Introduction To ATM

WHAT WE WILL COVER

MODULE 1 : B-ISDN AND ATM

MODULE 2 : ATM CONCEPTS

MODULE 3 : ATM PROTOCOL REFERENCE MODEL

MODULE 4 : ATM PHYSICAL LAYER

MODULE 5 : ATM LAYER

MODULE 6 : ATM SERVICE CATEGORIES

MODULE 7 : ATM ADAPTATION LAYERS

MODULE 8 : ATM TRAFFIC MANAGEMENT

MODULE 9 : SIGNALING IN ATM

MODULE 10 : RELATED AREAS AND DEVELOPMENTS

JARGON USED

ATM: ASYNCHRONOUS TRANSFER MODE

B-ISDN: BROADBAND INTEGRATED SERVICES DIGITAL NETWORK

CBR: CONSTANT BIT RATE

VBR: VARIABLE BIT RATE

ABR: AVAILABLE BIT RATE

UBR: UNSPECIFIED BIT RATE

JARGON USED

AAL: ATM ADAPTATION LAYER

SAAL: SIGNALING AAL

UNI: USER-NETWORK INTERFACE

PNNI: PRIVATE NETWORK-NETWORK INTERFACE

PMP: POINT-TO-MULTIPOINT

LIJ: LEAF INITIATED JOIN

Module 1
B-ISDN and ATM

B-ISDN SERVICES

- MESSAGING SERVICES
  - COMMUNICATION VIA STORAGE UNITS (MAILBOX ETC)
  - EMAILS, VIDEO MAILS

B-ISDN SERVICES

- RETRIEVAL SERVICES
  - PROVIDE USERS WITH CAPABILITY TO RETRIEVE INFORMATION STORED ELSEWHERE
  - HIGH RESOLUTION IMAGE RETRIEVAL, DOCUMENT RETRIEVAL SERVICES.

B-ISDN SERVICES

- DISTRIBUTED SERVICES
  - VIDEO AND AUDIO TRANSMISSION SERVICES.
  - ELECTRONIC NEWSPAPER
  - VIDEO SERVICES:
    - TV PROGRAM DISTRIBUTION
    - DIGITAL VIDEO LIBRARY

TYPES OF TRANSFER MODES

DIFFERENT TECHNIQUES TO TRANSFER DATA AND VOICE:

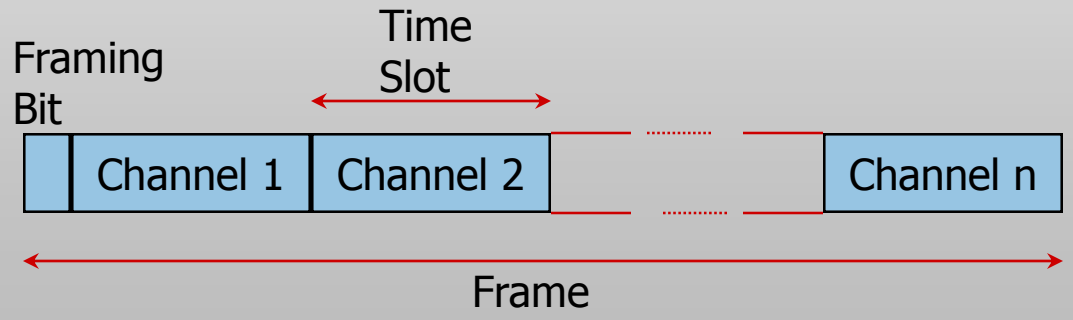
- CIRCUIT SWITCHING (VOICE TRANSFER)
- PACKET SWITCHING (DATA TRANSFER)

CIRCUIT SWITCHING

- A CIRCUIT IS ESTABLISHED FOR THE DURATION OF THE CONNECTION
- BASED ON TIME DIVISION MULTIPLEXING (TDM)
  - ALSO CALLED SYNCHRONOUS TRANSFER MODE (STM)
- BASED ON RECURRING STRUCTURE : FRAME

CIRCUIT SWITCHING

- A CHANNEL IS IDENTIFIED BY POSITION OF ITS TIME SLOTS WITHIN THE FRAME
  - A CHANNEL IS ASSIGNED A FIXED NUMBER OF SLOTS WITHIN EACH FRAME



CIRCUIT SWITCHING

- LOW SWITCHING DELAY : SWITCHING IN HARDWARE
- LOW DELAY VARIANCE
- NO OVERHEADS OF PACKETIZATION
  - NO ROUTING, NO LINK LEVEL ERROR CONTROL

CIRCUIT SWITCHING

- HIGHLY INFLEXIBLE
  - FIXED BANDWIDTH ALLOCATION : MULTIPLE OF 64 KBPS
  - SYNCHRONIZATION PROBLEMS BETWEEN VARIOUS CHANNELS OF A CONNECTION.
  - SELECTION OF BASIC CHANNEL BANDWIDTH IS A COMPLICATED ISSUE.
- INEFFICIENT FOR VARIABLE BIT-RATE TRAFFIC
  - BANDWIDTH IS ALLOCATED AT THE PEAK RATE

PACKET SWITCHING

- PACKET = USER DATA + HEADER
  - HEADER FOR ROUTING, ERROR AND FLOW CONTROL
- VARIABLE PACKET LENGTH
- COMPLEX LINK - TO - LINK PROTOCOL
  - ERROR AND FLOW CONTROL
- STORE AND FORWARD SWITCHING
- STATISTICAL SHARING OF RESOURCES

PACKET SWITCHING

- BEST EFFORT TRANSFER
  - DUE TO CONGESTION IN SWITCHES, PACKET LOSS MIGHT OCCUR
  - RESOURCES ARE NOT RESERVED FOR DIFFERENT APPLICATIONS

PACKET SWITCHING

- VARIABLE LENGTH PACKETS REQUIRE COMPLEX BUFFER MANAGEMENT SCHEMES
- VARIABLE PROCESSING AND SWITCHING DELAYS
- LOW EFFICIENCY FOR SMALL SIZE PACKETS
  - DUE TO HIGH HEADER OVERHEADS

WHICH SWITCHING TECHNIQUE DO WE USE FOR B-ISDN?

COMBINE BEST PACKET AND CIRCUIT SWITCHING FEATURES

- FLEXIBLE BANDWIDTH AND STATISTICAL MULTIPLEXING
  - PACKET SWITCHING : VIRTUAL CIRCUIT
- LOW DELAY VARIATION (JITTER)
  - FIXED ROUTE FOR ALL PACKETS OF THE CONNECTION

COMBINE BEST PACKET AND CIRCUIT SWITCHING FEATURES

- LESS DELAY FOR VOICE & REAL-TIME APPLICATIONS
  - SMALL PACKET SIZE (32 OR 64 BYTES): LESS PACKETIZATION TIME
  - FIXED PACKET SIZE FOR LESS SWITCHING AND PROCESSING TIME
- HIGH TRANSMISSION EFFICIENCY
  - REDUCE HEADER OVERHEADS : NO LINK BY LINK FLOW AND ERROR CONTROL

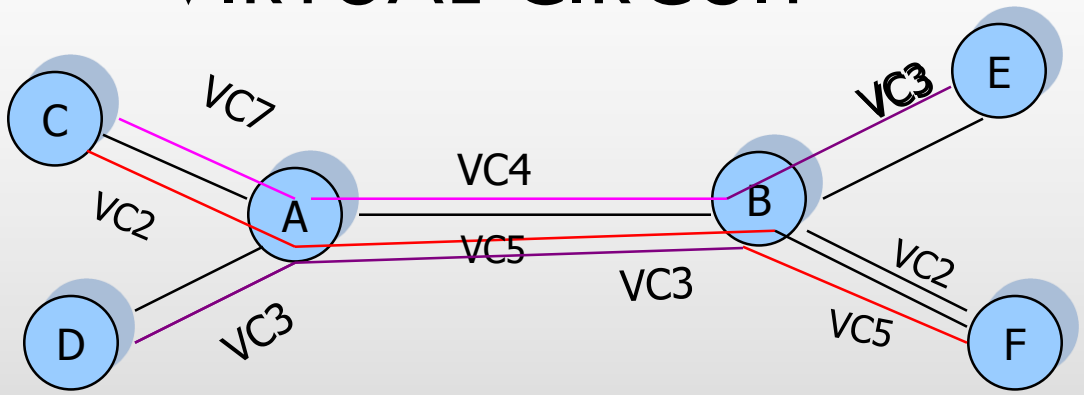
VIRTUAL CIRCUIT CONCEPT

- LOGICAL CONNECTION
- CONNECTION IS FIRST ESTABLISHED USING SIGNALING PROTOCOL
  - ROUTE FROM THE SOURCE TO THE DESTINATION IS CHOSEN
  - THE SAME ROUTE IS USED FOR ALL CELLS (FIXED SIZE PACKETS) OF THE CONNECTION
- NO ROUTING DECISION FOR EVERY CELL

VIRTUAL CIRCUIT CONCEPTS

- NO DEDICATED PATH (UNLIKE CIRCUIT SWITCHING)
- EACH LINK OF THE NETWORK IS SHARED BY A SET OF VIRTUAL CHANNELS
  - EACH CELL USES ONLY VIRTUAL CHANNEL NUMBER
- EACH PACKET CONTAINS ENOUGH INFORMATION FOR NODE (SWITCH) TO FORWARD IT TOWARDS THE DESTINATION

VIRTUAL CIRCUIT



IN LINK	IN VC	OUT LINK	OUT VC
CA	7	AB	4
CA	2	AB	5
DA	3	AB	3

Table at Node A

REQUIREMENTS OF VIRTUAL CIRCUIT TECHNOLOGY FOR B-ISDN

- PERFORMANCE REQUIREMENTS
  - SUPPORT FOR FLEXIBLE BANDWIDTH (VARIABLE ACCESS RATE)
- LIMITED ERROR RATE
    - BIT ERROR RATE $<$ 10^{-7} TO 10^{-10}
    - PACKET LOSS RATE $<$ 10^{-5} TO 10^{-7}

ATM : SOLUTION FOR B-ISDN

- SUITABLE FOR BOTH REAL-TIME AND NON REAL-TIME APPLICATIONS
- SUITABLE FOR BOTH LOSS-SENSITIVE AND LOSS-INSENSITIVE APPLICATIONS
- SEAMLESS NETWORKING
  - LAN TO MAN TO WAN
  - TO CARRY VOICE, TELEPHONY, MULTIMEDIA, DATA TRAFFIC

Module 2
ATM Concepts

ATM CONCEPTS

- ATM IS BASED ON VIRTUAL CIRCUIT TECHNOLOGY
- VIRTUAL CIRCUITS HAVE MANY ADVANTAGES OVER DATAGRAM AND CIRCUIT SWITCHING
- SIMILAR TO CIRCUIT SWITCHING, ATM USES SIGNALING PROTOCOL TO ESTABLISH CIRCUIT BEFORE DATA COMMUNICATION COMMENCES

ATM CONCEPTS

- UNLIKE CIRCUIT SWITCHING, ATM IS BASED ON STATISTICAL MULTIPLEXING (SIMILAR TO PACKET SWITCHING)
- IN ORDER DELIVERY OF CELLS DUE TO VIRTUAL CIRCUITS

ATM CONCEPTS

- NO ERROR PROTECTION OR FLOW CONTROL ON A LINK BY LINK BASIS
  - LINKS ARE ASSUMED TO BE HIGH QUALITY WITH LOW BIT ERROR RATE
  - PREVENTIVE ACTIONS: PROPER RESOURCE ALLOCATION AND QUEUE DIMENSIONING TO REDUCE PACKET LOSS
  - END-TO-END ERROR PROTECTION AND RECOVERY.

ATM CONCEPTS

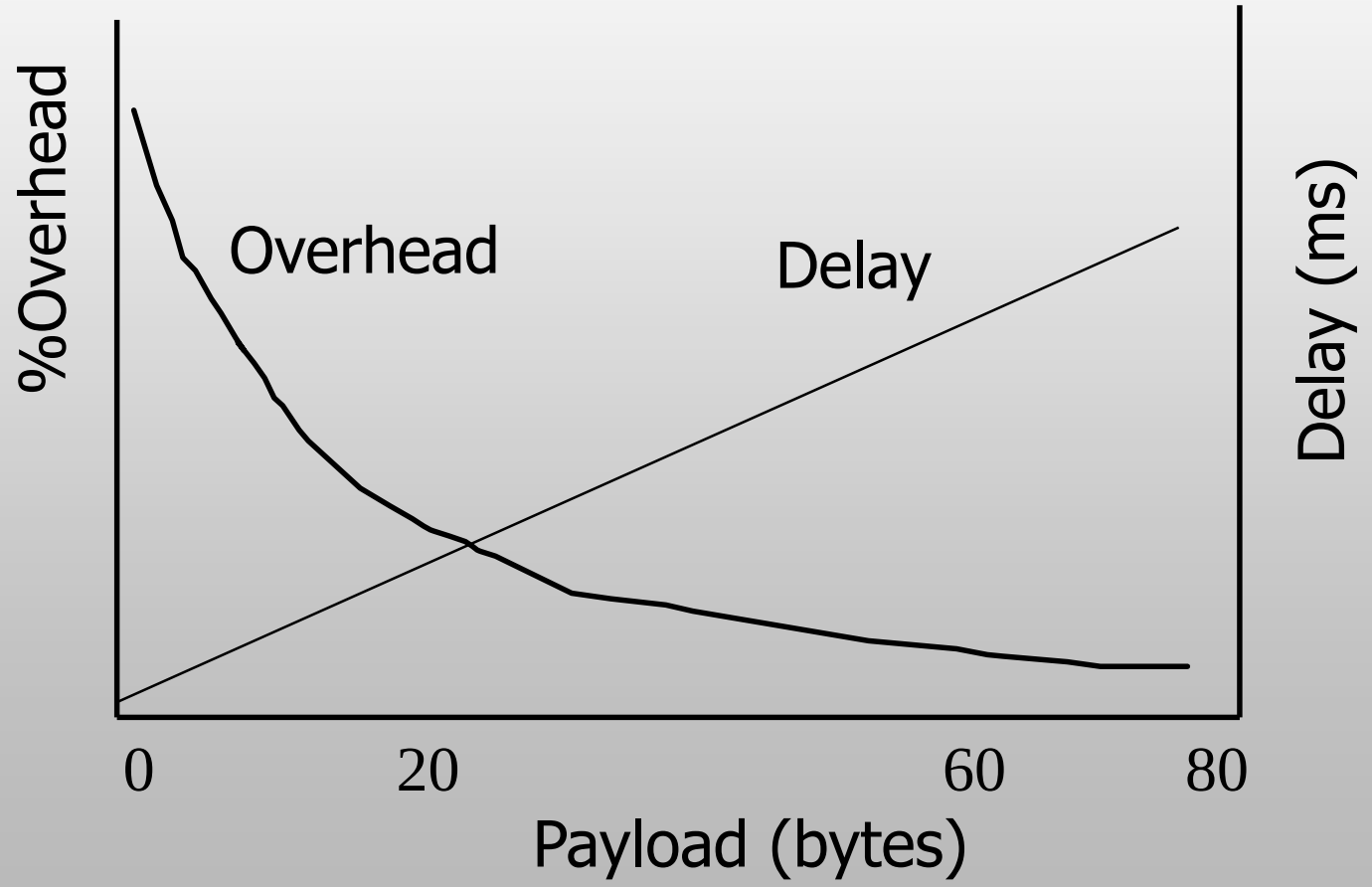
- FLOW CONTROL BY INPUT RATE CONTROL AND CAPACITY RESERVATION
- CONGESTION CONTROL : AVOID CONGESTION
  - DROP CELLS WHEN CONGESTION OCCURS
- FIXED SIZE PACKETS CALLED CELLS
  - SIZE 53 BYTES = 48 BYTES PAYLOAD + 5 BYTES HEADER

