ATM

Asynchronous Transfer Mode (ATM)

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

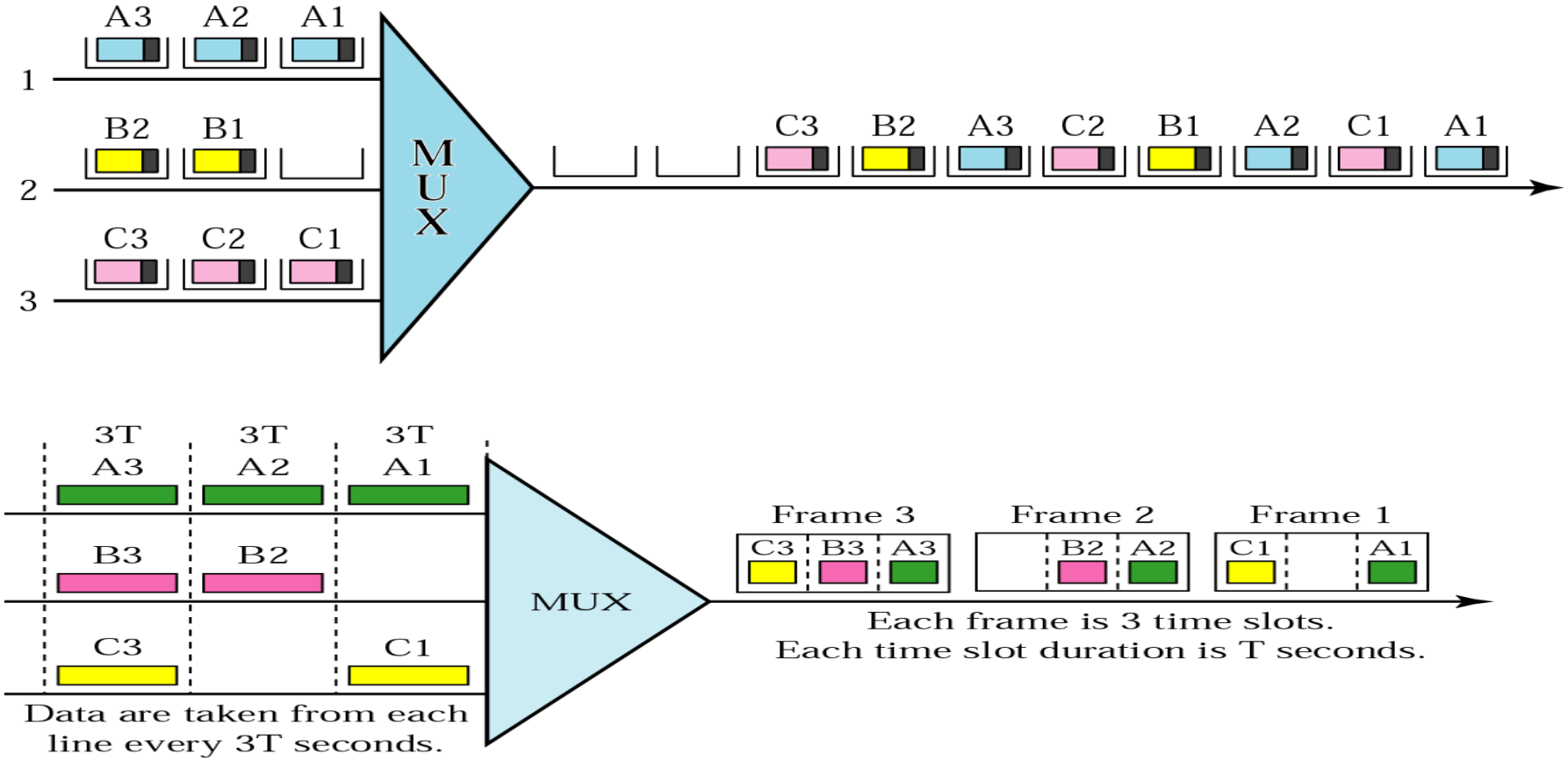
ATM Overview

- ATM 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 Features

- 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.

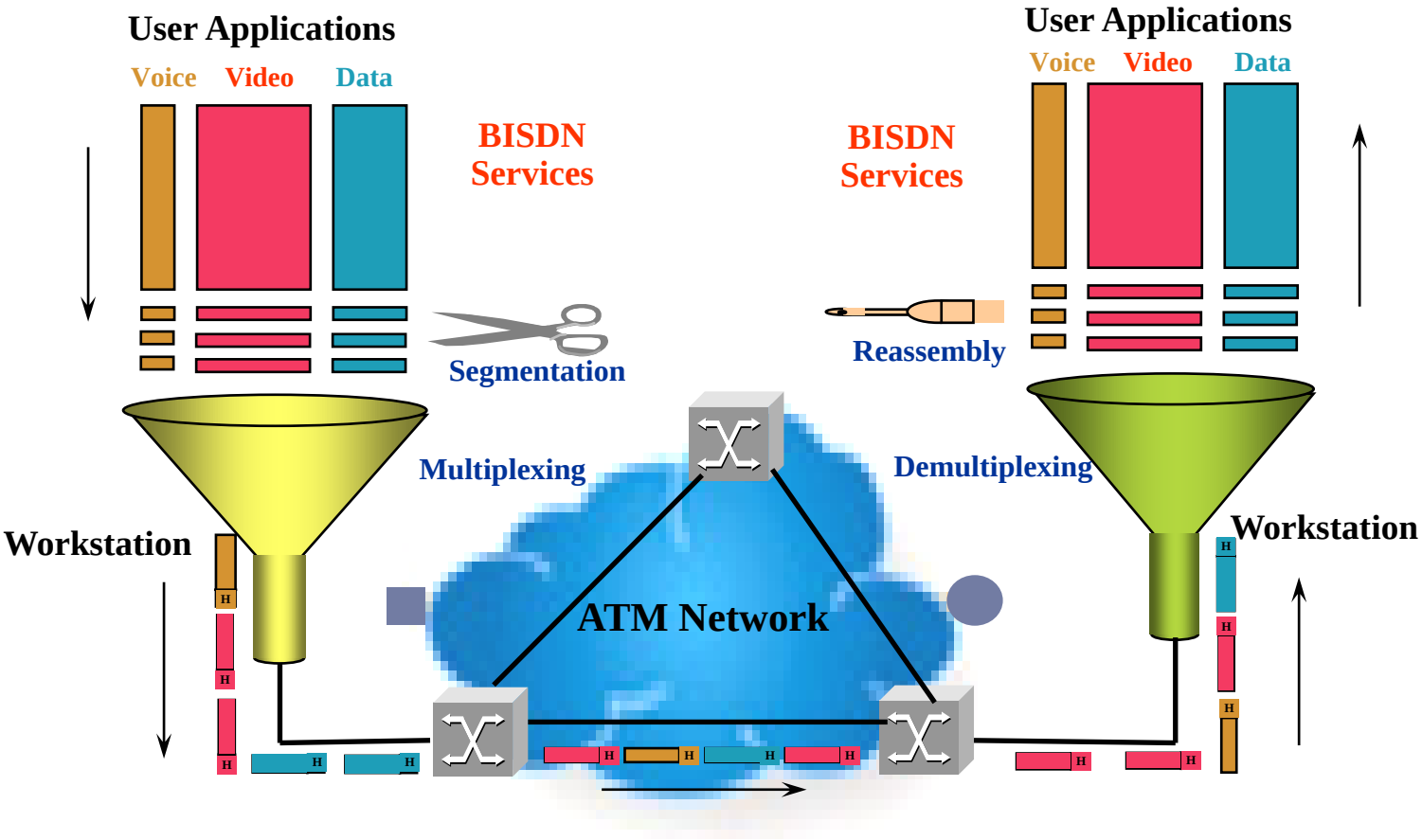
ATM multiplexing



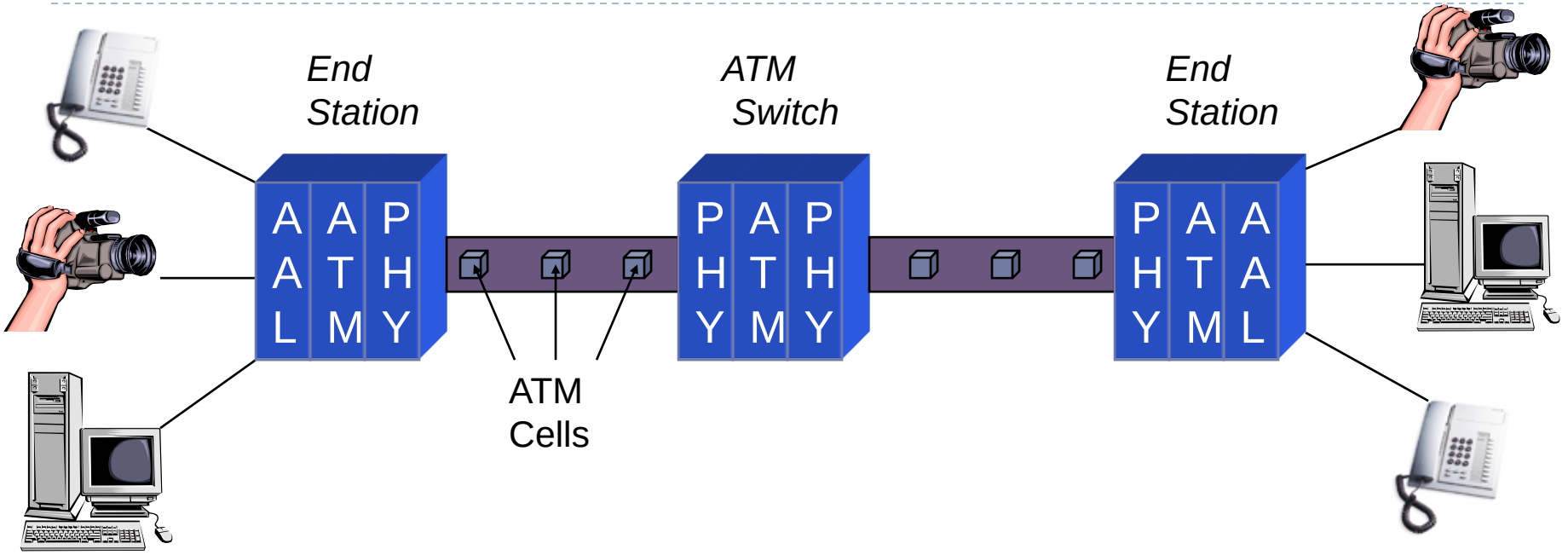
a) Asynchronous TDM : ATM multiplexers fill a slot with a cell from any input channel that has a cell.

