Asynchronous Transfer Mode

Group Member

- Augustino Dere
- Puthyrak KANG

Presentation Objectives

Answer three basic Questions :

What? – what is ATM

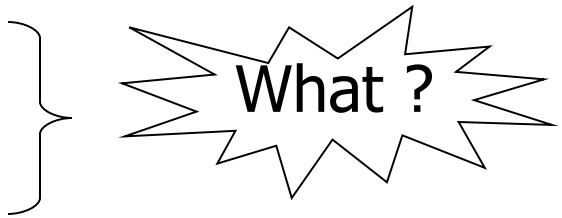
How ? – how it works.

Why? -- why it's used (benefits)

Outline

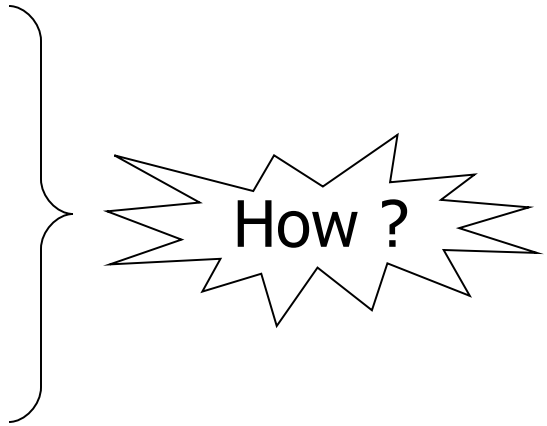
I - Introduction:

- Definition
- Overview: History, Features



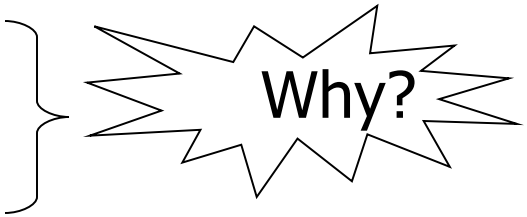
II - ATM Protocol/Architecture

- Reference Model
- Architecture of ATM network
- Virtual Connection
- Cell Formatted
- ATM Routing
- Congestion Control
  - Service
  - Quality of Service
  - Rate-Based Approach



III- ATM Benefit

IV - Conclusion



ATM Definition

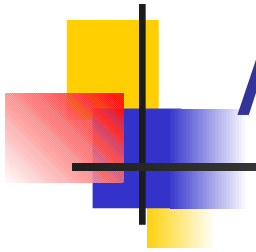
Asynchronous Transfer Mode (ATM)

A high-performance, cell-oriented switching and multiplexing technology that utilizes fixed-length packets to carry different types of traffic.

ATM Overview

ATM:

- ATM was designed in early 1990s
- In October 1991, ATM Forum with four companies as members– Adaptive (NET), CISCO, Norther Telecom, and Sprint. Since then, ATM Forum members has grown to over 200 principal members.
- ATM aim is to expedite the process of integrating AMT into the market.
- It is designed for high-performance multimedia networking.
- It enables carriers to transmit voice, video, and future media applications.
- It's suitable for bursty traffic.
- It allows communication between devices that operate at different speeds.
- It can be offered as an end-user service by service providers, or as a networking infrastructure
- It is a set of international interface and signaling standards defined by ITU-T Standards Sector.



ATM Overview

So far, ATM has been implemented in :

- PC, workstation, and server network interface cards
- Switched-Ethernet and token-ring workgroup hubs
- ATM enterprise network switches
- ATM multiplexers
- ATM-edge switches
- ATM-backbone switches

ATM Features

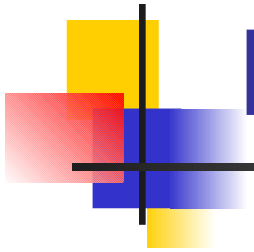
Main features of ATM

- Service is connection oriented, with data transferred over a VC
- A cell-switched network (architecture).
- Fixed-size cell (53-Bytes)
- Uses Asynchronous time-division multiplexing (Asynchronous TDM)
- The Quantity of Service (QofS) enable carriers to transmit voice, data, and video.
- ATM is independent of the transmission medium. ATM cells can be sent on a wire or fiber, and can also be packaged inside the payload of other carrier system.

Fixed and Small Size Cell

Advantage:

- Transmitted with predictability and uniformity.
- Easy to be multiplexed with other cells, and routed through the cell network.
- With high speed of the links, small and fixed-size cells seem to arrive their respective destinations in an approximation of continuous stream, despite interleaving. E.g. phone call.
- Simpler buffer hardware, avoiding memory fragmentation problem
- Simpler cells scheduling:
  - Easier to allocate different bandwidths and delays to different VCs.
  - Easier to implement priority
  - Fixed sized can be switched in parallel in synchronous fashion.
- It's suitable for time-critical information such as voice or video
- Quicker recovery in case of circuit failure.



