NEAR EAST UNIVERSITY

FACULTY OF ENGINEERING

Department Of Computer Engineering

ATM Networking

Graduation Project
Com- 400

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Lefkosa- January -2001

ACKNOWLEDGEMENTS

First of all I am happy to complete the task which I had given with blessing of God, I would like to thanks my dearest parents for their continued guidance and prayer.

I wish to thank my supervisor **Prof. Dr. Fakhreddin Mamedov** for intellectual support, encouragement, and enthusiasm, which made this project possible, and his patience for correcting both my stylistic and scientific errors.

My sincerest thanks must go to my friends, Nazik Euybolu, Muhammad Ali, Who shared their suggestion and evaluation throughout the completion of my project, The comments from these friends enabled me to present this project successfully.

ABBREVIATION

Atm asynchronous transfer mode

ATMP Atm protocol

Atp acceptance test plan

ATV advanced television

BDF buliding distribution frame

BICI board band intercarrier interface

BICISI Building industry consulting services, International

B-ISDN Broad band integrated services, International

BNI broad band networks, Inc.

BT burst tolerance

BTA basic trade area

BUS broad cost and unknown server

CAC connaction admission control

CAD customer access device

CM cable modem

CLP cell loss priority

C/N carrier –to-noise ratio

CoS class of service

DFB direct feed back

DSL digital subscriber line

FR frame relay

GFC generic frame control

ICR initial cell rate

IP internet protocol

IPX internet packet exchange

LED light emitting diode

LEO low earth orbit

LAN lane service (ATM)

MCR maximum cell rate

MDU multiple dwelling unit

MTA major trading area

OC optical carrier

OSI open system interconnection

OSS operation support system

TOP technical and office protocol

VBR variable bit rate

VLAN virtual lane

VOD video on demand

WAN wide area net work

WLL wireless local loop

ABSTRACT

Asynchronous Transfer Mode (ATM) has been standardized by the ITU-T as the common data transport technology for Broadband ISDN. It is intended to support varied services, such as video, audio, image, and packet data. This project looks at a variety of issues associated with applying ATM to the task of supporting a small, multimedia LAN. The terminal contains ATM Adaptation Layer (AAL) services implemented in software, and a customized network interface to re-route ATM cells and separate video, audio, and packet data at the lowest possible level.

Traffic traces from a live IP network are used to analyze the probable impact of running IP over ATM connections. The average cell utilization is calculated separately for WAN and LAN oriented traffic, and the impact of varying the cells payload size is assessed. For WAN traffic the 48 byte cell payload is poor (a finding consistent with other work in this area). However, for LAN traffic, cell payloads between 40 and 96 bytes achieve roughly comparable cell utilization. Header compression of the IP traffic's TCP component is shown to provide a marginal improvement for LAN oriented traffic, and a significant improvement for WAN traffic. The value of matching sample lengths of packet audio to the underlying ATM cell size is discussed.

Development of an ATM LAN requires a signaling protocol. This project describes a protocol designed to be simple, low overhead, and able to create UNI cast and multicast Virtual Channel and Virtual Path connections. A key point is its support for point-to-point or shared-media technologies on switch ports, allowing an ATM LAN to be based on traditional fibers, alternative wire based media, and future wireless ATM systems.

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INTRODUCTION

In the emerging field of high-speed virtual networking, Asynchronous Transfer Mode (ATM) is a key component. ATM is a telecommunications concept defined by ANSI and ITU (formally CCITT) standards for carriage of a complete range of user traffic, including voice, data, and made signals, on any User-to-Network Interface (ITN). As such, ATM is extremely well suited to high speed networking in the 1990s. ATM technology can be used to aggregate user traffic from existing applications onto a single UNI (e.g. PBX tie trunks, host-to-host private lines, video conference circuits), and to facilitate multi-media networking between high speed devices (e.g. workstations, supercomputers, routers or bridges) at multi-megabit Speeds (e.g. 150-M bit/s).

On the basis of its numerous strengths, ATM has been chosen by standards committees (e.g. ANSI T1, ITU SG XIII) as an underlying transport technology within much Broadband Integrated Services Digital Network (B-ISDN) protocol stacks. In this context, "transport" refers to the use of ATM switching and multiplexing techniques at the data link layer (i.e., OSI Layer 2) to convey end-user traffic from source to 35destination within a network.

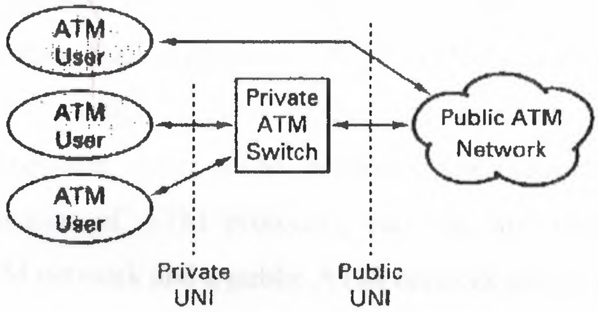
While B-ISDN is a definition for public networks, ATM can also be used within private networking products. In recognition of this fact, and for clarity, this document defines two distinct forms of ATM UNI:

1. **Public UNI** which will typically be used to interconnect an ATM user with an ATM switch deployed in a public service provider's network,
2. **Private UNI** which will typically be used to interconnect an ATM user with an ATM switch that is managed as part of the same corporate network (e.g., MIS department responsible for the user device is also responsible for the private ATM switch).

The primary distinction between these two classes of UNI is physical reach. There is also some functionality differences between the public and private UNI due to the applicable requirements associated with each of these interfaces. Both UNIs share an ATM layers specification, but may utilize different physical media. Facilities that connect users to switches in public central offices must be capable of spanning long distances. In contrast, private switching equipment can often be located in the same room as the user device (e.g. computer, PBX), and hence can use limited distance technologies.

The term "ATM user" represents any device that makes use of an ATM network via an ATM UNI, as illustrated in Figure 1-1.

Figure 1-1 Implementations of the ATM UNI



For example, an ATM user device may be either of the following:

- An Intermediate System (IS), such as an IP router, that encapsulates data into ATM cells, and then forwards the cells across an ATM UNI to a switch (either privately owned, or within a public network),
- A private network ATM switch, which uses a public network ATM service for the transfer of ATM cells (between public network Unisia) to connect to other ATM user devices.

The carriage of user information within ATM format cells is defined in standards as the "ATM Bearer Service". Implementation of an ATM bearer service involves the specification of both an ATM protocol layer (Layer 2) and a compatible physical media (Layer 1). The scope of the document includes the following:

- Background information on ATM technology and protocols used for broadband networking.
- The initial service attributes defined at the User-Network Interface.

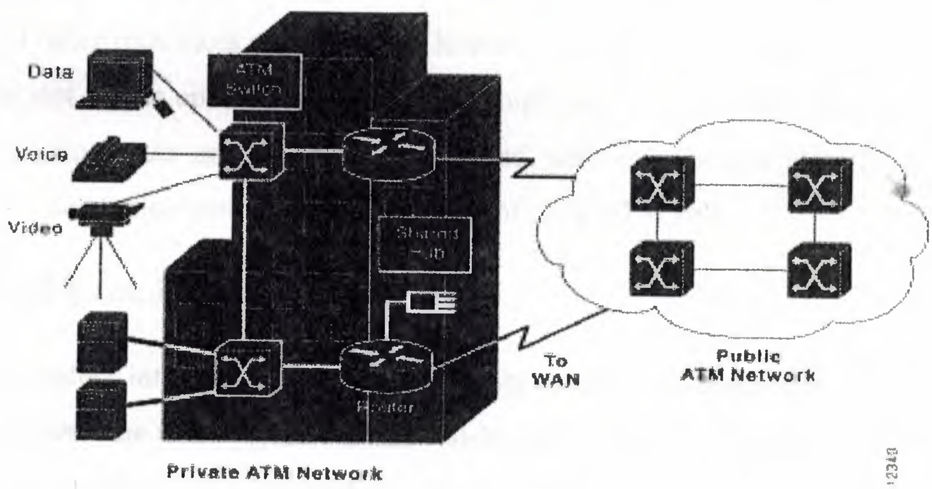
The set of physical layer specifications supported for the carriage of ATM cells.

1. Asynchronous Transfer Mode (ATM) Switching

1.1 Background

Asynchronous Transfer Mode (ATM) is an International Telecommunication union- Telecommunication Standardization Sector (ITU-T) standard for cell relay wherein information for multiple service types, such as voice, video, or data, is conveyed in small, fixed-size cells. ATM networks are connection oriented. This chapter provides summaries of ATM protocols, services, and operation. Figure 1-1 illustrates a private ATM network and a public ATM network carrying voice, video, and data traffic.

Figure 1-1: A private ATM network and a public ATM network both can carry voice, video, and data traffic.



1.2 Standards

ATM is based on the efforts of the ITU-T Broadband Integrated Services Digital Network (BISDN) standard. It was originally conceived as a high-speed transfer technology for voice, video, and data over public networks. The ATM Forum extended the ITU-T's vision of ATM for use over public *and* private networks. The ATM Forum has released work on the following specifications:

- User-to-Network Interface (UNI) 2.0
- UNI 3.0
- UNI 3.1
- Public-Network Node Interface (P-NNI)
- LAN Emulation (LANE)

1.3 ATM Devices and the Network Environment

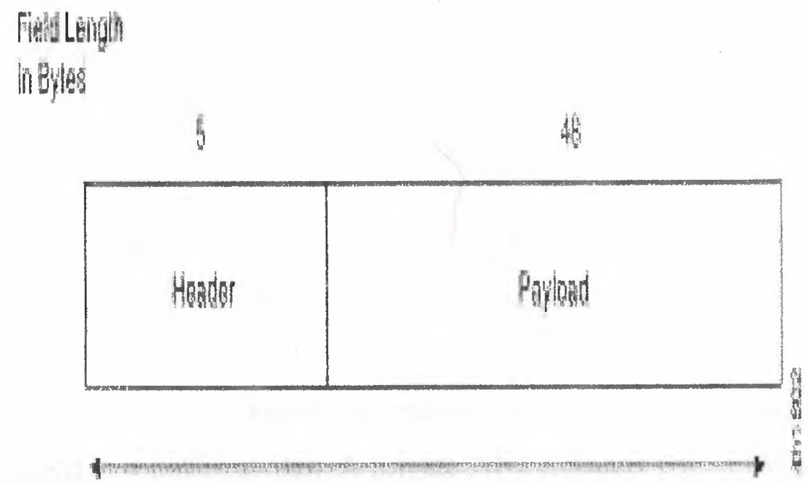
ATM is a cell-switching and multiplexing technology that combines the benefits of circuit switching (guaranteed capacity and constant transmission delay) with those of packet switching (flexibility and efficiency for intermittent traffic). It provides scalable bandwidth from a few megabits per second (Mbps) to many gigabits per second (Gbps). Because of its asynchronous nature, ATM is more efficient than synchronous technologies, such as time-division multiplexing (TDM).

With TDM, each user is assigned to a time slot, and no other station can send in that time slot. If a station has a lot of data to send, it can send only when its time slot comes up, even if all other time slots are empty. If, however, a station has nothing to transmit when its time slot comes up, the time slot is sent empty and is wasted. Because ATM is asynchronous, time slots are available on demand with information identifying the source of the transmission contained in the header of each ATM cell.

1.4 ATM Cell Basic Format

ATM transfers information in fixed-size units called *cells*. Each cell consists of 53 octets, or bytes. The first 5 bytes contain cell-header information, and the remaining 48 contain the "payload" (user information). Small fixed-length cells are well suited to transferring voice and video traffic because such traffic is intolerant of delays that result from having to wait for a large data packet to download, among other things. Figure 1-2 illustrates the basic format of an ATM cell.

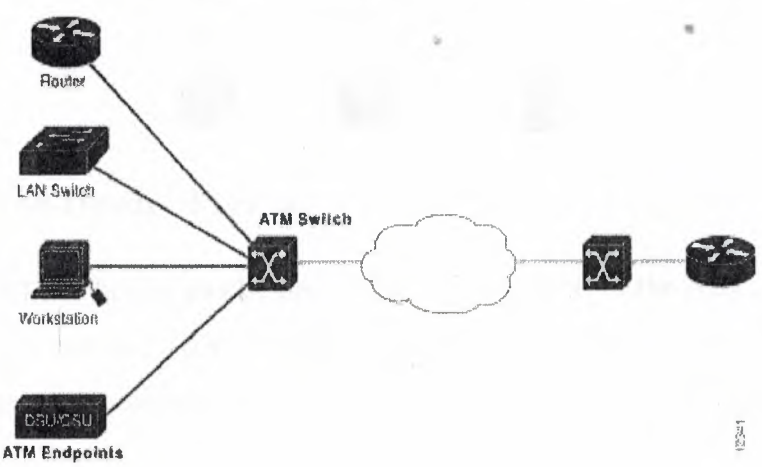
Figure 1-2: An ATM network comprises ATM switches and endpoints.



1.5 ATM Devices

An ATM network is made up of an ATM *switch* and ATM endpoints. An ATM switch is responsible for cell transit through an ATM network. The job of an ATM switch is well defined: it accepts the incoming cell from an ATM endpoint or another ATM switch. It then reads and updates the cell-header information and quickly switches the cell to an output interface toward its destination. An ATM endpoint (or end system) contains an ATM network interface adapter. Examples of ATM endpoints are workstations, routers, digital service units (DSUs), LAN switches, and video coder-decoders (CODECs). Figure 1-3 illustrates an ATM network made up of ATM switches and ATM endpoints.

