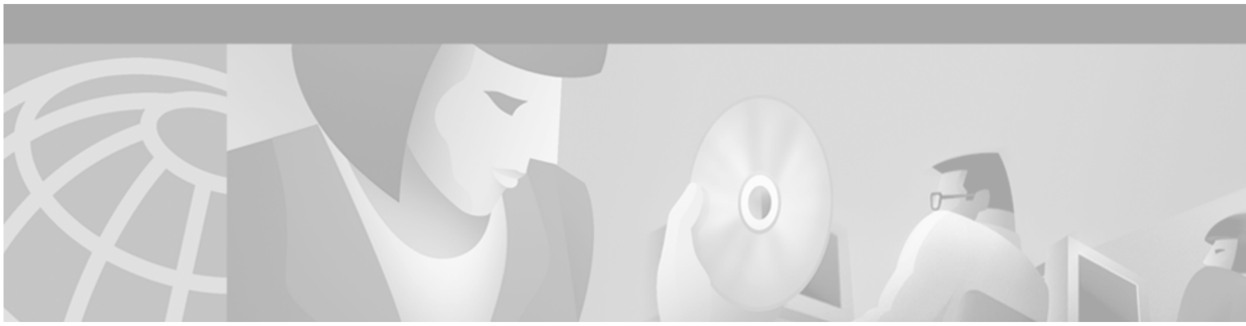

# Wide-Area Networking Overview

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 Asynchronous Transfer Mode (ATM). LAN emulation (LANE) provides connectivity between ATM and other LAN types. Refer to the *Cisco IOS Dial Technologies Configuration Guide: Volume 1 of 2* 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
- Broadband Access: PPP and Routed Bridge Encapsulation
- 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

The *Cisco IOS Wide-Area Networking Configuration Guide* includes the following chapters:

- Configuring ATM
- Configuring Broadband Access: PPP and Routed Bridge Encapsulation
- 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 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 or point-to-multipoint 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 permanent virtual circuit (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 V3.0/3.1/4.0.

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 relevant to the router only when it is equipped with either a CES (Circuit Emulation Service) ATM interface card, or when it has voice over AAL2 capabilities. 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, in supported routers
- ATM Port Adapter, Enhanced Port Adapter, and ATM-CES Port Adapter, in supported routers
- Network Processor Module, in supported routers
- 1-Port ATM-25 Network Module, in supported routers
- ATM OC-3 Network Modules, 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

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 ATM interface processor (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

Cisco 4500 and Cisco 4700 routers support one OC-3c network processor module (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* at http://www.cisco.com/univercd/cc/td/doc/product/access/acs_mod/cis2600/net_mod2/conntatm.htm.

## ATM OC-3 Network Modules

The ATM OC-3 network modules are available on the Cisco 3600 series routers. For complete information about installing this network module, refer to *Connecting ATM Network Modules* at http://www.cisco.com/univercd/cc/td/doc/product/access/acs_mod/cis2600/net_mod2/conntatm.htm.

## 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 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.

## Multiport T1/E1 ATM Port Adapter with Inverse Multiplexing over ATM

The multiport T1/E1 ATM port adapters with inverse multiplexing over ATM are available on the Cisco 7100, Cisco 7200, and Cisco 7500 series routers. For more information about the physical characteristics of the ATM T1 or E1 IMA port adapters for the Cisco 7200 series routers, or for instructions on how to install the port adapters, see the *Inverse Multiplexing over ATM (IMA) Port Adapter Installation and Configuration Guide* that came with your ATM T1 or E1 IMA port adapter or find you platform-specific port adapter installation instructions at http://www.cisco.com/univercd/cc/td/doc/product/core/index.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 modules, 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 modules.
- Support for up to 256 virtual circuits on each interface of the multiport T1/E1 ATM network modules with inverse multiplexing over ATM (IMA) on Cisco 2600 and Cisco 3600 series routers.
- Support for up to 512 virtual circuits on each User-Network Interface (UNI) and 512 interface virtual circuits per link on each IMA interface of the multiport T1/E1 ATM port adapter with inverse multiplexing over ATM on Cisco 7100, Cisco 7200, and Cisco 7500 series routers.
- Support for permanent virtual path connections (PVPs).
- Support for AAL3/4 and AAL5 (AAL3/4 is is supported on the Cisco 4500 and 4700 series routers and on the AIP for Cisco 7000 series routers only.)
- 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 operation, administration, and maintenance (OAM) end-to-end loopback, segment loopback, Alarm Indication Signal (AIS), and Remote Defect Indication (RDI) F4 and F5 cells.
- 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 OC-3/STM-1 ATM Circuit Emulation Service network module and 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
- 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 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 modules has a single SC connector with signals compliant with the ATM Forum recommendation for the 155 Mbps multimode fiber 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 T1 and E1 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 supported on the Cisco 4500 and 4700 series routers and on the AIP for Cisco 7000 series routers only)

- 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 *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.

# Broadband Access: PPP and Routed Bridge Encapsulation

Cisco IOS software supports a wide range of features and applications that enable a central office broadband aggregator to provide the service and network selection capabilities required in the delivery of advanced broadband services.

