

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 Integrated Services Digital Network (ISDN), packet switching via Frame Relay, and the benefits of both circuit and packet switching via Asynchronous Transfer Mode (ATM). LAN emulation (LANE) provides connectivity between ATM and other LAN types. Refer to the *Dial Solutions Configuration Guide* for further information on configuring ISDN. Refer to the *Cisco IOS Switching Services Configuration Guide* for information on configuring LANE.

Document Objectives

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

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

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

Document Organization

This document includes 7 chapters. The first 4 chapters describe how to configure ATM for the following platform configurations:

- Configuring ATM Access over a Serial Interface
- Configuring ATM on the AIP for Cisco 7500 Series Routers
- Configuring ATM on the ATM Port Adapter for Cisco 7200 and 7500 Series Routers
- Configuring ATM on the NPM for Cisco 4500 and 4700 Routers

The last 3 chapters describe how to configure Frame Relay, SMDS, and LAPB and X.25, respectively.

ATM

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).

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

- Serial interface, in devices that lack an ATM Interface Processor (AIP), ATM port adapter, or network processor module (NPM)
- AIP, in supported routers
- ATM port adapters, in supported routers
- NPM, in supported routers

In routers outside the Cisco 4500, Cisco 4700, Cisco 7200 series, and Cisco 7500 series, a serial interface can be configured for multiprotocol encapsulation over the Asynchronous Transfer Mode-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, Internet Protocol (IP), and Novell Internetwork Packet Exchange protocol (IPX) traffic.

Note 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.

If you configure ATM access over a serial interface, an ATM data service unit (ADSU) is required 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

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 TAXI interfaces, 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.

ATM port adapters are available on Cisco 7200 series routers and on the second-generation Versatile Interface Processor (VIP2) in Cisco 7500 series routers. For a complete description of the ATM port adapter on the Cisco 7200 series and Cisco 7500 series routers, refer to the *PA-A1 ATM Port Adapter Installation and Configuration* publication.

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 Synchronous Optical Network/Synchronous Digital Hierarchy (SONET/SDH) 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 document called “Installing Network Processing Modules in the Cisco 4000 Series” (online, it is in the *Cisco 4000 Series Configuration Notes*).

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 supports the proprietary *Cisco AAL5 MIB* that is an extension to RFC 1695.

ATM Environment

ATM is a connection-oriented environment. All traffic to or from an ATM network is prefaced with a virtual path identifier (VPI) and virtual channel identifier (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 signaling mechanism. This signaling 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 router’s ATM processor card 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. Cisco supports both AAL3/4 and AAL5 on the AIP for Cisco 7500 series routers. On the ATM port adapter for Cisco 7200 series routers and Cisco 7500 series routers, only AAL5 is supported. On the NPM for Cisco 4500 and Cisco 4700 routers, AAL3/4 and AAL5 are supported, but AAL3/4 is not supported at OC-3 rates; if AAL3/4 is configured on an OC-3c interface, you must limit the interface to E3 or DS3 rates by configuring a rate queue. See the “Configure the Rate Queue” section in the “Configuring ATM on the NPM for Cisco 4500 and 4700 Routers” chapter for more information.

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.

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*.

Effective with Cisco IOS Release 11.0, point-to-multipoint signaling allows pseudobroadcasting to be eliminated. On routers with point-to-multipoint signaling, 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.

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 subnetwork (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.

Cisco's 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. Cisco's ATM ARP client works with any ARP server that is fully compliant with RFC 1577.

Cisco AIP

This section provides an overview of the ATM features, interfaces, microcode, and virtual circuits available on the AIP, currently supported on the Cisco 7500 series routers.

AIP Features

The AIP supports the following features:

- Multiple rate queues.
- Reassembly of up to 512 buffers simultaneously. 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.
- Support for both AAL3/4 and AAL5.
- Support for both process-switched transparent bridging and fast-switched transparent bridging over ATM.

Process-switched bridging over ATM supports AAL3/4-SMDS encapsulated packets only. All frames that originate at or are forwarded by the Cisco IOS software are sent as 802.3 bridge frames without frame check sequence (FCS)—that is, in RFC 1483 bridge frame formats with 0x0007 in the Protocol Identification (PID) field of the Subnetwork Access Protocol (SNAP) header. You can enable process-switched bridging for SMDS as described later in this chapter.

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, Fiber Distributed Data Interface (FDDI), and Token Ring packets sent in AAL5-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.
- Support for transmitting 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 signaling cells are not considered raw.)

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 document called “ATM Interface Processor (AIP)” (online, it is in the *Interface Processor Installation and Configuration Guide*) for descriptions of ATM connectors.