Figure 1-3: An ATM network comprises ATM switches and endpoints.



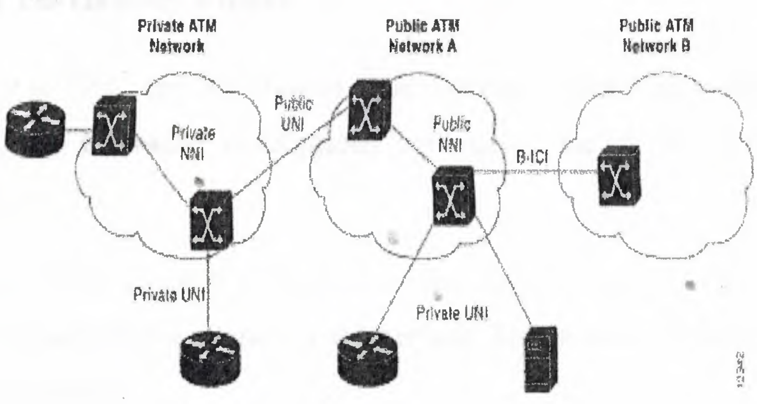
1.6 ATM Network Interfaces

An ATM network consists of a set of ATM switches interconnected by point-to-point ATM links or interfaces. ATM switches support two primary types of interfaces: UNI and NNI. The UNI connects ATM end systems (such as hosts and routers) to an ATM switch. The NNI connects two ATM switches.

Depending on whether the switch is owned and located at the customer's premises or publicly owned and operated by the telephone company, UNI and NNI can be further subdivided into public and private UNIs and NNIs. A private UNI connects an ATM endpoint and a private ATM switch. Its public counterpart connects an ATM endpoint or private switch to a public switch. A private NNI connects two ATM switches within the same private organization. A public one connects two ATM switches within the same public organization.

An additional specification, the Broadband Interchange Carrier Interconnect (B-ICI), connects two public switches from different service providers. Figure 1-4 illustrates the ATM interface specifications for private and public networks.

Figure 1-4: ATM interface specifications differ for private and public networks.

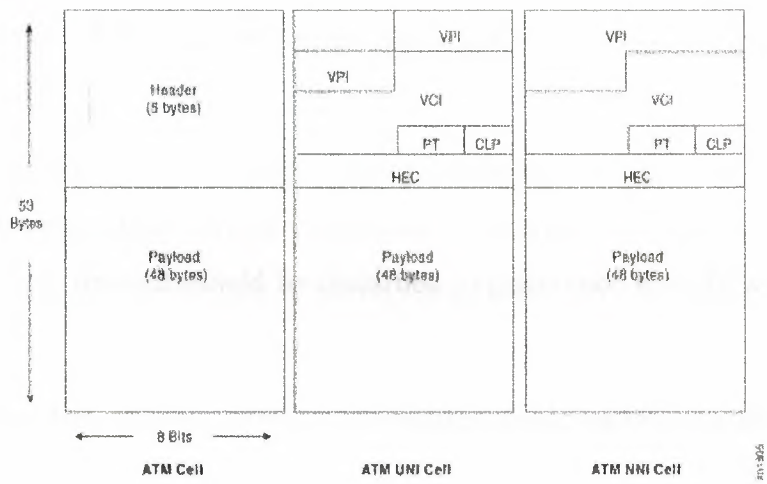


1.7 ATM Cell-Header Format

An ATM cell header can be one of two formats: UNI or the NNI. The UNI header is used for communication between ATM endpoints and ATM switches in private ATM networks. The NNI header is used for communication between ATM switches. Figure

1-5 depicts the basic ATM cell format, the ATM UNI cell-header format, and the ATM NNI cell-header format.

Figure 1-5: An ATM cell, UNI cell, and ATM NNI cell header each contain 48 bytes of payload.



Unlike the UNI, the NNI header does not include the Generic Flow Control (GFC) field. Additionally, the NNI header has a Virtual Path Identifier (VPI) field that occupies the first 12 bits, allowing for larger trunks between public ATM switches.

1.7.1 ATM Cell-Header Fields

In addition to GFC and VPI header fields, several others are used in ATM cell-header fields. The following descriptions summarize the ATM cell-header fields illustrated in figure 1-5.

- Generic Flow Control (GFC)---Provides local functions, such as identifying multiple stations that share a single ATM interface. This field is typically not used and is set to its default value.

- Virtual Path Identifier (VPI)---In conjunction with the VCI, identifies the next destination of a cell as it passes through a series of ATM switches on the way to its destination.

- Virtual Channel Identifier (VCI)---In conjunction with the VPI, identifies the next destination of a cell as it passes through a series of ATM switches on the way to its destination.

- Payload Type (PT)---Indicates in the first bit whether the cell contains user data or control data. If the cell contains user data, the second bit indicates congestion, and the third bit indicates whether the cell is the last in a series of cells that represent a single AAL5 frame.

- Congestion Loss Priority (CLP)---Indicates whether the cell should be discarded if it encounters extreme congestion as it moves through the network. If the CLP bit equals 1, the cell should be discarded in preference to cells with the CLP bit equal to zero.

- Header Error Control (HEC)---Calculates checksum only on the header itself.

1.8 ATM Services

Three types of ATM services exist: *permanent virtual* circuits (PVC), *switched virtual* circuits (SVC), and *connectionless service* (which is similar to SMDS).

A PVC allows direct connectivity between sites. In this way, a PVC is similar to a leased line. Among its advantages, a PVC guarantees availability of a connection and does not require call setup procedures between switches. Disadvantages of PVCs include static connectivity and manual setup.

An SVC is created and released dynamically and remains in use only as long as data is being transferred. In this sense, it is similar to a telephone call. Dynamic call control requires a signaling protocol between the ATM endpoint and the ATM switch. The advantages of SVCs include connection flexibility and call setup that can be handled automatically by a networking device. Disadvantages include the extra time and overhead required to set up the connection.

1.9 ATM Virtual Connections

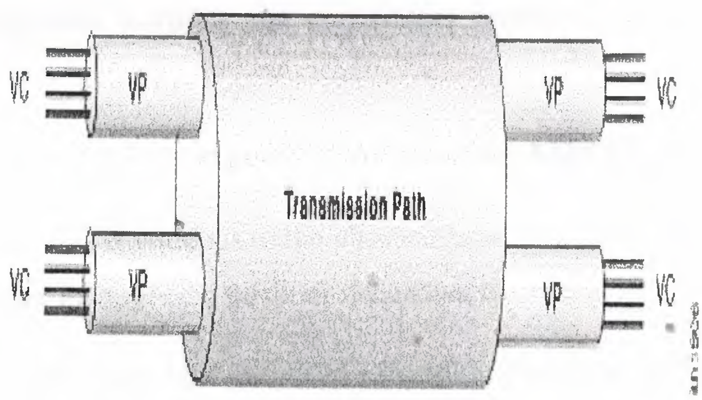
ATM networks are fundamentally connection oriented, which means that a virtual channel (VC) must be set up across the ATM network prior to any data transfer. (A virtual channel is roughly equivalent to a virtual circuit.)

Two types of ATM connections exist: virtual paths, which are identified by virtual path identifiers, and virtual channels, which are identified by the combination of a VPI and a virtual channel identifier (VCI).

A virtual path is a bundle of virtual channels, all of which are switched transparently across the ATM network on the basis of the common VPI. All VCIs and VPIs, however, have only local significance across a particular link and are remapped, as appropriate, at each switch.

A transmission path is a bundle of VPs.Figure 1-6 illustrates how VCs concatenate to create VPs, which, in turn, concatenate to create a transmission path.

Figure 1-6: VC concatenate to create VPs.



1.10 ATM Switching Operations

The basic operation of an ATM switch is straightforward: The cell is received across a link on a known VCI or VPI value. The switch looks up the connection value in a local translation table to determine the outgoing port (or ports) of the connection and the new VPI/VCI value of the connection on that link. The switch then retransmits the cell on that outgoing link with the appropriate connection identifiers. Because all VCIs and VPIs have only local significance across a particular link, these values are remapped, as necessary, at each switch.

1.11 ATM Reference Model

The ATM architecture uses a logical model to describe the functionality it supports. ATM functionality corresponds to the physical layer and part of the data link layer of the OSI reference model.

The ATM reference model is composed of the following planes, which span all layers:

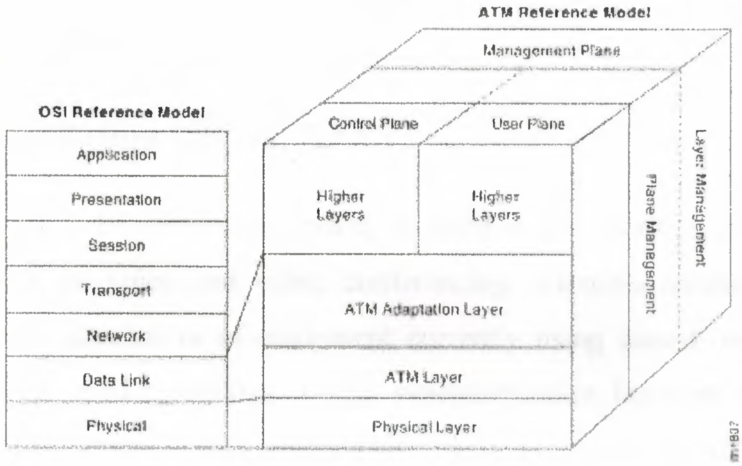
- *Control*---This plane is responsible for generating and managing signaling requests.
- *User*--- This plane is responsible for managing the transfer of data.
- Management--- This plane contains two components:
- Layer management manages layer-specific functions, such as the detection of failures and protocol problems.
- Plane management manages and coordinates functions related to the complete system.

The ATM reference model is composed of the following ATM layers:

- *Physical layer*---Analogous to the physical layer of the OSI reference model, the ATM physical layer manages the medium-dependent transmission.
- *ATM layer*---Combined with the ATM adaptation layer, the ATM layer is roughly analogous to the data link layer of the OSI reference model. The ATM layer is responsible for establishing connections and passing cells through the ATM network. To do this, it uses information in the header of each ATM cell.
- ATM adaptation layer (AAL)---Combined with the ATM layer, the AAL is roughly analogous to the data data-link layer of the OSI model. The AAL is responsible for isolating higher-layer protocols from the details of the ATM processes.

Finally, the higher layers residing above the AAL accept user data, arrange it into packets, and hand it to the AAL.figure1-7 illustrates the ATM reference model.

Figure 1-7: The ATM reference model relates to the lowest two layers of the OSI reference model.



1.12 The ATM Physical Layer

The ATM physical layer has four functions: bits are converted into cells, the transmission and receipt of bits on the physical medium are controlled, ATM cell boundaries are tracked, and cells are packaged into the appropriate types of frames for the physical medium.

The ATM physical layer is divided into two parts: the physical medium-dependent (PMD) sub layer and the transmission-convergence *(TC)* sub layer.

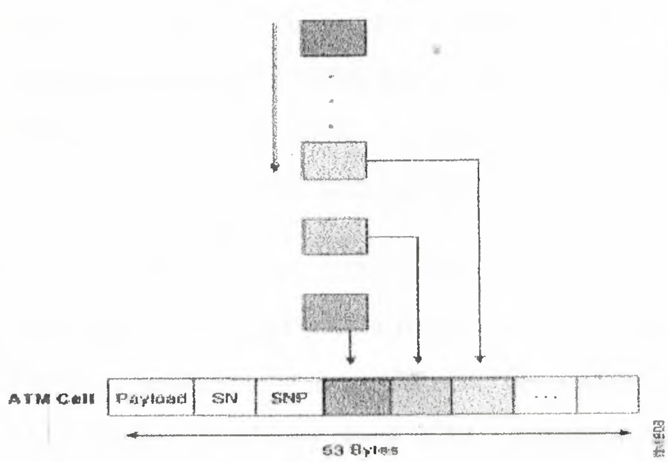
The PMD sub layer provides two key functions. First, it synchronizes transmission and reception by sending and receiving a continuous flow of bits with associated timing information. Second, it specifies the physical media for the physical medium used, including connector types and cable. Examples of physical medium standards for ATM include Synchronous Optical Network/Synchronous Digital Hierarchy (SONET/SDH), DS-3/E3, 155 Mbps over multimode fiber (MMF) using the 8B/10B encoding scheme, and 155 Mbps 8B/10B over shielded twisted-pair (STP) cabling.

The TC sub layer has four functions: cell delineation, header error-control (HEC) sequence generation and verification, cell-rate decoupling, and transmission-frame adaptation. The cell delineation function maintains ATM cell boundaries, allowing devices to locate cells within a stream of bits. HEC sequence generation and verification generates and checks the header error-control code to ensure valid data. Cell-rate decoupling maintains synchronization and inserts or suppresses idle (unassigned) ATM cells to adapt the rate of valid ATM cells to the payload capacity of the transmission system. Transmission frame adaptation packages ATM cells into frames acceptable to the particular physical-layer implementation.

1.13 ATM Adaptation Layers: AAL1

AAL1, a connection-oriented service, is suitable for handling circuit-emulation applications, such as voice and video conferencing. Circuit-emulation service also accommodates the attachment of equipment currently using leased lines to an ATM backbone network. AAL1 requires timing synchronization between the source and destination. For this reason, AAL1 depends on a medium, such as SONET, that supports clocking. The AAL1 process prepares a cell for transmission in three steps. First, synchronous samples (for example, 1 byte of data at a sampling rate of 125 microseconds) are inserted into the Payload field. Second, Sequence Number (SN) and Sequence Number Protection (SNP) fields are added to provide information that the receiving AAL1 uses to verify that it has received cells in the correct order. Third, the remainder of the Payload field is filled with enough single bytes to equal 48 bytes. Figure 1-8 illustrates how AAL1 prepares a cell for transmission.

