM Explicit Forward Congestion Indicator (EFCI) in both directions, depending upon the configuration. In some cases, it may be desirable for the mapping to occur, but in many cases it is better to turn the mapping off. Mapping is configurable on each PVC.
- Mapping occurs between the Frame Relay Command Response (C/R) field and the ATM common part convergence sublayer user-to-user least significant bit (CPCS-UU LSB).
- PVC Management interworking is supported. The optional asynchronous Local Management Interface (LMI) status message is not implemented.

SMDS

The Cisco implementation of the SMDS protocol is based on cell relay technology as defined in the Bellcore Technical advisories, which are based on the IEEE 802.6 standard. We provide an interface to an SMDS network using DS1 or DS3 high-speed transmission facilities. Connection to the network is made through a device called an *SDSU*—an SMDS digital service unit (DSU). The SDSU attaches to a router or access server through a serial port. On the other side, the SDSU terminates the line.

The implementation of SMDS supports the IP, DECnet, AppleTalk, XNS, Novell IPX, Banyan VINES, and OSI internetworking protocols, and transparent bridging.

The implementation of SMDS also supports SMDS encapsulation over an ATM interface. For more information and for configuration tasks, see section “Configuring ATM Subinterfaces for SMDS Networks” in the chapter “Configuring ATM.”

Routing of AppleTalk, DECnet, IP, IPX, and ISO CLNS is fully dynamic; that is, the routing tables are determined and updated dynamically. Routing of the other supported protocols requires that you establish a static routing table of SMDS neighbors in a user group. Once this table is set up, all interconnected routers and access servers provide dynamic routing.



Note

When configuring IP routing over SMDS, you may need to make adjustments to accommodate split horizon effects. Refer to the “Configuring IP Enhanced IGRP” chapter in the *Cisco IOS IP and IP Routing Configuration Guide* for information about how our software handles possible split horizon conflicts. By default, split horizon is *disabled* for SMDS networks.

The SMDS implementation includes multiple logical IP subnetworks support as defined by RFC 1209. This RFC describes routing IP over an SMDS cloud in which each connection is considered a host on one specific private network, and points to cases where traffic must transit from network to network.

The implementation of SMDS also provides the Data Exchange Interface (DXI) Version 3.2 with *heartbeat*. The heartbeat mechanism periodically generates a heartbeat poll frame.

When a multicast address is not available to a destination, pseudobroadcasting can be enabled to broadcast packets to those destinations using a unicast address.

Link Access Procedure, Balanced and X.25

X.25 is one of a group of specifications published by the ITU-T. These specifications are international standards that are formally called *Recommendations*. The ITU-T *Recommendation X.25* defines how connections between DTE and DCE are maintained for remote terminal access and computer communications. The X.25 specification defines protocols for two layers of the Open Systems Interconnection (OSI) reference model. The data link layer protocol defined is LAPB. The network layer is sometimes called the *packet level protocol* (PLP), but is commonly (although less correctly) referred to as the *X.25 protocol*.

The ITU-T updates its *Recommendations* periodically. The specifications dated 1980 and 1984 are the most common versions currently in use. Additionally, the International Standards Organization (ISO) has published ISO 7776:1986 as an equivalent to the LAPB standard, and ISO 8208:1989 as an equivalent to the ITU-T 1984 *Recommendation X.25* packet layer. The Cisco X.25 software follows the ITU-T 1984 *Recommendation X.25*, except for its Defense Data Network (DDN) and Blacker Front End (BFE) operation, which follow the ITU-T 1980 *Recommendation X.25*.



Note

The ITU-T carries out the functions of the former CCITT. The 1988 X.25 standard was the last published as a CCITT *Recommendation*. The first ITU-T *Recommendation* is the 1993 revision.