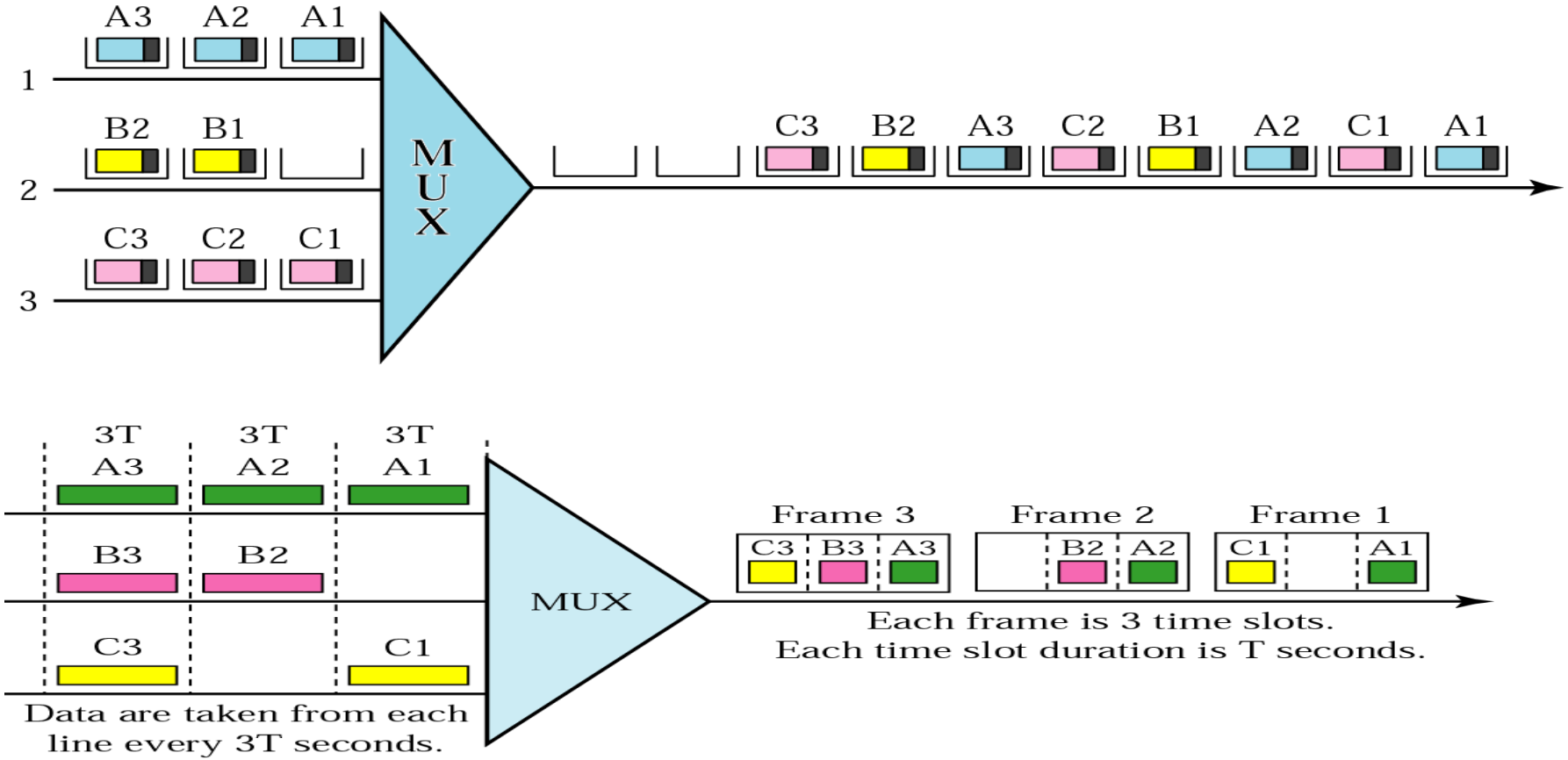
Fixed-Size and Small Cell

Disadvantage:

- Processing overhead as messages are segmented into cells

- Segmentation mismatch, as the last cell in a fragmented message may not be fully used. This effect will decrease as the message length increases.

ATM multiplexing

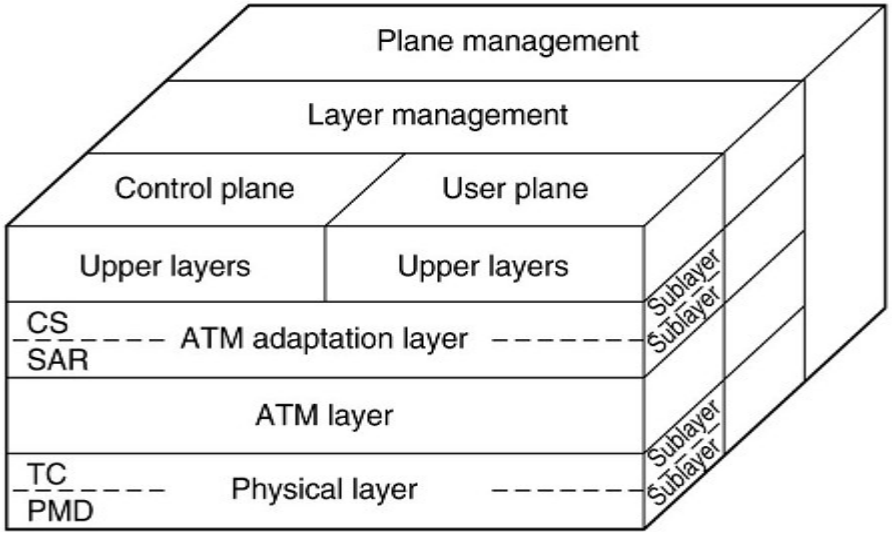


a) Asynchronous TDM : ATM multiplexers fill a slot with a cell from any input channel that has a cell.

b) TDM

How does ATM work ?

ATM Technology
Reference Model



- **Control**

  responsible for generating and managing signaling request (connection management).

- **User**

  deals with data transport, flow control, error correction, and other user functions.

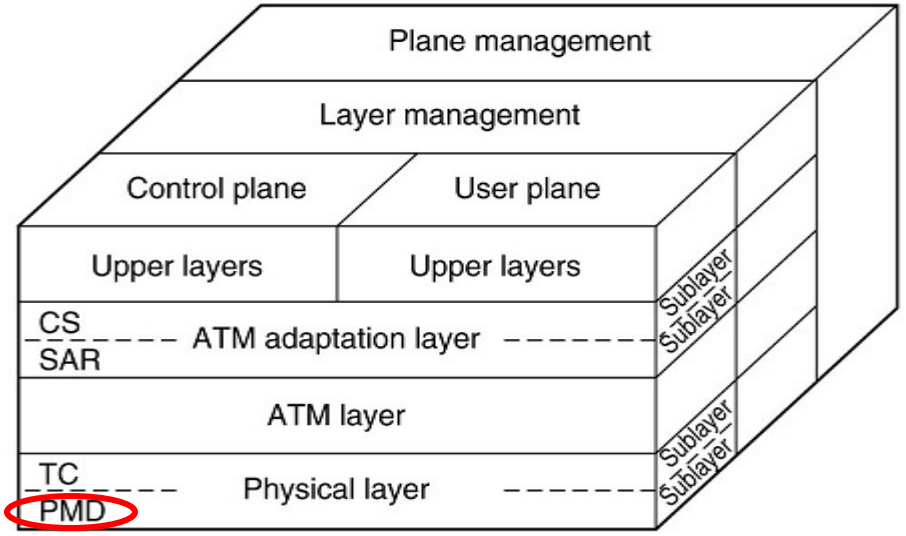
- **Layer Management** :

  manages layer-specific functions (detection of failures and protocol problems)

- **Plane Management:**

  manages and coordinates functions related to the complete system.

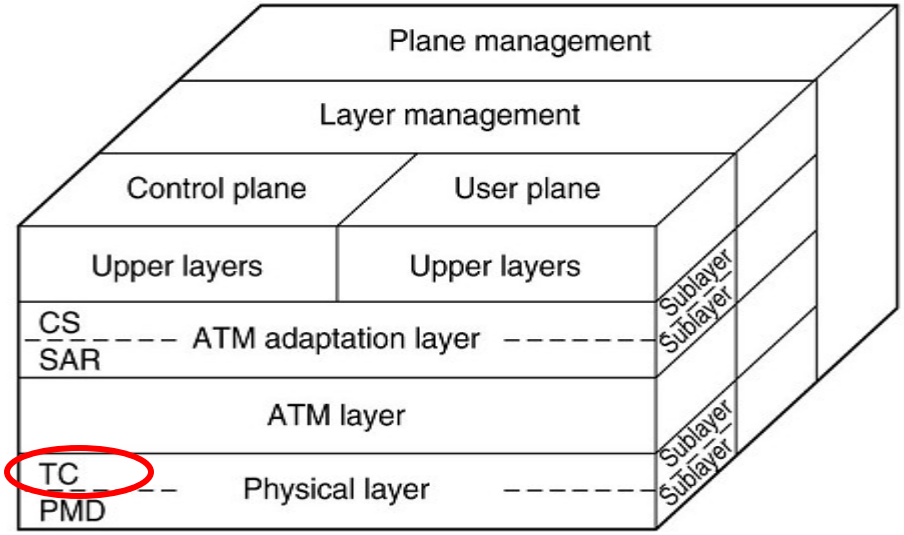
ATM Technology
Reference Model



Physical Medium-Dependent (PMD)– having two functions:

- Synchronizes transmission and reception by sending and receiving a continuous flow of bits with associated timing information.
- Specifies the physical media for the physical medium used, including connector type and cable.