CELL SIZE

BASED ON :

- TRANSMISSION EFFICIENCY
- END-TO-END DELAY
  - PACKETIZATION DELAY
  - TRANSMISSION DELAY
  - SWITCHING DELAY

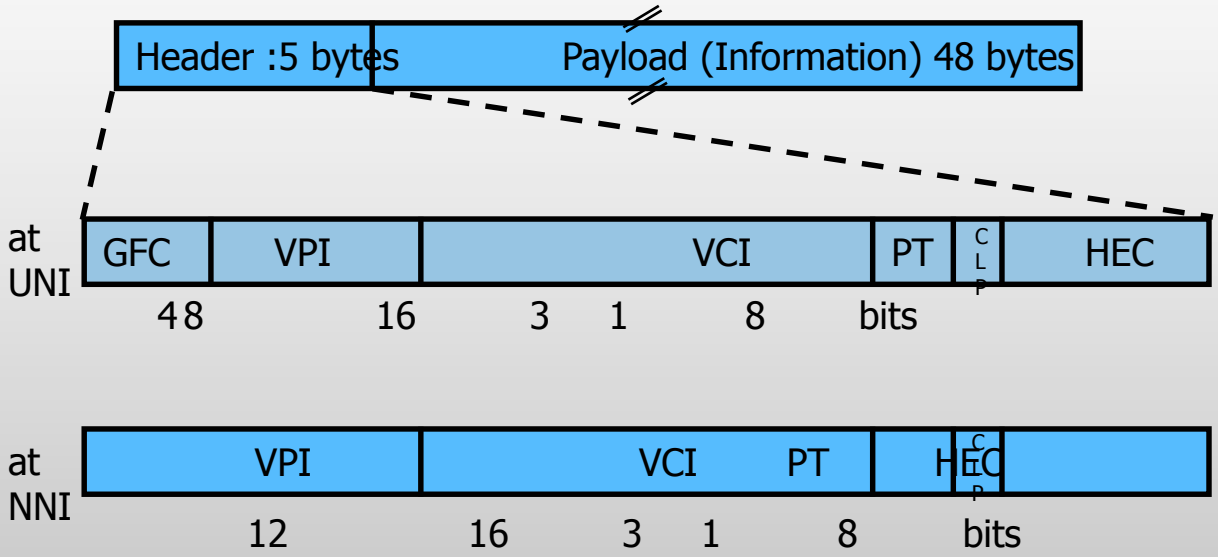
WHY SMALL CELLS ?



CELL SIZE: 32 BYTES OR 64 BYTES?

- CELL SIZE OF 32 AND 64 BYTES:
  - 64 BYTES CELLS HAVE BETTER TRANSMISSION EFFICIENCY
  - 32 BYTES CELLS HAVE SMALL DELAY
  - BOTH SIZES ARE INTEGER POWER OF 2
- EUROPE WANTED 32 BYTES SIZE, US AND JAPAN WANTED 64 BYTES SIZE
- COMPROMISE: 48 BYTES

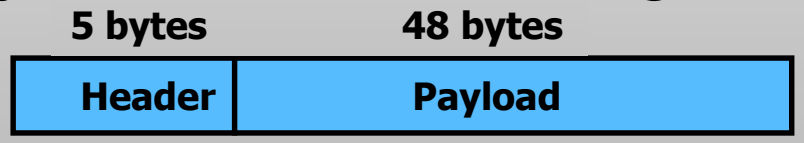
ATM CELL FORMAT



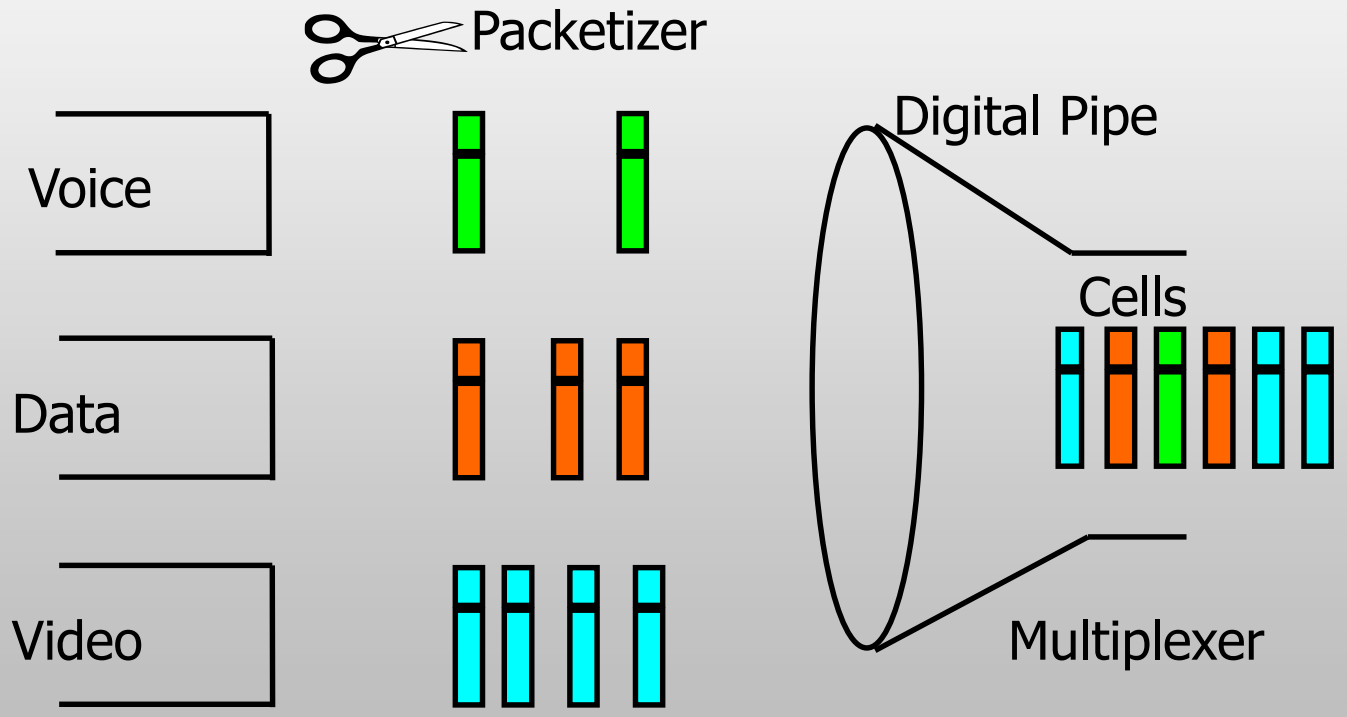
GFC : Generic Flow Control
VPI : Virtual Path Identifier
VCI : Virtual Circuit Identifier
PT : Payload Type
CLP : Cell Loss Priority
HEC : Header error Check
UNI : User Network Interface
NNI : Network-Network Interface

ATM CONCEPTS

- REDUCED HEADER FUNCTIONALITY
  - PROVISION FOR MULTIPLEXING, HEAD-ERROR DETECTION / CORRECTION AND LIMITED CONTROL AND MAINTENANCE FUNCTION
  - NO SEQUENCE NUMBER
  - NO DESTINATION AND SOURCE ADDRESS



ASYNCHRONOUS MULTIPLEXING OF CELLS



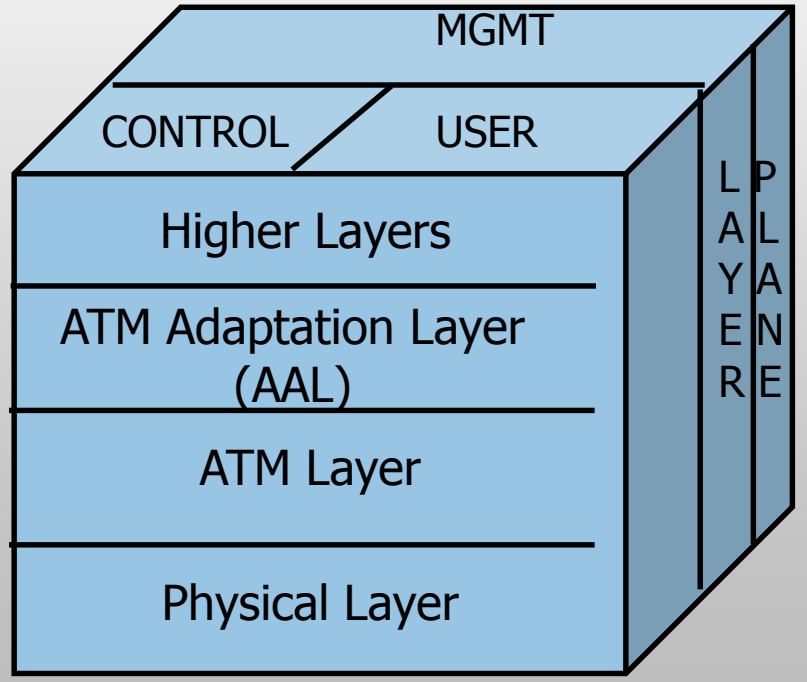
FEATURES OF ATM

- SIMPLE QUEUE MANAGEMENT AND CELL PROCESSING DUE TO THE FIXED SIZE CELLS
- SUITABILITY FOR
  - DELAY SENSITIVE AND LOSS INSENSITIVE TRAFFIC
  - DELAY INSENSITIVE AND LOSS SENSITIVE TRAFFIC
- QUALITY OF SERVICE (QOS) CLASS SUPPORT
- SWITCHED ACCESS
  - MULTIPLE ACCESS SPEEDS (25 MBPS - 155 MBPS)
- EASILY SCALABLE

Module 3

B-ISDN ATM Protocol Reference Model

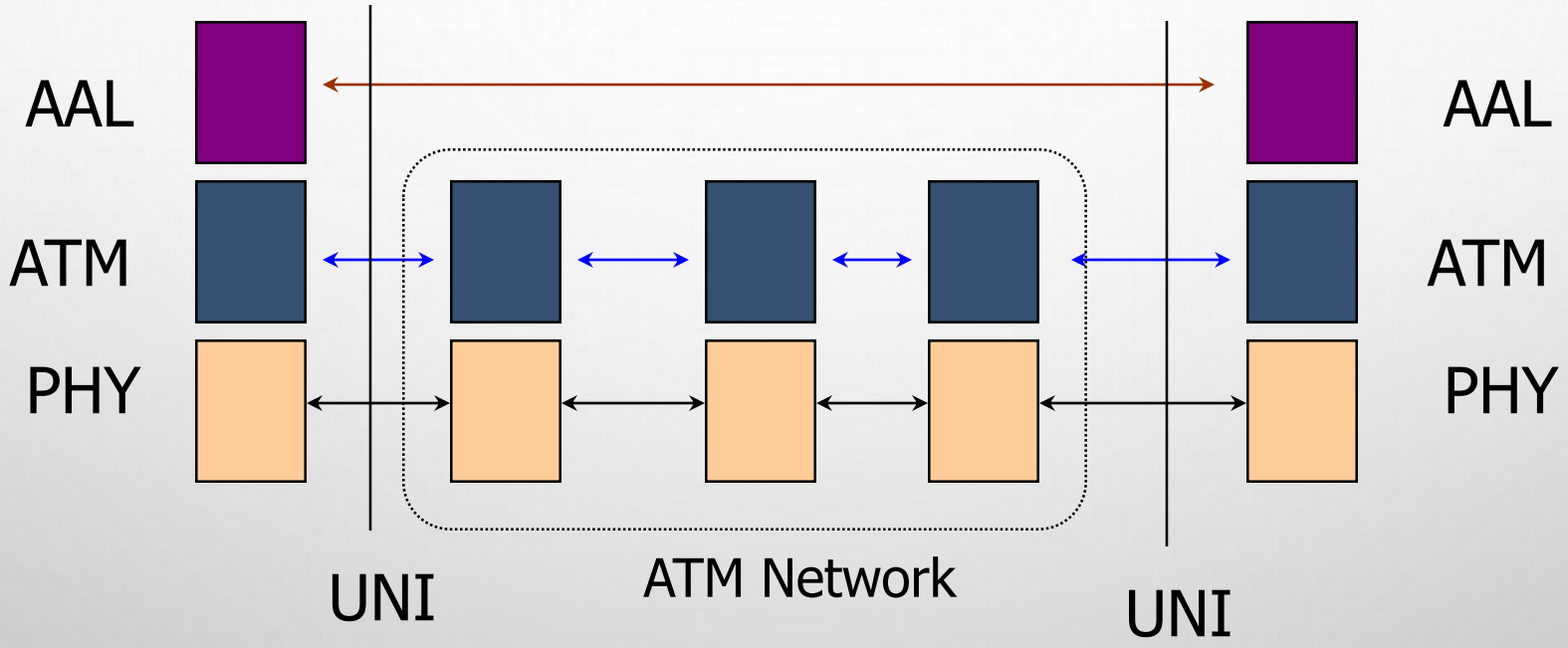
B-ISDN ATM PROTOCOL REFERENCE MODEL (PRM)



ATM PRM

- CONTROL PLANE : USED FOR CONNECTION CONTROL, INCLUDING CONNECTION SETUP AND RELEASE FUNCTIONS.
- USER PLANE : DATA IS TRANSMITTED USING ONE OF THE PROTOCOLS IN THE USER PLANE ONCE THE CONNECTION IS ESTABLISHED.
- MANAGEMENT PLANE : MANAGEMENT FUNCTIONS RELATING TO USER AND CONTROL PLANES.