- b) TDM

How does ATM work ?


User Applications
Voice
Video
Data
BISDN Services
Segmentation
Multiplexing
Workstation
ATM Network
User Applications
Voice
Video
Data
BISDN Services
Reassembly
Demultiplexing
Workstation
H

Functions B-ISDN Layers

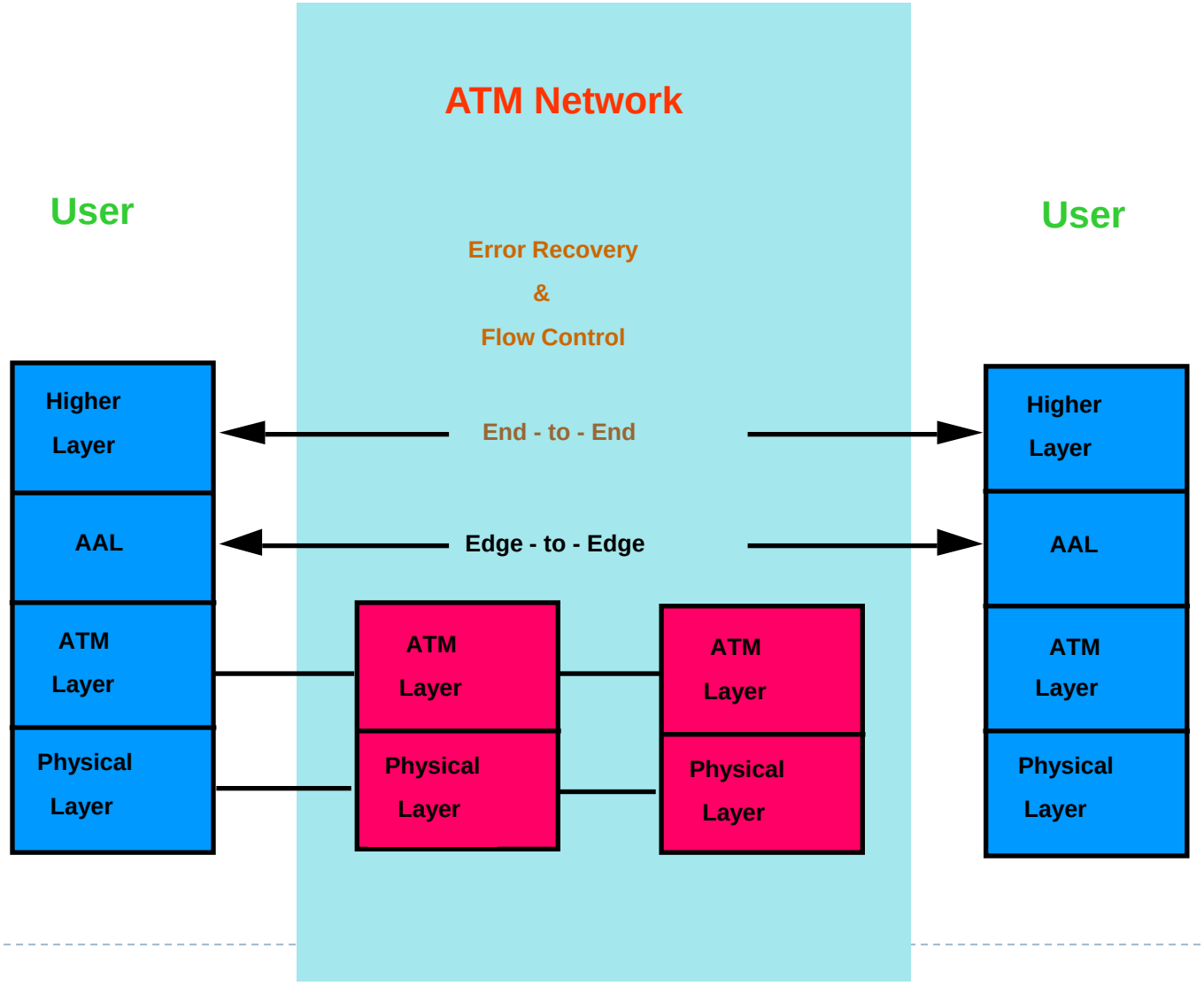


- Adaptation Layer (AAL): Inserts/extracts information into 48 byte payload
- ATM Layer: Adds/removes 5 byte header to payload
- Physical Layer: Converts to appropriate electrical or optical format

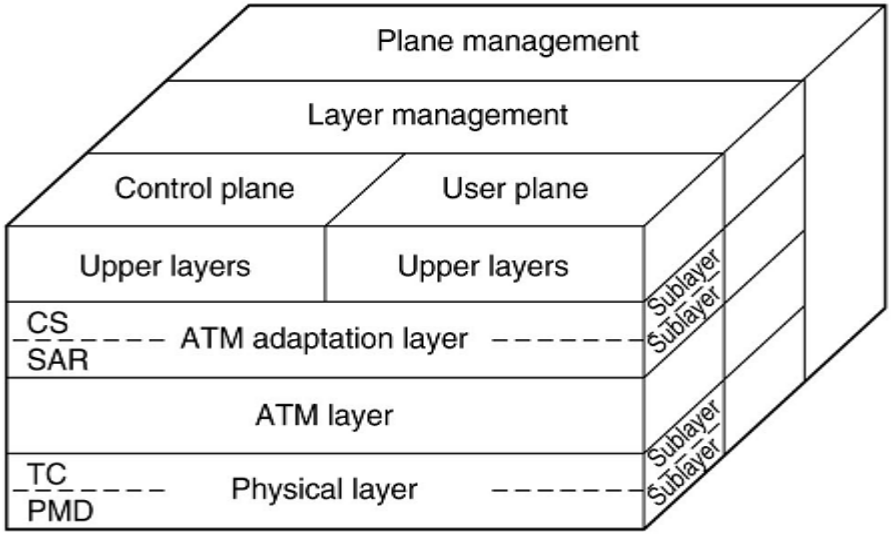
ATM Layers and Sub layers

<table>
<tr><td colspan="2">Higher Layers</td></tr>
<tr><td rowspan="2">ATM Adaptation Layer (AAL)</td><td>Convergence Sublayer (CS)</td></tr>
<tr><td>Segmentation and Reassembly Sublayer (SAR)</td></tr>
<tr><td>ATM Layer (ATM)</td><td>Virtual Channel (VC)
Virtual Path (VP)</td></tr>
<tr><td rowspan="2">Physical Layer (PL)</td><td>Transmission Convergence Sublayer (TC)</td></tr>
<tr><td>Physical Medium Sublayer (PM)</td></tr>
</table>

ATM Information Transport Concept



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.

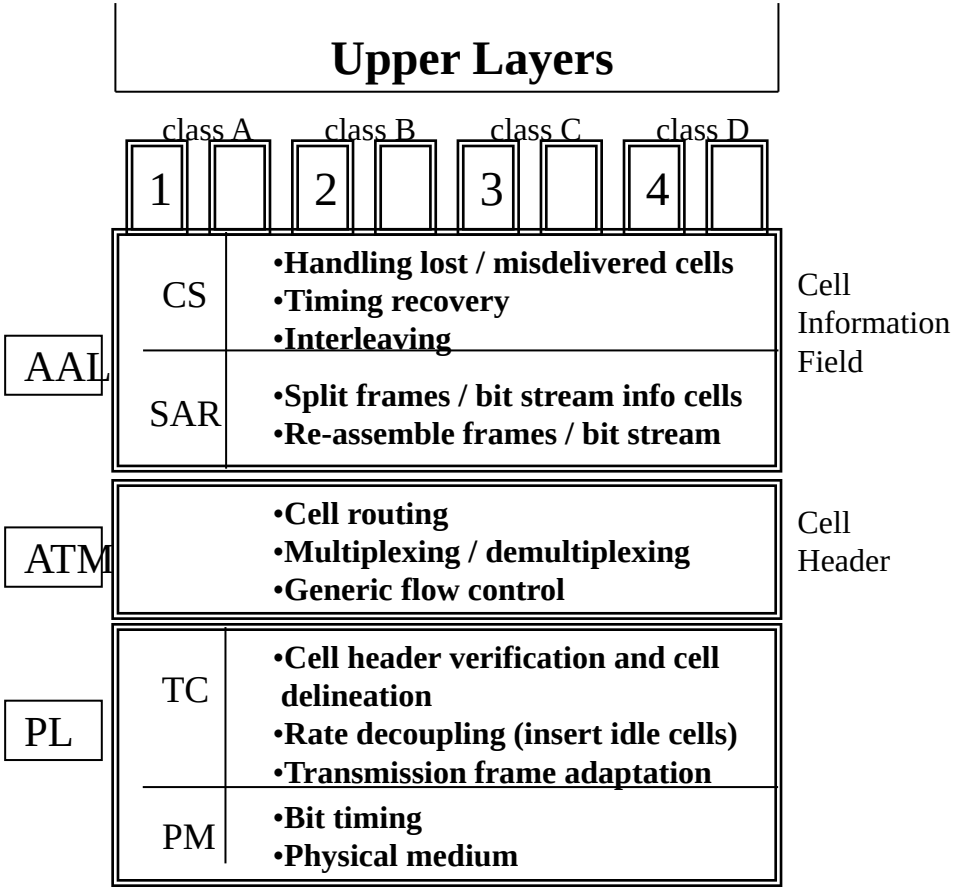
- **Layer Management** :

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

- **Plane Management:**

  manages and coordinates functions related to the complete system.

