ATM

Topics

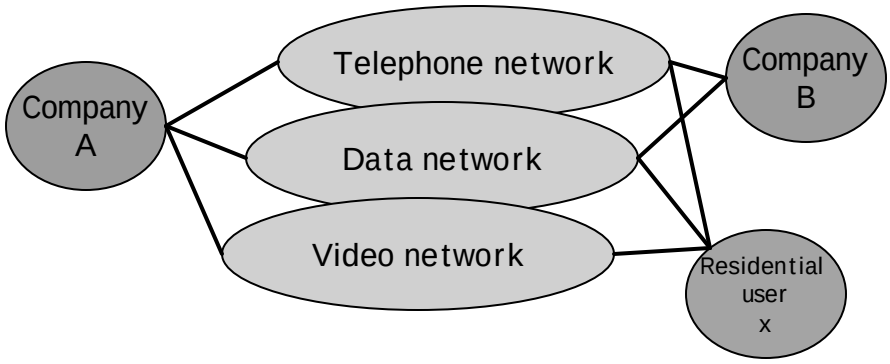
Introduction
ATM Architecture Overview
ATM Cell
ATM Connections
Addressing and Signaling
ATM Layer Services
IP over ATM

Introduction

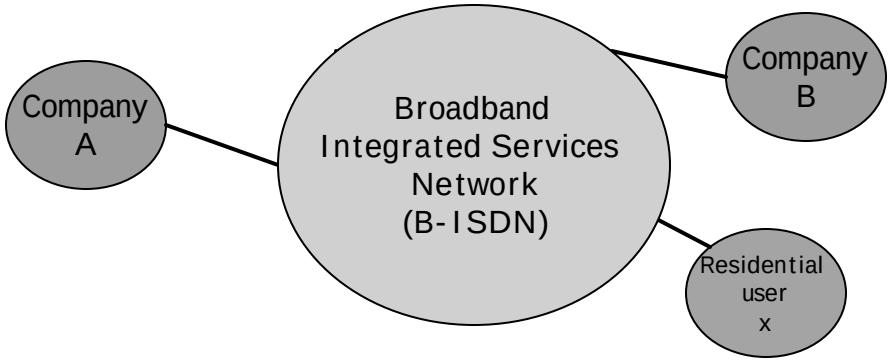
Broadband Integrated Services Networks

- In the mid-1980s, the ITU-T (formerly CCITT) initiated a standardization effort to merge voice, video and data on a single network
- The goal was to replace all existing networks (telephony networks, Cable TV network, data networks) with a single network infrastructure. The effort was called **B-ISDN (Broadband Integrated Services Digital Networks)**
- The technology selected for B-ISDN was **Asynchronous Transfer Mode (ATM)** and **SONET/SDH (Synchronous Optical Network/Synchronous Digital Hierarchy)**

Traditional Network Infrastructure



B-ISDN

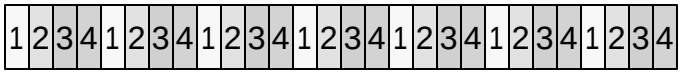


ATM: The official definition

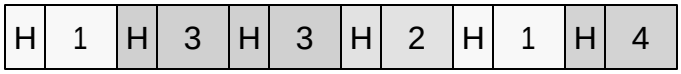
- **CCITT Definition (**I.113, Section 2.2**)**
  - A transfer mode in which the information is organized into cells; it is asynchronous in the sense that the recurrence of cells containing information from a particular user is not necessarily periodic

Why “asynchronous”?

Synchronous transfer mode (= Time division multiplexing)
- Each source gets period assignment of bandwidth
  - good: fixed delays, no overhead
  - bad: poor utilization for bursty sources



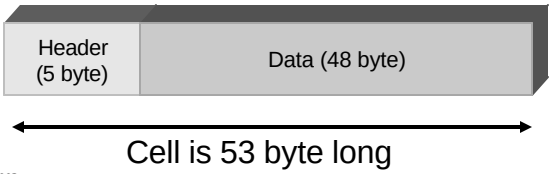
Asynchronous transfer mode (= Statistical multiplexing)
- Sources packetize data. Packets are sent only if there is data
  - good: no bandwidth use when source is idle
  - bad: packet headers, buffering, multiplexing delay



ATM's Key Concepts

- **ATM uses Virtual-Circuit Packet Switching**
  - ATM can reserve capacity for a virtual circuit. This is useful for voice and video, which require a minimum level of service
  - Overhead for setting up a connection is expensive if data transmission is short (e.g., web browsing)

- **ATM packets are small and have a fixed sized**
  - Packets in ATM are called ***cells***
  - Small packets are good for voice and video transmissions



53 Byte Cells

- **Why 53 Bytes?**
  A 48 byte payload was the result of a compromise between a 32 byte payload and a 64 byte payload