ATM Technology
Reference Model



Transmission Convergence (TC) – having four functions:

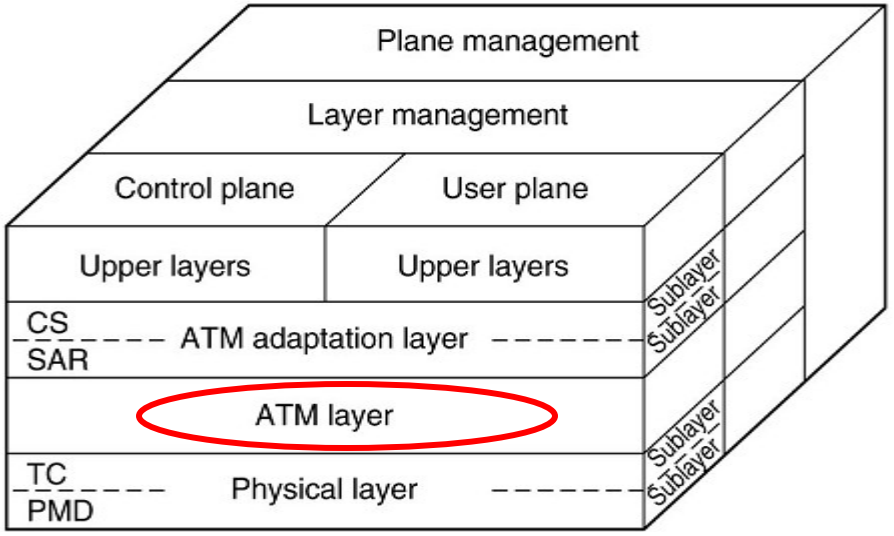
- Cell delineation, generating cell boundaries.
- Header error control (HEC) sequence generation and verification
- Cell-rate decoupling, maintaining synchronization and inserting or suppressing idle ATM cells to rate of valid ATM cells to the payload capacity of transmission system.
- Transmission frame adaptation, packaging cells into frame acceptable to the particular physical layer implementation.

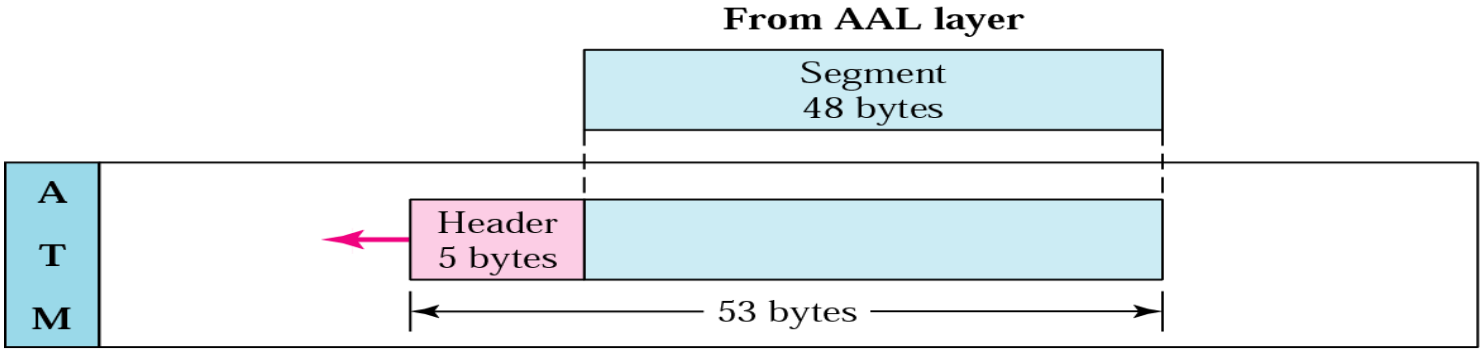
ATM Technology
Reference Model

ATM Layer

Provides

- Defining cells layout
- Defining header
- Routing
- Establishment and release VC.
- Switching
- Multiplexing
- Congestion control.



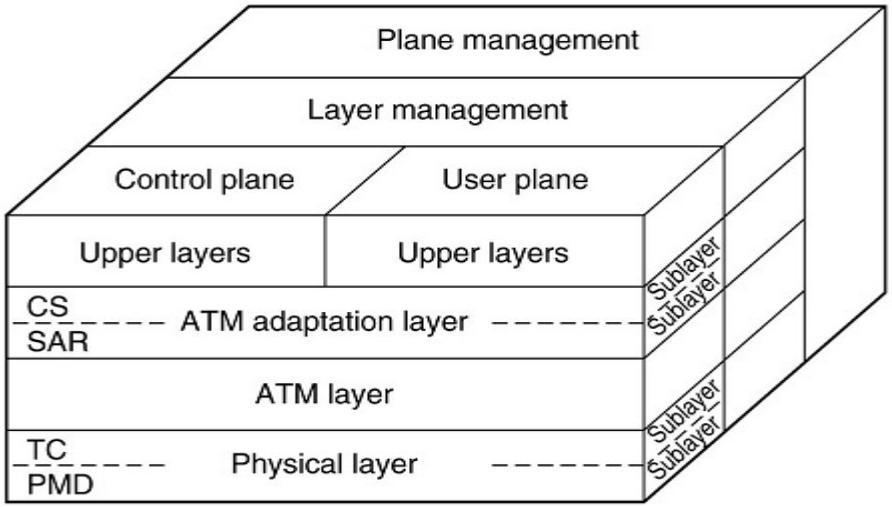


ATM Technology
Reference Model

ATM defines four versions of the AAL:

- **AAL1:** Support Constant-bit-rate data (CBR) from upper layer; video and voice.
- **AAL2:** Used for low-bit-rate and short-frame traffic such as audio (compressed or uncompressed), video, or fax. AAL2 allows the multiplexing of short frames into one cell.
- **AAL3/4:** support connection-oriented and connenctionless data services
- **AAL5:** Assumes that all cells belonging to a single message travel sequentially and that control functions are included in the layers of the sending application.