Protocol Reference Model in the User Plane



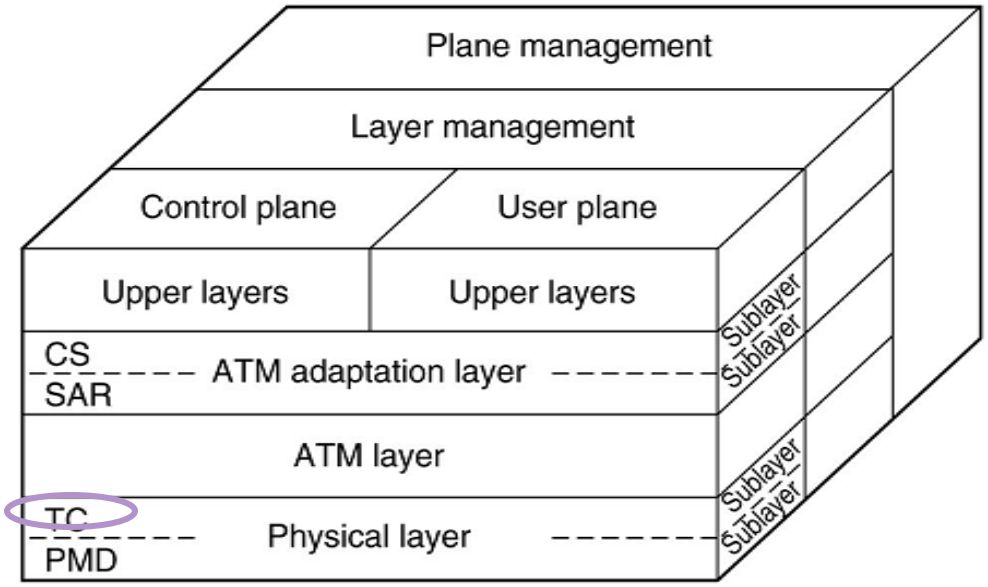
Abbreviations

AAL = ATM Adaptation Layer
SAR = Segmentation and Reassembly
CS = Convergence Sublayer
PL = Physical Layer
TC = Transmission Convergence
PM = Physical Medium

Service Classes for AAL

Class	Type
A	**Constant Bit Rate**
B	**Variable Bit Rate**
C	**Connection Oriented Data**
D	**Connectionless Data**

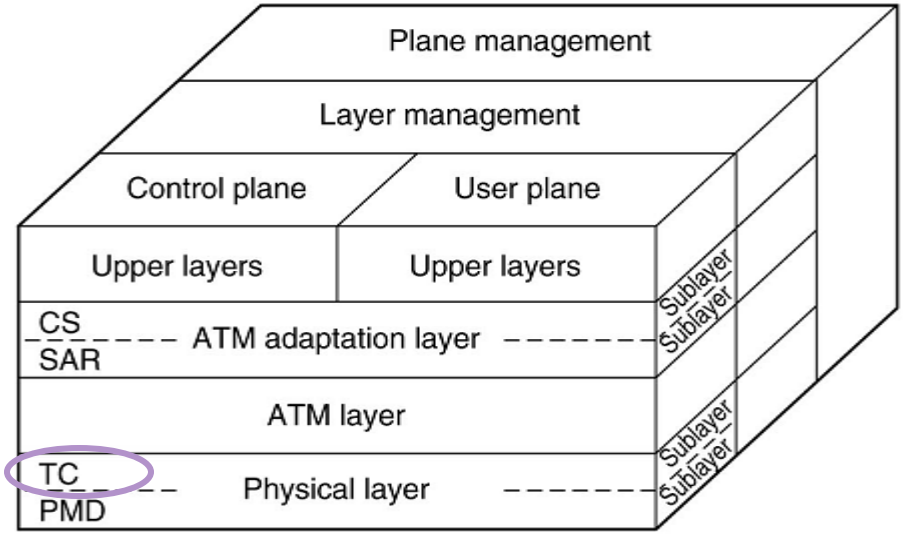
ATM Technology
Reference Model



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.

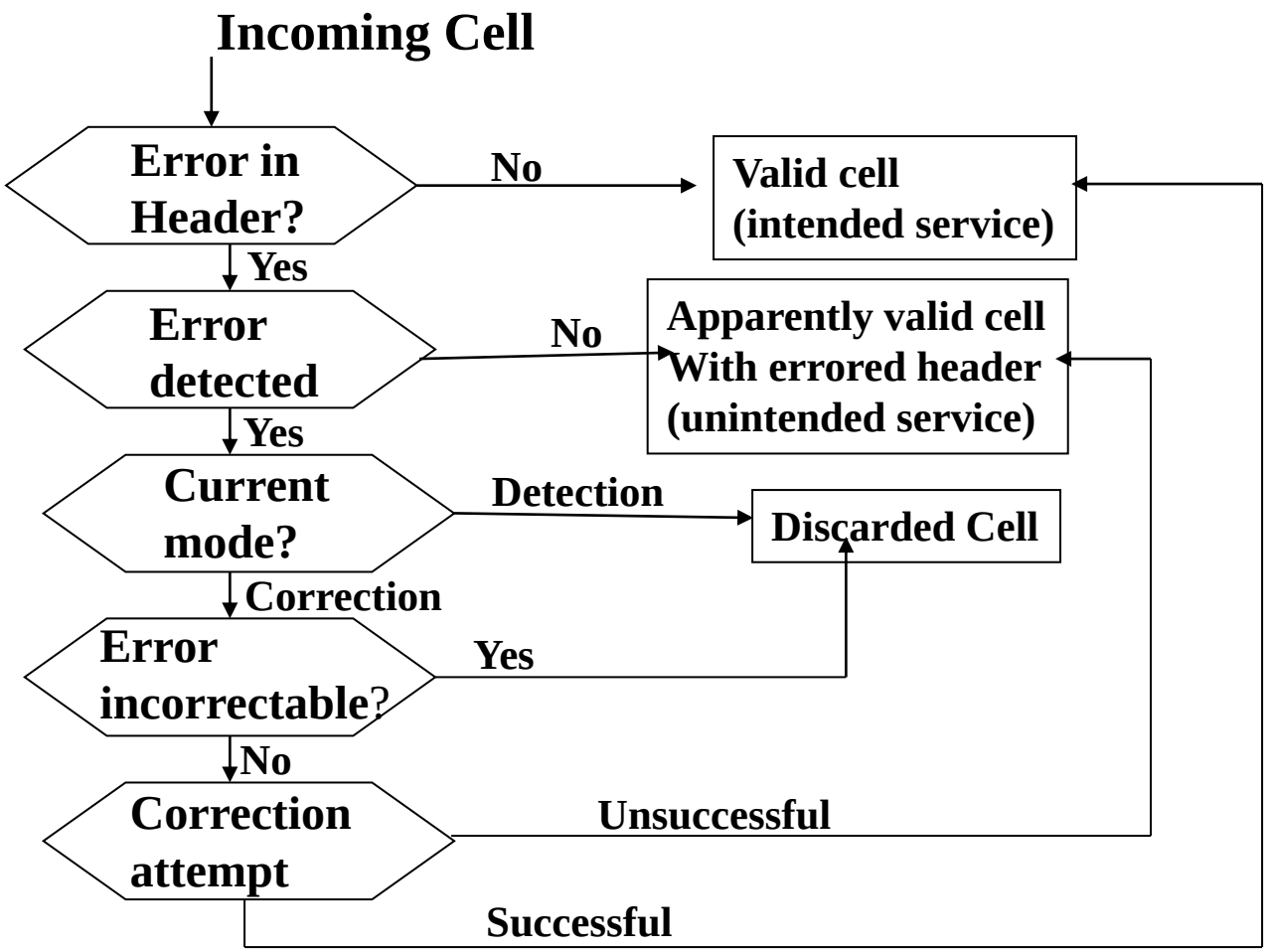
ATM Technology
Reference Model



Transmission Convergence (TC) – having four functions:

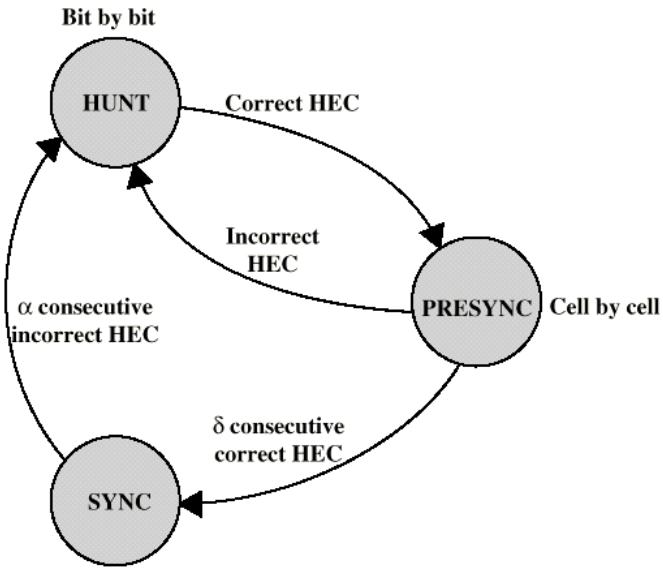
- Cell delineation, generating cell boundaries.
- Header error control (HEC) sequence generation and verification
- Cell-rate decoupling, maintaining synchronization and inserting or suppressing idle ATM cells to rate of valid ATM cells to the payload capacity of transmission system.
- Transmission frame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

EFFECT OF ERROR IN CELL HEADER (HEC)



Cell Delineation

- **In Hunt State → a cell delineation algorithm is performed bit-by-bit to determine if the HEC coding law is observed (i.e., match between received HEC and calculated HEC).**
- **Once a match is achieved, it is assumed that one header has been found and the method enters the PRESYNCH state.**
- **The HEC algorithm is performed cell-by-cell. If δ consecutive correct HECs are found, SYNCH state is entered; if not the system goes back to HUNT state.**
- **SYNCH is only left (to HUNT) state if α consecutive incorrect HECs are identified.**



Physical Layer Functions

a) Physical Medium (PM)

- PM sublayer provides the bit transmission capability including bit alignment
- Line coding and, if necessary, electrical/optical conversion is performed in this sublayer
- Optical fiber is used for the physical medium. Other media, coax cables are also possible
- Bit rates → 155 Mbps or 622.080 Mbps.

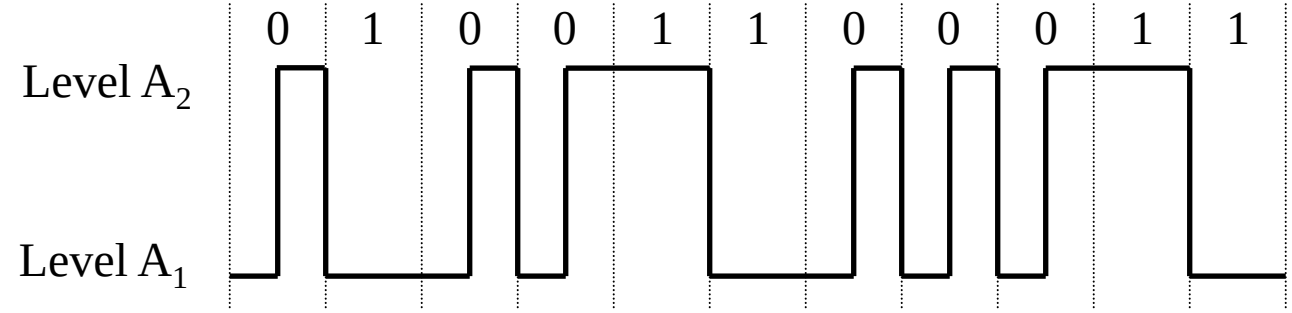
b) Bit Timing

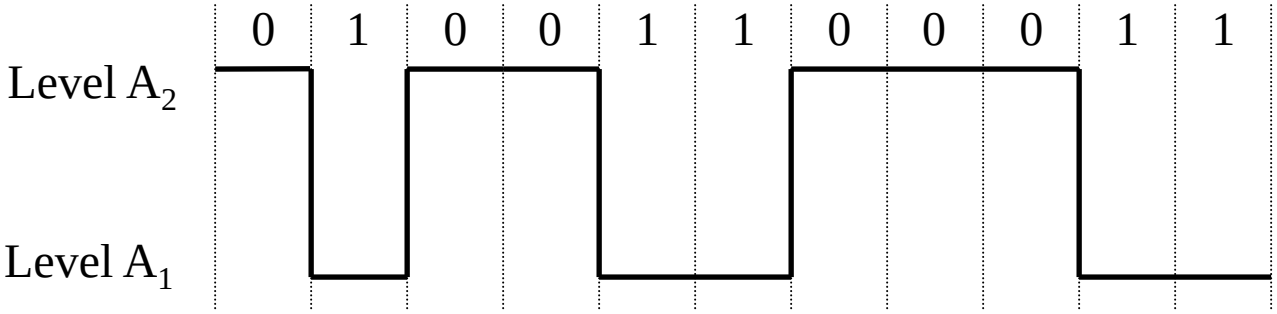
- Generation and reception of waveforms which are suitable for the medium, the insertion, and extraction of bit timing information and the line coding if required
- CMI (Code Mark Inversion) 155.520 Mbps interface.
- NRZ “Nonreturn to Zero” code proposed for optical interface.

LINE CODING

Electrical Interface: Coded Mark Inversion (CMI)

- For binary 0 → always a positive transition at the midpoint of the binary unit time interval.
- For binary 1 → always a constant signal level for the duration of the bit time. This level alternates between high and low for successive binary 1s.





Optical Interface:
Nonreturn to Zero (NRZ)

ATM INTERFACES

- **SONET/SDH : 155 Mbps and 622 Mbps over OC-3 (single mode fiber)**
- **Cell Based**
- **PDH Based (ATM cells mapped into PDH signals) (59 columns and 9 rows frame). Frame at 34.368 Mbps.**
- **FDDI based or 100 Mbps (same as in FDDI PMD uses multimode fiber and line coding of 4B/5B). (called TAXI interface). Early private UNI interfaces were based on TAXI interfaces.**
- **DS-3 (45 Mbps) Transfer of ATM cells on T3 (DS-3) public carrier interface. It is cheaper than SONET links.**
- **STS-3 (155 Mbps) over Multimode fiber uses line coding of 8B/10B.**

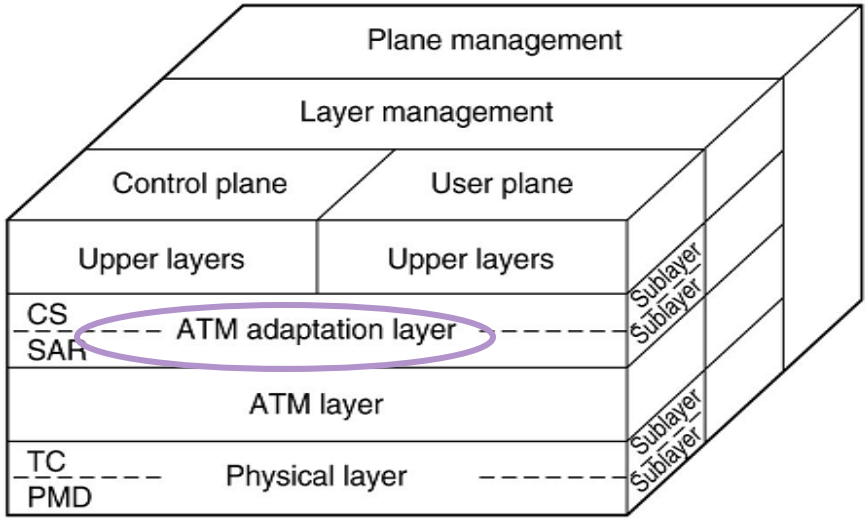
D1-T1 carriers (1.5 Mbps)

ATM Technology
Reference Model

ATM Layer

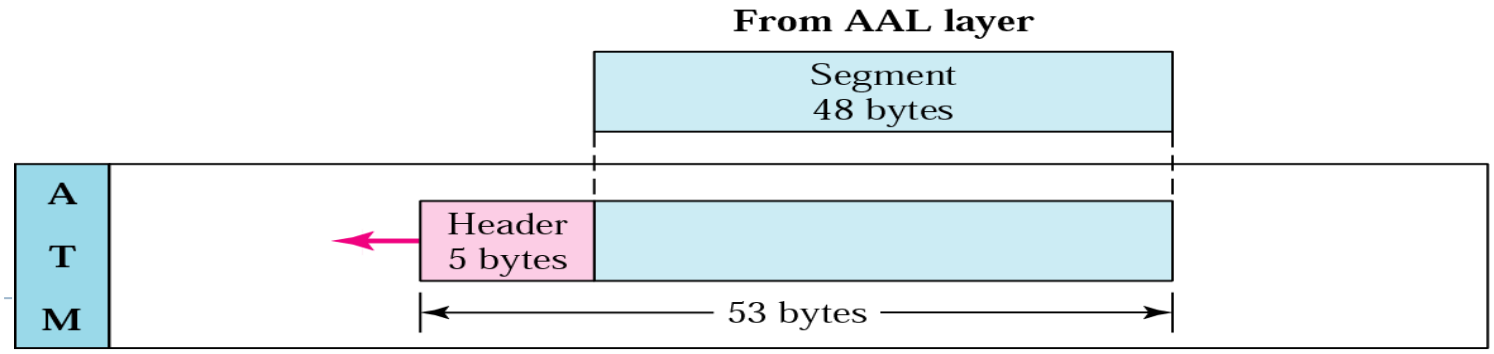
Provides

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



•**Segmentation and reassembly (SAR)**

•**Convergence sublayer**: adds sequencing and control information to aid SAR process



ATM Technology
Reference Model

ATM defines four versions of the AAL:

- **AAL1:** Support Constant-bit-rate data (CBR) from upper layer; video and voice.