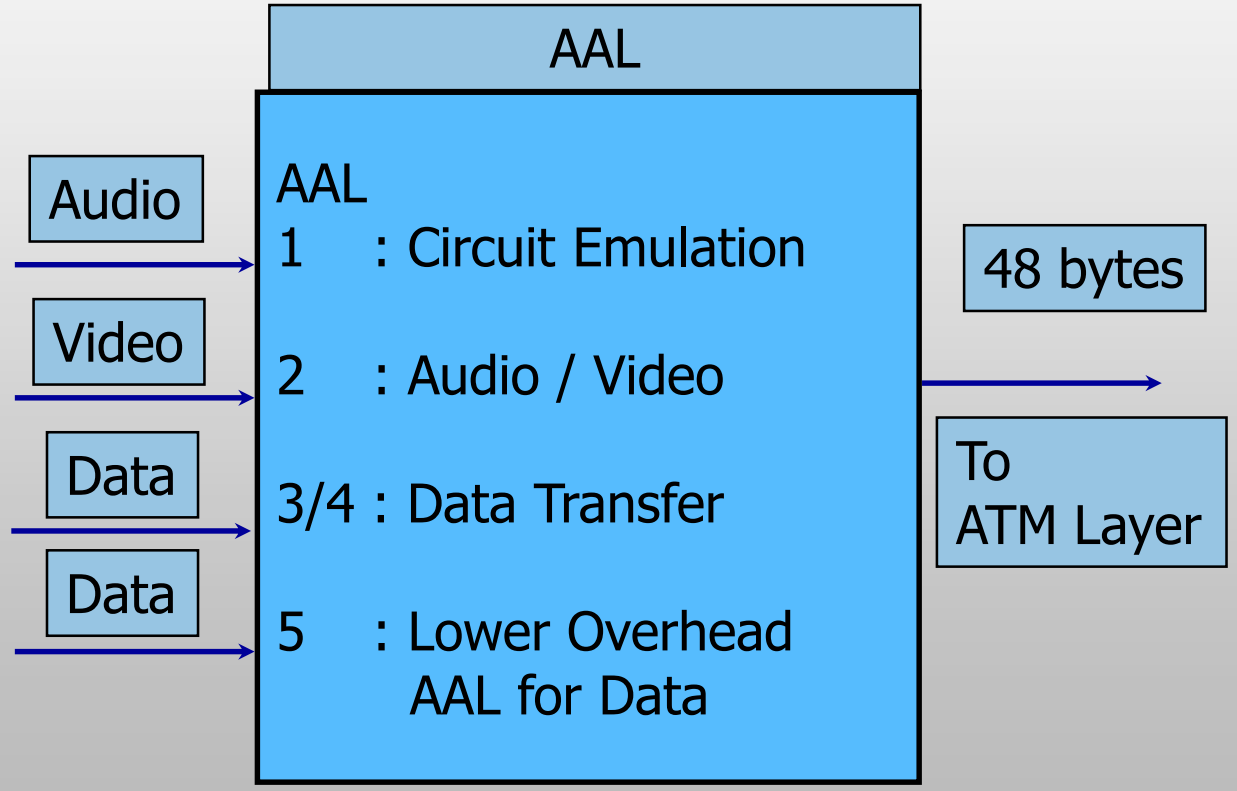
LAYERED ARCHITECTURE



ATM ADAPTATION LAYER

- PROVIDES MAPPING OF DIFFERENT TYPE OF APPLICATIONS TO ATM SERVICE OF THE SAME TYPE
- SEGMENTS AND REASSEMBLES INTO 48 BYTE PAYLOAD
- ACCEPTS, DELIVERS 48 BYTE PAYLOADS TO ATM LAYER

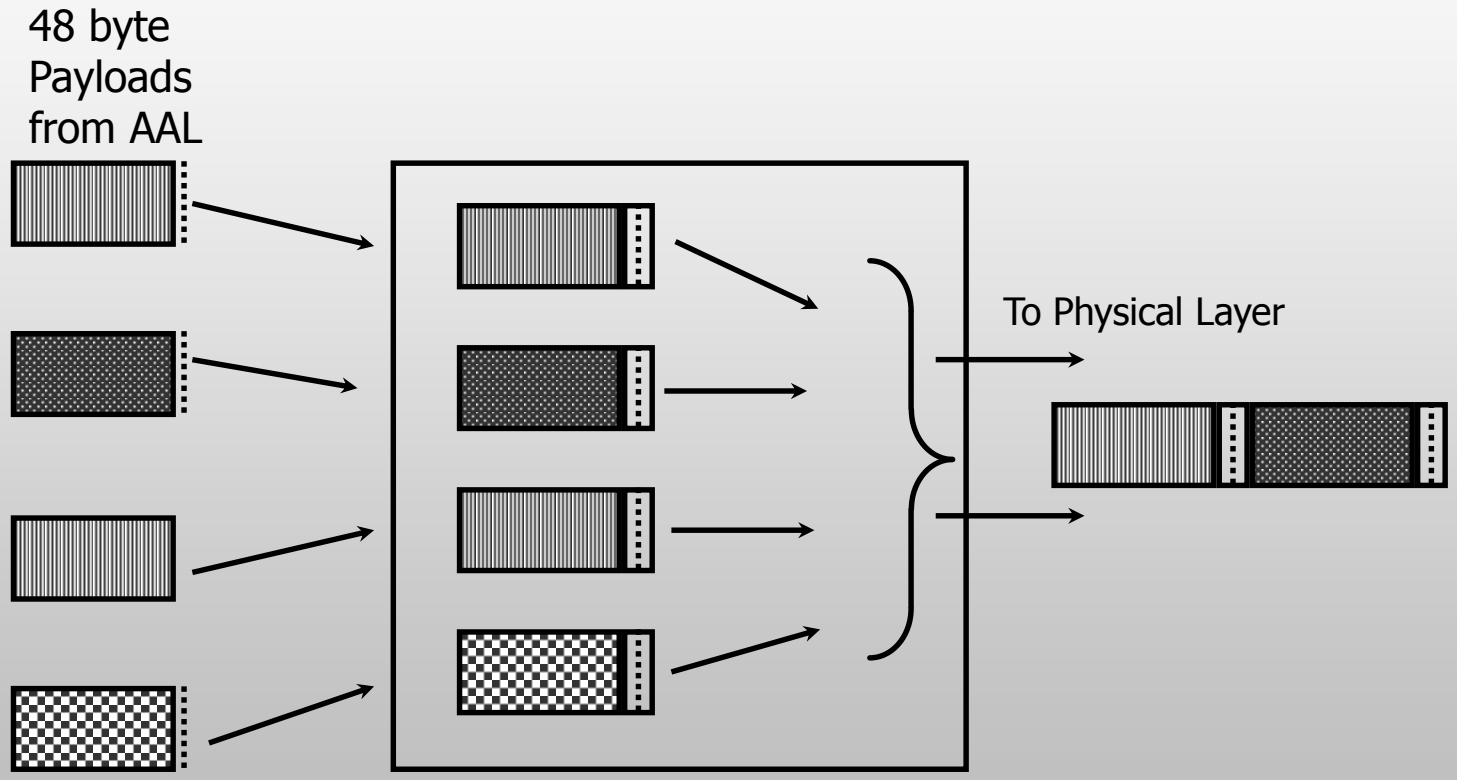
ATM ADAPTATION LAYER



ATM LAYER

- HEADER PROCESSING
  - ADDING / REMOVING HEADER TOP 48 BYTE PAYLOAD
- HANDLING OF CONNECTION IDENTIFIERS
  - VCI AND VPI TRANSLATION
- CELL MULTIPLEXING AND DEMULTIPLEXING
- GENERIC FLOW CONTROL

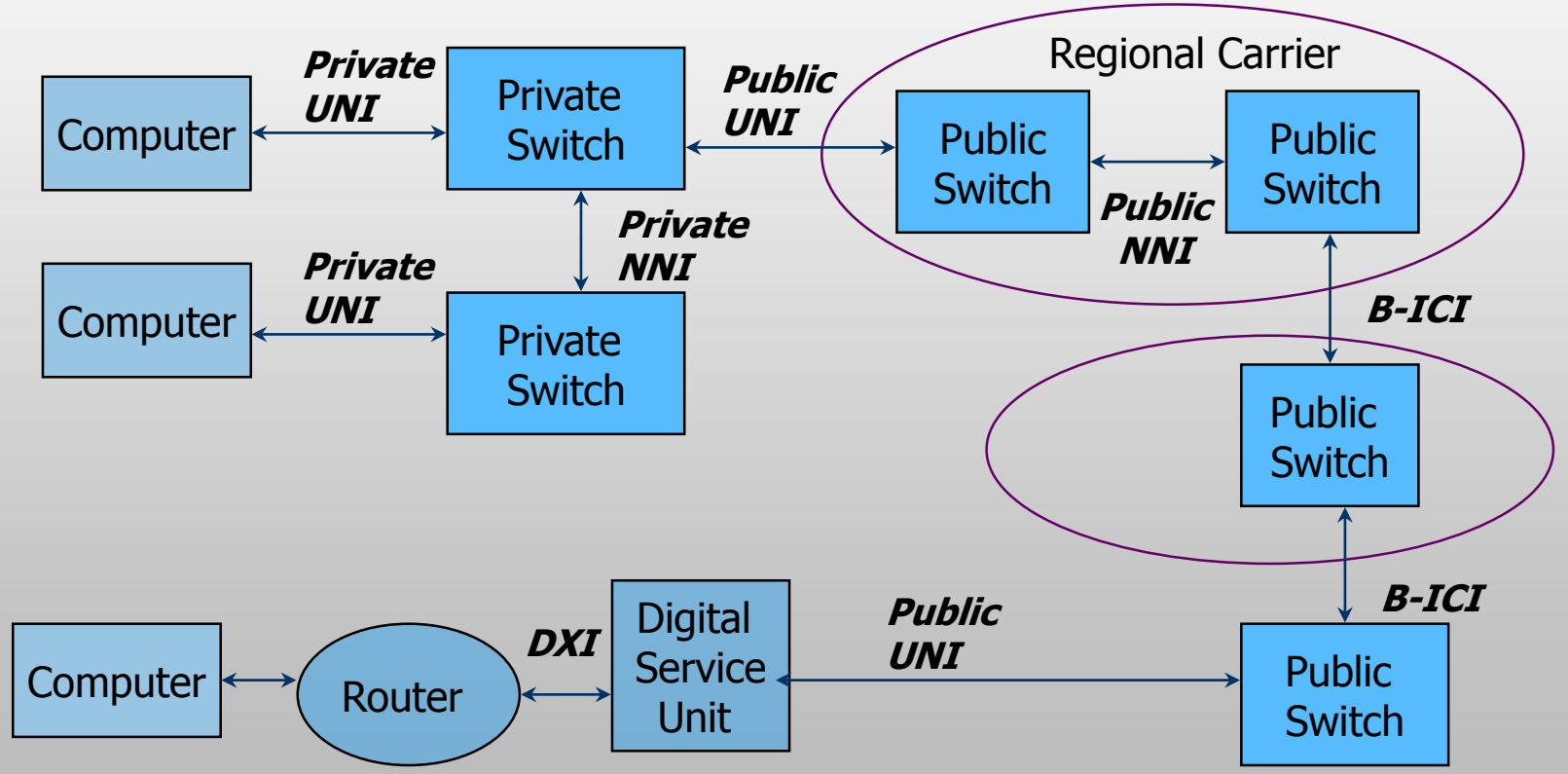
ATM LAYER



PHYSICAL LAYER

- TRANSMISSION FRAME ADAPTATION
- CELL DELINEATION
- CELL RATE DECOUPLING

ATM NETWORK INTERFACES



Module 4
ATM Physical Layer

PHYSICAL LAYER

- INTRODUCTION
- PHYSICAL MEDIUM CHOICES AT UNI AND NNI
- TC SUBLAYER
- CELL DELINEATION
- CELL PAYLOAD SCRAMBLING

ATM PHYSICAL LAYER : INTRODUCTION

- PHYSICAL MEDIUM TO CARRY ATM CELLS
- TWO SUBLAYERS
  - TRANSMISSION CONVERGENCE (TC) SUBLAYER
  - PHYSICAL MEDIUM DEPENDENT (PMD) SUBLAYER

TRANSMISSION CONVERGENCE SUBLAYER

- TRANSMISSION CONVERGENCE SUBLAYER
  - CONVERT BIT STREAM TO CELL STREAM
  - TRANSMISSION FRAME ADAPTATION : PACKING CELLS INTO FRAME
  - CELL DELINEATION : SCRAMBLING AND CELL RECOVERY
  - HEC GENERATION / VERIFICATION
  - CELL RATE DECOUPLING : INSERTION AND SUPPRESSION OF IDLE CELLS

PMD SUBLAYER

- PHYSICAL MEDIUM DEPENDENT SUBLAYER
  - FIBER, TWISTED PAIR, COAX, SONET, DS3
  - FUNCTIONS
    - BIT TIMING
    - LINE CODING

CELL-STREAM PHYSICAL LAYER

- CELLS ARE TRANSMITTED AS A STREAM WITHOUT ANY REGULAR FRAMING
- OAM CELLS ARE IDENTIFIED BY VPI:0, VCI:9
- SYNCHRONIZATION IS ACHIEVED BY TRANSMISSION CONVERGENCE SUBLAYER

PHYSICAL MEDIUM CHOICES

- PLESIOCHRONOUS DIGITAL HIERARCHY (PDH) BASED INTERFACES
  - USES EXISTING TRANSMISSION NETWORK INFRASTRUCTURE
  - DS1(1.544MBPS), E1 (2.048 MBPS), E3 (34.368 MBPS) , DS3 (44.736 MBPS), E4 SPEEDS
  - CELL DELINEATION AND SYNCHRONIZATION WITH HEC
- 25.6 MBPS UTP

SONET / SDH BASED PHYSICAL LAYER

- SYNCHRONOUS OPTICAL NETWORK: (SONET)
- SYNCHRONOUS DIGITAL HIERARCHY (SDH)
- LOWER SPEED ATM STREAMS CAN BE MULTIPLEXED OVER HIGHER SPEED SONET STREAMS
- SONET SUPPORTS A HIERARCHY OF DIGITAL SIGNALS WITH A BASIC RATE OF 51.84 MBPS
- BASED ON TIME DIVISION MULTIPLEXING

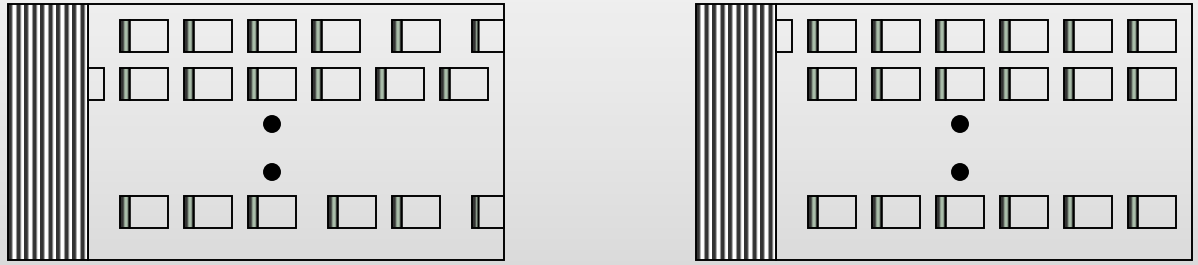
SONET / SDH BASED PHYSICAL LAYER

- H4 OCTET IN THE PATH HEADER INDICATES OFFSET TO THE BOUNDARY OF THE FIRST CELL FOLLOWING H4
- PARTS OF A CELL MAY BE CARRIED OVER TWO SUCCESSIVE SONET FRAMES

SDH PHYSICAL LAYER FOR ATM

- THE MOST COMMON PHYSICAL LAYER TO TRANSPORT ATM CELLS IN PUBLIC NETWORKS
- STANDARDS ARE DEFINED FOR ENCAPSULATION OF ATM CELLS IN SDH (SONET) FRAMES