ATM Technology
Reference Model



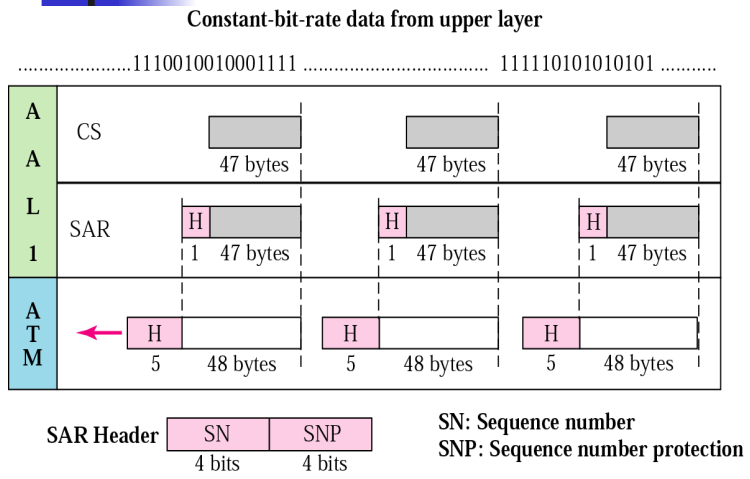
ATM Adaptation Layer (AAL)

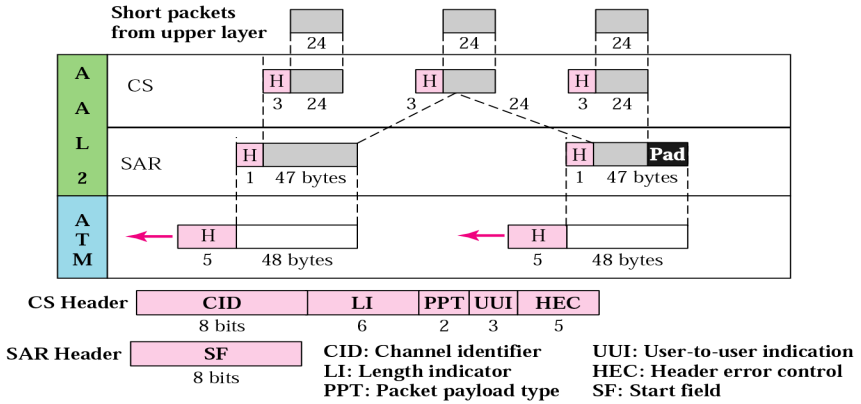
- Enables ATM to accept any type of payload, both data frames and streams of bits
- Fragments them into small and fixed-size Cells
- Reassembles Cells

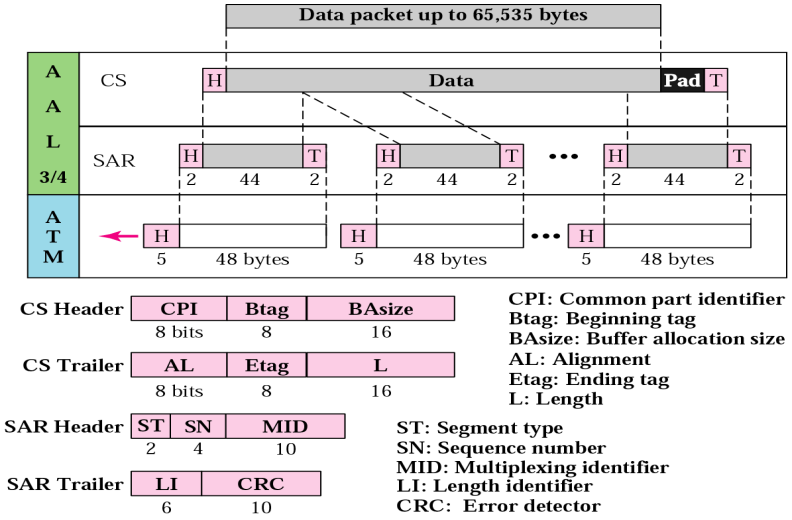
Convergence sub layer (CS): prepares data to ensure their integrity, providing standard interface.

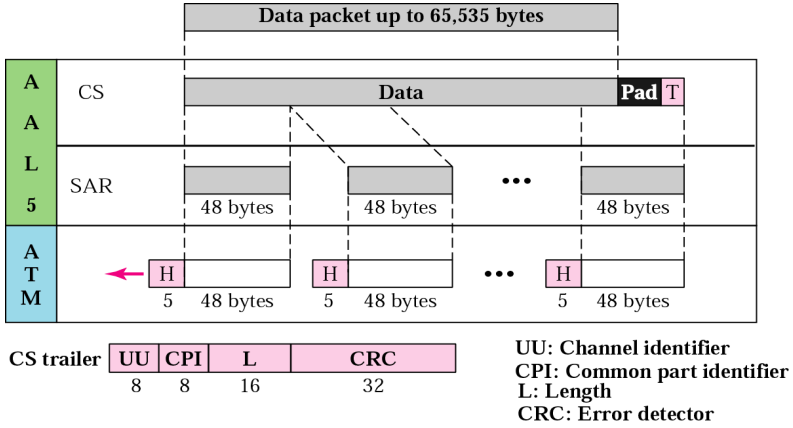
Segmentation and Reassembly (SAR): Segments the payload into 48-byte cells, and at the destination, reassemble them to recreate the original payload.