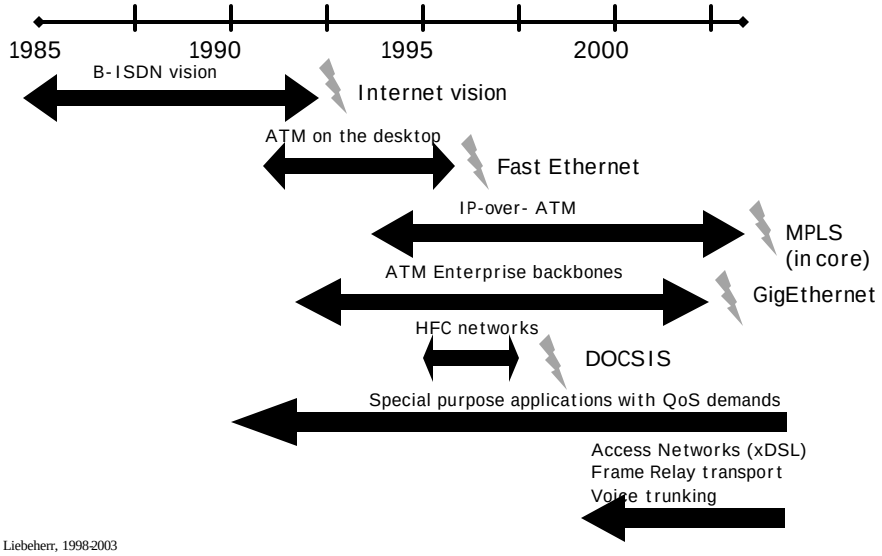
- **Advantages**
  - Low packetization delay for continuous bit rate applications (video, audio)
  - Processing at switches is easier

- **Disadvantages**
  - High overhead (5 Bytes per 48)
  - Poor utilization at lower line rates links

ATM Standardization

- Until 1991, standardization occurred within CCITT (now: ITU-T) in a series of recommendations in the I series
- In 1991, ATM Forum was formed as an industry consortium
  - ATM Forum starts to prepare specifications to accelerate the definition of ATM.
  - Specifications are passed to ITU-T for approval
  - Since 1993, ATM Forum drives the standardization process
- IETF publishes Request for Comments (RFCs) that relate to IP/ATM issues

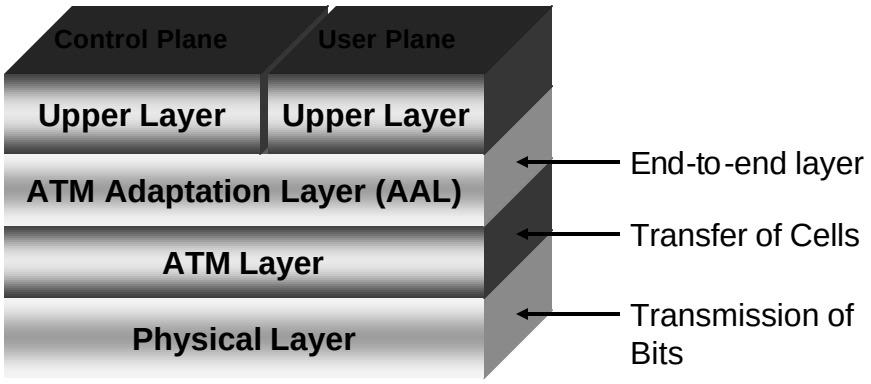
Uses of ATM



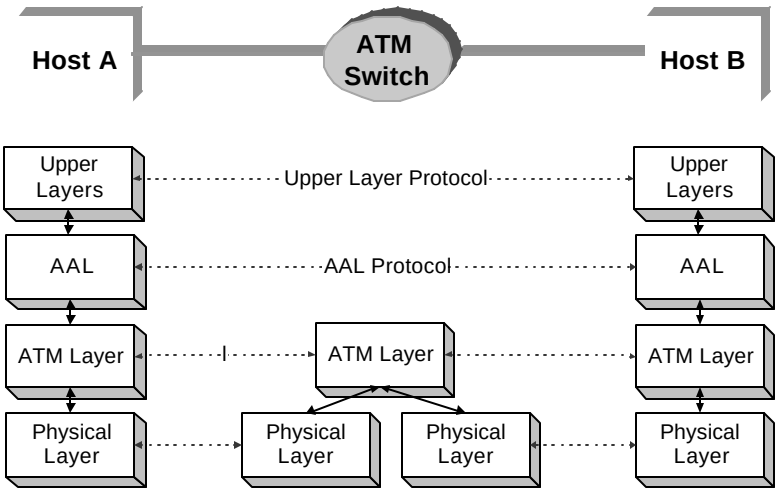
ATM Architecture Overview

The ATM Reference Model

- ATM technology has its own protocol architecture



Layers of ATM



Function of the Layers

Convergence		AAL
Segmentation and Reassembly		
Generic Flow Control Cell VPI/VCI translation Cell multiplexing and demultiplexing Cell header generation and extraction		ATM
HEC header sequence generation and verification Cell delineation Transmission frame generation and recovery	TC	Physical
Bit timing Physical medium	PM	