SDH PHYSICAL LAYER FOR ATM



- TOTAL : 9 ROWS * 270 COLUMNS
- STM-1/STS-3C : 9*260*8/125 μSEC
  =145.76 MBPS PAYLOAD

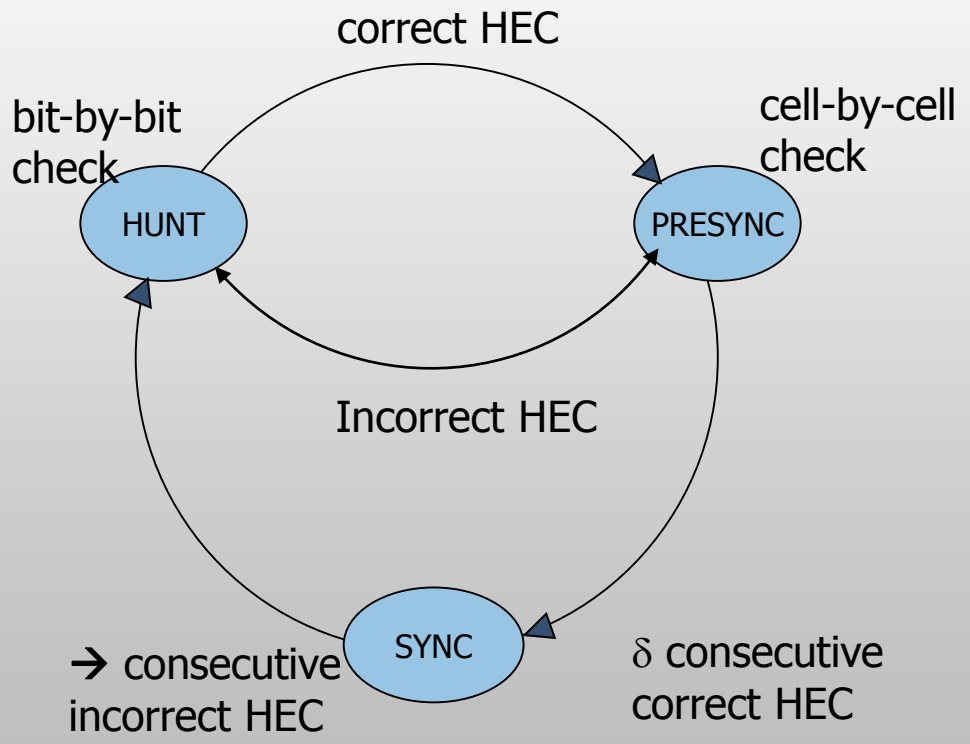
CELL DELINEATION

- IDENTIFIES CELL BOUNDARIES IN A CELL STREAM
- PHYSICAL LAYERS MAY USE THEIR OWN MECHANISMS
  - SONET USES H4 POINTER

CELL DELINEATION

- CCITT RECOMMENDED HEC-BASED ALGORITHM
  - GENERIC
  - CAN BE USED WITH CELL-STREAM WHEN THERE IS NO FRAMING STRUCTURE
  - CONTRAST WITH MARKER BASED FRAMING

CELL DELINEATION BY HEC FIELD



Initially HUNT state

- Bit-by-bit check to match computed HEC with the received HEC
- CCITT recommendation
- → < 7
- δ < 6

CELL PAYLOAD SCRAMBLING

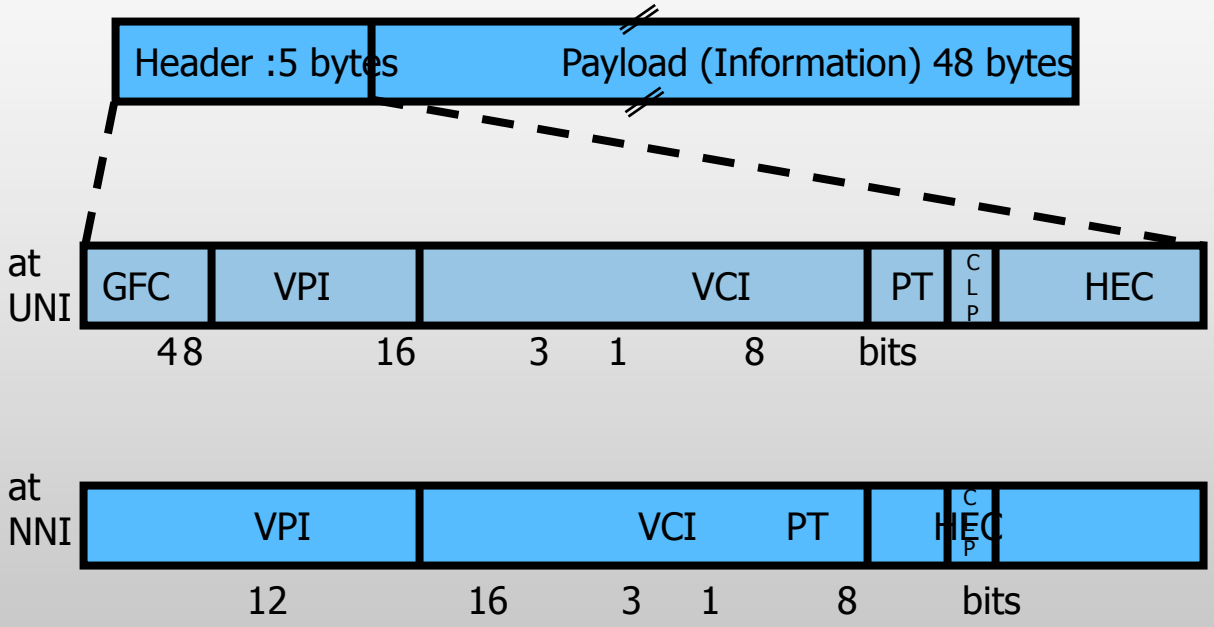
- AT SOURCE, SCRAMBLE THE CELL PAYLOAD
- AT RECEIVER, DESCRAMBLE THE CELL PAYLOAD
- TO INCREASE THE SECURITY AND ROBUSTNESS
  - TO PROTECT AGAINST MALICIOUS USERS OR UNINTENDED SIMULATION OF A CORRECT HEC IN THE INFORMATION FIELD

SUMMARY

- WIDE RANGE OF PHYSICAL INTERFACES ARE AVAILABLE :
  - DS1 TO STS-12
- ATM CELLS CAN ALSO BE CARRIED OVER (STANDARDS ARE BEING DEFINED)
  - SATELLITE
  - WIRELESS
- TWO SUBLAYERS : CONVERGENCE SUBLAYER AND PHYSICAL MEDIUM DEPENDENT SUBLAYER

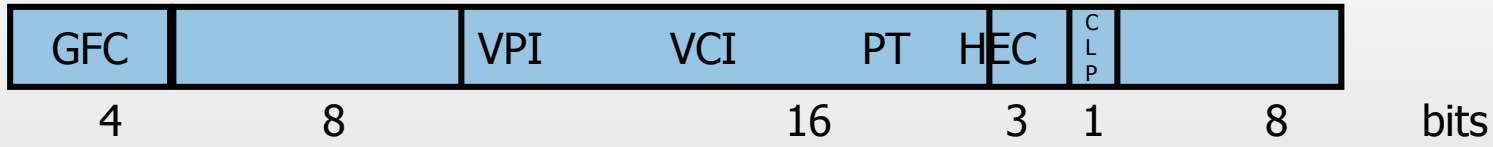
Module 5
ATM Layer

ATM CELL FORMAT



GFC : Generic Flow Control **VPI : Virtual Path Identifier**
VCI : Virtual Circuit Identifier **PT : Payload Type**
CLP : Cell Loss Priority **HEC : Header error Check**
UNI : User Network Interface **NNI : Network-Network Interface**

ATM CELL FORMAT



GFC : GENERIC FLOW CONTROL (4 BITS)

- USED FOR FLOW CONTROL AT UNI
- EXACT GFC PROCEDURE IS NOT YET DEFINED
- PT: PAYLOAD
  - TYPE OF PAYLOAD CARRIED WITHIN A CELL
    - USER DATA
    - OPERATION AND MAINTENANCE DATA (OAM)

ATM CELL FORMAT

CONTAINS CONGESTION INDICATION (CI) BIT

- CI BIT MAY BE MODIFIED BY ANY SWITCH TO INDICATE CONGESTION TO END USERS

PT INTERPRETATION

000	USER DATA; TYPE 0; NO CONGESTION
001	USER DATA, TYPE 1; NO CONGESTION
010	USER DATA; TYPE 0; CONGESTION
011	USER DATA; TYPE 1; CONGESTION

ATM CELL FORMAT

PT INTERPRETATION

100 OAM CELL

101 OAM CELL

110 RESOURCE MANAGEMENT CELL (TO BE DEFINED)

111 RESERVED FOR FUTURE USE

ATM CELL FORMAT

CLP : CELL LOSS PROBABILITY (1 BIT)

- INDICATES RELATIVE PRIORITY OF A CELL
- INDICATES IF A CELL CAN BE DISCARDED IN CASE OF CONGESTION
  - CLP = 0; HIGH PRIORITY; CELL NOT TO BE DISCARDED
  - CLP = 1; LOW PRIORITY; CELL MAY BE DISCARDED
- CLP BIT IS SET BY THE USER OR BY THE SERVICE PROVIDER
  - IN CBR CONNECTION, CELLS HAVE CLP = 0

VIRTUAL CIRCUITS IN ATM

VIRTUAL CIRCUIT IDENTIFIER IS REPRESENTED JOINTLY BY:

- VIRTUAL CHANNEL IDENTIFIER (VCI)
- VIRTUAL PATH IDENTIFIER (VPI)

VIRTUAL CHANNEL (VC)

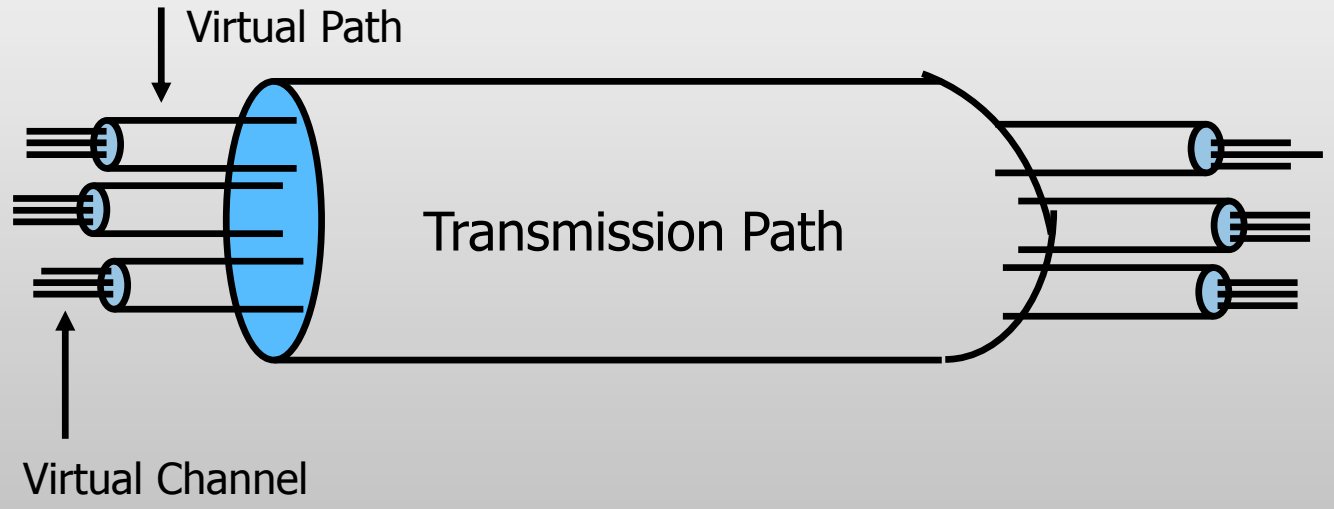
- PATH FOR CELL ASSOCIATED WITH A CONNECTION
- SUPPORTS TRANSPORTATION OF A DATA STREAM
- EACH VC IS ASSIGNED A UNIQUE VCI ON A LINK

VIRTUAL CHANNELS IN ATM

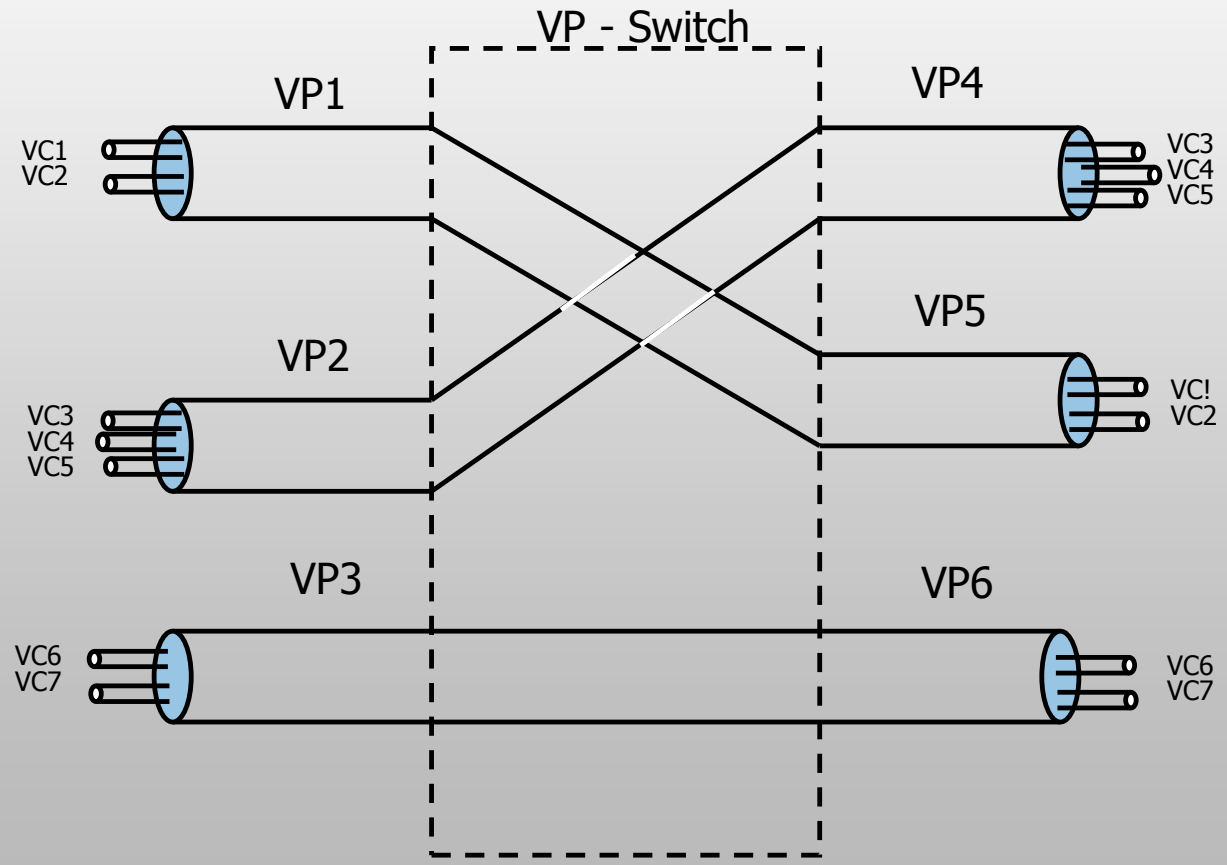
VIRTUAL PATH (VP)

- GROUPING OF VIRTUAL CHANNELS ON A PHYSICAL LINK
- SWITCHING CAN BE PERFORMED ON THE PATH BASIS:
  - REDUCED OVERHEADS
- EACH VIRTUAL PATH IS ASSIGNED VIRTUAL PATH IDENTIFIER (VPI)