Figure 1-8: AAL1 prepares a cell for transmission so that the cells retain their order.



1.13.1 ATM Adaptation Layers: AAL3/4

AAL3/4 supports both connection-oriented and connectionless data. It was designed for network service providers and is closely aligned with Switched Data Service (SMDS). AAL3/4 is used to transmit SMDS packets over an ATM network.

AAL3/4 prepares a cell for transmission in four steps. First, the convergence sub layer *(CS) creates a* protocol data unit (PDU) by pretending a beginning/end tag header to the frame and appending a length field as a trailer. Second, the segmentation and reassembly *(SAR)* sub layer fragments the PDU and pretends a header to it. Then, the SAR sub layer appends a CRC-10 trailer to each PDU fragment for error control. Finally, the completed SAR PDU becomes the Payload field of an ATM cell to which the ATM layer pretends the standard ATM header.

An AAL 3/4 SAR PDU header consists of Type, Sequence Number, and Multiplexing Identifier fields. Type fields identify whether a cell is the beginning, continuation, or end of a message. Sequence number fields identify the order in which cells should be reassembled.

The Multiplexing Identifier field determines which cells from different traffic sources are interleaved on the same virtual circuit connection (VCC) so that the correct cells are reassembled at the destination.

1.13.2 ATM Adaptation Layers: AAL5

AAL5 is the primary AAL for data and supports both connection-oriented and connectionless data. It is used to transfer most non-SMDS data, such as classical IP over ATM and LAN Emulation (LANE). AAL5 also is known as the simple and efficient adaptation layer (SEAL) because the SAR sub layer simply accepts the CS-PDU and segments it into 48-octet SAR-PDUs without adding any additional fields.

AAL5 prepares a cell for transmission in three steps. First, the CS sub layer appends a variable-length pad and an 8-byte trailer to a frame. The pad ensures that the resulting PDU falls on the 48-byte boundary of an ATM cell. The trailer includes the length of the frame and a 32-bit cyclic redundancy check (CRC) computed across the entire PDU. This allows the AAL5 receiving process to detect bit errors, lost cells, or cells that are out of sequence. Second, the SAR sub layer segments the CS-PDU into 48-byte blocks. A header and trailer are not added (as is in AAL3/4), so messages cannot be interleaved. Finally, the ATM layer places each block into the Payload field of an ATM cell. For all cells except the last, a bit in the Payload Type (PT) field is set to zero to indicate that the cell is not the last cell in a series that represents a single frame. For the last cell, the bit in the PT field is set to one.

1.14 ATM Addressing

The ITU-T standard is based on the use of E.164 addresses (similar to telephone numbers) for public ATM (BISDN) networks. The ATM Forum extended ATM addressing to include private networks. It decided on the sub network or overlay model of addressing, in which the ATM layer is responsible for mapping network-layer addresses to ATM addresses. This sub network model is an alternative to using network-layer protocol addresses (such as IP and IPX) and existing routing protocols (such as IGRP and RIP). The ATM Forum defined an address format based on the structure of the OSI network service access point (NSAP) addresses.

1.14.1 Sub network Model of Addressing

The sub network model of addressing decouples the ATM layer from any existing higher-layer protocols, such as IP or IPX. Therefore, it requires an entirely new addressing scheme and routing protocol. Each ATM system must be assigned an ATM address, in addition to any higher-layer protocol addresses. This requires an ATM address resolution protocol (ATM ARP) to map higher-layer addresses to their corresponding ATM addresses.

1.14.2 NSAP Format ATM Addresses

The 20-byte NSAP-format ATM addresses are designed for use within private ATM networks, whereas public networks typically use E.164 addresses, which are formatted as defined by ITU-T. The ATM Forum has specified an NSAP encoding for E.164 addresses, which is used for encoding E.164 addresses within private networks, but this address can also be used by some private networks.

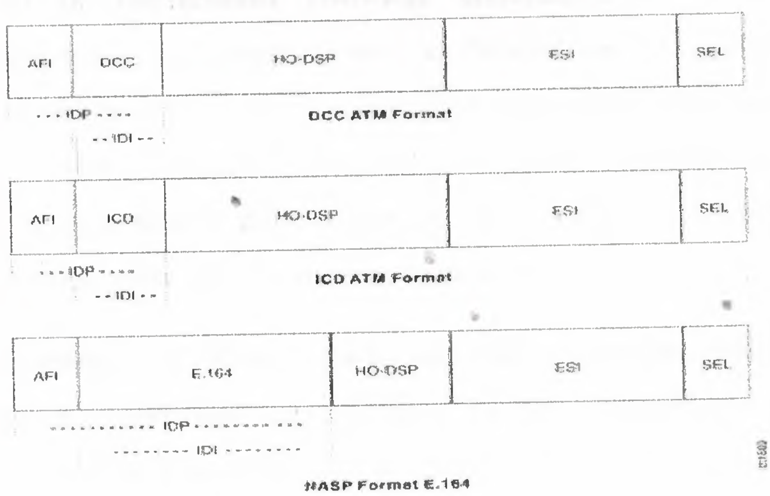
Such private networks can base their own (NSAP format) addressing on the E.164 address of the public UNI to which they are connected and can take the address prefix from the E.164 number, identifying local nodes by the lower-order bits.

All NSAP-format ATM addresses consist of three components: the authority and format identifier (AFI), the initial domain identifier (IDI), and the domain specific part (DSP). The AFI identifies the type and format of the IDI, which, in turn, identifies the address allocation and administrative authority. The DSP contains actual routing information.

Three formats of private ATM addressing differ by the nature of the AFI and IDI. In the NSAP-encoded E.164 format, the IDI is an E.164 number. In the DCC format, the IDI is a data country code (DCC), which identifies particular countries, as specified in ISO 3166. Such addresses are administered by the ISO National Member Body in each country. In the ICD format, the IDI is an international code designator (ICD), which is allocated by the ISO 6523 registration authority (the British Standards Institute). ICD codes identify particular international organizations.

The ATM Forum recommends that organizations or private-network service providers use either the DCC or ICD formats to form their own numbering plan.

Figure 1-9: Three formats of ATM addresses are used for private networks.



1.14.3 ATM Address Fields

The following descriptions summarize the fields illustrated in figure 20-9.

- AFI---Identifies the type and format of the address (DCC, ICD, or E.164).

- DCC---Identifies particular countries.

- High-Order Domain Specific Part (HO-DSP)---Combines the routing domain (RD) and area indentifier (AREA) of the NSAP addresses. The ATM Forum combined these fields to support a flexible, multilevel addressing hierarchy for prefix-based routing protocols.

- End System Identifier (ESI)---Specifies the 48-bit MAC address, as administered by the Institute of Electrical and Electronic Engineers (IEEE).

Selector (SEL)---Used for local multiplexing within end stations and has no network significance.

ICD--- Identifies particular international organizations.

E.164---Indicates the BISDN E.164 address.

1.15 ATM Connections

ATM supports two types of connections: point-to-point and point-to-multipoint.

Point-to-point connects two ATM end systems and can be unidirectional (one-way communication) or bidirectional (two-way communication). Point-to-multipoint connects a single-source end system (known as the root node) to multiple destination end systems (known as leaves). Such connections are unidirectional only. Root nodes can transmit to leaves, but leaves cannot transmit to the root or each other on the same connection. Cell replication is done within the ATM network by the ATM switches where the connection splits into two or more branches.

It would be desirable in ATM networks to have bidirectional multipoint-to-multipoint connections. Such connections are analogous to the broadcasting or multicasting capabilities of shared-media LANs, such as Ethernet and Token Ring. A broadcasting capability is easy to implement in shared-media LANs, where all nodes on a single LAN segment must process all packets sent on that segment. Unfortunately, a multipoint-to-multipoint capability cannot be implemented by using AAL5, which is the most common AAL to transmit data across an ATM network. Unlike AAL3/4, with its Message Identifier (MID) field, AAL5 does not provide a way within its cell format to interleave cells from different AAL5 packets on a single connection. This means that all AAL5 packets sent to a particular destination across a particular connection must be received in sequence; otherwise, the destination reassembly process will be unable to reconstruct the packets. This is why AAL5 point-to-multipoint connections can be only unidirectional. If a leaf node were to transmit an AAL5 packet onto the connection, for example, it would be received by both the root node and all other leaf nodes. At these nodes, the packet sent by the leaf could be interleaved with packets sent by the root and possibly other leaf nodes, precluding the reassembly of any of the interleaved packets.

1.15.1 ATM and Multicasting

ATM requires some form of multicast capability. AAL5 (which is the most common AAL for data) currently does not support interleaving packets, so it does not support multicasting.

If a leaf node transmitted a packet onto an AAL5 connection, the packet can get intermixed with other packets and be improperly reassembled. Three methods have been proposed for solving this problem: VP multicasting, multicast server, and overlaid point-to-multipoint connection.

Under the first solution, a multipoint-to-multipoint VP links all nodes in the multicast group, and each node is given a unique VCI value within the VP. Interleaved packets hence can be identified by the unique VCI value of the source. Unfortunately, this mechanism would require a protocol to uniquely allocate VCI values to nodes, and such a protocol mechanism currently does not exist. It is also unclear whether current SAR devices could easily support such a mode of operation.

A multicast server is another potential solution to the problem of multicasting over an ATM network. In this scenario, all nodes wanting to transmit onto a multicast group set up a point-to-point connection with an external device known as a multicast server (perhaps better described as a sequencer *or* serial). The multicast server, in turn, is connected to all nodes wanting to receive the multicast packets through a point-to-multipoint connection. The multicast server receives packets across the point-to-point connections and then retransmits them across the point-to-multipoint connection---but only after ensuring that the packets are serialized (that is, one packet is fully transmitted prior to the next being sent). In this way, cell interleaving is precluded.

An overlaid point-to-multi point connection is the third potential solution to the problem of multicasting over an ATM network. In this scenario, all nodes in the multicast group establish a point-to-multipoint connection with each other node in the group and, in turn, become leaves in the equivalent connections of all other nodes. Hence, all nodes can both transmit to and receive from all other nodes. This solution requires each node to maintain a connection for each transmitting member of the group, whereas the multicast-server mechanism requires only two connections. This type of connection would also require a registration process for informing the nodes that join a group of the other nodes in the group so that the new nodes can form the point-to-multipoint connection. The other nodes must know about the new node so that they can add the new node to their own point-to-multipoint connections. The multicast-server mechanism is more scalable in terms of connection resources but has the problem of requiring a centralized resequencer, which is both a potential bottleneck and a single point of failure.

1.15.2 ATM Quality of Service (QoS)

ATM supports QoS guarantees composed of traffic contract, traffic shaping, *and* traffic policing.

A traffic contract specifies an envelope that describes the intended data flow. This envelope specifies values for peak bandwidth, average sustained bandwidth, and burst size, among others. When an ATM end system connects to an ATM network, it enters a contract with the network, based on QoS parameters.

Traffic shaping is the use of queues to constrain data bursts, limit peak data rate, and smooth jitters so that traffic will fit within the promised envelope. ATM devices are responsible for adhering to the contract by means of traffic shaping. ATM switches can use traffic policing to enforce the contract The switch can measure the actual traffic flow and compare it against the agreed-upon traffic envelope. If the switch finds that traffic is outside of the agreed-upon parameters, it can set the *cell-loss priority* (CLP) bit of the offending cells. Setting the CLP bit makes the cell discard eligible, which means that any switch handling the cell is allowed to drop the cell during periods of congestion.

1.15.3 ATM Signaling and Connection establishment

When an ATM device wants to establish a connection with another ATM device, it sends a signaling-request packet to its directly connected ATM switch. This request contains the ATM address of the desired ATM endpoint, as well as any QoS parameters required for the connection.

ATM signaling protocols vary by the type of ATM link, which can be either UNI signals or NNI signals. UNI is used between an ATM end system and ATM switch across ATM UNI, and NNI is used across NNI links.

The ATM Forum UNI 3.1 specification is the current standard for ATM UNI signaling. The UNI 3.1 specification is based on the Q.2931 public network signaling protocol developed by the ITU-T. UNI signaling requests are carried in a well-known default connection: VPI = 0, VPI = 5.

Standards currently exist only for ATM UNI signaling, but standardization work is continuing on NNI signaling.

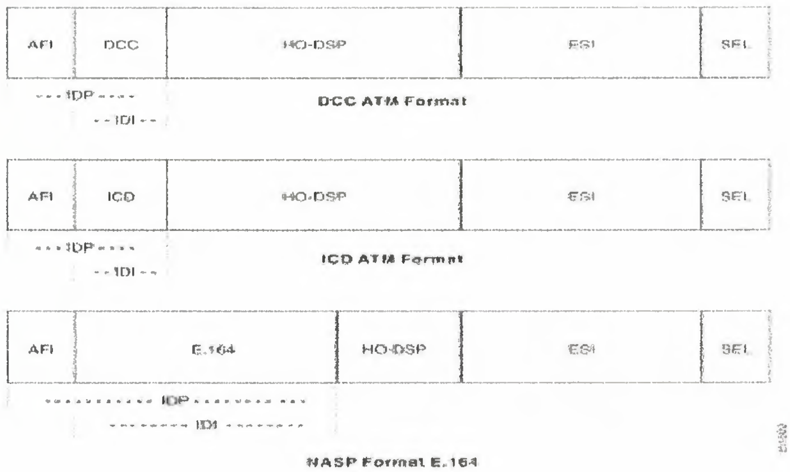
1.15.4 The ATM Connection-Establishment Process

ATM signaling uses the *one-pass* method of connection setup that is used in all modern telecommunication networks, such as the telephone network. An ATM connection setup proceeeds in the following manner. First, the source end system sends a connection-signaling request. The connection request is propagated through the network. As a result, connections are set up through the network. The connection request reaches the final destination, which either accepts or rejects the connection request.