TC: transmission convergence
PM Physical medium

ATM Layer

- The ATM Layer is responsible for the transport of 53 byte cells across an ATM network
- Multiplex logical channels within a physical channel

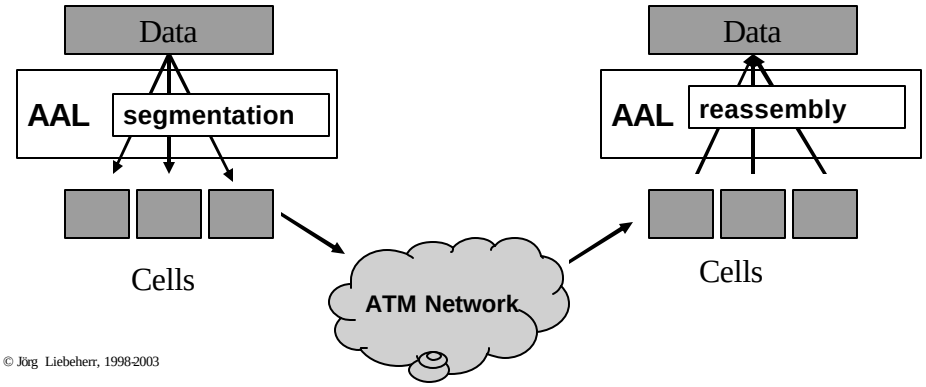
ATM Layer

The ATM Layer can provide a variety of services for cells from an ATM virtual connection:

- **Constant Bit Rate (CBR)**
  - guarantees a fixed capacity, similar to circuit switching
  - guarantees a maximum delay for cells
- **Variable Bit Rate (VBR)**
  - guarantees an average throughput and maximum delay
- **Available Bit Rate (ABR)**
  - guarantees 'fairness" with respect to other traffic
- **Unspecified Bit Rate (UBR)**
  - service is on a "best effort" basis
- **Guarantees Frame Rate (GFR)**
  - Throughput guarantee for multiple cell frames

ATM Adaptation Layer (AAL)

- AAL encapsulates user-level data
- Performs segmentation and reassembly of user-level messages

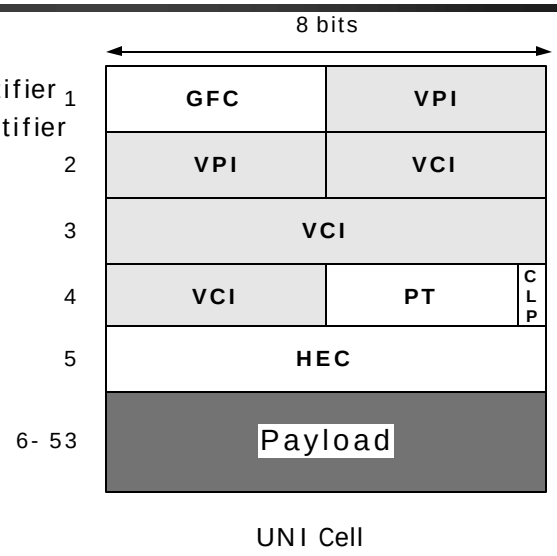


ATM Cells

ATM Cells

- 4-bit Generic flow control
- 8/12 bit Virtual Path Identifier
- 16 bit Virtual Channel Identifier
- 3 bit Payload Type
- 1 bit Cell Loss Priority
- 8 bit Header Error Control
- 48 byte payload

- GFC field only in UNI cells

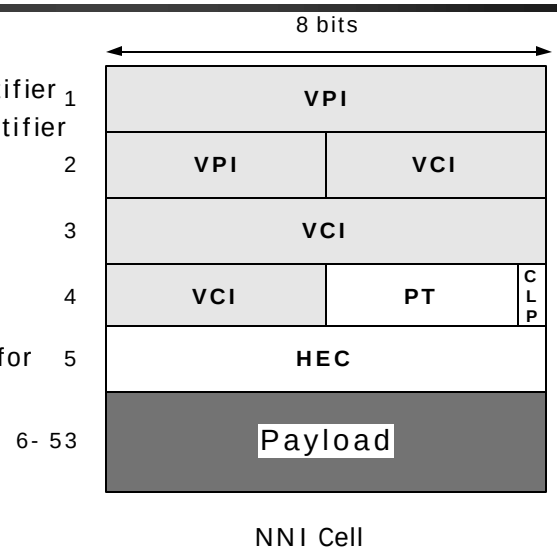


UNI Cell

ATM Cells

- 4-bit Generic flow control
- 8/12 bit Virtual Path Identifier
- 16 bit Virtual Channel Identifier
- 3 bit Payload Type
- 1 bit Cell Loss Priority
- 8 bit Header Error Control
- 48 byte payload