The AIP provides an interface to ATM switching fabrics for transmitting 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:

- Transparent Asynchronous Transmitter/Receiver Interface (TAXI) 4B/5B 100-Mbps multimode fiber optic cable
- SONET/SDH 155-Mbps multimode fiber optic cable—STS-3C or STM-1
- SONET/SDH 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).

AIP Microcode

The AIP microcode is a software image that provides card-specific software instructions. An onboard read-only memory (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 downloading procedures, refer to the document called "ATM Interface Processor (AIP)" (online, it is in the *Interface Processor Installation and Configuration Guide*) and the *Configuration Fundamentals Configuration Guide*.

AIP 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 for the AIP when the virtual circuit is created include the following:

- Quality of service (QoS)
- AAL mode—AAL3/4 and AAL5
- Encapsulation type—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 signaling PVC that is used for setting up or tearing down SVCs), SMDS, and PPP over ATM.
- Protocol traffic to be carried—multiprotocol or single-protocol traffic
- Peak and average transmission rates
- Point-to-point or point-to-multipoint

Each virtual circuit supports the following router functions:

- Multiprotocol—AppleTalk, Connectionless Network Service (CLNS), DECnet, IP, IPX, Banyan VINES, and Xerox Network Systems (XNS)
- On routers with a serial interface configured for ATM, fast switching of IP, IPX, AppleTalk, and VINES packets; on the Cisco 7500 series routers, fast switching of AppleTalk, CLNS, IP, IPX and VINES
- Autonomous switching of IP packets
- 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. Autonomous switching must be explicitly enabled per interface.

Cisco ATM Port Adapter

This section provides an overview of the ATM features, interfaces, and virtual circuits available on the ATM port adapter, currently supported on the Cisco 7200 series and Cisco 7500 series routers.

ATM Port Adapter Features

The ATM port adapter supports the following features:

- Segmentation and Reassembly (SAR) of up to 512 buffers simultaneously. Each buffer represents a packet.
- Up to 256 transmit buffers for simultaneous fragmentation.
- 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 SAR virtual circuits.
- Support for AAL5.
- Support for transmitting 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.
- Support for both process-switched transparent bridging and fast-switched transparent bridging over ATM.

Process-switched bridging over ATM supports AAL3/4-SMDS encapsulated packets only. All frames that originate at, or are forwarded by, the Cisco IOS software are sent as 802.3 bridge frames without frame check sequence (FCS)—that is, in RFC 1483 bridge frame formats with 0x0007 in the Protocol Identification (PID) field of the Subnetwork Access Protocol (SNAP) header. You can enable process-switched bridging for SMDS as described later in this chapter.

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, Fiber Distributed Data Interface (FDDI), and Token Ring packets sent in AAL5-SNAP encapsulation over ATM. You can enable fast-switched bridging for AAL5-SNAP as described later in this chapter.

ATM Port Adapter Interface Types

The ATM port adapter provides a single SONET/SDH 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 SONET/SDH multimode or SONET/STC-3C single-mode optical fiber cable (STS-3C or STM-1 physical layer) to connect the router to an external DSU (an ATM network).

ATM Port Adapter 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 for the AIP when the virtual circuit is created include the following:

- AAL mode—AAL5
- Encapsulation type—Logical Link Control (LLC)/SNAP and QSAAL (encapsulation used on a signaling PVC that is used for setting up or tearing down SVCs).
- Protocol traffic to be carried—multiprotocol or single-protocol traffic
- Point-to-multipoint

Each virtual circuit supports the following router functions:

- Multiprotocol—AppleTalk, Connectionless Network Service (CLNS), DECnet, IP, IPX, Banyan VINES, and Xerox Network Systems (XNS)
- On routers with a serial interface configured for ATM, fast switching of IP, IPX, AppleTalk, and VINES packets; on the Cisco 7500 series routers, fast switching of AppleTalk, CLNS, IP, IPX and VINES
- Autonomous switching of IP packets
- Pseudobroadcast support for multicast packets

By default, optimum switching is enabled on all ATM port adapter interfaces.

Cisco NPM

This section provides an overview of the ATM features, interfaces, and virtual circuits available on the NPM, currently supported on the Cisco 4500 and 4700 routers.

NPM Features

The NPM supports the following features:

- Up to four rate queues.
- Reassembly of up to 192 buffers simultaneously. Each buffer represents a packet.
- Support for up to 1023 virtual circuits.
- Fast switching of IP and IPX.
- Support for AAL3/4 and AAL5.

An ATM adaptation layer (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.

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* manual and the *Installing NPMs in the Cisco 4000 Series* manual for descriptions of ATM connectors.