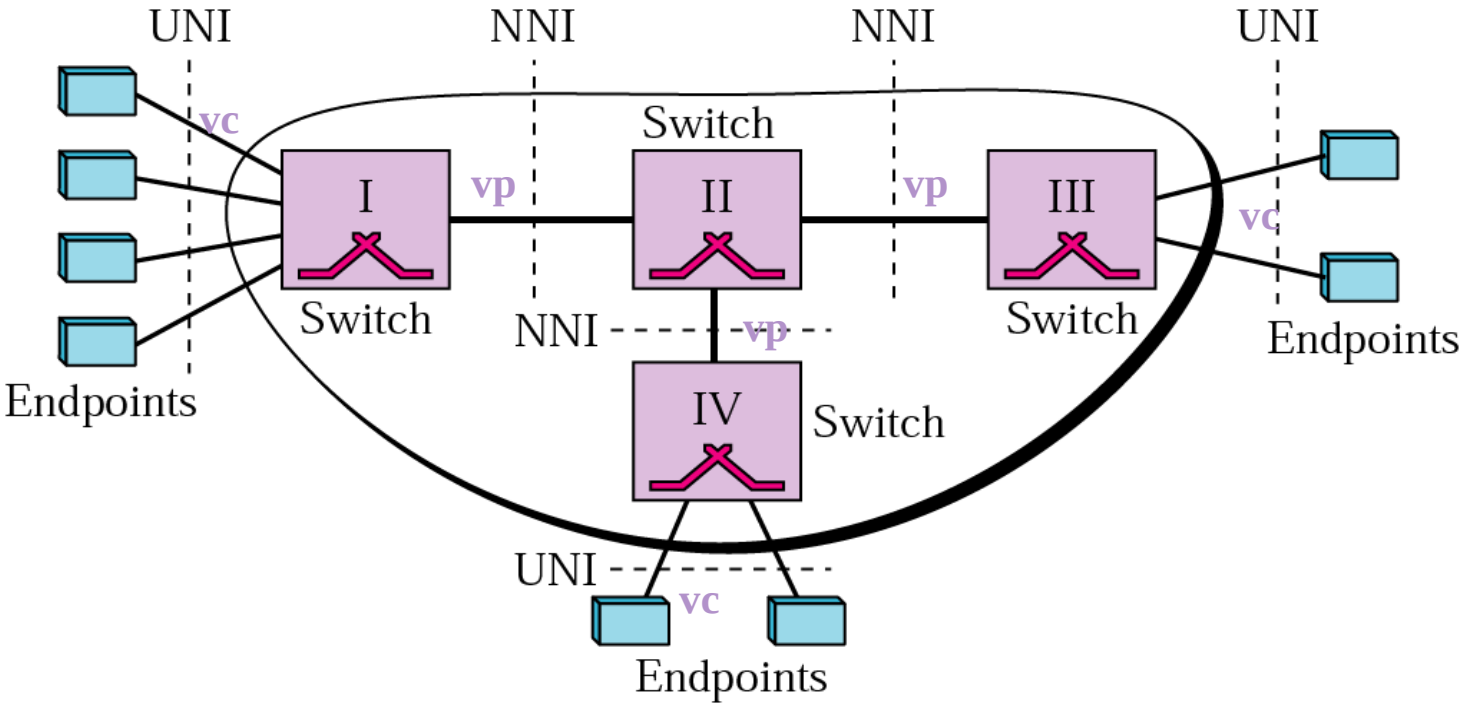
- **AAL2:** Used for low-bit-rate and short-frame traffic such as audio (compressed or uncompressed), video, or fax. AAL2 allows the multiplexing of short frames into one cell.

- **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

Architecture of ATM Network

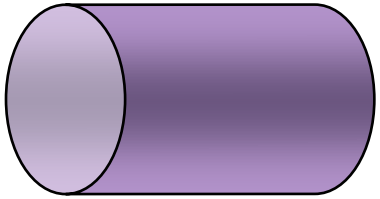


User-to-network interface (**UNI**): interface between endpoint (user access devices) and network switches.

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

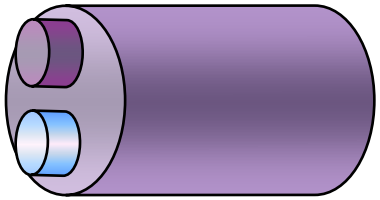
Virtual Circuits

First we have the cable...



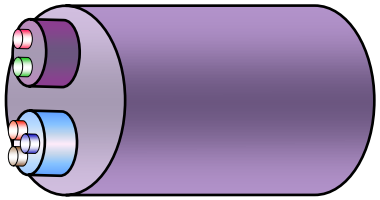
Next, ATM Addressing Defines Paths...

- VP's



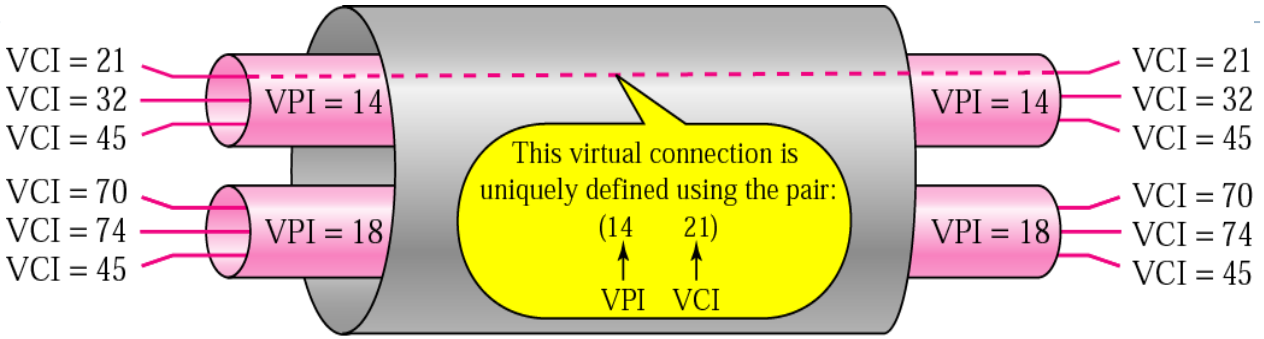
Then Channels.

- VC's



ATM Technology

ATM Virtual Connection



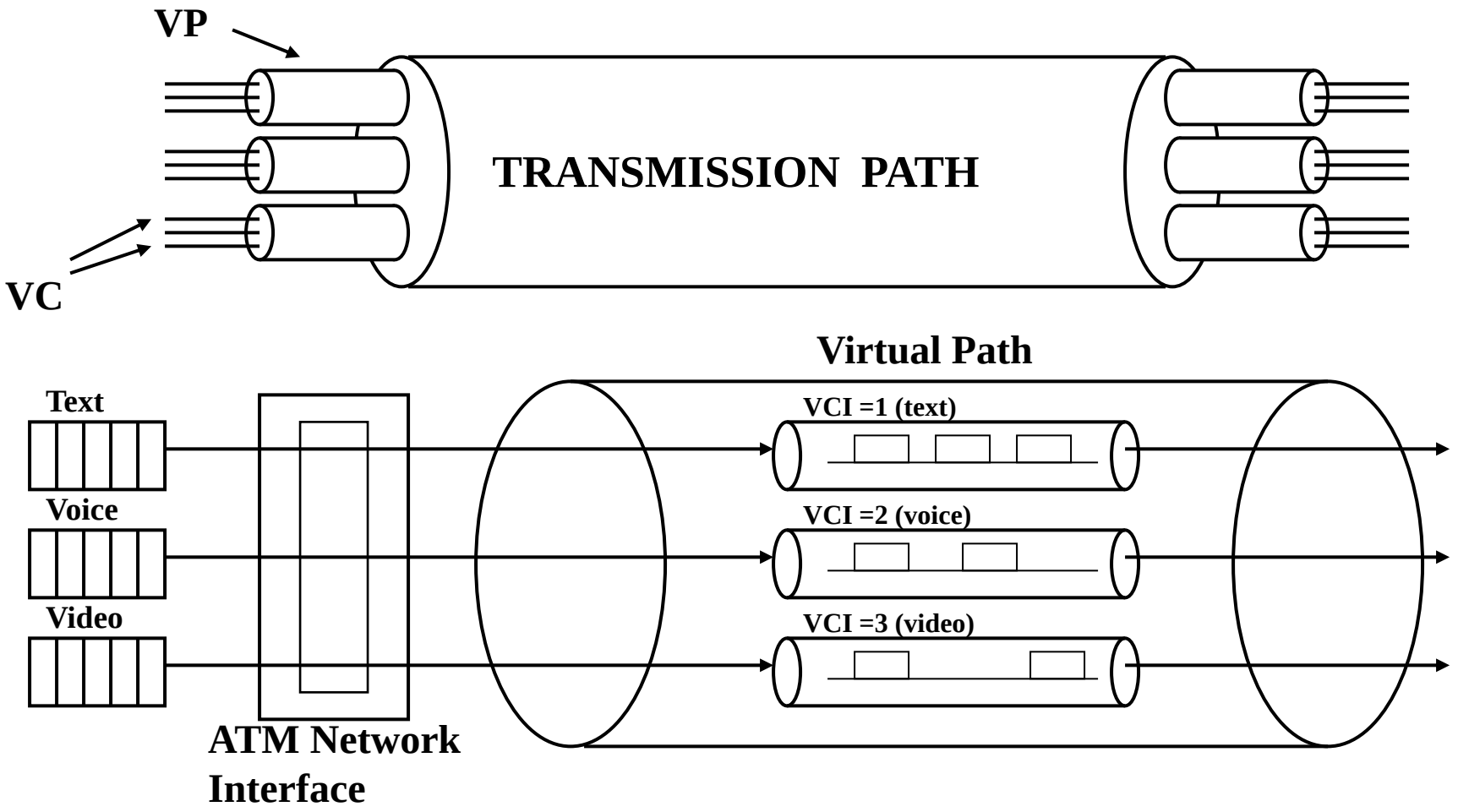
1- Transmission Path (TP): the physical connection (wire, cable, satellite, …) between an endpoint and a switch or between two switches.