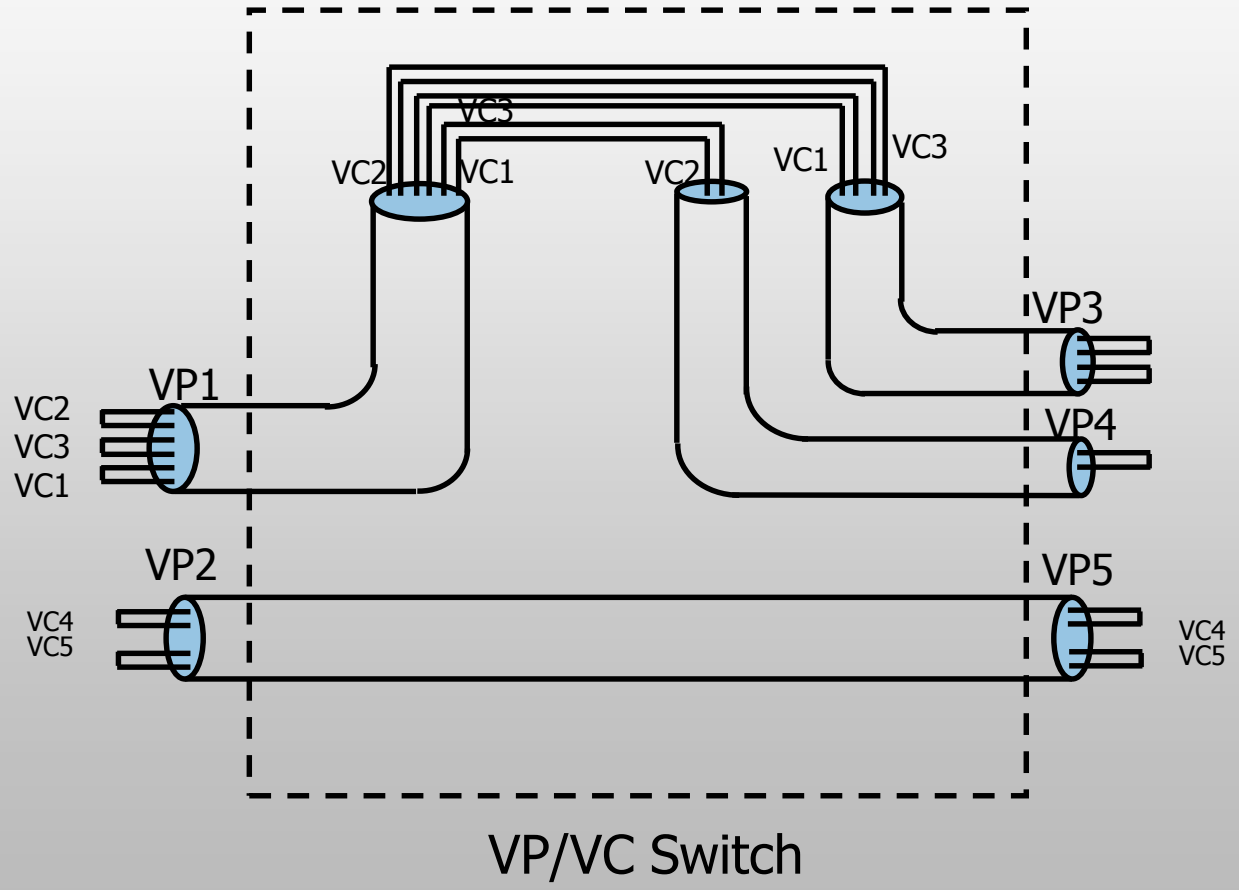
VCS IN ATM



VIRTUAL PATH SWITCH (VP - SWITCH)



VP / VC SWITCH


VC3
VC2
VC1
VC2
VC1
VC3
VP3
VP1
VC2
VC3
VC1
VP4
VP2
VP5
VC4
VC5
VC4
VC5
VP/VC Switch

WHY VPI / VCI
RATHER THAN A SINGLE VC NUMBER?

- SEMI-PERMANENT VP REDUCES THE SETUP TIME
- VCS CAN BE EASILY ADDED TO THE EXISTING VPS
- REDUCED SIZE OF THE ROUTING TABLE
- SEPARATE GROUPS FOR DIFFERENT TYPES OF STREAMS: VOICE, DATA, AND VIDEO
- DIFFERENT QOS CAN BE APPLIED TO DIFFERENT VPS

SUMMARY

- CELL MULTIPLEX AND DEMULTIPLEX
  - IN THE TRANSMIT DIRECTION, CELLS FROM DIFFERENT STREAMS ARE MULTIPLEXED INTO ONE STREAM
  - AT THE RECEIVING SIDE, INCOMING CELLS ARE DEMULTIPLEXED INTO INDIVIDUAL STREAMS
- CELL VPI/VCI TRANSLATION
- CELL HEADER GENERATION - EXTRACTION
  - EXCEPTING HEC

Module 6
ATM Service Categories

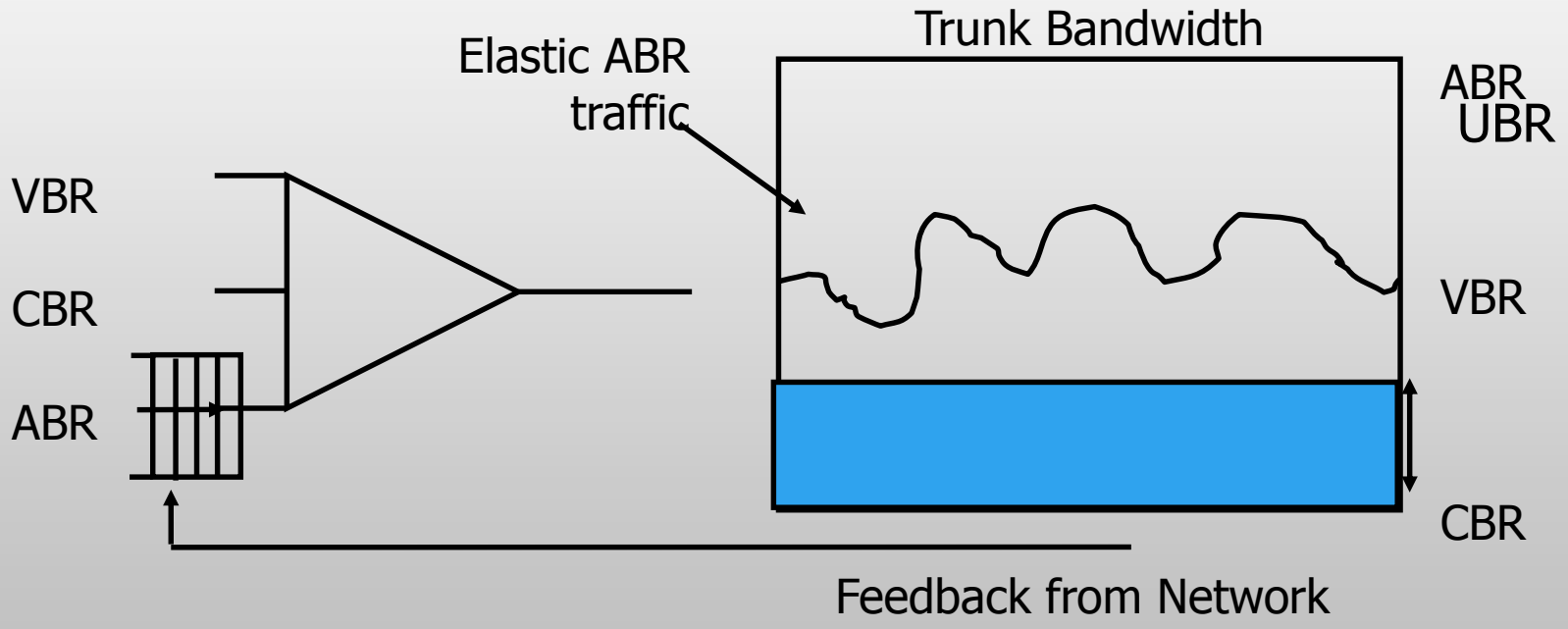
APPLICATIONS ON ATM

Application Class	Example Applications
Interactive Video	Video Conferencing, Distributed Classroom
Interactive Audio	Telephone
Interactive Text / Data	Banking Transactions, Credit Card Verification
Interactive Image	Multimedia conferencing
Video Messaging	Multimedia Email
Audio Messaging	Voice Mail
Text / Data Messaging	Email, telex, Fax
Image Messaging	High Resolution Fax
Video Distribution	Television
Audio Distribution	Radio, Audio Feed
Text Distribution	News Feed, netnews
Image Distribution	Weather Satellite pictures
Video Retrieval	Video On Demand (VOD)
Audio Retrieval	Audio Library
Text / Data Retrieval	File Transfer
Image Retrieval	Library Browsing
Aggregate LAN	LAN Interconnection or Emulation
Remote Terminal	Telecommuting, telnet
RPC	Distributed Simulation

ATM SERVICE CATEGORIES

- CBR : CONSTANT BIT RATE
- RT-VBR : REAL-TIME VARIABLE BIT RATE
- NRT-VBR : NON REAL-TIME VARIABLE BIT RATE
- UBR : UNSPECIFIED BIT RATE
- ABR : AVAILABLE BIT RATE

ATM SERVICE CATEGORIES



CONSTANT BIT RATE (CBR)

- EMULATES A COPPER WIRE OR OPTICAL FIBER (CIRCUIT EMULATION)
- NO ERROR CHECKING OR PROCESSING
- PROVIDES RESERVED BANDWIDTH WITH MINIMUM CELL LOSS OR VARIATION IN DELAY (JITTER)
- SUITABLE FOR
  - VOICE GRADE PCM, REAL-TIME AUDIO AND VIDEO SYSTEMS, CONSTANT BIT RATE VIDEOS

REAL-TIME VARIABLE BIT RATE (RT-VBR)

- VARIABLE BIT RATE
- STRINGENT REAL-TIME REQUIREMENTS - TIGHT BOUND ON DELAY
- ACCEPTABLE LOSS RATE AND JITTER ARE SPECIFIED
- SUITABLE FOR
  - COMPRESSED REAL-TIME VIDEO (MPEG) AND AUDIO SERVICES

NON REAL-TIME VBR (NRT-VBR)

- VBR WITH LESS STRINGENT BOUND IN LOSS RATE, DELAY AND DELAY VARIATION
- SUITABLE FOR MULTIMEDIA EMAIL AND FRAME RELAY
- THE LOSS RATE ALLOWS FOR STATISTICAL MULTIPLEXING

UNSPECIFIED BIT RATE (UBR)

PROVIDES BEST EFFORT DELIVERY

- NO GUARANTEE ON CELL LOSS OR DELAY VARIATION
- OPEN LOOP SYSTEM : NO FEEDBACK ABOUT CONGESTION
- UBR IS DESIGNED TO ALLOW USE OF EXCESS BANDWIDTH

UNSPECIFIED BIT RATE (UBR)

- IN CASE OF CONGESTION, UBR CELLS WILL BE DROPPED
  - WELL SUITED FOR TCP/IP PACKETS, NON REAL-TIME BURSTY DATA TRAFFIC

AVAILABLE BIT RATE (ABR)

- SUITABLE FOR DATA TRAFFIC
- USES EXCESS NETWORK BANDWIDTH
- DATA TRAFFIC IS EXTREMELY BURSTY AND IT CAN NOT BE CARRIED USING CBR OR VBR WITHOUT DISTURBING OTHER CONNECTIONS
- BANDWIDTH REQUIREMENTS MAY VARY DYNAMICALLY IN TIME AND RESOURCE ALLOCATION IS NOT AN EFFICIENT SOLUTION

ABR

- BASED ON CLOSED LOOP FEEDBACK MECHANISM
  - REPORTS NETWORK CONGESTION
  - ALLOWS END STATIONS TO REDUCE THEIR TRANSMISSION RATE TO AVOID CELL LOSS
- IDEAL FOR TRANSMITTING LAN AND OTHER BURSTY UNPREDICTABLE DATE TRAFFIC OVER ATM NETWORKS

TRAFFIC DESCRIPTORS

- PEAK CELL RATE (PCR)
  - MAXIMUM ALLOWABLE CELL RATE ON A CIRCUIT
- MINIMUM CELL RATE (MCR)
  - THE MINIMUM CELL RATE GUARANTEED BY THE SERVICE PROVIDER

TRAFFIC DESCRIPTORS

- SUSTAINABLE CELL RATE (SCR)
  - THE EXPECTED OR REQUIRED CELL RATE AVERAGED OVER A LONG TIME INTERVAL
- CELL DELAY VARIATION TOLERANCE (CDVT)
  - VARIATION IN CELL TRANSMISSION TIME
- BURST TOLERANCE (BT)
  - THE LIMIT TO WHICH A TRANSMISSION CAN RUN AT ITS PEAK CELL RATE (PCR)

QUALITY OF SERVICE

- LOSS GUARANTEES
  - CELL LOSS RATIO (CLR) : LOST CELL / TOTAL CELLS
- DELAY GUARANTEES
  - CELL TRANSFER DELAY (CTD)
  - CELL DELAY VARIATION (CDV)
- RATE GUARANTEES
  - ON PCR, SCR, MCR, AND ACR (ACTUAL CELL RATE)

QOS FOR SERVICE CLASSES

- CBR
  - PCR, CTD AND CDV, CLR
- RT-VBR
  - SCR, CTD AND CDV, CLR
- NRT-VBR
  - SCR, NO DELAY GUARANTEE, CLR

QOS FOR SERVICE CLASSES

- ABR
  - MCR AND ACR (ALLOWED CELL RATE - DYNAMICALLY CONTROLLED)
  - NO DELAY GUARANTEE, CLR (NETWORK SPECIFIC)
- UBR
  - NO RATE GUARANTEES
  - NO DELAY GUARANTEES
  - NO LOSS GUARANTEES

SUMMARY

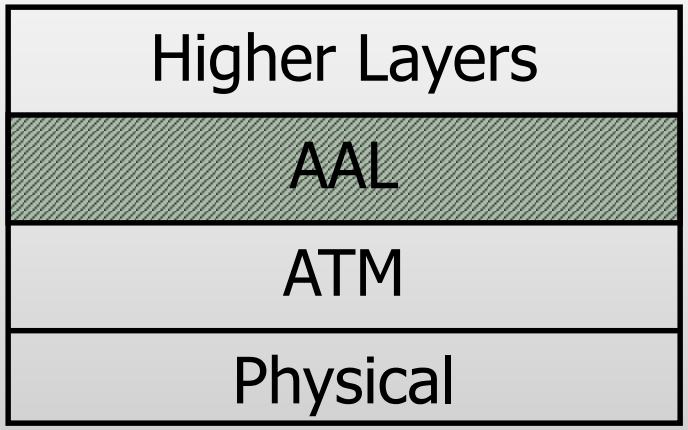
- USER DESCRIBE TRAFFIC DESCRIPTORS FOR A CONNECTION
- USER CAN NEGOTIATE QOS PARAMETERS FROM THE SERVICE PROVIDER
- CLASSES OF SERVICE : CBR, RT-VBR, NRT-VBR, ABR, AND UBR