ATM Technology
Reference Model

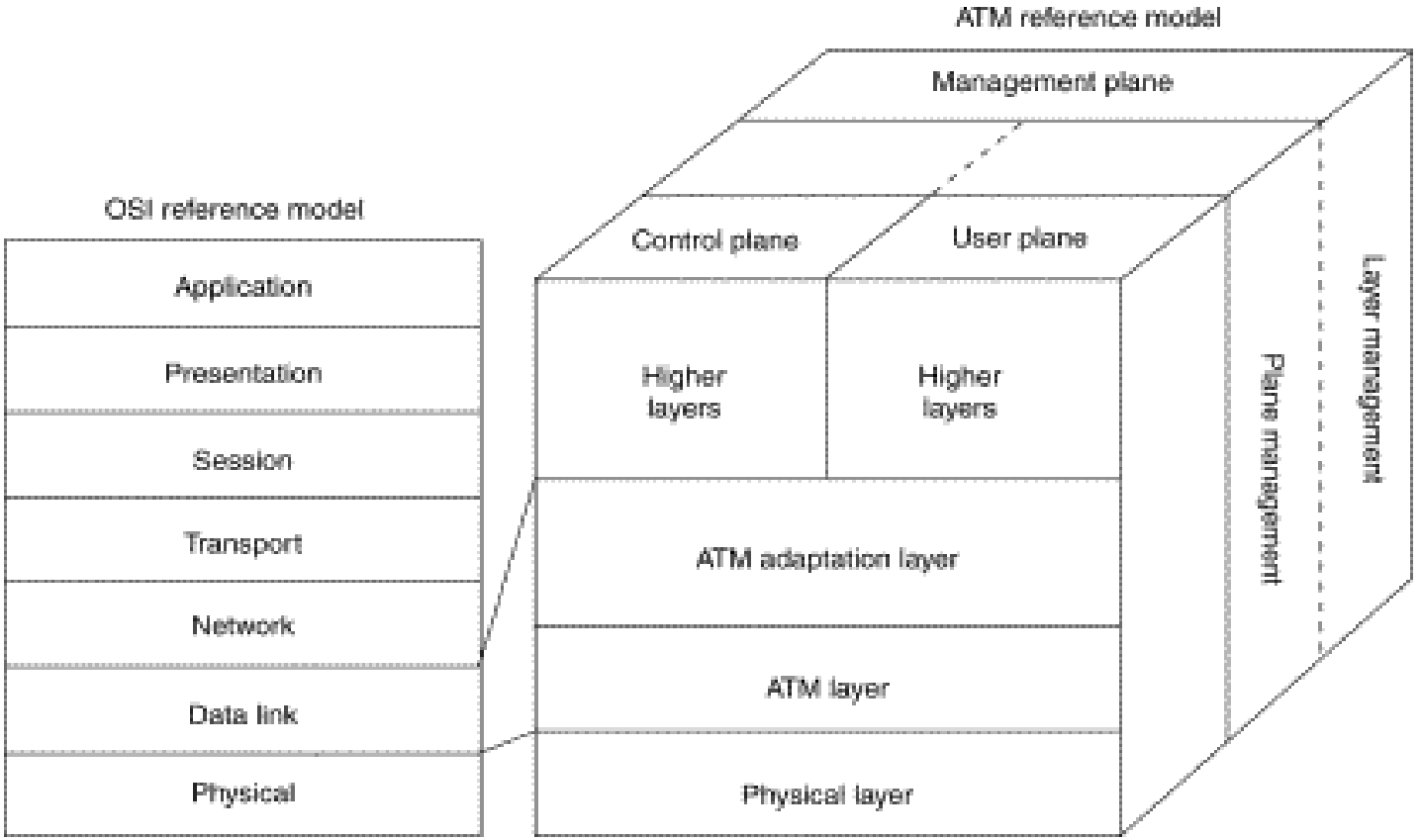




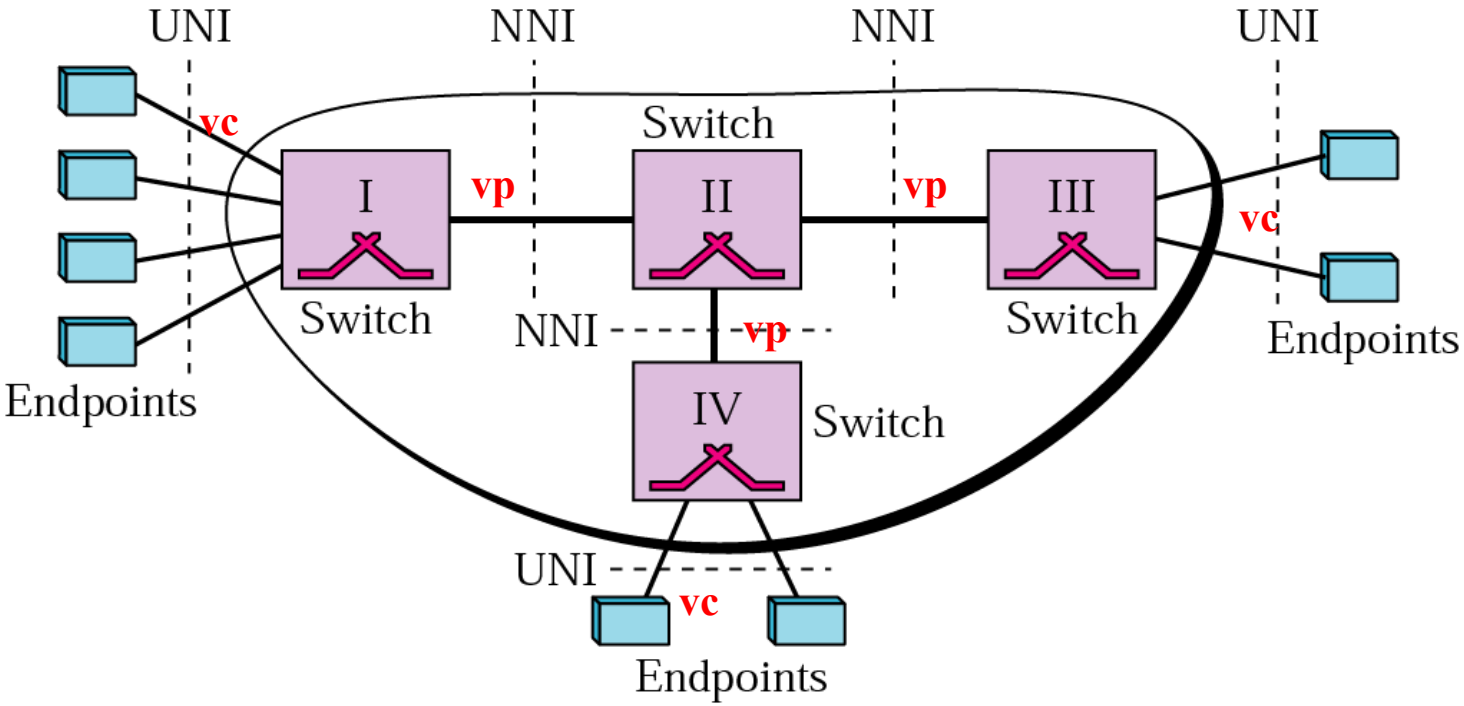




ATM Technology
Reference Model



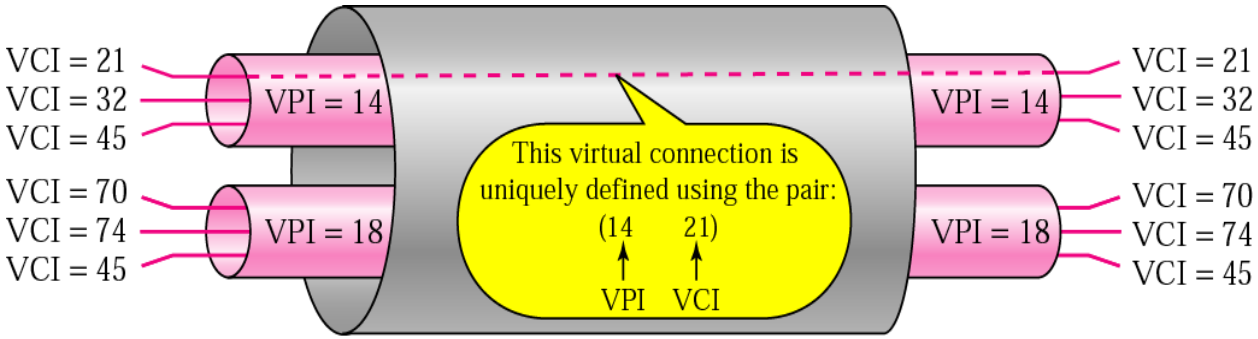
ATM Technology
Architecture of ATM Network



User-to-network interface (**UNI**): interface between endpoint (user access devices) and network switches.

Network-to-network interface (**NNIs**): interface between switches insides the network.