- At NNI: GFC byte is used for additional VPI

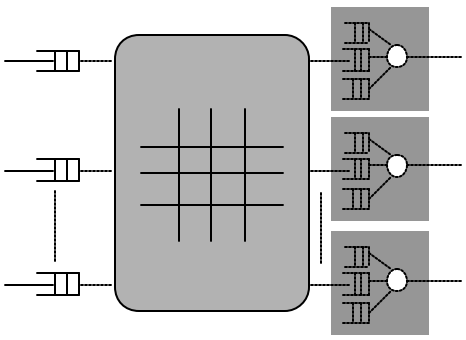


NNI Cell

ATM Connections

A Packet Switch

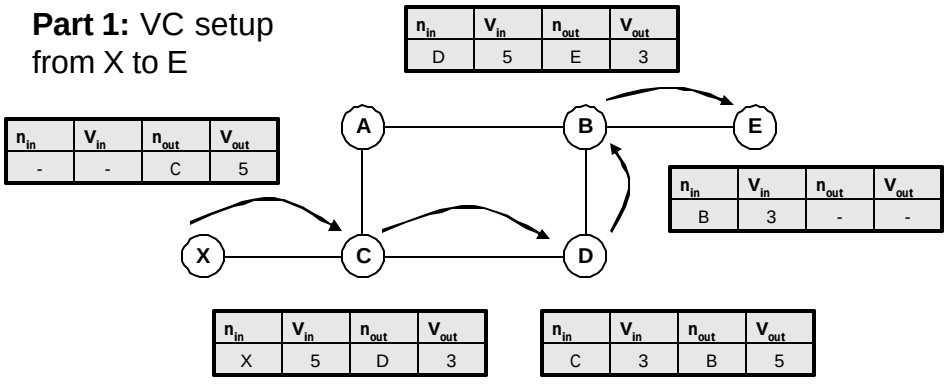
Packet



Packet switch

Forwarding with VCs

Part 1: VC setup from X to E



n_{in}	V_{in}	n_{out}	V_{out}
D	5	E	3

n_{in}	V_{in}	n_{out}	V_{out}
-	-	C	5

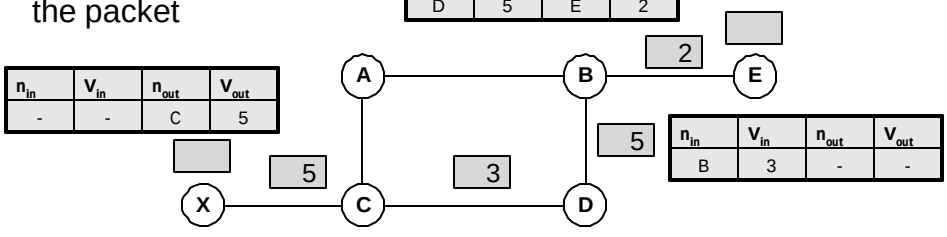
n_{in}	V_{in}	n_{out}	V_{out}
B	3	-	-

n_{in}	V_{in}	n_{out}	V_{out}
X	5	D	3

n_{in}	V_{in}	n_{out}	V_{out}
C	3	B	5

Forwarding with VCs

Part 2: Forwarding the packet



n_{in}	V_{in}	n_{out}	V_{out}
D	5	E	2

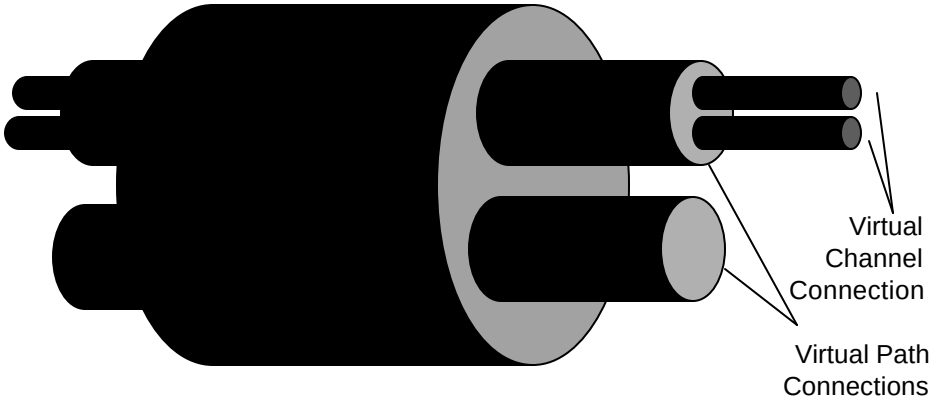
n_{in}	V_{in}	n_{out}	V_{out}
-	-	C	5

n_{in}	V_{in}	n_{out}	V_{out}
B	3	-	-

n_{in}	V_{in}	n_{out}	V_{out}
X	5	D	3

n_{in}	V_{in}	n_{out}	V_{out}
C	3	B	5

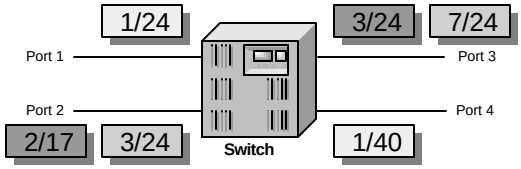
Virtual Paths and Virtual Circuits



VPI identifies virtual path (8 or 12 bits)