1.15.5 Connection-Request Routing and Negotiation

Routing of the connection request is governed by an ATM routing protocol (which routes connections based on destination and source addresses), traffic, and the QoS parameters requested by the source end system. Negotiating a connection request that is rejected by the destination is limited because call routing is based on parameters of initial connection; changing parameters might, in turn, affect the connection routing. Figure 1-10 highlights the one-pass method of ATM connection establishment.

Figure 1-10: ATM devices establish connections through the one-pass method.



1.15.6 ATM Connection-Management Messages

A number of connection- management message types, including setup, call proceeding, connect, and release, are used to establish and tear down an ATM connection. The source end end-system sends a setup message (including the destination end-system address and any traffic QoS parameters) when it wants to set up a connection. The ingress switch sends a call

proceeding message back to the source in response to the setup message. The destination end system next sends a connect message if the connection is accepted. The destination end system sends a release message back to the source end system if the connection is rejected, thereby clearing the connection.

Connection-management messages are used to establish an ATM connection in the following manner. First, a source end system sends a setup message, which is forwarded to the first ATM switch (ingress switch) in the network. This switch sends a call proceeding message and invokes an ATM routing protocol. The signaling request is propagated across the network. The exit switch (called the *egress* switch) that is attached to the destination end system receives the setup message. The egress switch forwards the setup message to the end system across its UNI, and the ATM end system sends a connect message if the connection is accepted. The connect message traverses back through the network along the same path to the source end system, which sends a connect acknowledge message back to the destination to acknowledge the connection. Data transfer can then begin.

2. Designing of ATM Internet works

This chapter describes current Asynchronous Transfer Mode (ATM) technologies that network designers can use in their networks today. It also makes recommendations for designing non-ATM networks so that those networks can take advantage of ATM in the future without sacrificing current investments in cable.

2.1 Role of ATM in Internet works

Today, 90 percent of computing power resides on desktops, and that power is growing exponentially. Distributed applications are increasingly bandwidth-hungry, and the emergence of the Internet is driving most LAN architectures to the limit. Voice communications have increased significantly with increasing reliance on centralized voice mail systems for verbal communications. The internetwork is the critical tool for information flow. Internet works are being pressured to cost less yet support the emerging applications and higher number of users with increased performance.

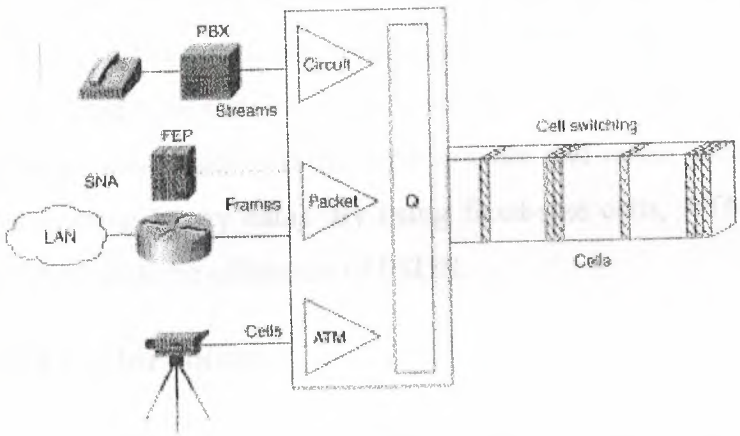
To date, local and wide-area communications have remained logically separate. In the LAN, bandwidth is free and connectivity is limited only by hardware and implementation cost. The LAN has carried data only. In the WAN, bandwidth has been the overriding cost, and such delay-sensitive traffic as voice has remained separate from data. New applications and the economics of supporting them, however, are forcing these conventions to change.

The Internet is the first source of multimedia to the desktop and immediately breaks the rules. Such Internet applications as voice and real-time video require better, more predictable LAN and WAN performance. In addition, the Internet also necessitates that the WAN recognize the traffic in the LAN stream, thereby driving LAN/WAN integration.

2.2 Multi service Networks

ATM has emerged as one of the technologies for integrating LANs and WANs. ATM can support any traffic type in separate or mixed streams, delay-sensitive traffic, and nondelay-sensitive traffic, as shown in figure2-1.

Figure 2-1: ATM support of various traffic types.



ATM can also scale from low to high speeds. It has been adopted by all the industry's equipment vendors, from LAN to private branch exchange (PBX). With ATM, network designers can integrate LANs and WANs, support emerging applications with economy in the enterprise, and support legacy protocols with added efficiency.

2.3 TDM Network Migration

In addition to using ATM to combine multiple networks into one multi service network, network designers are deploying ATM technology to migrate from TDM networks for the following reasons:

- To reduce WAN bandwidth cost
- To improve performance
- To reduce downtime

2.3.1 Reduced WAN Bandwidth Cost

ATM switches provide additional bandwidth through the use of voice compression, silence compression, repetitive pattern suppression, and dynamic bandwidth allocation. The implementation of ATM combines the strengths of TDM-whose fixed time slots are used by telephone companies to deliver voice without distortion---with the strengths of packet-switching data networks---whose variable size data units are used by computer networks, such as the Internet, to deliver data efficiently.While building on the strengths of TDM, ATM avoids the weaknesses of TDM (which wastes bandwidth by transmitting the fixed time slots even when no one is speaking) and PSDNs (which cannot accommodate time-sensitive traffic, such as voice and video, because PSDNs are designed for transmitting bursty data). By using fixed-size cells, ATM combines the isochronicity of TDM with the efficiency of PSDN.

2.3.2 Improved Performance

ATM offers improved performance through performance guarantees and robust WAN traffic management that support the following capabilities:

- Large buffers that guarantee Quality of Service (QoS) for bursty data traffic and demanding multimedia applications
- Per-virtual circuit (VC) queuing and rate scheduling
- Feedback---congestion notification

2.3.3 Reduced Downtime

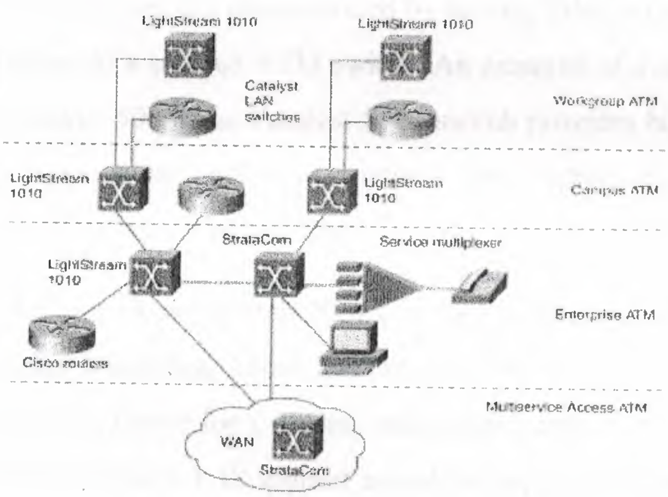
ATM offers high reliability, thereby reducing downtime. This high reliability is available because of the following ATM capabilities.

- The capability to support redundant processors, port and trunk interfaces, and power supplies
- *The capability to rapidly reroute around failed trunks*

2.4 Integrated Solutions

The trend in internetworking is to provide network designers greater flexibility in solving multiple internetworking problems without creating multiple networks or writing off existing data communications investments. Routers can provide a reliable, secure network and act as a barrier against inadvertent broadcast storms in the local networks. Switches, which can be divided into two main categories---LAN switches and WAN switches---can be deployed at the workgroup, campus backbone, or WAN level, as shown in figure 2-1.

Figure 2-1: The role of ATM switches in an internet work.



Underlying and integrating all Cisco products is the Cisco IOS software.The Cisco IOS software enables disparate groups, diverse devices, and multiple protocols all to be integrated into a highly reliable and scalable network.

2.5 Different Types of ATM Switches

Even though all ATM switches perform cell relay, ATM switches differ markedly in the following ways:

- Variety of interfaces and services that are supported
- Redundancy
- Depth of ATM internetworking software
- Sophistication of traffic management mechanism

Just as there are routers and LAN switches available at various price/performance points with different levels of functionality, ATM switches can be segmented into the following four distinct types that reflect the needs of particular applications:

- Workgroup and campus ATM switches
- Enter price ATM switches
- Multi service access switches

2.5.1 Workgroup and Campus ATM Switches

Workgroup ATM switches are characterized by having Ethernet switch ports and an ATM uplink to connect to a campus ATM switch. An example of a workgroup ATM switch is the Cisco Catalyst 5000.The Catalyst 5500 switch provides high-performance switching between workstations, servers, switches, and routers in wiring closet, workgroup, and campus backbone environments.

The Catalyst 5500 LAN is a 13-slot switch. Slot 1 is reserved for the supervisor engine module, which provides switching, local and remote management, and dual Fast Ethernet uplinks. Slot 2 is available for a second, redundant supervisor engine, or any of the other supported modules. Slots 3-12 support any of the supported modules.

Slot 13 can be populated only with a LightStream 1010 ATM Switch Processor (ASP). If an ASP is present in slot 13, slots 9-12 support any of the standard LightStream 1010 ATM switch port adapter modules (PAMs).

The Catalyst 5500 has a 3.6-Gbps media-independent switch fabric and a 5-Gbps cell-switch fabric. The backplane provides the connection between power supplies, supervisor engine, interface modules, and backbone module. The 3.6-Gbps media-independent fabric supports Ethernet, Fast Ethernet, FDDI/CDDI, ATM LAN Emulation, and RSM modules. The 5-Gbps cell-based fabric supports a LightStream 1010 ASP module and ATM PAMs.

Campus ATM switches are generally used for small-scale ATM backbones (for instance, to link ATM routers or LAN switches). This use of ATM switches can alleviate current backbone congestion while enabling the deployment of such new services as virtual LANs (VLANs). Campus switches need to support a wide variety of both local backbone and WAN types but be price/performance optimized for the local backbone function. In this class of switches, ATM routing capabilities that allow multiple switches to be tied together is very important. Congestion control mechanisms for optimizing backbone performance is also important. The Light Stream 1010 family of ATM switches is an example of a campus ATM switch. For more information on deploying workgroup and campus ATM switches in your internet work.

2.5.2 Enterprise ATM Switches

Enterprise ATM switches are sophisticated multi service devices that are designed to form the core backbones of large, enterprise networks. They are intended to complement the role played by today's high-end multi protocol routers. Enterprise ATM switches are used to interconnect campus ATM switches. Enterprise-class switches, however, can act not only as ATM backbones but can serve as the single point of integration for all of the disparate services and technology found in enterprise backbones today. By integrating all of these services onto a common platform and a common ATM transport infrastructure, network designers can gain greater manageability and eliminate the need for multiple overlay networks.

BPX/AXIS is a powerful broadband ATM switch designed to meet the demanding, high-traffic needs of a large private enterprise or public service provider.

2.5.3 Multi service Access Switches

Beyond private networks, ATM platforms will also be widely deployed by service providers both as customer premises equipment (CPE) and within public networks. Such equipment will be used to support multiple MAN and WAN services---for instance, Frame Relay switching, LAN interconnect, or public ATM services---on a common ATM infrastructure. Enterprise ATM switches will often be used in these public network applications because of their emphasis on high availability and redundancy, their support of multiple interfaces, and capability to integrate voice and data.

3. Concept of the Wireless ATM Network

The vision of the wireless ATM network is quite simple; to provide transparent wireless access to the fixed ATM network. This chapter presents some more specific aims for the foreseen system. The justification of the existence of a wireless ATM network will also be studied together with some applications foreseen to be used in a wireless ATM network. When the applications are known, it is fairly easy to specify the services needed from the wireless ATM system.

3.1. Demand for a wireless access to ATM

The B-ISDN vision aims to integrate all communications into one universal system. Mobile communication plays a very important role in the communication field today and it is expected to play an even more significant role in the future. It would be easy to say that this is enough to justify the introduction of the mobility aspects into the B-ISDN. However, this section tries to find more arguments to expect the wireless ATM concept to materialise.

ATM is currently making strong progress in the field of long distance communication; mainly connecting LANs in different locations. ATM based solutions for local area networks, wireless and wired, benefit from the compatibility with the backbone ATM network. The ATM seems to be the first technology capable to offer switched broadband communication and still guarantee the Quality of Service (QoS). Both the bandwidth and QoS are available on demand.

Wireless access to ATM/B-ISDN will be required by users. History shows that users tend to seek for wireless access to popular fixed networks. The users find the new services offered by the fixed network useful and want to be able to use them also in a mobile environment. It is expected that this will also happen to the ATM technology. While inter working could be used to connect the wireless system into the fixed system, integration is more effective solution; inter working introduces overhead and leads to a less transparent access to the fixed network.

There is an application need for wireless platform with multimedia support. The introduction of mobile multimedia applications is foreseen. Multimedia requires the transmission of many different types of information simultaneously, placing strict and often contradictory requirements to the network. The QoS thinking of ATM can support this. As an example, one can imagine a teleconferencing application where video and audio needs to be carried together with still pictures (slides) and computation data (shared word processing application).