Module 7
ATM Adaptation Layer

OVERVIEW

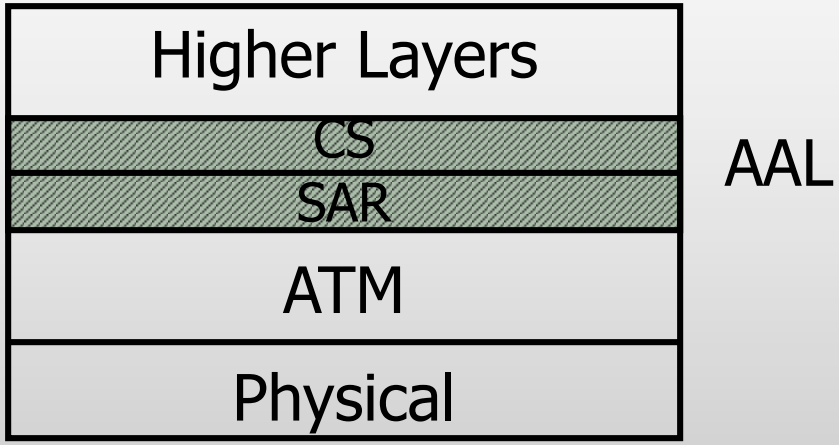
- ATM ADAPTATION LAYERS : INTRODUCTION
- AAL LAYERS
  - AAL1 LAYER
  - AAL2 LAYER
  - AAL 3/4 LAYER
  - AAL 5 LAYER

ATM ADAPTATION LAYER (AAL)



- PROVIDES SERVICES OVER ATM LAYER
- PERFORMS SEGMENTATION AND REASSEMBLY FUNCTIONS
- PERFORMS SERVICE DEPENDENT FUNCTION
  - TIME/ CLOCK RECOVERY
  - MESSAGE IDENTIFICATION

AAL SUBLAYERS



- SAR - SEGMENTATION AND REASSEMBLY
- CS - CONVERGENCE SUBLAYER
  - APPLICATION DEPENDENT
  - TIME/CLOCK RECOVERY
  - MULTIPLEXING/ MESSAGE IDENTIFICATION
  - HANDLING OF CELL DELAY VARIATION

AAL TYPES

- AAL1
  - CBR — EX: CIRCUIT EMULATION
  - CONNECTION ORIENTED
  - TIMING INFORMATION EXISTS
- AAL2
  - REAL TIME VBR — EX: COMPRESSED VIDEO
  - CONNECTION ORIENTED
  - REQUIRES TIMING INFORMATION
  - EX: COMPRESSED VIDEO
  - AAL2 IS UNDER DEVELOPMENT

AAL TYPES

- AAL 3/4
  - NRT-VBR EX: FRAME RELAY
  - CONNECTION ORIENTED OR CONNECTIONLESS
  - NO TIMING INFORMATION
- AAL5
  - VBR EX: DATA COMMUNICATION
  - CONNECTION ORIENTED
  - NO TIMING INFORMATION
  - SIMPLER THAN AAL 3/4
  - STARTED IN ITU; COMPLETED IN ATM FORUM

SERVICE CLASSES AND AAL TYPES

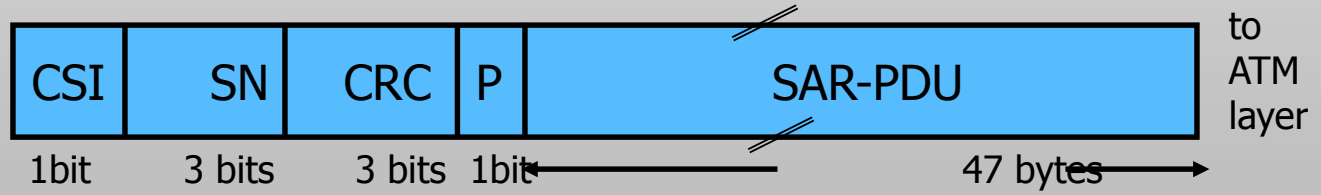
	Class A	Class B	Class C	Class D
Timing Relation between source & destination	Required		Not Required	
Bit Rate	Constant	Variable		
Connection Mode	Connection Oriented			Connectionless
AAL Types	AAL1	AAL2	AAL 3/ 4, 5	AAL 3/ 4, 5

EXAMPLES

- CLASS A: 64 KBPS DIGITAL VOICE
- CLASS B: VARIABLE BIT RATE ENCODED VIDEO
- CLASS C: FRAME RELAY OVER ATM
- CLASS D: CCITT I.364 (SMDS) OVER ATM
- CLASS X: RAW CELL SERVICE

AAL1 LAYER

- TRANSFER OF SDU AT CBR.
- INDICATION OF LOST INFORMATION.
- BLOCK OF 124 CELLS WITH 4 ERROR CORRECTING CELLS.



AAL1 LAYER

- CONVERGENCE SUBLAYER INDICATION (CSI): TWO USES
  - CSI BITS FROM FOUR SUCCESSIVE CELLS (1, 3, 5, 7) FORM SYNCHRONOUS RESIDUAL TIME STAMP (SRTS) FOR SOURCE CLOCK RECOVERY AT THE DESTINATION
  - FOR STRUCTURED DATA TRANSFER
  - STRUCTURED DATA TRANSFER
    - CSI = 1 INDICATES THAT THE FIRST BYTE OF PAYLOAD IS THE POINTER TO START OF STRUCTURED BLOCK
    - CSI = 0 : NO POINTER FOR PARTIALLY FILLED CELLS

AAL1 LAYER

- SN
  - SEQUENCE NUMBER
  - TO DETECT LOST OR MISINSERTED CELL
- CRC
  - 3 BIT SEQUENCE NUMBER PROTECTION FOR DETECTING ERROR IN SN
- P
  - 1 BIT EVEN PARITY FOR PREVIOUS 7 BITS

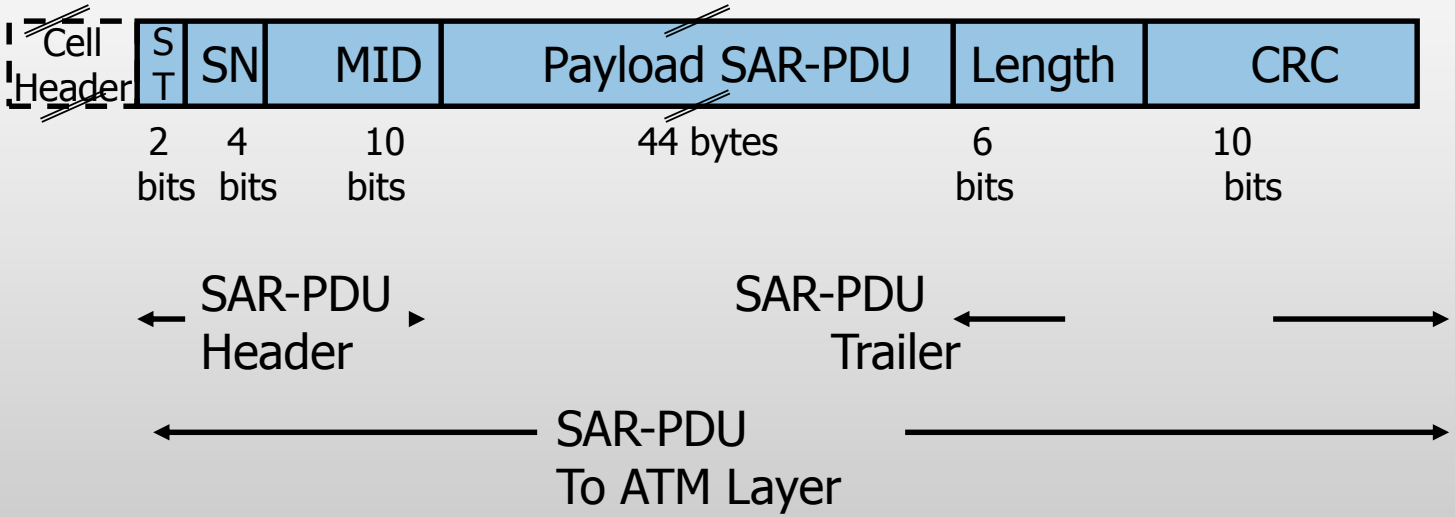
AAL1 FUNCTIONS

- HANDLING OF CELL DELAY VARIATION
  - BUFFER IS USED
- HANDLING OF CELL PAYLOAD ASSEMBLY DELAY
- SOURCE CLOCK RECOVERY AT THE RECEIVER
- MONITORING OF LOST AND MISINTERPRETED CELLS AND POSSIBLE CORRECTIVE ACTION
- MONITORING OF USER INFORMATION FIELD FOR BIT ERRORS AND POSSIBLE CORRECTIVE ACTION

AAL 3/4

- DESIGNED FOR DATA TRANSFER
- NON REAL-TIME VBR
- LOSS SENSITIVE, DELAY INSENSITIVE
- CONNECTION ORIENTED OR CONNECTIONLESS
  - CONNECTION ORIENTED PDUS MAY BE MULTIPLEXED ON A VC CONNECTION
  - CONNECTIONLESS PDUS ARE HANDLED SEPARATELY

SAR - PDU (CELL) FORMAT

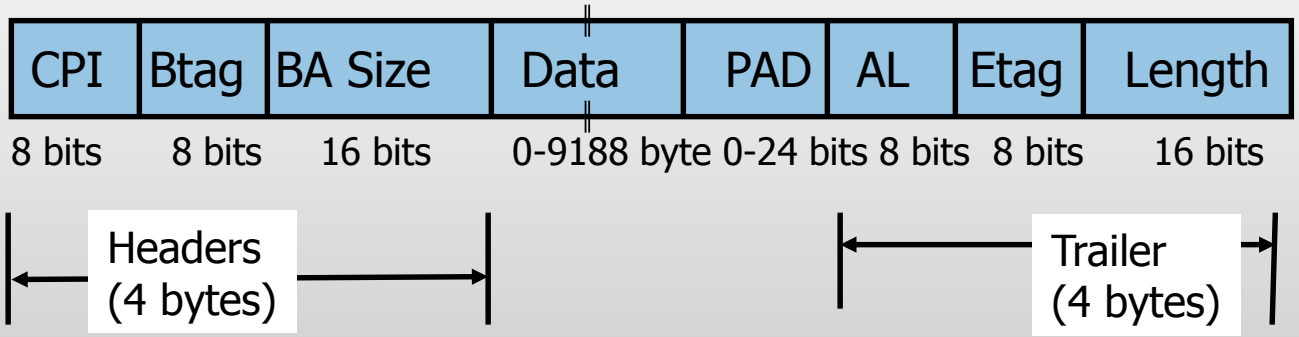


- ST - SEGMENT TYPE
  - INDICATES WHICH PART OF THE PACKET (CS-PDU) IS CARRIED IN THE CELL : BEGINNING, MIDDLE, END OF MESSAGE

AAL 3/4 CELL FORMAT

- LENGTH : 6 BITS
  - INDICATES THE LENGTH OF PAYLOAD
  - LAST CELL MAY HAVE LESS THAN 44 BYTES
- CRC : 10 BITS : FOR THE CELL
- SN - SEQUENCE NUMBER : 4 BITS
- MID - MULTIPLEXING IDENTIFIER : 10 BITS
  - ALLOWS MULTIPLEXING OF UPTO 2^{10} AAL USERS ON A SINGLE ATM CONNECTION

AAL 3/4 CONVERGENCE SUBLAYER

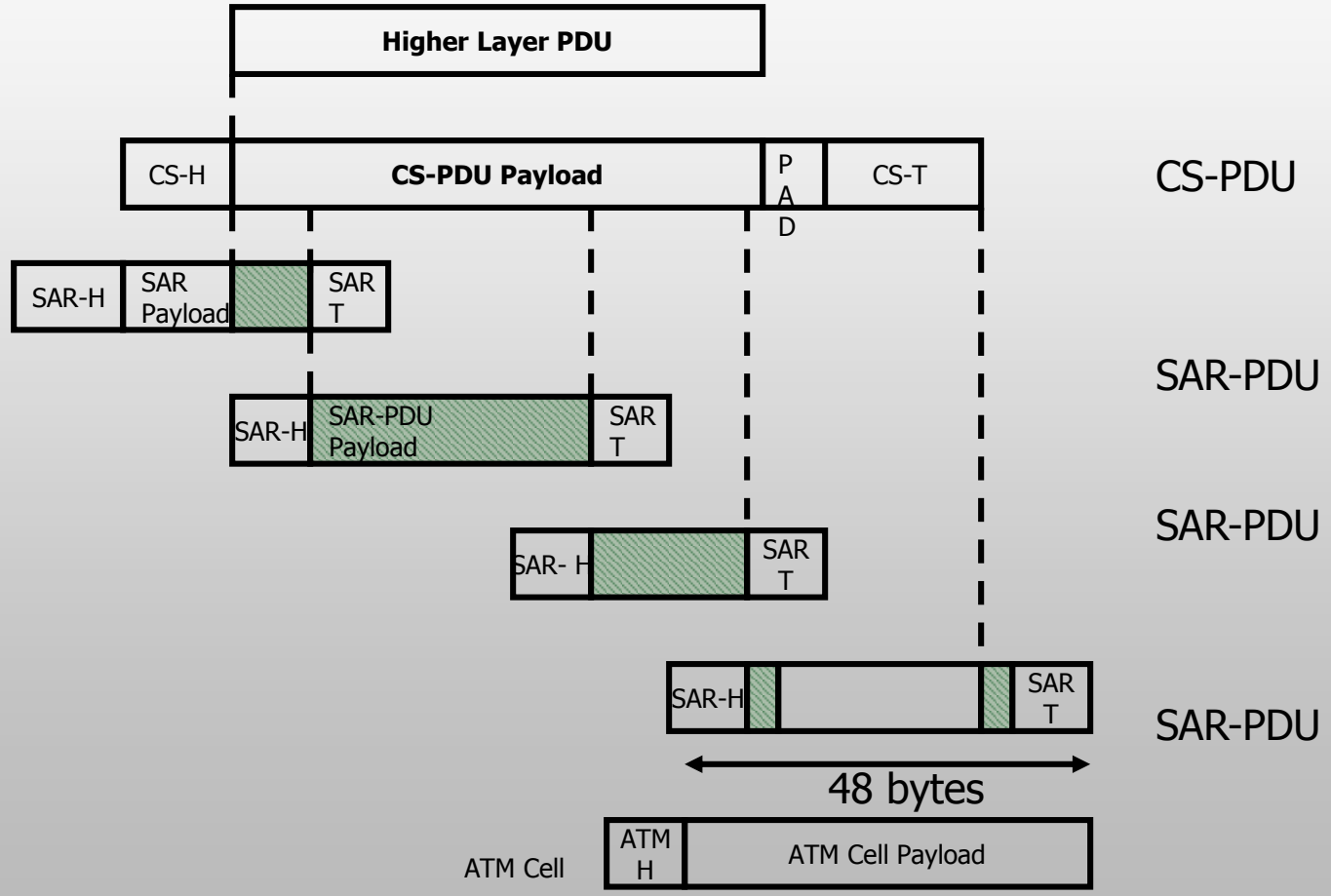


- CPI - COMMON PART INDICATOR : 8 BITS
  - INTERPRETATION OF PDU (FORMAT) : CURRENTLY ONE FORMAT IS DEFINED

AAL 3/4 CONVERGENCE SUBLAYER

- B-TAG AND E-TAG
  - TO TAG PACKETS TO AVOID REASSEMBLY TO MULTIPLE PACKETS INTO A SINGLE PACKET ; B-TAG SHOULD BE SAME AS E-TAG
- BA SIZE - BUFFER ALLOCATION SIZE : 18 BITS
  - INFORM RECEIVER ABOUT THE MAXIMUM BUFFER REQUIREMENT FOR THE PACKET REASSEMBLY
- PAD - PADDING FIELD : 0 TO 24 BITS
  - TO ENSURE THAT PACKET PAYLOAD IS INTEGER MULTIPLE OF 4 BYTES (ACTUAL PAYLOAD MAY BE 0 TO 3 BYTES LONG)
- AL - ALIGNMENT (32 BIT TRAILER ALIGNMENT)
  - MAKES PDU A MULTIPLE OF 32-BIT