VCI identifies virtual channel in a virtual path (16 bits)

VPI/VCI assignment at ATM switches



Routing Table of switch v

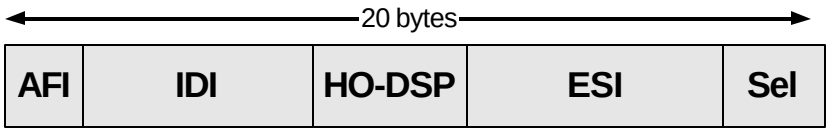
port	VPI/ VCI	to	VPI/ VCI
2	3/24	3	7/24
1	1/24	4	1/40
2	2/17	3	3/24

Addressing and Signaling

ATM Endsystem Addresses (AESA)

- All ATM addresses are 20 bytes long
- Source and destination address are supplied when setting up a connection
- ATM endpoints use the NSAP (Network Service Access Point) format from ISO OSI
- Three different types of addresses
  - **NSAP encoding for E.164:** ISDN telephone numbers (e.g., 001-434-9822200)
  - DCC format: for public networks
  - ICD format: for private networks

ATM Endsystem Addresses (AESA)



AFI (1 byte): Authority and Format Identifier
Tells which addressing scheme to use

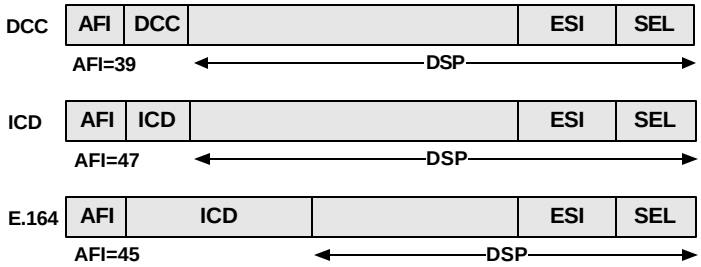
IDI (2-8 bytes): Initial Domain Identifier
Identifies a domain within scope of addressing authority

HO-DSP (4-10 bytes): High-order bits of domain specific part
similar to network prefix of IP address

ESI (6 bytes): Endsystem identifier
similar to host number of IP address

SEL (1 byte): Selector
for endsystem use only

Formats of an ATM address



AFI: Authority and Format Identifier

DCC: Data Country Code

ICD: International Code Designator

E.164: ISDN (telephone) Number

IDI: Initial Domain Identifier

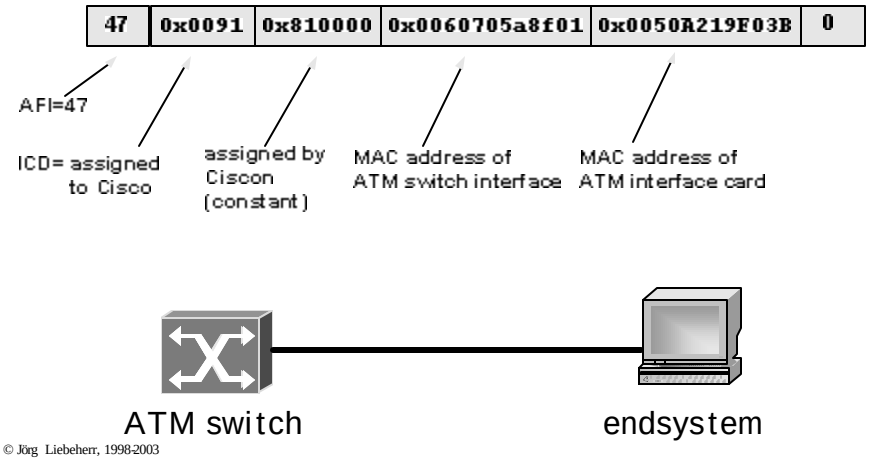
DSP: Domain Specific Part

ESI: Endsystem identifier

SEL: Selector

Example: Default Assignment of ATM addresses by Cisco Systems

47.009181000000001604799FD01.0050A219F03B.0



Which Address Format To Use?