The NPM provides an interface to ATM switching fabrics for transmitting 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 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

NPM Virtual Circuits

A virtual circuit is a point-to-point 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 for the NPM when the virtual circuit is created include the following:

- Quality of service—QoS
- AAL mode—AAL5 or AAL3/4
- Encapsulation type—LLC/SNAP, MUX, NLPID, NLPID/SNAP, RFC 1483, and PPP over ATM
- Protocol traffic to be carried—multiprotocol or single-protocol traffic
- Peak and average transmission rates

Each virtual circuit supports the following router functions:

- Multiprotocol—AppleTalk, CLNS, DECnet, IP, IPX, Banyan VINES, and XNS
- Fast switching of IP, IPX, AppleTalk, and CLNS

Frame Relay

Cisco's Frame Relay implementation currently supports routing on IP, DECnet, AppleTalk, Xerox Network Service (XNS), Novell IPX, International Organization for Standards (ISO) Connectionless Network Service (CLNS), Banyan VINES, and transparent bridging.

Although Frame Relay access was originally restricted to leased lines, dial-up access is now supported. For more information, see the "Configure DDR over Frame Relay" section for dialer profiles or for legacy DDR in the "Configuring DDR" chapter.

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 *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 *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 International Telecommunication Union Telecommunication Standardization Sector (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 1294, 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.

Switched virtual circuits (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 queuing support on a per-virtual circuit basis—Custom queuing, priority queuing, and weighted fair queuing 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 Address Resolution Protocol (Inverse ARP) as described in RFC 1293 for the AppleTalk, Banyan VINES, DECnet, IP, and IPX protocols, as well as 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. Cisco's 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 does not have to 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 permanent virtual circuits (PVCs) under separate subinterfaces, which in turn are located under a single physical interface. See the “Configure Frame Relay Subinterfaces” and the “Subinterface Examples” sections in the “Configuring Frame Relay” chapter of this publication.
- Support for fast-path transparent bridging, as described in RFC 1490, for Frame Relay encapsulated serial and High-Speed Serial Interfaces) (HSSI) on all platforms.
- Support of the Frame Relay DTE Management Information Base (MIB) specified in RFC 1315. However, the error table is not implemented. To use the Frame Relay MIB, refer to your MIB publications.

SMDS

Cisco’s 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 DS-1 or DS-3 high-speed transmission facilities. Connection to the network is made through a device called an *SDSU*—an SMDS channel service unit/digital service unit (CSU/DSU) developed jointly by Cisco Systems and Kentrox. The SDSU attaches to a Cisco router or access server through a serial port. On the other side, the SDSU terminates the line.

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

Cisco’s implementation of SMDS also supports SMDS encapsulation over an Asynchronous Transfer Mode (ATM) interface. For more information and for configuration tasks, see the configuring ATM chapters in this publication.

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 *Network Protocols Configuration Guide, Part 1* for information about how our software handles possible split horizon conflicts. By default, split horizon is *disabled* for SMDS networks.

Cisco’s 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.

Cisco’s 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.

LAPB and X.25

X.25 is one of a group of specifications published by the International Telecommunication Union Telecommunication Standardization Sector (ITU-T); these specifications are international standards that are formally called *Recommendations*. The ITU-T Recommendation X.25 defines how connections between data terminal equipment (DTE) and data communications equipment (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 Link Access Procedure, Balanced (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 X.25 Recommendation packet layer. Cisco's X.25 software follows the ITU-T 1984 X.25 Recommendation, except for its Defense Data Network (DDN) and Blacker Front End (BFE) operation, which follow the ITU-T 1980 X.25 Recommendation.

Note The ITU-T carries out the functions of the former Consultative Committee for International Telegraph and Telephone (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, Cisco's 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 *Network Protocols Configuration Guide, Part 1*, *Network Protocols Configuration Guide, Part 2*, and *Network Protocols Configuration Guide, Part 3*.

Briefly, 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 a host's X.25 address and its datagram protocol addresses allow these datagrams to be routed through an X.25 network, thereby allowing an X.25 public data network (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 (*X.25-over-TCP* or *XOT*, previously called *remote switching* or *tunneling*). XOT encapsulates the X.25 packet level inside a TCP connection, allowing X.25 equipment to be connected via a TCP/IP-based network. Cisco's 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 public data network (PDN).

- ISDN D Channel—X.25 traffic over the D channel (up to a speed of 9.6 kbps) 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 over the ISDN D channel, refer to the “Configuring X.25 on ISDN” chapter in the *Dial Solutions Configuration Guide*.
- 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. Cisco’s 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 Cisco Systems’ DDN X.25 Standard Service implementation for attachment to the Defense Data Network. Cisco’s DDN implementation also includes Blacker Front End (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.

Cisco’s X.25 implementation does not support fast switching.