UMTS and wireless LANs simply cannot meet all future data user needs. Mobile phone systems cannot support the bandwidth and the LAN services are too unreliable and not ATM compatible. UMTS will offer bandwidth only up to 2 Mbit/s and in practice the actual transmission rate per terminal is expected to be lower. The RLANs are based on random access methods inherited from the fixed LANs and cannot support the transmission of delay critical broadband data.

For a new system to be successful, its capabilities and the needs of its users has to be congruent. A scenario about the operation environment, applications and user behavior has to be made and specific requirements placed on the system. The WATM model is designed to meet the requirements of a specific usage scenario. This scenario, called the WATM usage scenario, is presented in the next section. Later, when the system has been established, new requirements will be placed on it. Two scenarios about the future users of the system are also presented. More sophisticated systems could be designed to meet their needs. These scenarios have much in common with the WAND usage scenarios.

3.2. The WATM usage scenario

This section will present the vision behind the WATM model. The scenario presents the users who are foreseen to be the first ones requiring wireless access to ATM networks. Also the terminals and applications the users are likely to use are discussed.

In this scenario, it is expected that the need for wireless ATM services will first materialise in large companies having their own networks in their premises. Fixed ATM based local area networks are expected to replace local area networks currently used by these companies. Later on, other communications, such as fax, telephone and videoconferencing, could also be moved to the ATM network. Users might request for the ability to move while using the LAN, thus generating a demand for a wireless access to the ATM network. The system described by the vision is a wireless customer premises ATM network supporting both fixed and mobile terminals.

A typical mobile terminal in the WATM usage scenario is a lap top computer used by an office worker. The user wants to be able to use his or her computer in different parts of the office building and also in other frequently visited buildings. The network services should be equally available in office rooms, in meeting rooms, in the cafeteria, etc. When the user works at his own desk, he should be able to use the fixed access available to get greater performance than the wireless access to the network can offer. Being able to used both fixed and wireless system will also lower the overall load of the wireless system.

The applications foreseen to be used are typical B-ISDN applications that must be supported for mobile users with an acceptable QoS. The QoS expected from the wireless ATM system could be somewhat lower than the QoS of a fixed ATM system. The user is assumed to realise that a small loss in QoS is the price paid for the mobility gained. For example, the Cell Lost Rate might be larger (resulting in somewhat lower 'goodput'), and a short interruption in the connection because of a hand over is tolerated. For non-real time connections the aim should be a loss and over, that is, some delay is inflicted but no data is lost. Also the security issues has to be considered as in any wireless system.

Some possible applications in the WATM usage are:

3.2.1 Computing

Typical computing applications foreseen to be used in the proposed system are client server applications, file systems, e-mail delivery, fax, group ware and computer games. A powerful computer in the network could assist the mobile terminal to run computation intensive applications like Computer Aided Design (CAD). Connection quality close to the one offered by a fixed ATM LAN is needed. Increased CLR and interruptions will increase the retransmission frequency, so the delay performance is expected to the be weaker.

Computing applications are asymmetric and greedy. A greedy application takes as much bandwidth as possible. The traffic is assumed to be highly bursty non-realtime data. The average bit rate for both up and down link is assumed to be larger than 100 k bit/s and the peak bit rate around 1 M bit/s.

3.2.2 Multimedia databases

Encyclopaedias, diagnosis, electronic newspaper, bulletin boards, World Wide Web (WWW) type services, manuals, etc. Also these applications are asymmetric and greedy with bursty non-realtime data (but not as bursty as for computing due to very large files included in data).

For example a "Super WWW" application where the pages contain high quality pictures, sound and a significant proportion of video is assumed to produce highly bursty down link traffic of at least 1 M bit/s average. The traffic on the up link control channel is bursty with 100 byte bursts and very low average bit rate.

3.2.3 Audio

The audio applications foreseen include public announcement, high quality telephone or a wireless equipment for Digital Audio Broadcasting (DAB) quality program production. The ordinary telephone service is the most commonly used telecommunication service and is likely to be requested by the user also in the future. It is possible that more than one simultaneous connection exists for a terminal.

The PCM coding could be used in the mobile telephone service; the advantage of not having to do trans coding and compression is considered to justify the waste of radio interface bit rate. Using PCM a constant bit rate of 64 k bit/s is required in both directions. Musicam is the compression technology to be used in DAB system to achieve a good voice quality with two separated channels (stereo). A Musicam codec typically produces an average bit rate of 384 k bit/s.

3.2.4 Video phone

Powerful laptop computers likely to available in the future are good platforms for videophone applications. While the need for residential video phony is unlikely to materialise, the demand for a videophone in office environment has been foreseen. The picture quality does not need to be excellent, because of the limited display facilities in the terminal (limited resolution of 10-12 inch displays of lap top computers). In this type of application, the up link and down link are symmetric. [15]

H.320 is one of the most commonly used coding methods today. It is typically used on 256 k bit/s constant bit rate connections, but the coding method supports a wide range of bit rates. If H.320 coding is used for the audio and video channels, an average of 256 k bit/s is needed for both up and down link. Up to 1.5M bit/s variable bit rate real time data connection is needed if MPEG-1 coding is used.

The applications in the WATM usage scenario tend to require broadband, highly reliable non real time data transfer services or narrow band time critical services. The non real time bursty traffic could be carried by ABR. For applications with different requirements, CBR, rt-VBR and nrt-VBR traffic classes should also be implemented. The bandwidth and bit error rate of the radio link are hard to predict. To achieve low CLR, some kind of retransmission technology is likely to be used. This will introduce delay. So, a trade-off has to be made between the CLR and delay parameters. It is assumed that a reasonable QoS could be offered also for these traffic classes while the terminal is not moving, but the user is likely to notice the execution of a hand over. While using a high cell rate, the buffers of the radio interface could easily become too large to be practically implemented. The flow control mechanism of ABR traffic class offers relief to this problem. The ABR is seen to be a key technology in the implementation of a system aiming to meet the challenge of the WATM usage scenario.

3.3. Future scenarios

When a wireless infrastructure is present in a company, it is expected that many new applications that otherwise would be supported by other wired or wireless systems, are moved to the wireless ATM environment. There are various reasons to expect this to happen.Installation and maintenance costs will be reduced by having only one system. The simultaneous operation of two different wireless systems is difficult or impossible because of the limited frequency band available. It has been suggested that the wireless ATM systems could allowed to use the same frequencies as the existing wireless LANs.

Mass production of equipment will lower their price (economics of scale) and make it possible to use them for purposes that would not otherwise justify the extra cost of a broadband wireless system.

The new applications foreseen to be integrated in the wireless ATM system in the future scenario can be divided roughly into two main categories. The first one is a scenario where wireless access is used as a replacement for wired access to ATM. This is expected to happen in places where wiring is difficult or expensive to install or the terminals are movable but not actually mobile. In the second future scenario the wireless ATM system is used to offer narrow band application. These applications could be supported by other mobile systems or narrow band wireless LANs, but are cost efficiently supported in the WATM model type system already installed in the premises.

3.3.1. Wired ATM replacement applications

In the scenario, where the wireless ATM is used as a replacement for the wired access to ATM the terminal could be a workstation, a PC or any other B-ISDN capable terminal. Also the applications are typical B-ISDN applications without any mobility specific features. In this scenario the user device is mostly stationary and the main benefit derived from the Wireless ATM is the fact that no wiring is needed. Thus the wireless ATM network in this scenario must provide nearly fixed network QoS to a stationary user. The user should not be able to notice the difference between using the wireless and a fixed ATM system with the same access bandwidth.

Multimedia conference is an example of a sophisticated B-ISDN application. The combination of high quality multiparty videophone, high resolution still picture transfer and shared applications between participating users are seen as an alternative for traditional meetings. Large video displays are used to achieve the good picture quality needed. High quality (e.g., MPEG-1 coded) video and audio channels (up to 5 simultaneous channels) with multiparty data links for the transmission of still images or other types of computer data are foreseen. For the uplink a connection supporting up to 1.5 Mbit/s bandwidth for the variable bit rate realtime video/audio data is needed. The down link could have more than one of these video/audio connections. The bit rate per audio/video channel is up to 5 Mbit/s if MPEG-2 coding is used for better picture quality. Shared word processing application and the additional transmission of slides will produce highly bursty traffic with high peak bandwidth (for example 200 kbit/s average and 1 Mbit/s peak).

A high quality videophone with a multiparty option could also be introduced. The videophone in this scenario can offer better picture quality because of the larger display in the terminal than the one foreseen in the WATM usage scenario. Up link transmission capability for variable bit rate real time data with a bandwidth between 128 k bit/s and 1.5 M bit/s is needed. The requirements for the down link are similar to the up link, but up to 3 simultaneously calls are required if the multiparty option is supported.

Also in this scenario, the computing applications are foreseen to play an important role. The quality of service (QoS) should be comparable to the QoS offered by a fixed ATM LAN. The computation applications are asymmetric and greedy and generate highly bursty non-realtime data.

It would be possible to use directive antennas in this scenario to achieve lower cell lost rate without the use of retransmission technology. The quality of the handover function does not need to be considered because the terminals are expected to be stationary.

3.3.2. Narrow band applications

The terminal of this scenario is expected be handheld, for example a personal digital assistant (PDA) with a wireless ATM card or a dedicated terminal (like a mobile phone). The applications are mostly dedicated mobile applications capable of operating at a lower QoS as they would use mobile specific features like mobile middle ware to compensate for some mobile related problems. The term narrow band is considered to mean any bandwidth under 2 Mbit/s

Data applications like client server, e-mail, paging, messaging, groupware, games and other typical PDA services are expected. Emphasis on mobile specific applications is expected and hence there is more tolerance for the temporary QoS degradation. The applications are expected to produce up to one Mbit/s asymmetric bursty non-real time traffic.

Wireless databases could be used for applications such as inventory of available goods, on-floor customer services in shops, menu of the company cafeteria or telephone and contact information directory. The traffic generated is strongly depended on the type of information stored in the system. The applications do not typically include pictures or sound; in that case the bandwidth is expected to be up to few hundred kilobits per second for the down link and somewhat lower for the uplink. The traffic would be bursty non-real time data.

Wireless phone service could be offered on the wireless ATM network. The quality of the audio connection could vary from low quality to high quality depending on the application. This would require symmetric or asymmetric constant bit rate connection for realtime data. Bandwidths vary from 64 kbit/s (PCM or packet voice) up to 384 kbit/s needed to achieve good quality with Musicam coding. The higher quality could be used for example in a wireless microphone or in public addressing applications.

The videophone application in this scenario is considered to be asymmetric. This is because of the display facilities on the mobile terminal can differ significantly from those present on the other terminal. The up link has either low or high picture quality, while the quality of the down link is likely to be of low quality. The required variable bit rate transfer service for the real time data has a bandwidth up to 1.5 Mbit/s (MPEG-1). If lower picture quality is acceptable, H.261 coding could be used for bit rates from 64 kbit/s to 384 k bit/s. The use of MPEG-4 coding to compress the data to less than 64 kbit/s is also possible. The compatibility with other systems would be a better reason to use MPEG-4 than the saved bandwidth. [15]

Security and monitoring applications are also foreseen. The wireless network could be used for video/audio surveillance, industrial security service or alarms of different kind. For example good quality video transmitted from the hand held terminal to the security control center and duplex voice connection and narrow band data transfer.

3.4. The aims of a wireless ATM network

The next generation mobile systems, RLANs and fixed access to ATM networks are available or are going to be available during the next decade. These systems offer new services for the user and make new sophisticated applications possible. The wireless access to ATM has to offer additional value over the next generation mobile systems and RLANs. Some of the main points in which the wireless ATM should be superior to these systems are, Support the use of standard ATM services. This means that the ATM traffic classes should be supported with a sufficient QoS. The services provided by other systems, especially by the third generation mobile phone systems, should be available also in the new wireless system.

Support broadband connections and still guarantee the Quality of Service. Different applications need different quality from the network; some are delay critical, some critical to the lose of data, some produce bursty data some constant bandwidth, etc. The current RLANs capable to support the required bandwidth offer no guarantees about the quality of the service.

The wireless ATM systems would be tightly integrated to the fixed ATM systems, thus reducing the overhead caused by inter working. The existing infrastructure should be reused as much as possible; this means reuse of ATM switches, B-ISDN signaling protocols, wiring, ATM/B-ISDN terminals, etc. This is maybe the most important factor having impact on the economical possibilities to introduce a new system.

Offer standard ATM access to fixed users. Strong tendency for developing ATM LANs has been identified. In the future a large number of ATM terminals, mostly computers, are assumed to be present in the premises of the company operating the wireless ATM network. The adoption of the wireless ATM system is much easier if users and terminals can roam between fixed and wireless ATM systems. If the fixed infrastructure of the wireless ATM network offers the services of a standard fixed ATM network, the cost of having to operate two systems can be avoided. In this case the system could be called an integrated ATM network rather that a wireless ATM network.

It is likely that the first wireless ATM networks will be designed to meet the needs of specific user groups. It is easier to satisfy the needs of a known user than to support all features possible. The WATM model presented in this thesis describes an ATM local area network supporting both fixed and mobile terminals. The first users of such a system are expected to be companies operating the system in its premises. The network is considered to be mainly located indoors and to have a large number of base stations to ensure continuous coverage and a large capacity. A fixed ATM network is assumed to be used in the premises and the fixed ATM infrastructure can be used for the WATM model, thus making its implementation more cost effective. The traffic in the system is assumed to be mostly computer data.