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

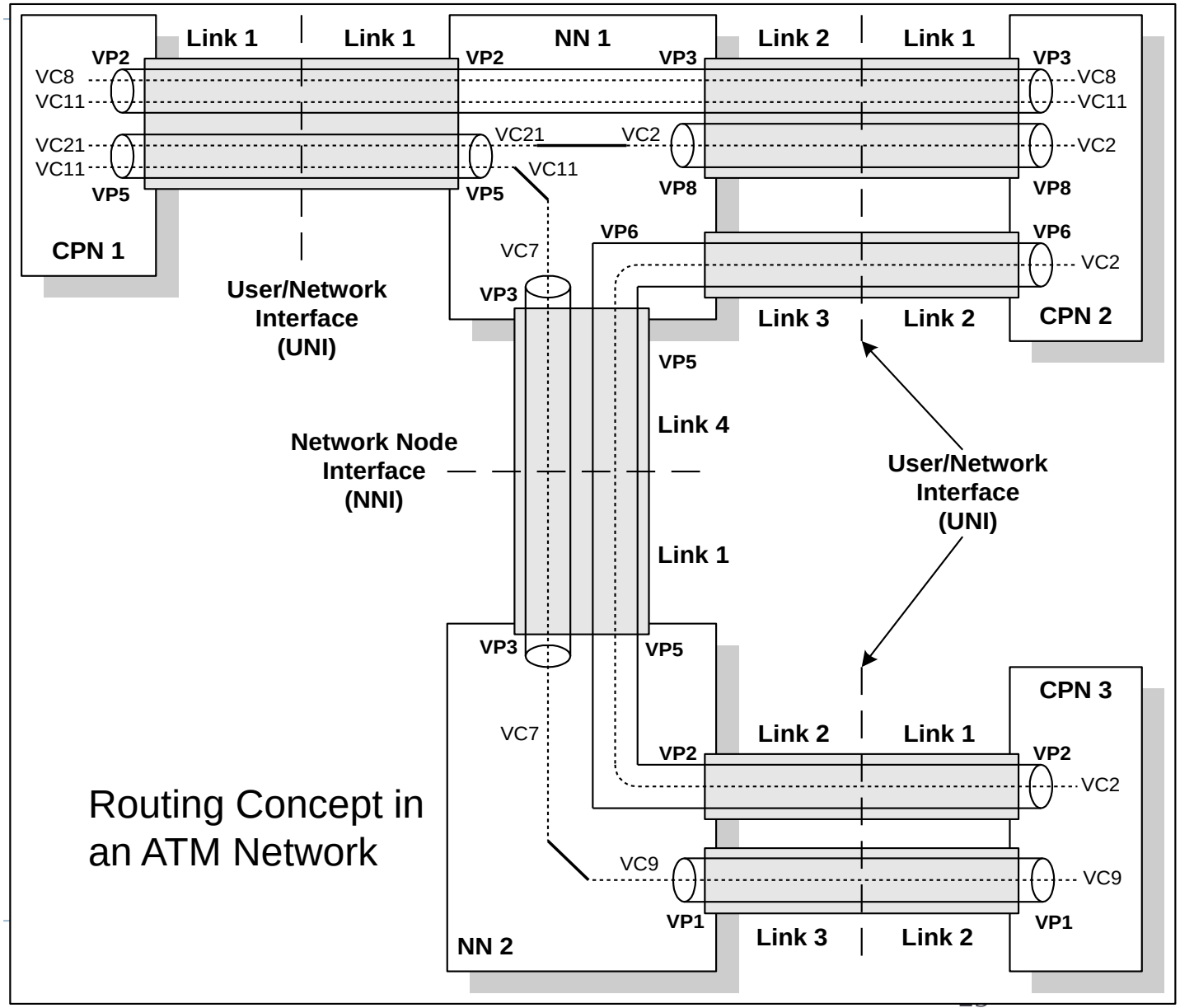
3- Virtual Circuits (VCs): Cell networks are based on virtual circuits. All cells belonging a single message follow the same virtual circuit and remain in their original order until they reach their destination.