ATM Technology
ATM Virtual Connection



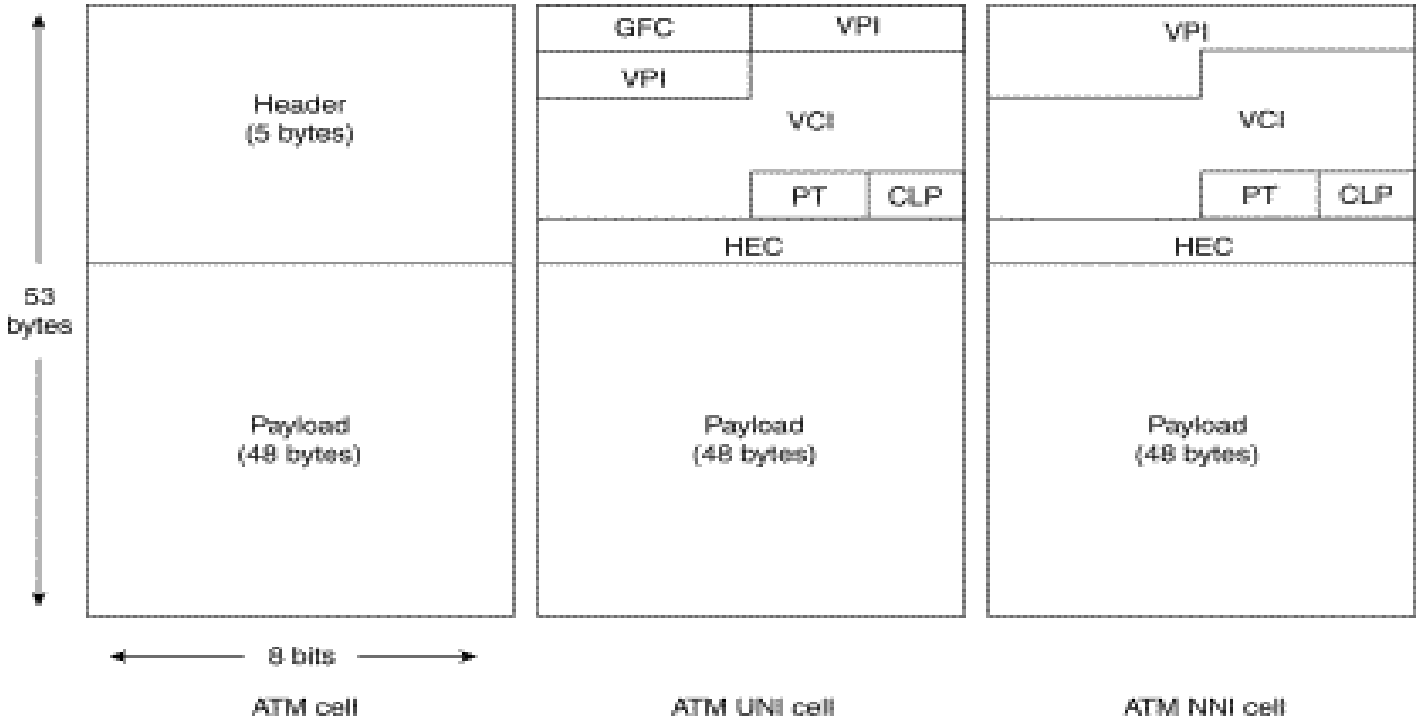
1- Transmission Path (TP): the physical connection (wire, cable, satellite, …) between an endpoint and a switch or between two switches.

2- Virtual Paths (VPs): provides a connection or a set of connections between two switches.

3- Virtual Circuits (VCs): Cell networks are based on virtual circuits. All cells belonging a single message follow the same virtual circuit and remain in their original order until they reach their destination.

VC must be set up across the ATM network prior to any data transfer.

ATM Technology
ATM Frame and Header Structure



ATM Technology
ATM Frame and Header Structure

Generic Flow Control (GFC)

provides flow control at the UNI level

Virtual Path Identifier (VPI)

identifies the cell's next VP to pass through a series of network.

Virtual Channel Identifier (VCI)

Identifies the cell's next VC inside the VP.

Payload Type (PT)

The first bit indicates whether the cell contains user data (bit 0) or control data (bit 1).
The second bit indicates congestion (0 = no congestion, 1 = congestion), and
The third bit indicates whether the cell is the last in a series of cells (1 = last cells for the frame)

Cell Loss Priority (CLP)

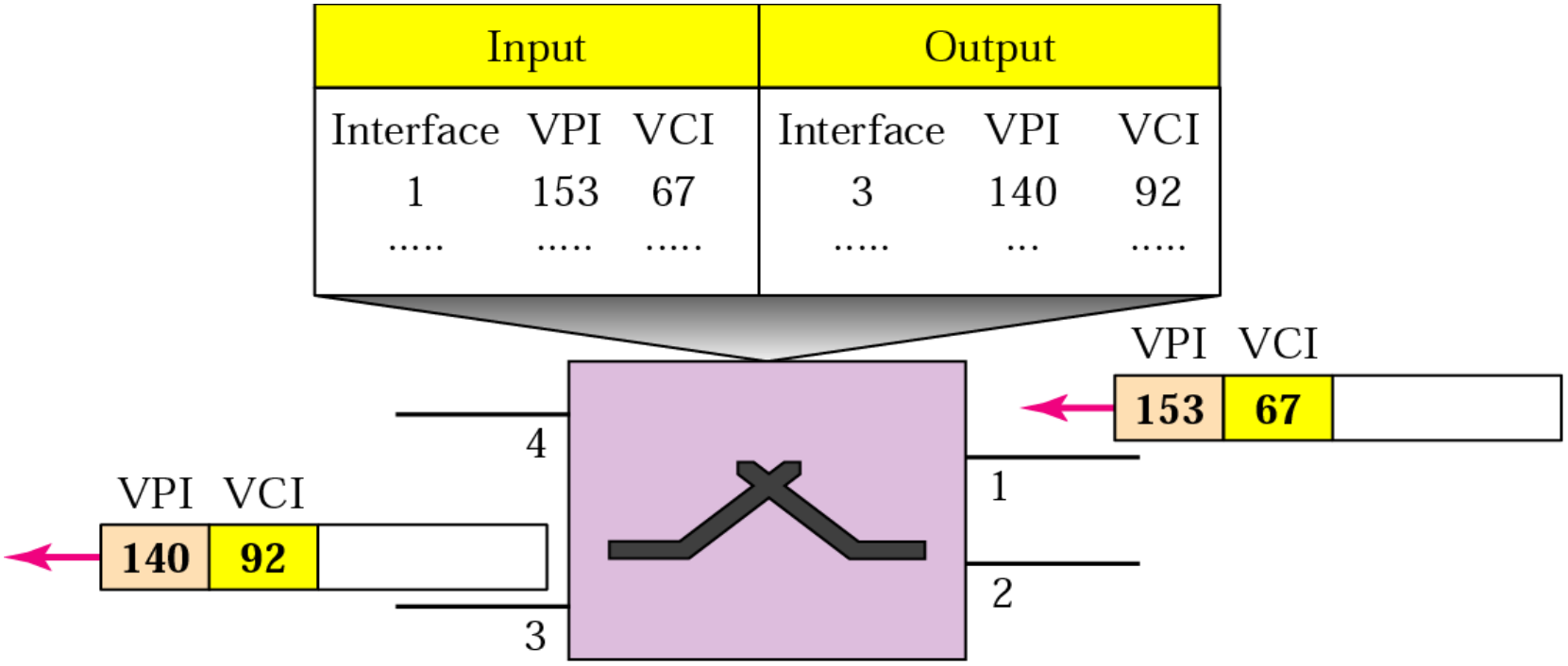
Indication if the cell should be discarded if it encounters extreme congestions as it moves through the network (bit 1 = discarded in referenced to cells with CLP equal to 0)