AAL 3/4


Higher Layer PDU
CS-H
CS-PDU Payload
PAD
CS-T
CS-PDU
SAR-H
SAR Payload
SAR T
SAR-PDU
SAR-H
SAR-PDU Payload
SAR T
SAR-PDU
SAR- H
SAR T
SAR-H
SAR T
SAR-PDU
48 bytes
ATM Cell
ATM H
ATM Cell Payload

LIMITATIONS OF AAL 3/4

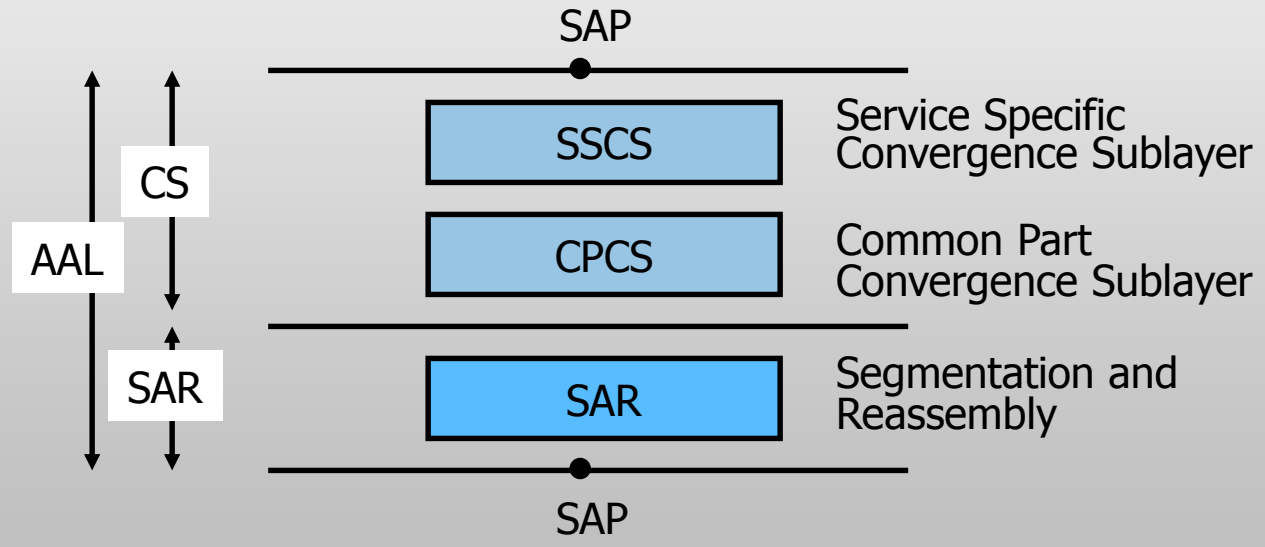
- AAL 3/4 IS NOT SUITED FOR HIGH SPEED CONNECTION ORIENTED DATA SERVICES
- HIGH OVERHEADS: 4 BYTES PER 48 BYTES CELL
  - 10 BIT CRC
  - 4 BIT SEQUENCE NUMBER
    - DOES NOT PROVIDE ENOUGH PROTECTION FOR CONVEYING VERY LONG BLOCKS OF DATA

AAL5

- VBR, DATA SERVICE, NO TIMING RELATION, CONNECTION ORIENTED
- NO SUPPORT FOR MULTIPLEXING
- LESS OVERHEAD AND BETTER ERROR DETECTION
- CAN BE USED FOR SIGNALING AND FRAME RELAY OVER ATM

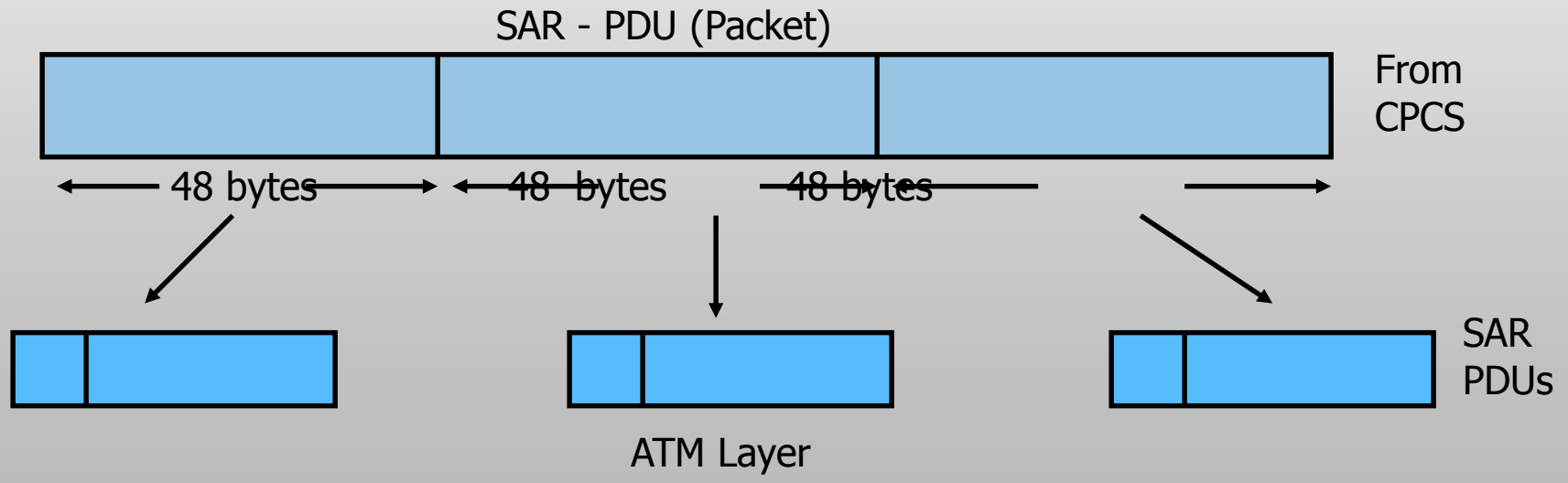
AAL5

- SSCS MAY BE NULL OR MAY BE USED FOR MULTIPLEXING



SAR - SUBLAYER

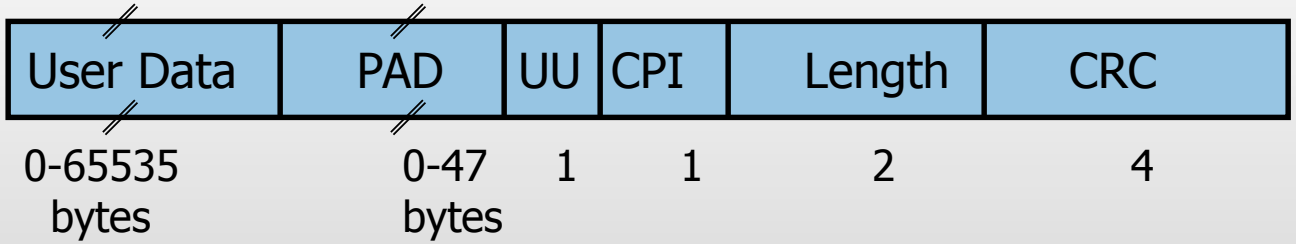
- IT ACCEPTS VARIABLE LENGTH SAR-SDU (PACKETS) THAT ARE AN INTEGER MULTIPLE OF 48 BYTES



SAR - SUBLAYER

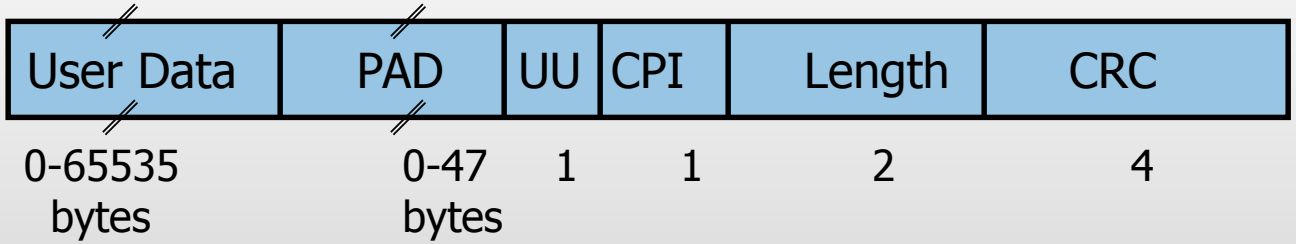
- FOR RECOGNITION (DELINEATION) OF PACKET BOUNDARIES, A BIT IN PT FIELD IN ATM HEADER IS USED
  - 0 : BEGINNING OR CONTINUATION OF PACKET
  - 1 : END OF PACKET

AAL 5 CONVERGENCE SUBLAYER



- PADF : PADDING
- USER TO USER FIELD
  - TO TRANSPARENTLY TRANSFER INFORMATION BETWEEN CPCS USERS

AAL 5 CONVERGENCE SUBLAYER



- CPI: COMMON PATH INDICATOR (CURRENTLY UNUSED)
- LENGTH: LENGTH OF USER DATA IN BYTES
- CRC: 32 BITS

SUMMARY : AAL LAYERS

- AAL1 : CLASS A SERVICES: RT-CBR
- AAL 2 : CLASS B SERVICES : RT-VBR
- AAL3/4 : CLASS C AND D SERVICES
  - QUITE COMPLEX AND HIGH OVERHEADS
  - USEFUL FOR CONNECTIONLESS MESSAGE TRAFFIC
- AAL5: CLASS C AND CLASS D SERVICES
  - REDUCED OVERHEADS AND SIMPLE
  - VERY USEFUL FOR CONNECTION ORIENTED STREAM TRAFFIC

Module 8
ATM Traffic Management

ATM TRAFFIC MANAGEMENT

- CONNECTION ADMISSION CONTROL AND RESOURCES MANAGEMENT
- USAGE PARAMETER CONTROL
- PRIORITY
- CONGESTION CONTROL
- FLOW CONTROL

TRAFFIC CONTRACTS

- TRAFFIC CONTRACTS OF A CONNECTION
  - QOS REQUIREMENTS
  - TRAFFIC DESCRIPTIONS
  - CONFORMANCE DEFINITION
  - SERVICE CATEGORY
- QOS REQUIREMENTS
  - CELL LOSS RATIO (CLR)
  - CELL TRANSFER DELAY (CTD)
  - CELL DELAY VARIATION (CDV)

TRAFFIC CONTRACTS

- TRAFFIC DESCRIPTORS
  - PEAK CELL RATE (PCR), SUSTAINABLE CELL RATE (SCR), MINIMUM CELL RATE (MCR)

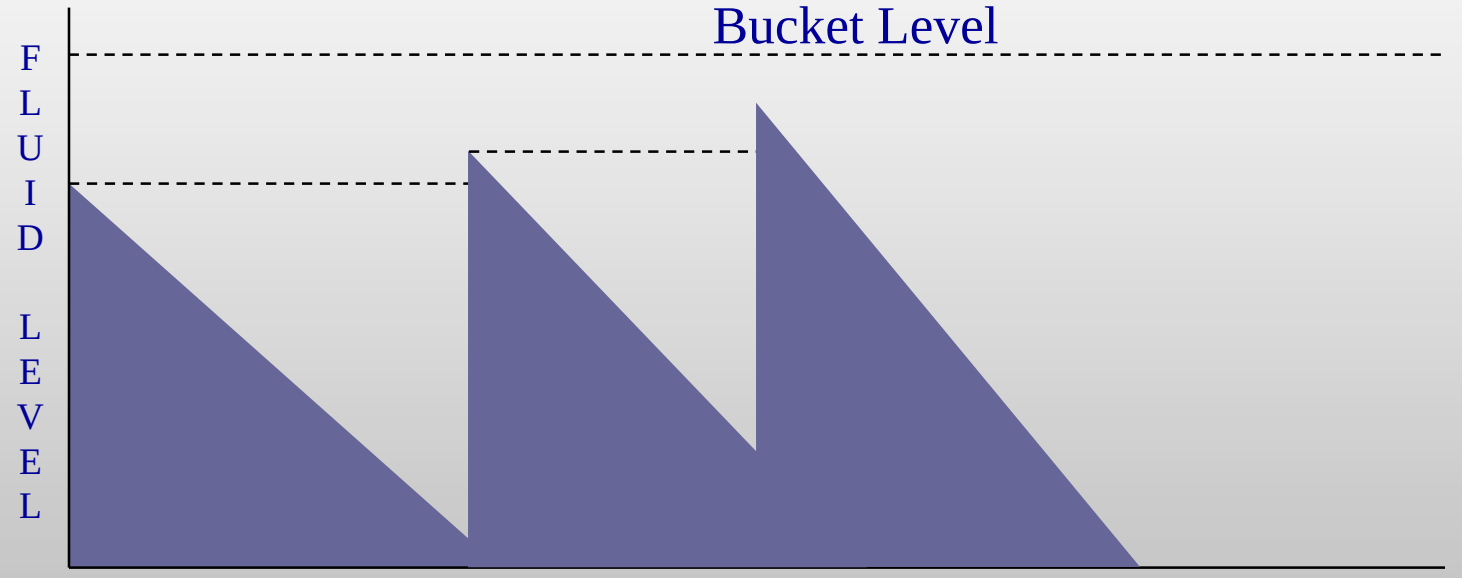
TRAFFIC CONTRACTS : CONFORMANCE

- GUARANTEES ARE VALID IF THE TRAFFIC CONFORMS TO THE NEGOTIATED TRAFFIC CONTRACT
- NON CONFORMING CAUSES :
  - EXCESSIVE RATE
  - EXCESSIVE BURST
- NON CONFORMING CELLS MAY BE DISCARDED OR WHEN PERMITTED, TAGGED WITH CLP = 1 (LOW PRIORITY)