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

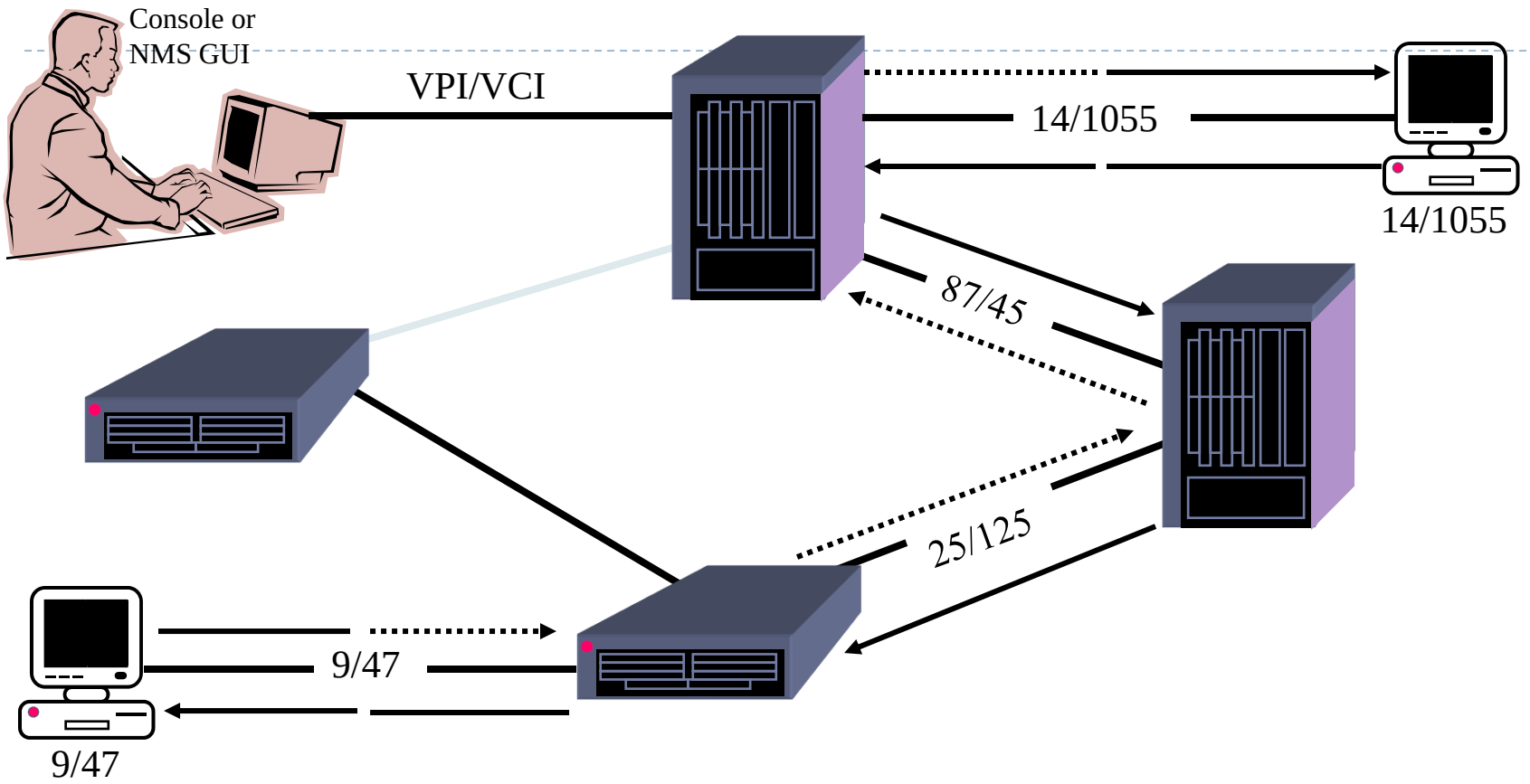
VIRTUAL PATH / VIRTUAL CIRCUIT CONCEPT



Concept –VPs and VCs in the Network

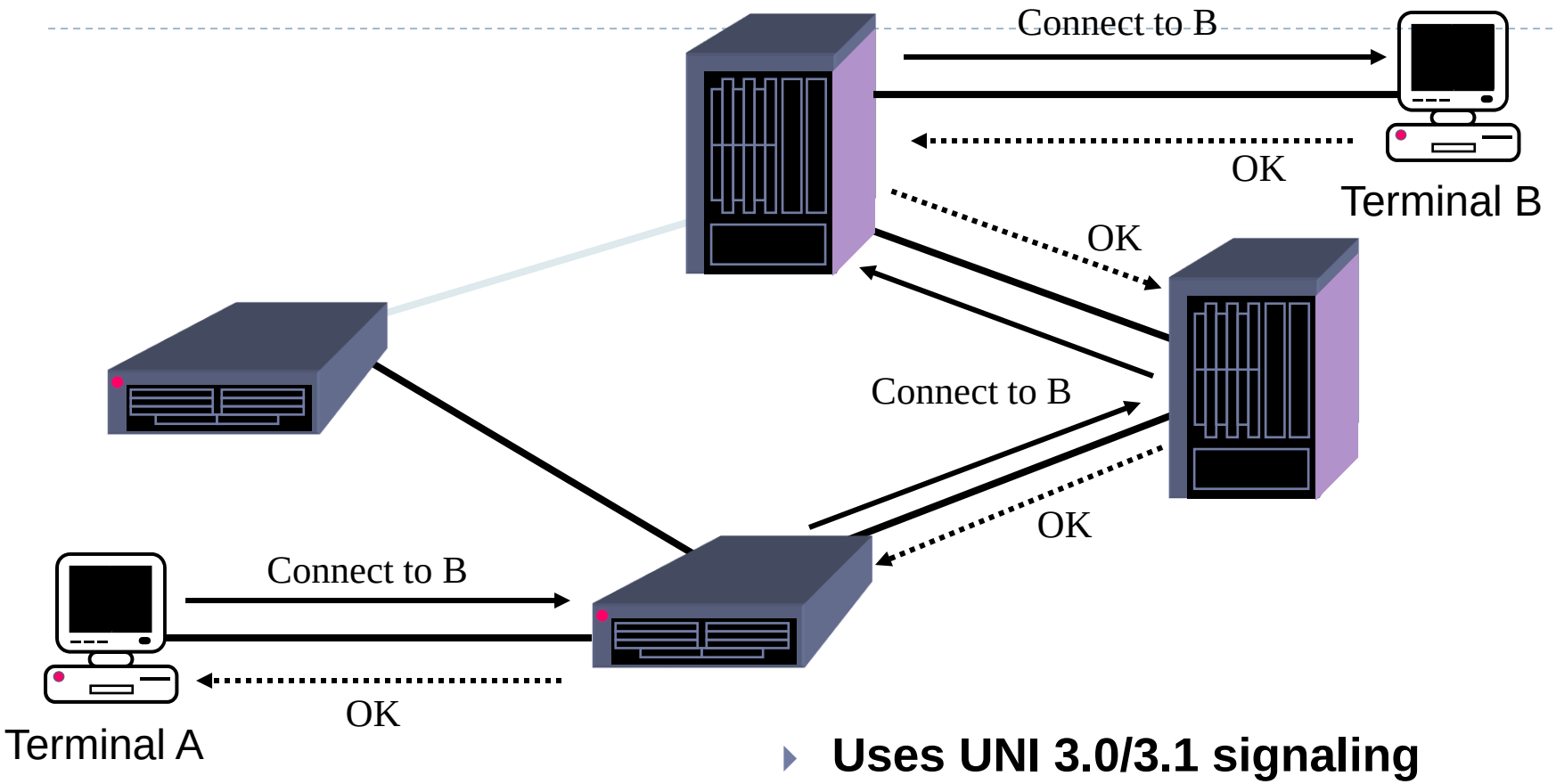


PVC - Manual Set Up



- **Pre-established connections**
- **Permanent**
- **No signaling required**

SVC - Automatic Set Up



- **Uses UNI 3.0/3.1 signaling**
  - **VPI/VCI = 0/5**
- **Automatic**
- **Transparent to User**

ATM ADAPTATION LAYER (AAL) SERVICE CLASSES AND AAL TYPES

	Class A	Class B	Class C	Class D
Timing between source & destination	Related		Not Related	
Bit rate	Constant	Variable		
Connection Mode	Connection Oriented			Connectionless
Examples of services	Circuit emulation, voice	variable bit rate video	connection-oriented data transfer	connectionless data transfer
AAL Type	1	2	3,5	4,5

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

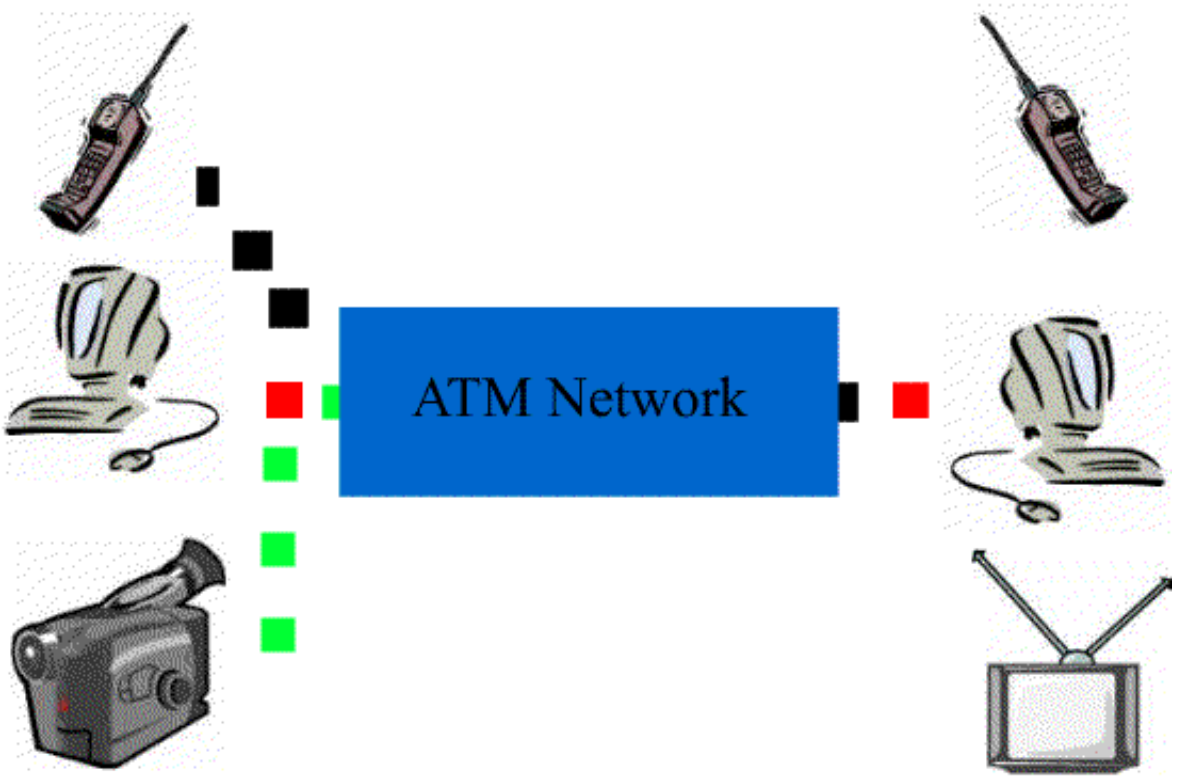
QoS Parameters	Definition
Cell Transfer Delay **(CTD)**	-The delay between the first bit of the cell is transmitted by the source and the last bit of the cell is received by the destination - Includes propagation delays, queuing delays at various switches, and service times at queuing points.
Cell Delay 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 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

Wireless ATM

What is ATM?

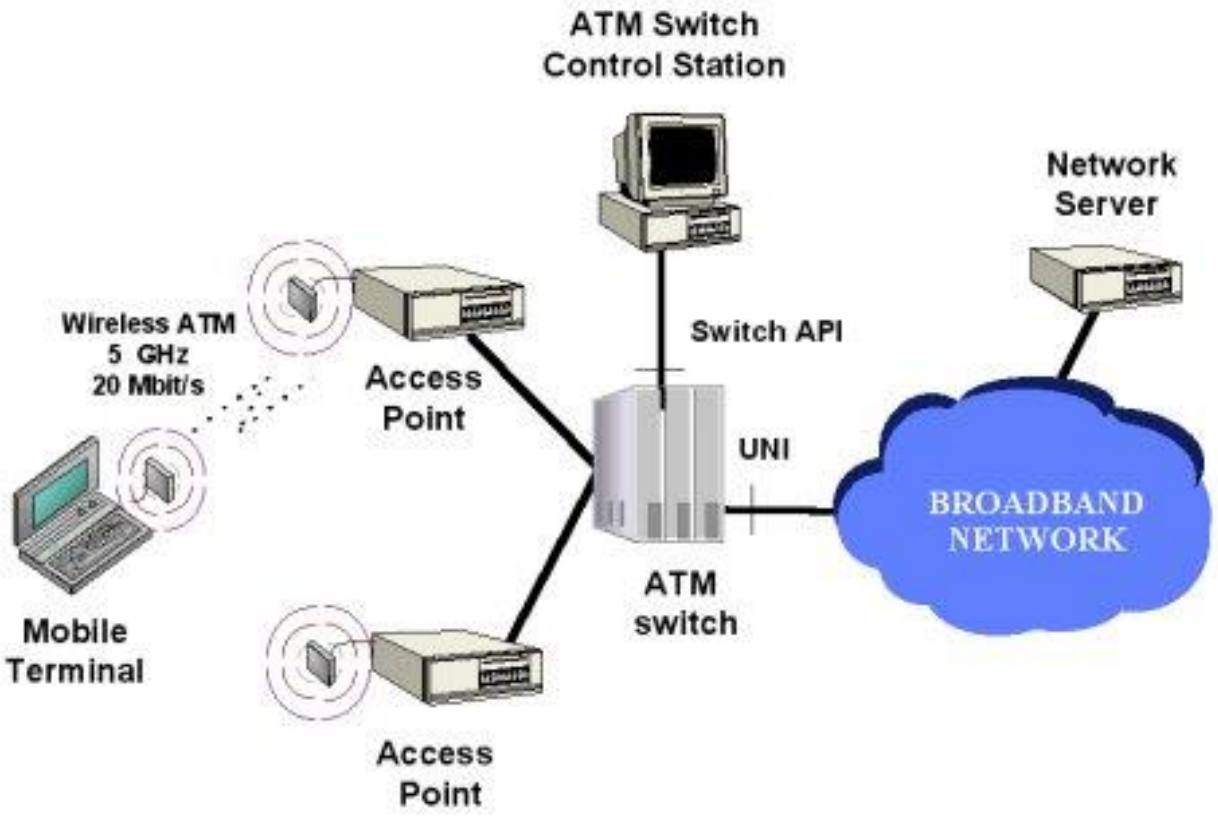


- The small cell size allows ATM to transmit video, audio, and computer data over the same network, while guaranteeing a preset QoS level for each.