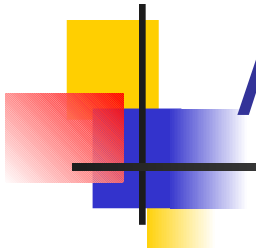
Header Error Control (HEC)

Calculates checksum only on the first 4 bytes of the header. HEC can detect error and correct a single bit error in these bytes—thus preserving the cell rather than discarding it.

ATM Routing

- A cell of 53 bytes is used as a data unit for transfer.
- ATM uses two types of connections: a permanent virtual circuit (PVC) and a Switch Virtual Circuit (SVC).
- ATM uses switches to route the cell from one source endpoint to the destination
- A switch routes the cell using both the VPIs and the VCIs.





Congestion Control and QoS

ATM Services

1- Constant Bit Rate (CBR):

- CBR is used by a connections that requires a static amount of bandwidth that is continuously available during the connection time.
- It appropriates for such applications as telephone traffic, video conferencing, interactive Audio, TV

2- Rate-Non-Real Time Variable Bit (nrt-VBR)

- Allows users to send traffic at a rate that varies with time depending on the availability of user information.
- Application: email.

3- Rate-Real Time Variable Bit Rate (rt-VBR):

- Intended for those application which requires tightly constrained delay and delay variation.
- Application: voice with speech activity detection (SAD) and interactive compressed video.

4- Available Bit Rate (ABR)

- Provides rate-based flow control
- Depending on the state of congestion in the network, the source is required to control its rate.
- Allows users to declare a minimum cell rate guaranteed to the connection by the network.
- Aimed at data traffic such as file transfer and e-mail.

5- Unspecified Bit Rate (UBR)

- Intended for non-real time application which do not require tightly constrained delay and delay variation.
- Widely used today for TCP/IP

ATM Quality of Service (QoS) and Traffic Attributes

The following QoS parameters need to be specified by the user when setting up the connection

QoS Parameters	Definition
Cell Transfer Delay **(CTD)**	-The delay between the first bit of the cell is transmitted by the source and the last bit of the cell is received by the destination - Includes propagation delays, queuing delays at various switches, and service times at queuing points.
Cell Delay Variation **(CDV)**	The difference of the maximum and minimum CTD experienced during the connection.
Cell Lost Ratio **(CLR)**	The percentage of cells lost in the network due to congestion and buffer overflow.
Cell Delay Variation Tolerance **(CDVT)**	Allows the users to send above PCR with a certain tolerance.

ATM Quality of Service (QoS) and Traffic Attributes

The following traffic attributes also needs to be specified by the user during the connection setup.

Traffic Parameters	Definition
Peak Cell Rate **(PCR)**	The maximum cell rate at which the user will transmit.
Sustained Cell Rate **(SCR)**	The maximum long-term average cell rate of the user.
Burst Tolerance **(BT)**	Determines the max burst that can be sent at the peak rate.
Maximum Burst Size **(MBS)**	The max number of cells that can be sent at the peak cell rate, but without violating the sustained cell rate.
Minimum Cell Rate **(MCR)**	The minimum rate desired by a user

ATM Quality of Service (QoS) and Traffic Attributes

Attribute	CBR	Rt-VBR	Nr-VBR	UBR	ABR
PCR and CDVT	YES	YES	YES	YES	YES
SCR, MBS, CDVT	n/a	YES	YES	n/a	n/a
MCR	n/a	n/a	n/a	n/a	YES
Peak-to-peak CDB	YES	YES	NO	NO	NO
Mean CTD	NO	NO	YES	NO	NO
Maximum CTD	YES	YES	NO	NO	NO
CLR	YES	YES	YES	NO	YES
Congestion Control	**NO**	**NO**	**NO**	**NO**	**YES**

Among these service classes, ABR is commonly used for data transmissions which require a guaranteed QoS, such as low probability of loss and error. Small delay is also required for some application. Due to the burstiness, upreditability and huge amount of the data traffic, *congestion control* of this class is the most needed.

Objectives of Congestion Control ?

- Support a set of QoS parameters and classes for all ATM services
- Minimize network and en-system complexity while maximizing the network utilization.

ATM Congestion Control

Congestion happens whenever the input rate is more that the available link capacity:

Sum (input rate) > Available Link Capacity

The **traffic management working group** was started in the Forum in May 1993– with main duties to establish a mechanism for *congestion control.*

There were a number of congestion schemes were presented– these are

- *Fast Resource Management,*
- *Delay-Based Rate Control,*
- *Backward Explicit Congestion Notification (BECN),*
- *Early Packet Discard,*
- *Link Window with End-to-End Binary Rate,*
- *Fair Queuing with Rate and Buffer feedback,*
- *Credit-Based Approach and*
- *Rate-Based Approach.*

However, the working group selected two key proposals – Credit-Based Approach and Rate-Based Approach– for the forum to make decision.

After a considerable debate which lasts for over a year, ATM Form adopted the Rate-Based Approach and rejected the credit-based approach.

ATM Congestion Control

The following is the main selection criteria used to sort out the above proposal:

1- Scalability:

The scheme should not be limited to a particular range of speed, distance, number of switches, or number of VCs. The scheme should be applicable for both LAN and WAN.

2- Optimality

A fair share of bandwidth among sources, which is based on such fairness criteria as Max-Min

3- Fairness Index

The share of bandwidth for each source should be equal to or converge to the optimal value according to some optimality criterion.

4- Robustness

The scheme should be insensitive to minor deviations such as slight mistuning of parameters or loss of control messages. It should also isolate misbehaving users and protect other users from them.

5- Implementability

The scheme should not dictate a particular switch architecture. It also should not be too complex both in term of time and space it uses.