4. Comparison of IP-over-ATM and IP-over-SONET

There are various differences in operating IP-over-SONET compared to running IP-over-ATM. Some of the important issues are summarized below.

4.1 Protocol Overheads

By far the biggest reason that ISPs are considering deploying IP-over-SONET as opposed to IP-over-ATM is the overhead imposed by ATM cell headers (5-bytes out of every 53-bytes), sometimes referred to as the cell tax. Additional overhead is added by AAL5 (padding, 8-byte trailer) and LLC/SNAP encapsulation (8-bytes). The following table indicates the overheads introduced by each layer in the protocol stack when running IP-over-ATM over a SONET STS-3c link with an IP packet size of 576 bytes:

Protocol Layer	Available Bandwidth (Mbps)	Percent of Line Rate	Percent Overhead Added by Each Layer
SONET	155.520	100	3.7
ATM	149.460	96.6	9.43
AAL	135.362	87.5	6.41
LLC/SNAP	126.937	80.7	1.37
IP	125.918	79.6	0

A similar comparison for IP-over-PPP over a SONET STS-3c link with an IP packet size of 576 bytes gives the following approximate results.

Protocol Layer	Available Bandwidth (Mbps)	Percent of Line Rate	Percent Overhead Added by Each Layer
SONET	155.520	100	3.7
PPP	149.460	96.6	1.54
IP	147.15	95.4	0

These tables show that IP achieves only about 80 percent of the available line rate when operating over ATM whereas it achieves 95 percent of the line rate when running over SONET. The added capacity when running IP-over-SONET is very compelling when expensive wide-area or otherwise bandwidth-constrained links are used for interconnecting backbone routers. For environments where bandwidth is plentiful, such as local area networks, bandwidth efficiency is not as much of an issue.

4.2 Bandwidth Management

ATM provides a full suite of capabilities for managing the bandwidth allocation to the various information's streams (VCCs) flowing over a link. It assigns flexible bandwidth to these VCCs based on the required quality of service. Because of its cell-switched nature, ATM allows multiple information streams to share the same link at the same time, while guaranteeing a certain amount of bandwidth for each stream.

PPP, on the other hand, does not have any provision for bandwidth management. It provides a simple point-to-point link, and the IP layer has to schedule its packet transmissions to ensure that each information flow receives its fair share of link bandwidth. There can be problems over slow links, in which the transmission of a large packet belonging to a low priority flow can block the transmission of other high priority packets. For example, a large packet in a low-priority file transfer flow can delay a much smaller but more time-sensitive voice packet. This variability in delay can negate the benefits of the bandwidth efficiency provided by IP-over-SONET, for delay sensitive real-time applications, over bandwidth constrained links.

4.3 Quality of Service

Quality of service (QoS) relates to parameters such as end-to-end packet delay, jitter, loss and throughput. ATM provides a rich set of QoS parameters that can be negotiated for each VCC. Intelligent queuing and scheduling mechanisms in the switches ensure that the negotiated QoS is provided. ATM provides various service classes that can fit different application requirements. For example, applications with very specific QoS requirements can use a Constant Bit Rate (CBR) or Variable Bit Rate (VBR) service. On the other hand, applications with elastic requirements can use Available Bit Rate (ABR) or Unspecified Bit Rate (UBR) service. These native ATM capabilities make it very easy to provide QoS at the IP level, at which each information flow with a specific QoS requirement can map to its own VCC with a specific QoS. For example, a voice flow can map to a real-time CBR or VBR connection while a file transfer can map to an ABR connection.

PPP operates over a single point-to-point link and does not provide any QoS capabilities. As mentioned earlier, the IP layer has to manage its packet transmissions intelligently to ensure proper QoS for the information flows.

Although ATM provides a rich set of QoS parameters, the QoS-based services are restricted to the ATM path connecting two routers. To provide end-to-end QoS to IP packets, the routers still have to provide intelligent queuing and scheduling mechanisms. In that sense, when an IP network is overlaid on top of an ATM network, the routers see ATM connections as point-to-point links, similar to PPP, even though the actual communication may occur over a network of ATM switches.

4.5 Addressing & Routing

ATM is specified as a full network layer with extensive capabilities for addressing end systems and routing connections. ATM networks can span vast geographical areas, providing a universal interconnection mechanism between routers regardless of their location.

In contrast, PPP operates over direct point-to-point links only and has no addressing or routing capabilities. In order to create a backbone network, point-to-point links have to be provisioned between the backbone routers. Multiple links have to be provisioned to allow for link failures. In some cases, a full mesh may need to be configured to minimize the number of hops needed to cross the backbone. A full mesh is not only very expensive, but may also be infeasible because access to pure SONET links in the wide area is limited.

When used with SVCs, ATM enables any-to-any connectivity among routers without the need to provision a full mesh. Even if some links in the ATM network fail, dynamic SVC routing can find alternate routes and always ensure a connection between any two routers. The most useful capability is that connections to other routers may be established over a single ATM interface, which can easily be obtained from the carriers. In the case of backbone router networks, most routers will need to communicate with each other, which means full mesh connectivity may eventually be needed regardless of whether point-to-point links are provisioned or SVCs are used. However, ATM still enables more flexible network engineering because of its ability to route the SVCs over different links and to connect one router to multiple destinations over the same access link.

4.6 Flow Control

ATM uses functions, such as call admission control (CAC), traffic shaping and user parameter control (UPC) or policing, and to ensure that information flows stay within the boundaries of the negotiated traffic contract. Excess traffic is tagged and may be discarded under network overload conditions. Thus end users get implicit information about congestion in the network based on tagged or lost packets. ATM's cell-level discarding can interact poorly with TCP's packet-level flow control. To alleviate this problem somewhat, hooks, such as partial packet discard (PPD) or early packet discard (EPD), have been designed for ATM to recognize packet (AAL frame) boundaries and to discard entire frames under overload conditions.

Recently, the ATM Forum defined the ABR service. It provides explicit feedback for flow control by indicating the allowed rate at which the ATM endpoint can send traffic into the network. This rate may change as the network load changes, allowing the user to access the available bandwidth without overloading the network. Ideally, ABR will remove cell loss in the network and push congestion conditions towards the boundary of the ATM network. This will require routers to buffer more packets.

PPP provides no flow control mechanisms, so TCP's flow control operates directly over PPP links. As noted earlier, routers, whether they are connected over ATM or directly over SONET, see a pipe (of a certain bandwidth) between each other and have to employ suitable buffering mechanisms to ensure reasonable throughput.

4.7 Multi protocol Encapsulation

ATM provides two mechanisms for multiple protocols to share the same link. The first mechanism, known as VCC Multiplexing, assigns each protocol to a separate VCC. The ATM layer multiplexes and demultiplexes VCCs so users do not need to add any other encapsulation headers to distinguish the various protocols. The second mechanism, known as LLC Multiplexing, allows multiple protocols to share the same VCC. It adds an 8-byte encapsulation header to each packet that identifies the protocol to which it belongs. This form of multiplexing may be used when the number of VCCs available is limited (due to cost or capacity), and there is a need to share the VCCs among the various protocols.

PPP provides a form of multiprotocol encapsulation similar to LLC Multiplexing in ATM. It uses a 1- or 2-byte protocol identifier field as an encapsulation header. For the most part, the multiprotocol encapsulation capabilities of PPP and ATM are equivalent.

4.8 Fault Tolerance

ATM provides recovery from failed links and switches by routing connections around them using a dynamic routing protocol, called the Private Network Node Interface (PNNI) protocol. Currently, PNNI provides a re-routing capability only during the initial connection establishment. The ATM Forum is adding to PNNI provisions for automatic re-routing of an established connection that is released due to network failure.

PPP does not have any fault tolerance capability because it operates over a single link. However, the underlying SONET layer has built-in protection switching to switch to the alternate ring when the working ring breaks down. This capability is also available to ATM when it operates over SONET.

4.8 possible Deployment

The previous sections have compared the relative merits of IP-over-ATM and IP-over-SONET. In essence, when using IP-over-SONET, routers are connected by fast point-to-point links, whereas when using IP-over-ATM, routers are connected over a network of links that carry multiplexed connections, each of which can be associated with a flexible bandwidth and a negotiated quality of service. The differences between the two technological options boil down to a fundamental contrast of speed versus flexibility. Depending on which factor is more critical in a particular situation, the following deployment scenarios are possible.

4.9 ISP Backbones

ISP backbones typically require high-speed interconnection between the backbone routers to maximize packet throughput. For this reason, ISPs and their suppliers are very interested in running IP-over-SONET to interconnect backbone routers. However, this interest is lessened because of IP-over-SONET's lack of bandwidth management, quality of service and flexible network engineering. Also, high-speed SONET links can deliver packets at a very fast rate - a rate that may be higher than most routers can handle. IP-over-SONET may have advantages when interconnecting high-speed backbone routers on expensive or bandwidth constrained wide area links in which quality of service is not required.

4.10 Corporate Intranets

Corporate intranets that span a wide area face many of the same issues as ISP backbones. IP-over-SONET may have advantages from a cost perspective. However, these advantages must be weighed against the cost of obtaining the requisite equipment and service. IP-over-SONET is still an emerging market and equipment costs can be relatively high. In contrast, IP-over-ATM is quickly becoming a commodity, and competition is driving equipment costs down. Similarly, carriers may sell ATM links at a cheaper price compared to SONET links because of the flexible bandwidth management capabilities that ATM provides to the carrier. Additionally, deploying

ATM allows easy sharing of the wide area bandwidth between IP and non-IP applications such as SNA, IPX, Appletalk, DECnet, etc.

4.11 Campus Backbones

These networks are less likely to deploy SONET because of the cost effectiveness of using cheaper physical interfaces such as TAXI over multi-mode fiber (100-155 Mbps), shielded twisted pair (STP) or unshielded twisted pair category 5 (UTP Cat-5) copper wires (155 Mbps). Even if SONET is deployed, bandwidth is probably plentiful, so the bandwidth efficiencies of IP-over-SONET may not outweigh the flexibility of IP-over-ATM.

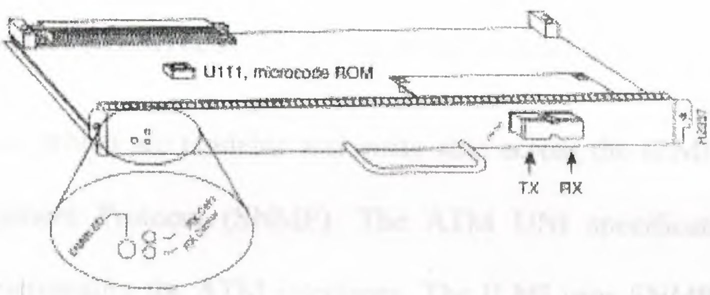
4.12 Carrier Networks

Carriers are deploying SONET across their networks. They are also highly likely to deploy ATM over SONET to provide flexible bandwidth management and to ensure quality of service to their paying customers. Consequently, it will be easier for them to offer IP-over-ATM services than to provision IP directly over SONET.

5. ATM Interface Processor (AIP)

The ATM interface processor (AIP) (see figure5-1) provides a single ATM network interface.

(Figure 5-1): ATM Interface Processor (AIP)



The AIP provides a direct connection between the high-speed Cisco Extended Bus (CxBus and CyBus) and external ATM networks. A physical layer interface module (PLIM) on the AIP determines the type of ATM connection. There are no restrictions on slot locations or sequence; you can install an AIP in any available interface processor slot.

The AIP provides the ATM connection between your router and an ATM switch. (To configure your ATM switch, refer to its user documentation.)

The AIP supports the following features:

- Multiple rate queues.
- Reassemble of up to 512 buffers simultaneously. Each buffer represents a packet.
- Up to 2,048 virtual circuits.

- Both AAL5 and AAL3/4.

- Exception queue, which is used for event reporting. Events such as CRC errors are reported to the exception queue.

- Raw queue, which is used for all raw traffic over the ATM network. Raw traffic includes Operation, Administration, and Maintenance (OAM) cells and Interim Local Management Interface (ILMI) cells. (ATM signaling cells are not considered raw.)

- MIB attributes, which are readable and write able across the ILMI using a Simple Network Management Protocol (SNMP). The ATM UNI specification defines the required MIB functionality for ATM interfaces. The ILMI uses SNMP, without UDP, and Internet Protocol (IP) addressing along with the ATM MIB.

- RFC 1213 interface MIBs as specified in the ATM MIB V2 specification. (Refer to the ATM UNI specification for additional details of the MIB.)

5.1 AIP Interface Types

All AIP ATM interfaces are full-duplex. You must use the appropriate ATM interface cable to connect the AIP with an external ATM network. 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 PLIM.

The AIP supports PLIMs that connect to the following physical layers (with product numbers included):

- TAXI 4B/5B 100-Mbps multimode (CX-AIP-TM[=])

- SONET/SDH 155-Mbps multimode--STS-3 or STM-1 (CX-AIP-SM[=])

- SONET/SDH 155-Mbps single-mode--STS-3 or STM-1 (CX-AIP-SS[=])
- E3 34 Mbps (CX-AIP-E3[=])
- DS3 45 Mbps (CX-AIP-DS3[=])

For wide-area networking, ATM is currently being standardized for use in Broadband Integrated Services Digital Networks (BISDNs) by the International Telecommunications 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).

The DS3 interface performs physical layer translation from the AIP to a DS3 line interface in accordance with ATM Forum UNI Specification Version 3.1, ACCUNET T45 service specifications, and ANSI T1.107.