- Currently each service provider makes its own choice
  - This introduces problems (SVC compatibility)
- Most ATM switches support multiple formats
- ATM Forum prepares standards to translate addresses at network boundaries (NNI interfaces)
  - Interworking of ATM Networks (IAN)

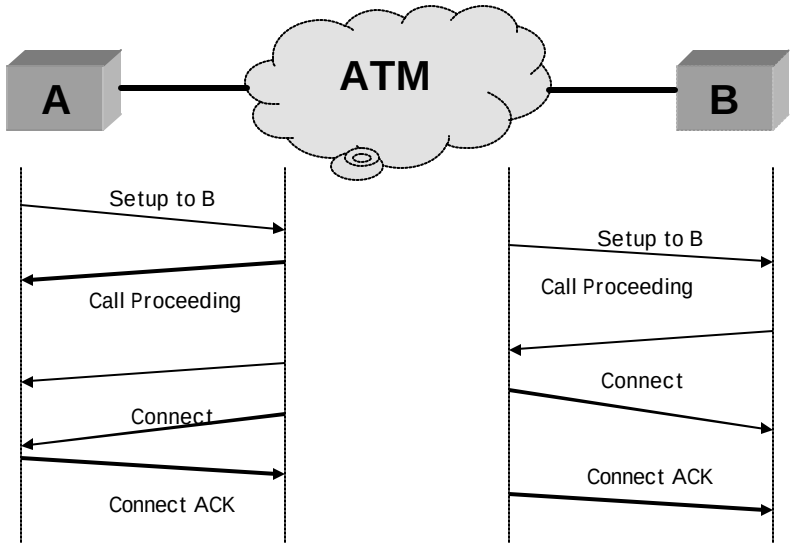
ATM UNI Signaling

- Significant Signaling Protocols

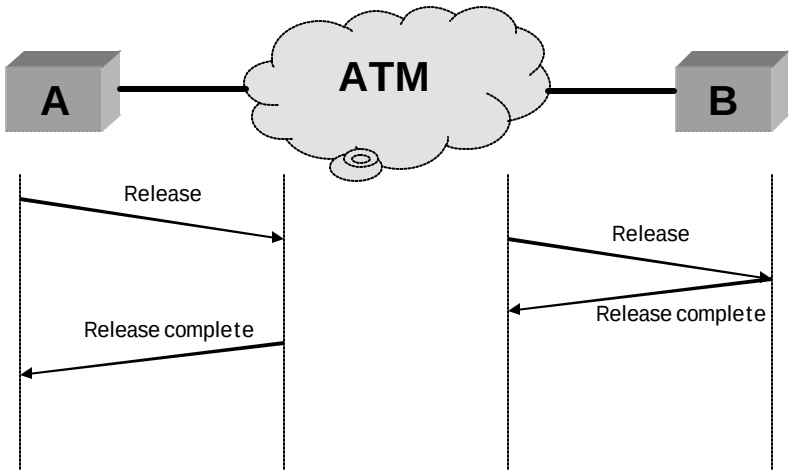
- **ATM Forum:**
- UNI 3.0. UNI signaling protocol for point-to-point connections.
- UNI 3.1. Supports point-to-multipoint connections.
- UNI 4.0. Supports Leaf initiated join multipoint connections
- PNNI. for network node signaling

- The ATM Forum signaling specifications are based on the Q.2931 public network signaling protocol developed by the ITU-T.
  - specifies a call control message format
    - message type (setup, call proceeding, release)
    - Addresses
    - AAL parameters
    - Quality of Service (QoS)

Basic Signaling Exchange: Setup of a SVC



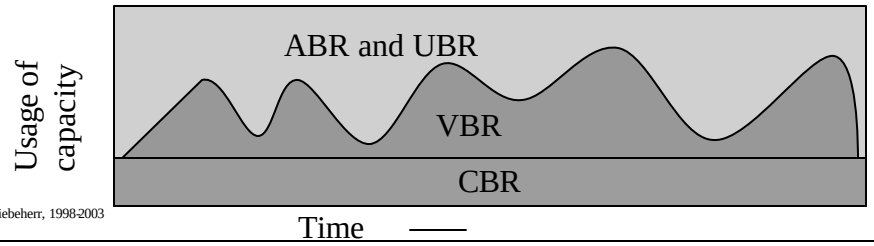
Basic Signaling Exchange: Tear down



6
ATM Layer Services

ATM Services at the ATM Layer

The following ATM services have been defined:
Constant Bit Rate (CBR)
Real-time Variable Bit Rate (rt-VBR)
Non-real-time Variable Bit Rate (nrt-VBR)
Available Bit Rate (ABR)
Unspecified Bit Rate (UBR)
Guaranteed Frame Rate (GFR)