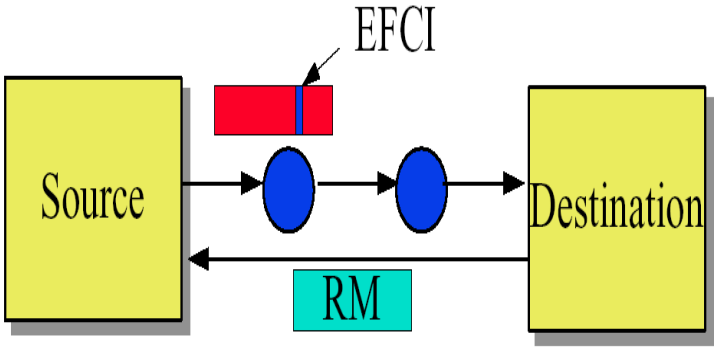
ATM Congestion Control – Rate-Based Approach

Rate-Based Approach' *basic concept*:

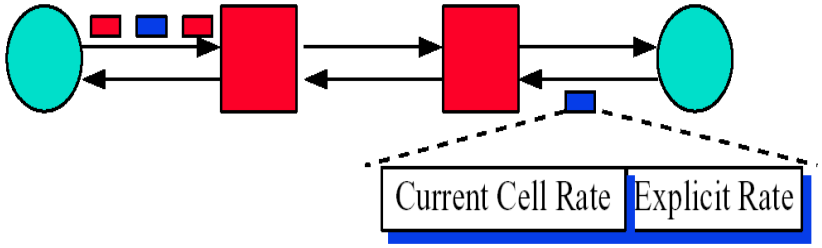
- This approach controls the rate by which the source can transmit.
- If the network is light loaded, the source are allowed to increase its cell rate.
- If the network is congested, the source should decrease its rate.
- Switches monitor their queue lengths and if congested set Explicit Forward Congestion Indicator (EFCI) to 1.
- The destination monitors these indications for a periodic interval and sends a RM cell back the source.
- The sources use an additive increase and multiplicative decrease algorithm to adjust their rates.

ATM Congestion Control – Rate-Based Approach

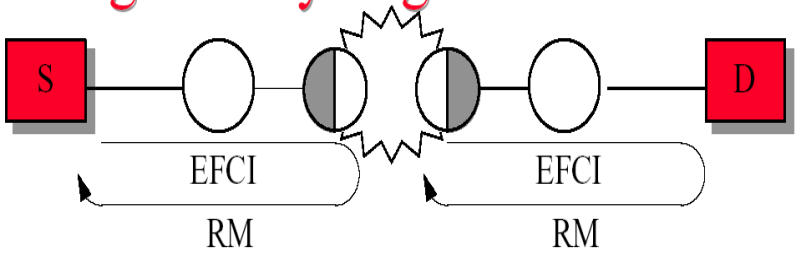
Initial Binary Rate-based Scheme



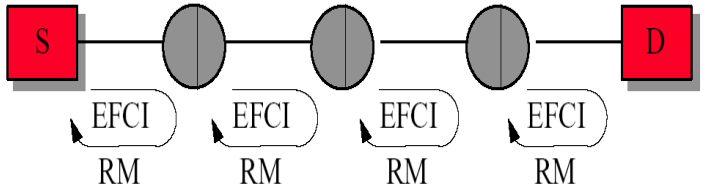
The Explicit Rate Scheme



Segment-by-Segment Control



Hop by Hop



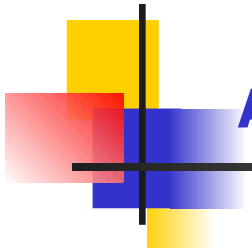
ATM Congestion Control – Rate-Based Approach

Structure of **Resource Management Cells**:

ATM Forum Technical Committee specifies the format of the RM-cell as follow:

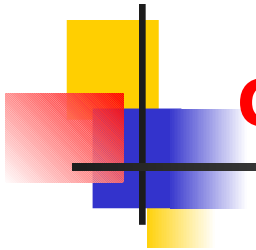
	ATM Header	1-5 Bytes	the standard ATM header
	Protocol ID	1 Byte	1 for ABR service
	Direction	1 bit	0 forward RM-cells; 1 for backward RM-cells
Message Type	Backward Notification	1 bit	1 for switch generated (BECN) RM-cells 0 for source generated RM-cells
Message Type	Congestion Indication	1 bit	1 : congestion; 0 : no congestion
Message Type	No Increase	1 bit	1 : no additive increase of rate; 0 : additive increase
Message Type	Request/Acknowledg e	1 bit	
Message Type	Reserved	3 bit	
	Explicit Cell Rate	2 Bytes	used to limit the source rate to a specific value.
	Current Cell Rate	2 Bytes	used to indicate to current cell rate of the source
	Minimum Cell Rate	2 Bytes	the minimum cell rate desired by the source.
	Queue Length	4 Bytes	
	Sequence Number	4 Bytes	
	Reserved	30.75 Bytes	
	CRC-10	10 Bits	

Why ATM is used ?



ATM Benefits

- Revenue opportunities
- Reduces infrastructure costs through efficient bandwidth management, operational simplicity, and the consolidation of overlay networks.
- High performance via hardware switching
- Dynamic bandwidth for bursty traffic



Conclusion

ATM is a flexible and powerful technology which integrates the cell-switching and multiplexing functions, and enables transmissions over a variety of carrier system.

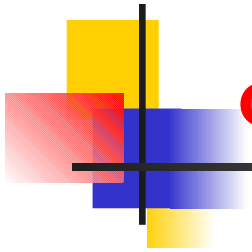
It's designed for high performance multimedia networking, and suitable for bursty traffic.

ATM technology is a powerful common platform for LAN and WAN to increase productivity, to reduce costs and to implement new applications and service.

Thus, the potential demand for ATM is a direct result of the widespread of LANs and WANs, massive demand for file transfers, and growing interest in "paperless office" technologies.

The growing in multimedia market is another huge potentiality of ATM.

However, the success of ATM will be determined by two sequential events: first how fast the standard is finalized and then how fast can vendors bring ATM products to the market.



Question

1 - Which field in the ATM header can check the header error?

Answer : HEC – **Header Error Control (HEC)**

2 – What is the size of ATM frame ?

Answer : 53 Bytes

References

Textbooks:

- Andrew S. Tanenbaum,"Computer Networks", fourth edition
- Behrouz A. Forouzan, "Data Communications and Networking," third edition

Online Sources

- International Engineering Consortium, http://www.iec.org/online/tutorials/atm_fund
- K. Siu and R. Jain, "A Brief Overview of ATM: Protocol Layers, LAN Emulation, and Traffic Management,"Computer Communications Review (ACM SIGCOMM), vol 25, no 2, April 1995. (http://www.cis.ohio-state.edu/~jain/papers/atm_tut.htm)
- ATM Switching, http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/atm.htm
- ATM Cell Structure, http://www.cisco.com/univercd/cc/td/doc/product/atm/c8540/12_0/13_19/trouble/cells.htm
- http://ntrg.cs.tcd.ie/undergrad/4ba2/atm/index.html
- ATM Traffic Control, http://ntrg.cs.tcd.ie/undergrad/4ba2/atm/ATMtraffic.html#nrm
- ATM Congestion Controls, http://www.cis.ohio-state.edu/~jain/cis788-95/ftp/atm_cong/index.html