The Promise of W-ATM

- Extension of LAN for mobile user
- Simplified wiring and configuration
- Provide high-speed data access for users without need for a new wired infrastructure
- Create unforeseen opportunities for future applications

W-ATM


ATM Switch
Control Station
Network
Server
Switch API
Wireless ATM
5 GHz
20 Mbit/s
Access
Point
UNI
BROADBAND
NETWORK
ATM
switch
Mobile
Terminal
Access
Point

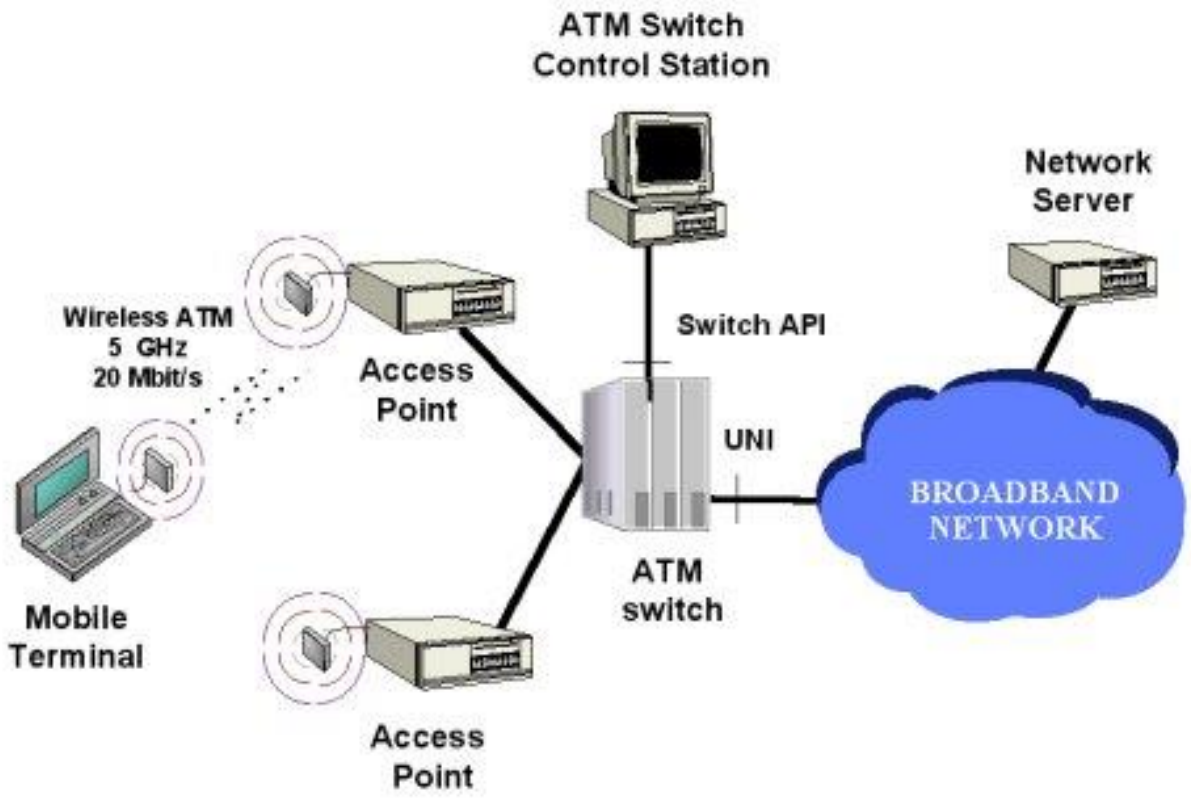
Operating Frequency

	Low Speed Wireless PHY	HighSpeed Wireless PHY
Frequency Band	5.15 – 5.35 GHz, 5.725 – 5.875 GHz	59 GHZ – 64 GHZ
Cell radius	80 m	10 – 15 m
Transmit power	100 mW	10 – 20 mW
Frequency reuse factor	up to 12	7
Channel bandwidth	30 MHz	150 / 700 MHz
Data Rate	25 Mbit / s	155 / 622 Mbit / s
Modulation	16 tone DQPSK	32 tone DQPSK
MAC interface	parallel, transfer speed 3.127 Mbyte / s	parallel, transfer speed 87.5 Mbyte / s
Fixed packet length	PHY header + MAC header + 4 * ATM cells	

Advantages of W-ATM

- Benefits of ATM made mobile
  - Free to roam
- Flexible bandwidth allocation
- Efficient multiplexing of traffic
- Availability of existent ATM switching
- Flexibility of reusing same frequency
- Soft handoff without any data loss

W-ATM Base Stations



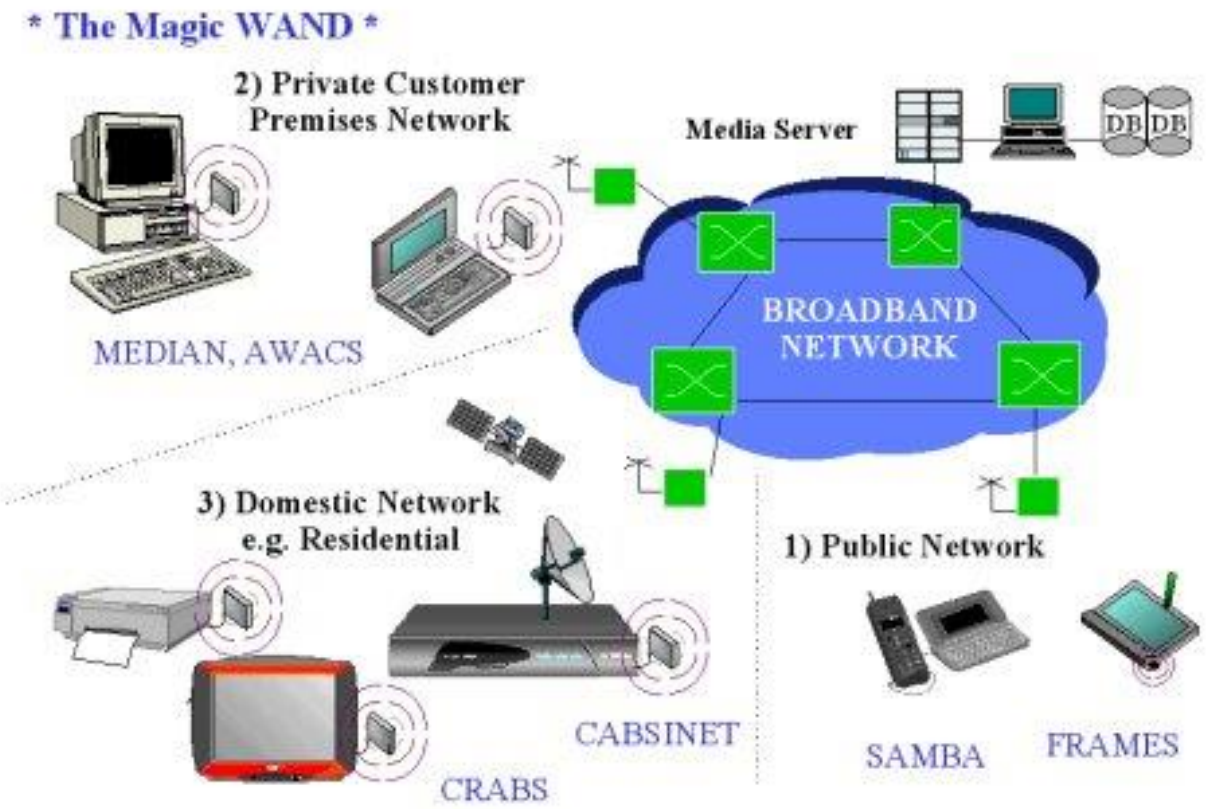
Disadvantages of W-ATM

- Delay to multi-path interference
- Hop-by-hop routing method not adequate
- Virtual connection takes longer
- Poor physical level characteristics
  - High noise interference
- Finding a suitable wireless channel

Research and Implementation
Magic WAND (Wireless ATM Network Demonstrator)

- Goals:
  - To specify and implement W-ATM
  - To promote the standardization of W-ATM
  - To demonstrate that W-ATM is technically feasible
- Achievements
  - Specifications of W-ATM
  - Standardization

Magic WAND


* The Magic WAND *
2) Private Customer Premises Network
Media Server
DB
DB
BROADBAND NETWORK
MEDIAN, AWACS
3) Domestic Network e.g. Residential
1) Public Network
CABSINET
SAMBA
FRAMES
CRABS