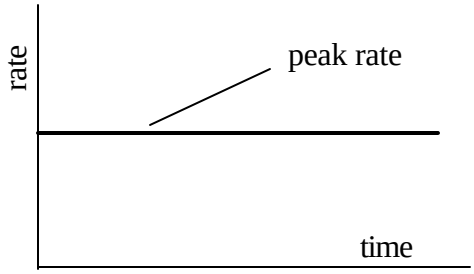
ATM Network Services

	Traffic Parameters		QoS Parameters		
Service	Bandwidth	Burst Size	Loss	Delay	Jitter
CBR	PCR		CLR	maxCTD	CDV
rt-VBR	PCR, SCR	MBS	CLR	maxCTD	CDV
nrt-VBR	PCR, SCR	MBS	CLR		
ABR	PCR, MCR		low		
UBR	PCR*				
GFR	PCR,MCR, MBS,MFS		low		

- CDVT characterizes an interface and is not connection specific
- PCR in UBR is not subject to CAC or UPC

Constant Bit Rate (CBR)

- For applications with constant rate requirements: video and audio
- Very sensitive to delay and delay variations
- Adaptation Layer: AAL1

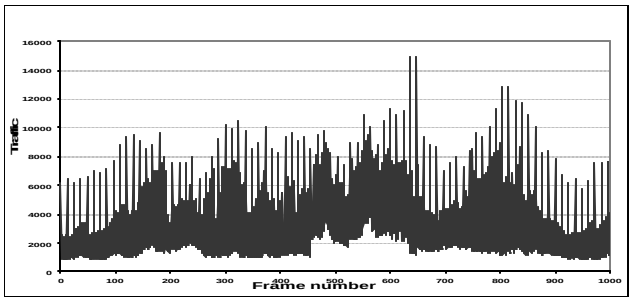


Variable Bit Rate (rt-VBR, nrt-VBR)

- For applications with variable rate requirements: compressed audio and video (rt-VBR) data applications (nrt-VBR), such as transactions
- Adaptation Layer: AAL2, AAL 3 /4, AAL5

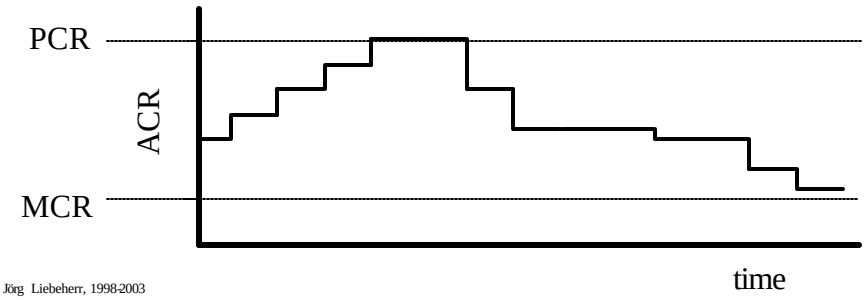
Example: 30 sec MPEG-1 trace (from Terminator)

- Peak rate: 1.9 Mbps
- Avg. rate: 0.261 Mbps



Available Bit Rate (ABR)

- For applications that can tolerate changes to rate Interconnection of LANs
- Transmission rate (ACR) changes between MCR and PCR
- ACR is set by a feedback algorithm (to be discussed)
- Adaptation Layer: AAL 5



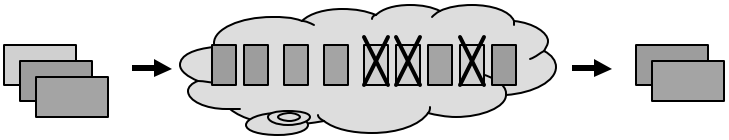
Unspecified Bit Rate (UBR)

- "Best effort service"
  - No bandwidth, loss, or delay guarantees
  - UBR gets the bandwidth that is not used by CBR, VBR, ABR
- No UPC and no feedback

- Applications: Non-critical data applications (file transfer, web access, etc.)
- Adaptation Layer: AAL5

Guaranteed Frame Rate (UBR)

- For non-real-time applications which guarantee a minimum rate guarantee
- Recognizes AAL5 boundaries
  - Frame consists of multiple cells
  - If a cell is dropped, remaining cells from that frame will be dropped as well



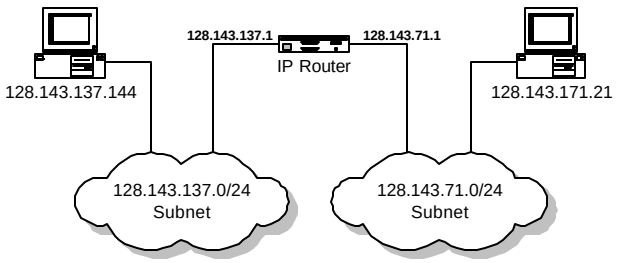
- Minimum rate (MCR) is guaranteed by network, the rest (up to PCR) is delivered on a best effort basis.
- Adaptation Layer: AAL5