5.2 Evaluating the Power Budget

To design an efficient optical data link, you need to evaluate the power budget. The power budget is the amount of light available to overcome attenuation in an optical link and to exceed the minimum power that the receiver requires to operate within its specifications. Proper operation of an optical data link depends on modulated light reaching the receiver with enough power to be correctly demodulated.

Attenuation, caused by the passive media components (cables, cable splices, and connectors), is common to both multi mode and single-mode transmission.

The following variables reduce the power of the signal (light) transmitted to the receiver in multi mode transmission:

- Chromatic dispersion (spreading of the signal in time because of the different speeds of light wavelengths)

- Modal dispersion (spreading of the signal in time because of the different propagation modes in the fiber)

Attenuation is significantly lower for optical fiber than for other media. For multi mode transmission, chromatic and modal dispersion reduce the available power of the system by the combined dispersion penalty (dB). The power lost over the data link is the sum of the component, dispersion, and modal losses.

Table2-2 lists the factors of attenuation and dispersion limit for typical fiber-optic cable.

Table 5-1: Typical Fiber-Optic Link Attenuation and Dispersion Limits

Limits	**Single-Mode**	**Multi mode**
Attenuation	0.5 dB	1.0 dB/km
Dispersion	No limit	500 MHzkm

The product of bandwidth and distance must be less than 500 megahertz per kilometer (MHzkm).

5.3 Multi mode Power for Transmission

The following is an example of a multi mode power margin calculation based on the following variables.

- Length of multi mode link = 3 kilometers (km), with a loss of 1.0 dB per km

- 4 connectors, each with a loss of 0.5 dB

- 3 splices, each with a loss of 0.5 dB
- Higher order loss (HOL) of 0.5 dB
- Clock recovery module (CRM), with a loss of 1.0 dB

Estimate the power margin as follows:

PM = 11.5 dB - 3 km (1.0 dB/km) - 4 (0.5 dB) - 3 (0.5 dB) - 0.5 dB (HOL) - 1 dB (CRM)

PM = 11.5 dB - 3 dB - 2 dB - 1.5 dB - 0.5 dB - 1 dB

PM = 2.5 dB

The value of 3.5 dB indicates that this link would have sufficient power for transmission.

5.3.1 Multi mode Power Margin Example of Dispersion Limit

Following is an example with the same parameters as the previous example, but with a multi mode link distance of 4 km:

PM = 11.5 dB - 4 km (1.0 dB/km) - 4 (0.5 dB) - 3 (0.5 dB) - 0.5 dB (HOL) - 1 dB (CRM)

PM = 11.5 dB - 4 dB - 2 dB - 1.5 dB - 0.5 dB - 1 dB

PM = 1.5 dB

The value of 1.5 dB indicates that this link would have sufficient power for transmission; however, because of the dispersion limit on the link (4 km x 155.52 MHz > 500 MHzkm), this link would not work with multi mode fiber. In this case, single-mode fiber would be the better choice.

5.4 Single-Mode Transmission

The single-mode signal source is an injection laser diode. Single-mode transmission is useful for longer distances because there is a single transmission path within the fiber, and smear does not occur. In addition, chromatic dispersion is reduced because laser light is essentially monochromatic.

The maximum overload specification on the single-mode receiver is -14 dB. The single-mode receiver can be overloaded when using short lengths of fiber because the transmitter can transmit up to -8 dB, while the receiver could be overloaded at -14 dB, but no damage to the receiver will result. To prevent overloading the receiver connecting short fiber links, insert a 5- to 10-dB attenuation on the link between any single-mode SONET transmitter and the receiver.

5.5 ATM Interface Cables

An ATM interface cable is used to connect your router to an ATM network or to connect two routers back-to-back.

Cables can be obtained from the following cable vendors:

AT&T

Siemens

Red-Hawk

Anixter

AMP

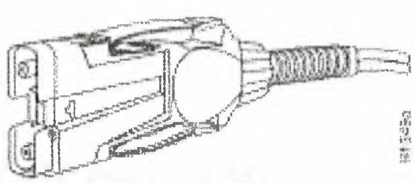
The AIP can support interfaces that connect to the following physical layers:

- Transparent Asynchronous Transmitter/Receiver Interface (TAXI) 4B/5B 100-Mbps multi mode fiber-optic
- SONET/SDH 155-Mbps multi mode fiber-optic--STS-3C or STM-1
- SONET/SDH 155-Mbps single-mode fiber-optic--STS-3C or STM-1
- E3 34-Mbps coaxial cable
- DS3 44.736-Mbps (±20 parts per million [ppm]) coaxial cable

Following are descriptions of the network interface cables used with the AIP.

- For TAXI 4B/5B traffic over multi mode fiber, use the multi mode MIC interface cable to connect the AIP with the external ATM switch.(See figure 5-2.)

Figure 5-2: Multi mode Network Interface Connector (MIC Type)



- For SONET/SDH multi mode connections, use one multi mode duplex SC connector (see figure5-2) or two single SC connectors (see figure 5-3).

Figure 5-3: Duplex SC Connector

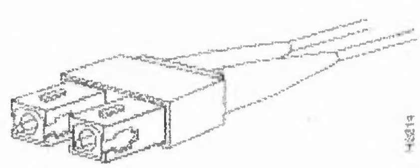
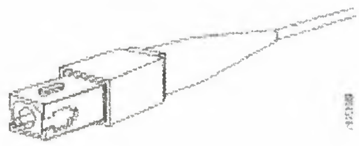
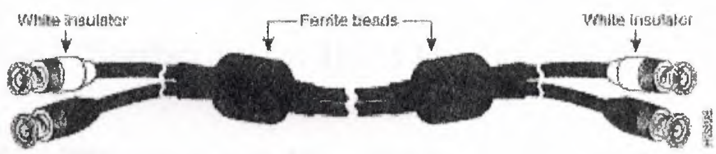


Figure 5-4: Simplex SC Connector



- For E3 and DS3 connections, use the 75-ohm, RG-59 coaxial cable CAB-ATM-DS3/E3, which has bayonet-style, twist-lock (BNC) connectors and ferrite beads. The E3 and DS3 PLIMs both require cable CAB-ATM-DS3/E3.

Figure 5-5:CAB-ATM-DS3/E3 Cable (RG-59 Coaxial Cable with BNC Connectors)



Use the following procedure to install a CAB-ATM-DS3/E3 cable and EMI filter clip:

5.6 Configuration of the AIP (and ATM) is a two-step process

Configure the AIP. To do so, complete the following tasks:

Enable the AIP

Configure the rate queue

Customize the AIP configuration (optional)

Configure PVCs

Configure SVCs

Monitor and maintain the ATM interface (optional).

The first two tasks are required, and then you must configure at least one PVC or SVC. The VC options you configure must match in three places: on the router, on the ATM switch, and at the remote end of the PVC or SVC connection.

Configure the ATM switch to which your AIP will connect.

On power up, the interface on a new AIP is shut down. To enable the interface, you must enter the no shutdown command in configuration mode. When the AIP is enabled (taken out of shutdown) with no additional arguments, the default interface configuration file parameters are used.

5.7 Interface Port Numbering for the ATM Interface

The Cisco 7000 series and Cisco 7500 series routers identify an interface address by its interface processor slot number and port number in the format *slot/port*. Because each AIP contains a single ATM interface, the port number is always 0. For example, the slot/port address of an ATM interface on an AIP installed in interface processor slot 0 would be 0/0; if installed in interface processor slot 1, the slot/port address changes to 1/0.

5.7.1 Configuring the Interface

Use the following guidelines to perform a basic configuration: enabling an interface and specifying IP routing. You might also need to enter other configuration subcommands, depending on the requirements for your system configuration and the protocols you plan to route on the interface.

Configuring the AIP first requires privileged-level access to the EXEC command interpreter. privileged-level access usually requires a password. (Contact your system administrator, if necessary, to obtain privileged-level access.)

The following steps describe a basic configuration. The system will prompt you for a password if one is set. Press the Return key after each configuration step unless otherwise noted.

Step 1 At the privileged-mode prompt, enter configuration mode and specify that the console terminal will be the source of the configuration subcommands as follows.

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#
```

Step 2 At the prompt, specify the new ATM interface to configure by entering the interface command, followed by the *type* (atm) and *slot/port* (interface processor slot number/port number). The example that follows is for an AIP in interface processor slot

```
Router(config)# interface atm 1/0
```

Step 3 If IP routing is enabled on the system, you can assign an IP address and subnet mask to the interface with the IP address configuration subcommand, as in the following example:

```
Router(config)# ip address 1.1.1.3 255.255.255.0
```

Step 4 Change the shutdown state to up and enable the ATM interface as follows:

```
Router(config)# no shutdown
```

The no shutdown command passes an enable command to the AIP, which then begins segmentation and reassembly (SAR) operations. It also causes the AIP to configure itself based on the previous configuration commands sent.

Step 5 Add any additional configuration subcommands required to enable routing protocols and adjust the interface characteristics.

Step 6 When you have included all of the configuration subcommands to complete the configuration, enter ^Z (hold down the Control key while you press Z) to exit configuration mode.

Step 7 Write the new configuration to memory as follows:

```
Router# copy running-config startup-config
[OK]
```

The system will display an OK message when the configuration has been stored.

After you have completed your configuration, you can check it using show commands. For an explanation of show commands, refer to the section Configuring the Rate Queue.

A rate queue defines the maximum speed at which an individual virtual circuit (VC) transmits data to a remote ATM host. There are no default rate queues. Every VC *must* be associated with one rate queue.

The AIP supports up to eight different *peak* rates. The peak rate is the maximum rate, in kilobits per second, at which a VC can transmit data. After attachment to this rate queue, the VC is assumed to have its peak rate set to that of the rate queue.

You can configure each rate queue independently to a portion of the overall bandwidth available on the ATM link. The combined bandwidths of all rate queues should not exceed the total bandwidth available for the AIP physical layer interface. The total bandwidth depends on the PLIM.

The rate queues are broken into a high (0 through 3) and low (4 through 7) bank. When the rate queues are configured, the AIP will service the high priority banks until they are empty and then service the low priority banks.

Virtual circuits get the entire bandwidth of the associated rate queue. If over subscription occurs, the other rate queues in bank A will miss the service opportunities. In the worst case, a 10-Mbps rate queue will take 100 Mbps if there are 10 VCs attached to it and all of them have packets to send at the same time.

To configure rate queue 1 at 10 Mbps, use the atm rate-queue *queue-number rate* command in interface configuration mode as follows:

```
Router(config-if)# atm rate-queue 1 10
```

where the *queue-number* is in the range of 0 to 7 and the *rate* (in Mbps) is in the range of 1 to 155. The no form of the command removes the rate queue.

You must create a rate queue before you can create permanent virtual circuits (PVCs) or switched virtual circuits (SVCs). If all rate queues are unconfigured, a warning message will appear, If the combined queue rates exceed the AIP physical layer interface bandwidth maximum, a warning message will appear, as follows:

```
%WARNING(ATM4/0): Total rate queue allocation nMbps exceeds
maximum of nMbps
```

5.7.2 Customizing the AIP Configuration

You can change the AIP default configuration values to match your network environment. Perform the tasks in the following sections if you need to customize the AIP's configuration:

5.7.3 Selecting an AIP Interface

The AIP's interface is referred to as atm in the configuration commands. An interface is created for each AIP found in the system at reset time.

To select a specific AIP interface, use the interface atm *slot/port* command, as follows:

```
Router(config)# interface atm slot/port
```

5.7.4 Setting the MTU Size

To set the maximum transmission unit (MTU) size, use the following command:

```
Router(config-if)# mtu bytes
```

where *bytes* is in the range of 64 through 9188 bytes; the default is 4470 bytes. (4470 bytes exactly matches FDDI and HSSI interfaces for autonomous switching.)

The no form of the command restores the default:

```
Router(config-if)# no mtu
```

5.7.5 Configuring SONET Framing

In STM-1 mode, the AIP sends *idle* cells for cell-rate decoupling. In STS-3C mode, the AIP sends *unassigned* cells for cell-rate decoupling. The default SONET setting is STS-3C. To configure for STM-1, use the following command:

```
Router(config-if)# atm sonet stm-1
```

To return to STS-3C, use the no atm sonet stm-1 command.

5.7.6 Configuring an ATM Interface for Local Loop back

To configure an ATM interface for local loop back (useful for checking that the AIP is working), use the following command:

```
Router(config-if)# loop back plim
```

The no form of the command turns off loop back

```
Router(config-if)# no loop back plim
```

5.7.7 Setting the Reassemble Buffers

The atm rxbuff command sets the maximum number of reassembles that the AIP can perform simultaneously. The AIP allows up 512 simultaneous reassembles; the default is 256. The no form of the command restores the default.

5.7.8 Setting the Transmit Buffers

To set the number of transmit buffers for simultaneous fragmentation, use the following command:

```
Router(con fig-if)# atm txbuff n
```

where *n* is in the range 0 to 512. The default is 256.

The no form of the command restores the default:

```
Router(con fig-if)# no atm txbuff
```

5.7.8 Setting the Source of the Transmit Clock

By default, the AIP uses the recovered receive clock to provide transmit clocking. To specify that the AIP generates the transmit clock internally for SONET, E3, and DS3 PLIM operation, use the following command:

```
Router(config-if)# atm clock internal
```

5.7.9 Configuring Virtual Circuits

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

- Quality of service (QOS)

- AAL mode (AAL3/4 or AAL5)
- Encapsulation type (LLC/SNAP, MUX, NLPID, and QSAAL)
- Peak and average transmission rates

Each VC supports the following router functions:

- Multi protocol (AppleTalk, CLNS, DECnet, IP, IPX, VINES, XNS, and so forth)
- Fast switching of IP, IPX, VINES, CLNS, and AppleTalk packets
- Autonomous switching of IP packets
- Pseudo broadcast 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.

5.7.10 Configuring Permanent Virtual Circuits

All permanent virtual circuits (PVCs) configured into the router remain active until the circuit is removed from the configuration. The PVCs also require a permanent connection to the ATM switch. All virtual circuit characteristics apply to PVCs. When a PVC is configured, all the configuration options are passed on to the AIP. These PVCs are writable into the nonvolatile RAM (NVRAM) as part of the configuration and are used when the Cisco IOS image is reloaded.

Some ATM switches have point-to-multi point PVCs that do the equivalent of broadcasting. If a point-to-multi point PVC exists, then that PVC can be used as the sole broadcast PVC for all multicast requests.

To configure a PVC, you must perform the following tasks:

- Create a PVC
- Map a protocol address to a PVC

5.7.11 Using PVC Configuration Commands

When you create a PVC, you create a virtual circuit descriptor (VCD) and attach it to the VPI and VCI. A VCD is an AIP-specific mechanism that identifies to the AIP which VPI/VCI to use for a particular packet. The AIP requires this feature to manage the packets for transmission. The number chosen for the VCD is independent of the VPI/VCI used.

When you create a PVC, you also specify the AAL and encapsulation. A rate queue is used that matches the peak and average rate selections, which are specified in kilobits per second. Omitting a peak and average value causes the PVC to be connected to the highest bandwidth rate queue available. In that case, the peak and average values are equal.

To create a PVC on the AIP interface, you use the atm pvc command as follows:

```
Router(con fig-if)# atm pvc vcd vpi vci aal-encap protocol-type-for-mux [peak-rate] [average-rate] [cell-quota]
```

- vcd is a per-AIP unique index value describing this VC in the range of 1 to MAXVC.

- vpi is the ATM network VPI to use for this VC, in the range of 0 through 255.

- vci is the ATM network VCI to use for this VC, in the range of 0 through 65,535.

- aal-encap is the ATM adaptation layer encapsulation type to use on this VC from the following:

  - aal5mux specifies the MUX-type for this VC. A protocol type must be specified.

  - aal5snap specifies that LLC/SNAP precedes the protocol datagram.

  - aal5nlpid specifies that NLPID precedes the protocol datagram.

  - aal34smds specifies that SMDS framing precedes the protocol datagram.

  - qsaal is a signaling type VC.

- **protocol-type-for-mux** is a protocol type compatible with the MUX and is required from the following protocols: ip, decnet, novell, vines, xns.

- **peak-rate** is the (optional) maximum rate, in kbps, at which this VC can transmit.

- **average-rate** is the (optional) average rate, in kbps, at which this VC will transmit.

- **cell-quota** is an (optional) integer value, in the range 1 through 2047, describing the maximum number of credits that a VC can accumulate. The AIP makes use of this in multiples of 32 cells. Every cell transfer consumes one cell credit. One cell transfer credit is issued to a VC in the average rate speed.

To remove a PVC, use the no form of this command, as follows:

```
Router(con fig-if)# no atm pvc vcd
```

Following is an example of the atm pvc command:

```
Router(con fig)# interface atm 2/0

Router(con fig-if)# atm pvc 2048 255 128 aal5snap ip 10 10
2046
```

The atm pvc command creates PVC *n* and attaches the PVC to *VPI* and *VCI*. The AAL used is specified by *aal* and encapsulation by encap. A rate queue is used that matches the *peak* and average (*avg*) rate selection. The *peak* and *avg* rate selection values are specified in kbps. Not specifying a *peak* and *avg* value causes the PVC to default to the highest bandwidth rate queue available.

5.7.12 Configuring the VP Filter

The vp-filter command configures the hexadecimal value used in the virtual path (vp) filter register in the reassemble operation. When a cell is received, the right half (most-significant byte) of the filter is exclusively NORed with the incoming virtual path identifier (VPI). The result is then ORed with the left half (least-significant byte) of the filter (the mask). If the result is all ones, then reassemble is done using the VCI/MID table. Otherwise, reassemble is done using the VPI/VCI table. The vp filter mechanism allows a way of specifying which VPI (or range of VPIs) will be used for AAL3/4 processing, all other VPIs mapping to AAL5 processing. In the case where only AAL5 processing is desired, the vp filter should be set to the default VPI of 0x7B (hexadecimal). In that case, AAL5 processing will be performed on the first 127 VPIs. Currently you can only configure one VPI for all the AAL3/4 packets.

```
Router(config)# atm vp-filter 1
```

All incoming cells with VPI = 1 will be reassembled via AAL3/4 processing, which is supported with Cisco IOS Release 10.2 and later.

```
Router(config)# atm vp-filter 0
```

All incoming cells with VPI = 0 will be reassembled via AAL3/4 processing. All other cells will be reassembled via AAL5 processing.

5.7.13 Mapping a Protocol Address to a PVC

The Cisco IOS software supports a mapping scheme that identifies the ATM address of remote hosts/routers. This address can be specified either as a virtual circuit descriptor (VCD) for a PVC or a network service access point (NSAP) address for SVC operation.

Enter mapping commands as groups; multiple map entries can exist in one map list. First create a map list, then associate the list with an interface.

Enter the map-list *name* command; then enter the protocol, protocol address, and other variables, as follows:

```
Router(config)# map-list name
protocol  address atm-vc vcd | atm-nsap nsap [broadcast]
```

The broadcast keyword specifies that this map entry receives the corresponding protocol broadcast requests to the interface (for example, any network routing protocol updates).

If you do not specify broadcast, the ATM software is prevented from sending routing protocol updates to the remote hosts.

After you create the map list, specify the ATM interface to which it applies with the interface command, as follows:

Router(con fig)# interface atm *slot/port*

Associate the map list to an interface with the following command:

Router(con fig-if)# map-group *name*

You can create multiple map lists, but only one map list can be associated with an interface. Different map lists can be associated with different interfaces.

Following is an example of mapping a list to an interface:

```
interface atm4/0
ip address 131.108.168.110 255.255.255.0
map-group atm
atm rate-queue 1 100
atm pvc 1 0 8 aal5snap
atm pvc 2 0 9 aal5mux decnet
decnet cost 1
map-list atm
ip 131.108.168.112 atm-vc 1 broadcast
decnet 10.2 atm-vc 2 broadcast
```

5.8 AIP Statistics

The AIP will maintain a count of certain errors. In addition to keeping a count of these errors, the AIP will also take a snapshot of the last VCI/VPI that caused an error. Each AIP error counter is 16 bits.

Errors include the following:

- CRC errors
- Giants received
- No buffers available
- Framing errors
- Applique/physical layer errors
- Packet timeout errors on receive

5.9 ATM show Commands

You can use the following ATM show commands to display the current state of the ATM network and the connected VCs:

- To show current VCs and traffic information, use the show atm vc command, as follows:

```
Router# show atm vc [vcd]
```

Specifying a VCD displays specific information about that VCD.

- To show current ATM-specific information about the AIP interface, use the show atm int interface command, as follows:

```
Router# show atm int interface
```

- To show current ATM traffic, use the show atm traffic command, as follows:

```
Router# show atm traffic
```

The show atm traffic command displays global traffic information to and from all ATM networks connected to the router.

- To show the current ATM mapping of the active list of ATM static maps to remote hosts on an ATM network, use the show atm map command, as follows:

```
Router# show atm map
```

5.9.1 Using show Commands to Check the Configuration

Following are descriptions and examples of the **show** commands that display AIP configuration information:

- Use the show controllers cbus command to display the internal status of the system processor and each interface processor, including the interface processor slot location, the card hardware version, and the currently-running micro code version. The show controllers cbus command also lists each interface (port) on each interface processor, including the logical interface number, interface type, physical (slot/port) address, and hardware (station address) of each interface. The following examples show an AIP installed in interface processor slot 0, the running AIP microcode is Version 170.46, the PLIM type is 4B/5B, and the available bandwidth is 100 Mbps:

```
Router# show cont cbus
(additional displayed text omitted from this example)
 AIP 4, hardware version 1.0, microcode version 170.46
 Microcode loaded from system
 Interface 32 - ATM0/0, PLIM is 4B5B(100Mbps)
    15 buffer RX queue threshold, 36 buffer TX queue limit,
buffer size 4496
  ift 0007, rql 12, tq 0000 0620, tql 36
  Transmitter delay is 0 microseconds
```

- Use the show interfaces atm slot/port command to display statistics for the ATM interface you specify by its interface address, as follows:

```
Router# show int atm 0/0
ATM interface ATM0/0:
AAL enabled:  AAL5, Maximum VCs: 1024, Current VCs: 6
Tx buffers 256, Rx buffers 256, Exception Queue: 32, Raw
Queue: 32
VP Filter: 0x7B, VCIs per VPI: 1024
PLIM Type:4B5B - 100Mbps, No Framing, TX clocking: LINE
4897 input, 2900 output, 0 IN fast, 0 OUT fast
Rate-Queue 1 set to 100Mbps, reg=0x4EA
```

The following sample shows the output from the show atm vc command when a *vcd* is specified, AAL3/4 is enabled, an ATM Switched Multi megabit Data Service (SMDS) subinterface has been defined, and a range of message identifier numbers (MIDs) has been assigned to the PVC:

```
Router# show atm vc 1
ATM0/0.1: VCD: 1, VPI: 0, VCI: 1, etype:0x1, AAL3/4 - SMDS,
Flags: 0x35
PeakRate: 0, Average Rate: 0, Burst: 0 *32cells, VCmode:
0xE200
MID start: 1, MID end: 16
InPkts: 0, OutPkts: 0, InFast: 0, Broadcasts: 0
```

- Use the show atm map command to display the PVC map, as follows:

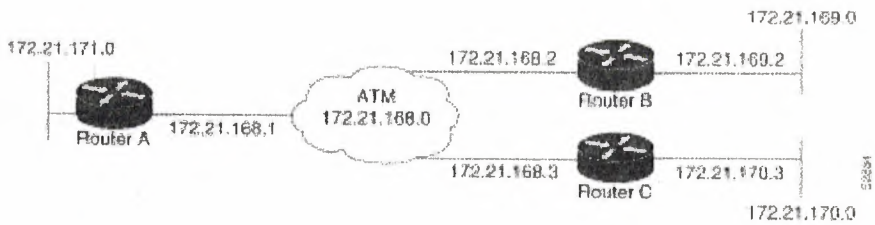
```
Router# show atm map
Map list atm:
vines 3004B310:0001 maps to VC 4, broadcast
ip 131.108.168.110 maps to VC 1, broadcast
clns 47.0004.0001.0000.0c00.6e26.00 maps to VC 6, broadcast
appletalk 10.1 maps to VC 7, broadcast
decnet 10.1 maps to VC 2, broadcast
```

- Use the show version command to display the configuration of the system hardware (the number of each interface processor type installed), the software version, the names and sources of configuration files, and the boot images.

5.9.2 PVCs in a Fully Meshed Network

(figure 5-5)illustrates an example of a fully meshed network.

Figure 5-5: Fully Meshed ATM Configuration Example



The term fully meshed indicates that any workstation can communicate with any other workstation.

In this example, the routers are configured to use PVCs; note the following:

- The two map list statements configured in Router A identify the ATM addresses of Routers B and C.
- The two map list statements in Router B identify the ATM addresses of Routers A and C.
- The two map list statements in Router C identify the ATM addresses of Routers A and B.

The configurations for Routers A, B, and C follow:

<u>Router A</u>

```
ip routing

interface atm 4/0

ip address 131.108.168.1 255.255.255.0

atm rate-queue 1 100
```

```
atm pvc 1 0 10 aal5snap
atm pvc 2 0 20 aal5snap
map-group test-a
map-list test-a
ip 131.108.168.2 atm-vc 1 broadcast
ip 131.108.168.3 atm-vc 2 broadcast
```

Router B

```
ip routing
interface atm 2/0
ip address 131.108.168.2 255.255.255.0
atm rate-queue 1 100
atm pvc 1 0 20 aal5snap
atm pvc 2 0 21 aal5snap
map-group test-b
map-list test-b
ip 131.108.168.1 atm-vc 1 broadcast
ip 131.108.168.3 atm-vc 2 broadcast
```

Router C

```
ip routing
interface atm 4/0
ip address 131.108.168.3 255.255.255.0
atm rate-queue 1 100
atm pvc 2 0 21 aal5snap
atm pvc 4 0 22 aal5snap
map-group test-c
```

```
map-list test-c
ip 131.108.168.1 atm-vc 2 broadcast
ip 131.108.168.2 atm-vc 4 broadcast
```

CONCLUSION

This graduation project is overview of explosive development in the field of network Communication, The finalization of technical standard in conjunction with the enormous investments already made assures competitive services in the long-distance and local loop segments in the future .ATM is an efficient technology to integrate LANs and WANs as well as to combine multiple networks into one multi service network.

This project described the current synchronous Transfer Mode (ATM) technologies that network designers can use in their networks. It also made recommendations for designing non-ATM networks. Option are based on experience ,when the long –range plan incorporation the integration of telephony , data ,and video ,an ATM based backbone is the winning architecture. It covers a vast area of application ,and provide collective inputs to a variety of problems and that gives lots for the benefit of mankind.

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