The following features and applications are supported:

- PPP over ATM—Enables a high-capacity central site router with an ATM interface to terminate multiple remote PPP connections. The benefits of PPP over ATM include security validation per user, IP address pooling, and service selection capability.
- PPP over Ethernet (PPPoE) over ATM—Provides the ability to connect a network of hosts over a simple bridging-access device to a remote access concentrator. With this model, each host utilizes its own PPPoE stack, and the user is presented with a familiar user interface. Access control, billing, and service selection can be configured on a per-user, rather than a per-site, basis.
- PPPoE over Ethernet—Provides direct connection to Ethernet interfaces. This Ethernet specification can be used by multiple hosts on a shared Ethernet interface to open PPP sessions to multiple destinations with one or more bridging modems.
- PPPoE over IEEE 802.1Q VLANs—Enables the connection of a VLAN-capable router with other VLAN-capable networking devices.
- ATM Routed Bridge Encapsulation—Routes IP over bridged RFC 1483 Ethernet traffic from a stub-bridged LAN. ATM routed bridge encapsulation reduces the security risk associated with normal bridging by reducing the size of the nonsecured network.

- ATM PVC range and routed bridge encapsulation subinterface grouping—Enables the configuration of a number of PVCs at once, saving configuration time and NVRAM and speeding boot-up time.
- PPPoE RADIUS port identification—Enables an L2TP access concentrator (LAC) and an LT2P network server (LNS) to identify and forward NAS-Port and NAS-Port-Type attribute values for PPPoE over ATM and PPPoE over IEEE 802.1Q VLANs.

To configure a central office aggregator for broadband access, see the chapter "Configuring Broadband Access: PPP and Routed Bridge Encapsulation."

# 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, for dialer profiles or for legacy dial-on-demand routing (DDR) see the see the section "Dial-on-Demand Routing Configuration" in the *Cisco IOS Dial Technologies Configuration Guide: Volume 1 of 2*.

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 chapter "Loading and Maintaining System Images" 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.

  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.

  The Cisco implementation of Frame Relay switching provides the following functionality:
  - Switching over an IP tunnel
  - Switching over Network-to-Network Interfaces (NNI) to other Frame Relay switches
  - Local serial-to-serial switching
  - Switching over ISDN B channels
  - Traffic shaping on switched PVCs
  - Congestion management on switched PVCs
  - Traffic policing on User-Network Interface (UNI) DCE
  - FRF.12 fragmentation on switched PVCs
- 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.
- Support for Frame Relay fragmentation. Cisco has developed the following three types of Frame Relay fragmentation:
  - End-to-End FRF.12 Fragmentation

    FRF.12 fragmentation is defined by the FRF.12 Implementation Agreement. This standard was developed to allow long data frames to be fragmented into smaller pieces (fragments) and interleaved with real-time frames. End-to-end FRF.12 fragmentation is recommended for use on PVCs that share links with other PVCs that are transporting voice and on PVCs transporting Voice over IP (VoIP).
  - Frame Relay Fragmentation Using FRF.11 Annex C

    When VoFR (FRF.11) and fragmentation are both configured on a PVC, the Frame Relay fragments are sent in the FRF.11 Annex C format. This fragmentation is used when FRF.11 voice traffic is sent on the PVC, and it uses the FRF.11 Annex C format for data.

    See the chapter “Configuring Voice over Frame Relay” in the *Cisco IOS Voice, Video, and Fax Configuration Guide* for configuration tasks and examples for Frame Relay fragmentation using FRF.11 Annex C.
  - Cisco Proprietary Fragmentation

    Cisco proprietary fragmentation is used on data packets on a PVC that is also used for voice traffic.

    See the chapter “Configuring Voice over Frame Relay” in the *Cisco IOS Voice, Video, and Fax Configuration Guide* for configuration tasks and examples for Cisco proprietary fragmentation.

# Frame Relay-ATM Internetworking

Cisco IOS software supports the Frame Relay Forum implementation agreements for Frame Relay-ATM Interworking. Frame Relay-ATM Interworking enables Frame Relay and ATM networks to exchange data, despite differing network protocols. There are two types of Frame Relay-ATM Interworking:

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

## FRF.5 Frame Relay-ATM Network Interworking

FRF.5 provides network interworking functionality that allows Frame Relay end users to communicate over an intermediate ATM network that supports FRF.5. Multiprotocol encapsulation and other higher-layer procedures are transported transparently, just as they would be over leased lines.

FRF.5 describes network interworking requirements between Frame Relay Bearer Services and Broadband ISDN (BISDN) permanent virtual circuit (PVC) services.

The FRF.5 standard is defined by the Frame Relay Forum Document Number FRF.5: *Frame Relay/ATM PVC Network Interworking Implementation Agreement.* For detailed information about which sections of this implementation agreement are supported by Cisco IOS software, Release 12.2, see Appendix A, “Frame Relay-ATM Interworking Supported Standards.”

## FRF.8 Frame Relay-ATM Service Interworking

FRF.8 provides service interworking functionality that allows a Frame Relay end user to communicate with an ATM end user. Traffic is translated by a protocol converter that provides communication among dissimilar Frame Relay and ATM equipment.

FRF.8 describes a one-to-one mapping between a Frame Relay PVC and an ATM PVC.

The FRF.8 standard is defined by the Frame Relay Forum Document Number FRF.8: *Frame Relay/ATM PVC Network Service Interworking Implementation Agreement.* For detailed information about which sections of this implementation agreement are supported by Cisco IOS software, Release 12.2, see Appendix A, "Frame Relay-ATM Interworking Supported Standards."

# 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 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 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 chapters “Configuring X.25 on ISDN” and “Configuring X.25 on ISDN Using AO/DI” in the *Cisco IOS Dial Technologies 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. 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 Blacker Front End 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.
- Closed User Groups (CUGs)—A CUG is a collection of DTE devices for which the network controls access between two members and between a member and a nonmember. An X.25 network can support up to 10,000 CUGs. CUGs allow various network subscribers (DTE devices) to be segregated into private subnetworks that have limited incoming or outgoing access.

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