9
IP-over-ATM

Issues with sending IP traffic over ATM

- Address resolution:
  - IP address ←→ VPI/VCI
  - IP address ←→ATM address
- Emulation of broadcast operation on IP subnetworks
- Routing

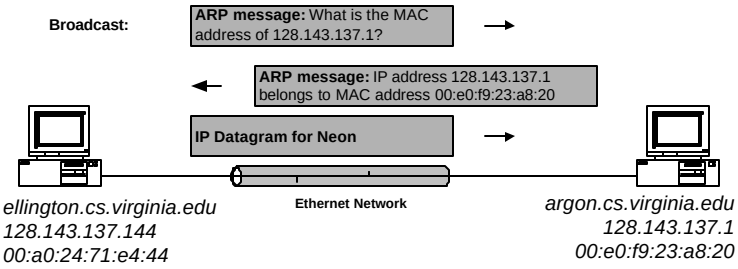
IP Networks 1 (simplified)



→ Recall: IP is a datagram packet switching network

- Hosts and routers are connected to "subnet". Subnets are connected by routers.
- IP packets (datagrams) to hosts on the same subnet are send directly
- IP datagrams to hosts on a different subnet are sent to a router

IP Networks 2 (simplified)



Sending datagram to host on the same subnet (assume Ethernet)

→ Host must translate IP address into MAC address
(MAC address = physical address)

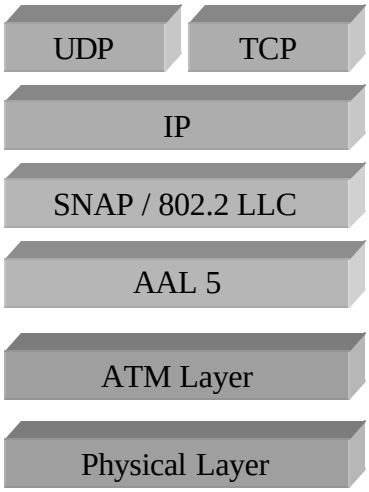
→ ARP protocol performs function:
- → Sender broadcasts ARP message
- → Destination replies

Solutions for IP-over-ATM

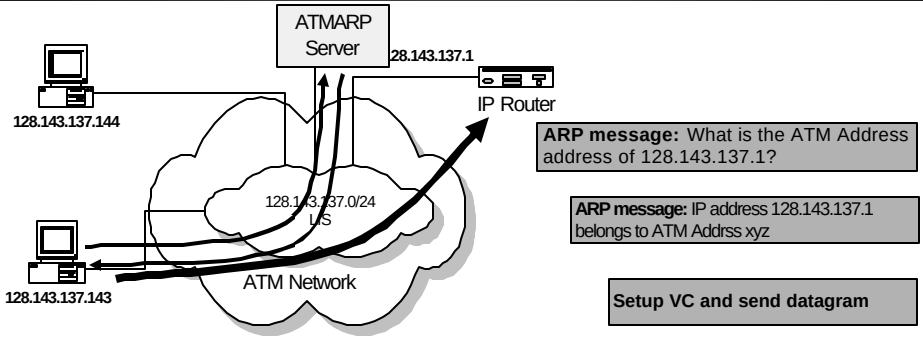
- Classical IP over ATM → by IETF
- Next Hop Resolution Protocol (NHRP) → by IETF
- LAN emulation (LANE) → by ATM Forum
- Multiprotocol over ATM → by IETF

Classical IP over ATM

- ATM network card is treated like an Ethernet card
- ATM Network consists of multiple logical subnets
- IP datagram is encapsulated and then passed to AAL5

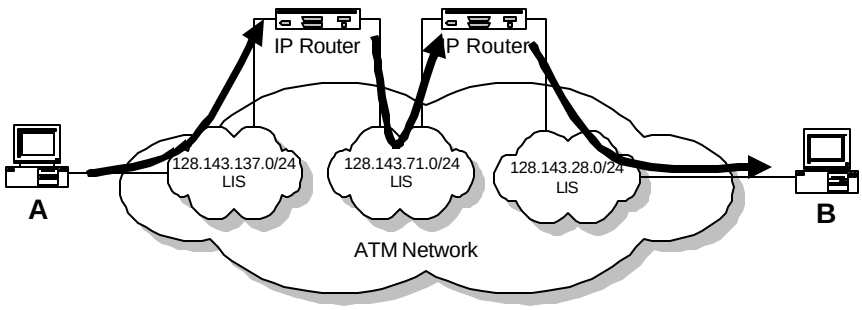


Logical IP Subnetwork (LIS)



- Each host has a VC to the ATMARP server
  → ATMARP translates between IP and ATM addresses
- Each host connects to another host on the same LIS with a dedicated VC
- IP datagrams to hosts on a different subnet are sent to router

Problem with Classical IP-over-ATM



- ATMARP server only resolve addresses for a single LIS
- Traffic from A to B goes through two IP routers, even though both hosts are on the same ATM network