In addition to providing remote terminal access, The Cisco X.25 software provides transport for LAN protocols—IP, DECnet, XNS, ISO CLNS, AppleTalk, Novell IPX, Banyan VINES, and Apollo Domain—and bridging. For information about these protocols, refer to the *Cisco IOS IP and IP Routing Configuration Guide*, *Cisco IOS AppleTalk and Novell IPX Configuration Guide*, and *Cisco IOS Apollo Domain, Banyan VINES, DECnet, ISO CLNS, and XNS Configuration Guide*.

Cisco IOS X.25 software provides the following capabilities:

- LAPB datagram transport—LAPB is a protocol that operates at Level 2 (the data link layer) of the OSI reference model. It offers a reliable connection service for exchanging data (in units called *frames*) with one other host. The LAPB connection is configured to carry a single protocol or multiple protocols. Protocol datagrams (IP, DECnet, AppleTalk, and so forth) are carried over a reliable LAPB connection, or datagrams of several of these protocols are encapsulated in a proprietary protocol and carried over a LAPB connection. Cisco also implements transparent bridging over multiprotocol LAPB encapsulations on serial interfaces.
- X.25 datagram transport—X.25 can establish connections with multiple hosts; these connections are called *virtual circuits*. Protocol datagrams (IP, DECnet, AppleTalk, and so forth) are encapsulated inside packets on an X.25 virtual circuit. Mappings between the X.25 address of a host and its datagram protocol addresses enable these datagrams to be routed through an X.25 network, thereby permitting an X.25 PDN to transport LAN protocols.

- X.25 switch—X.25 calls can be routed based on their X.25 addresses either between serial interfaces on the same router (local switching) or across an IP network to another router, using X.25 over TCP (XOT). XOT encapsulates the X.25 packet level inside a TCP connection, allowing X.25 equipment to be connected via a TCP/IP-based network. The Cisco X.25 switching features provide a convenient way to connect X.25 equipment, but do not provide the specialized features and capabilities of an X.25 PDN.
- ISDN D channel—X.25 traffic over the D channel, using up to 9.6 kbps bandwidth, can be used to support many applications. For example, it may be required as a primary interface where low volume sporadic interactive traffic is the normal mode of operation. For information on how to configure X.25 on ISDN, refer to the “Configuring X.25 on ISDN” and “Configuring X.25 on ISDN Using Always On/Direct ISDN (AO/DI)” chapters in the *Cisco IOS Dial Services Configuration Guide: Network Services*.
- PAD—User sessions can be carried across an X.25 network using the packet assembler/disassembler (PAD) protocols defined by the ITU-T Recommendations X.3 and X.29.
- QLLC—The Cisco IOS software can use the Qualified Logical Link Control (QLLC) protocol to carry SNA traffic through an X.25 network.
- Connection-Mode Network Service (CMNS)—CMNS is a mechanism that uses OSI-based network service access point (NSAP) addresses to extend local X.25 switching to nonserial media (for example, Ethernet, FDDI, and Token Ring). This implementation provides the X.25 PLP over Logical Link Control, type 2 (LLC2) to allow connections over nonserial interfaces. The Cisco CMNS implementation supports services defined in ISO Standards 8208 (packet level) and 8802-2 (frame level).
- DDN and BFE X.25—The DDN-specified Standard Service is supported. The DDN X.25 Standard Service is the required protocol for use with DDN Packet-Switched Nodes (PSNs). The Defense Communications Agency (DCA) has certified the Cisco DDN X.25 Standard Service implementation for attachment to the DDN. The Cisco DDN implementation also includes BFE and Blacker Emergency Mode operation.
- X.25 MIB—Subsets of the specifications in *SNMP MIB Extension for X.25 LAPB* (RFC 1381) and *SNMP MIB Extension for the X.25 Packet Layer* (RFC 1382) are supported. The LAPB XID Table, X.25 Cleared Circuit Table, and X.25 Call Parameter Table are not implemented. All values are read-only. To use the X.25 MIB, refer to the RFCs.

The Cisco X.25 implementation does not support fast switching.