TRAFFIC CONTRACT : CONFORMANCE

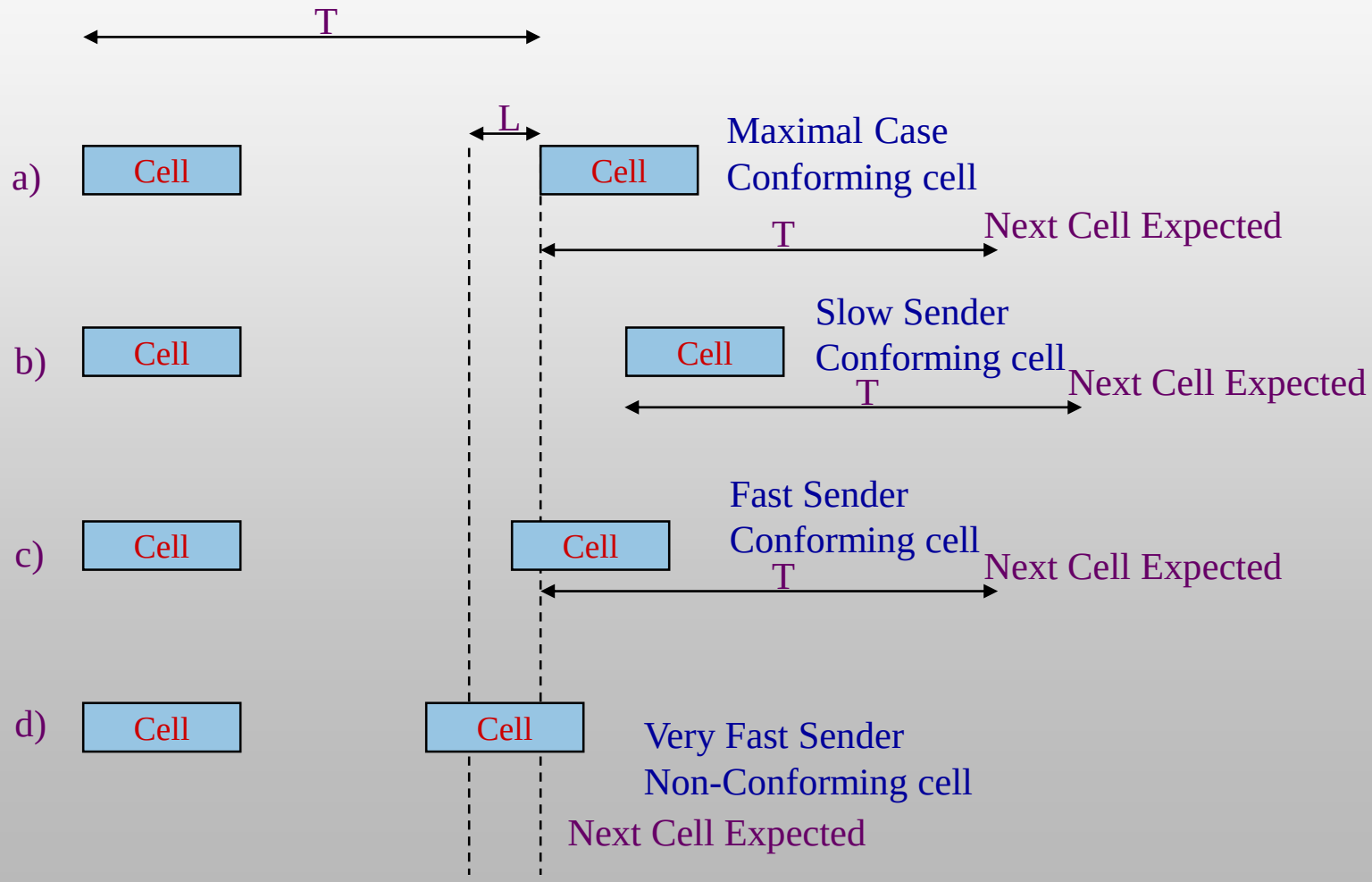
- FOR CBR, VBR AND UBR, CONFORMANCE IS DEFINED BY GENERIC CELL RATE ALGORITHM (GCRA) : BASED ON CONTINUOUS LEAKY BUCKET ALGORITHM

LEAKY BUCKET ALGORITHM



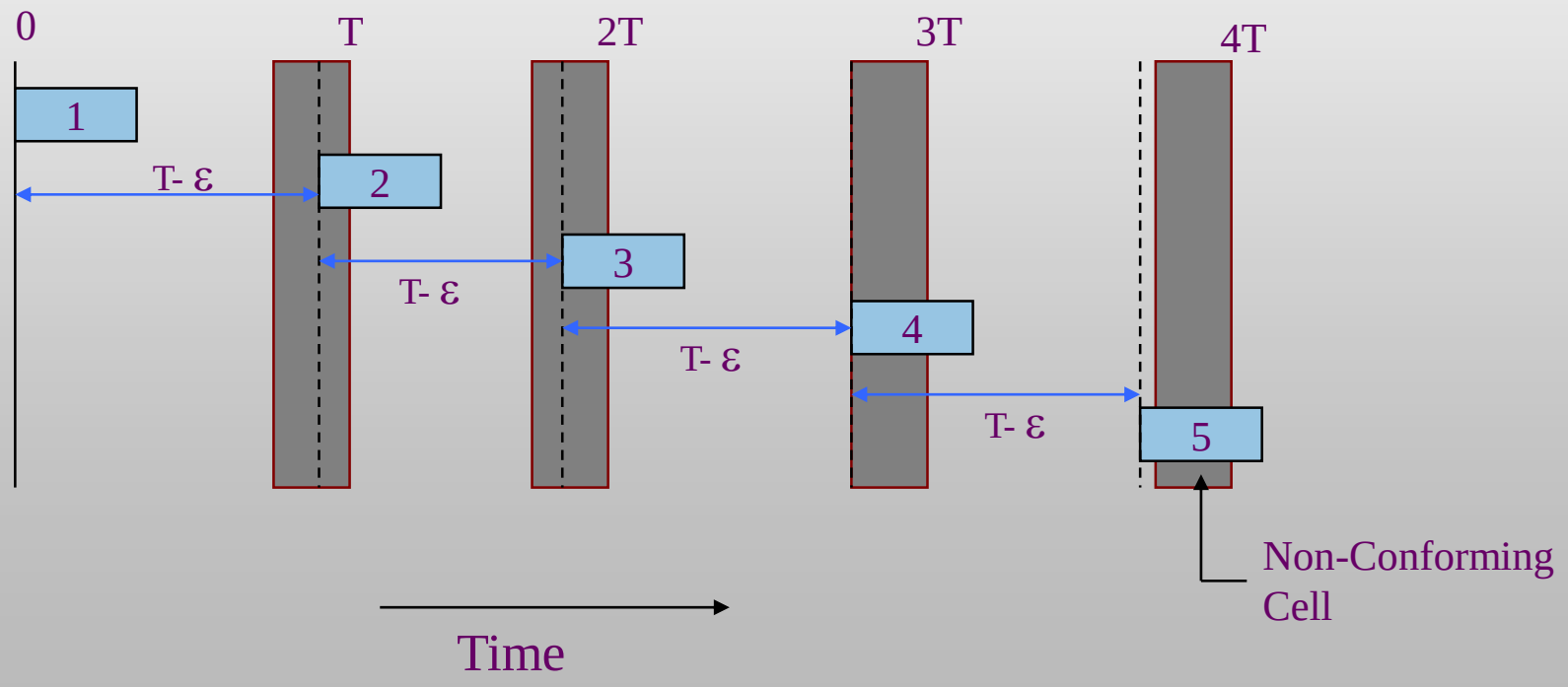
- Each Incoming Cell Pours T units of fluid into the leaky bucket
- The bucket leaks fluid at the rate of 1 unit/μsec
- If on arrival of a cell fluid level becomes greater than bucket level, then the cell is non-conforming

GENERIC CELL RATE ALGORITHM

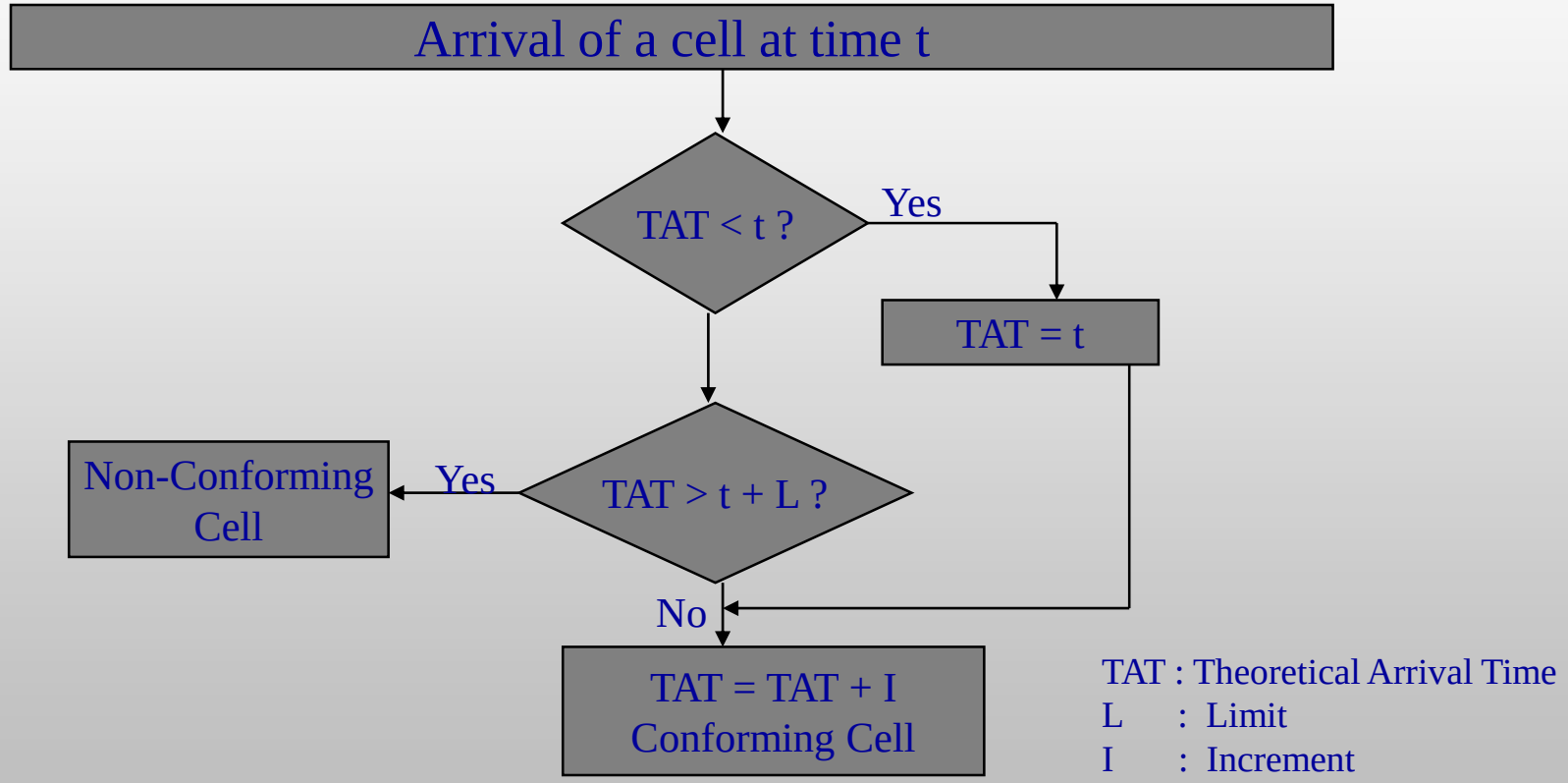


GENERIC CELL RATE ALGORITHM

What happens if the Source continuously sends cells earlier than expected?



GENERIC CELL RATE ALGORITHM



GENERIC CELL RATE ALGORITHM

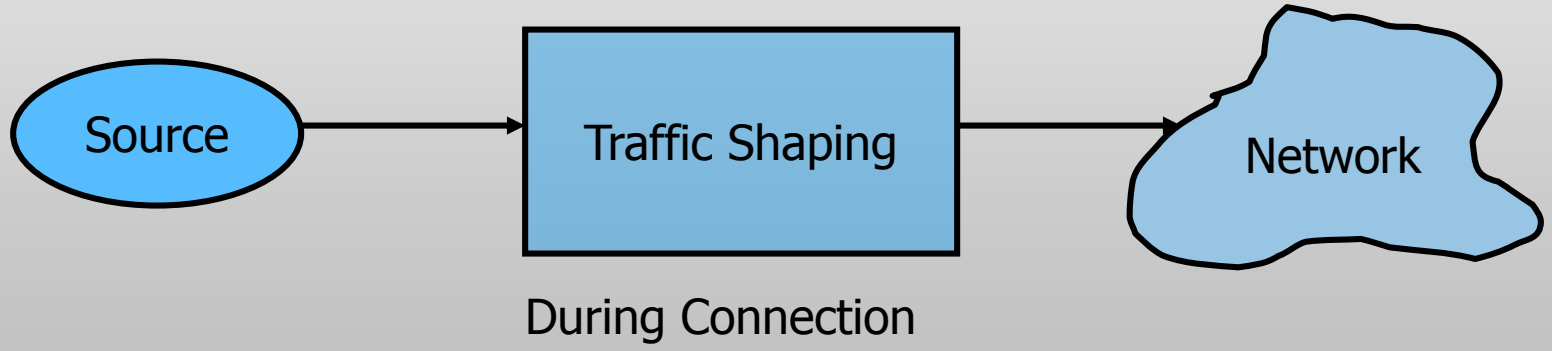
TWO TYPES OF MODELS:

- GCRA BASED ON PEAK CELL RATE (PCR) AND CELL DELAY VARIATION TOLERANCE (CDVT)
  - IDEAL FOR CBR

- GCRA BASED ON SUSTAINABLE CELL RATE (SCR) AND MAXIMUM BURST SIZE (MBS)
  - IDEAL FOR BURSTY TRAFFIC.

TRAFFIC SHAPING

- TRAFFIC SHAPING IS USED BY THE TERMINAL EQUIPMENT TO SCHEDULE THE ENTRY OF CELLS IN THE NETWORK SO THE TRAFFIC MEETS THE CONNECTION TRAFFIC DESCRIPTORS



During Connection

- LEAKY BUCKET APPROACH

TRAFFIC SHAPING

- TRAFFIC SHAPING INCREASES THE EFFICIENCY OF THE RESOURCE ALLOCATION BY INTRODUCING MORE DETERMINISTIC TRAFFIC PATTERN AND THUS REDUCES THE BURSTINESS
- TRAFFIC SHAPING ALLOWS THE CONTROL OF CDV AT THE INGRESS (ENTRY) OF THE NETWORK. AT THE EGRESS (EXIT) OF THE NETWORK, TRAFFIC SHAPING CANCELS THE ACCUMULATED CDV

CALL ADMISSION CONTROL

- TO SET UP NEW CONNECTION WITHOUT VIOLATING QOS OF EXISTING CONNECTION
- FOR CBR, VBR, UBR TRAFFIC NO DYNAMIC CONGESTION CONTROL IS PRESENT
- WHEN A USER WANTS A NEW CONNECTION, IT MUST DESCRIBE TRAFFIC AND SERVICE EXPECTED

CALL ADMISSION CONTROL

- NETWORK CHECKS IF THIS CONNECTION CAN BE ADMITTED WITHOUT ADVERSELY AFFECTING EXISTING CONNECTIONS
- ALTERNATE ROUTES ARE TRIED

RESOURCE RESERVATION

- RESOURCES ARE RESERVED AT CALL SET-UP TIME
- RESOURCE RESERVATION BASED ON TRAFFIC DESCRIPTORS : PCR, SCR, ETC.

USAGE PARAMETER CONTROL

- CHECK THE VALIDITY OF VPI/VCI
- MONITOR CELLS OF A CONNECTION TO DETERMINE WHETHER THEY CONFORM TO THE TRAFFIC DESCRIPTIONS
- TAG (CLP = 1), DISCARD OR PASS THE NONCONFORMING CELLS
- OPERATE IN A TIMELY MANNER WITHOUT AFFECTING THE CELL FLOWS

FRAME DISCARD

- IN AAL5 FRAME, EVEN IF ONE CELL IS DROPPED, THE WHOLE FRAME IS REQUIRED TO BE TRANSMITTED.
- EFFICIENCY CAN BE IMPROVED IF THE NETWORK DISCARDS TOTAL FRAMES RATHER THAN INDIVIDUAL CELLS.

FRAME DISCARD

- TO IMPLEMENT EARLY FRAME DISCARD, THE NETWORK WATCHES FOR THE END OF AAL5 FRAMES AND, IF CONGESTED, DISCARDS THE WHOLE NEXT FRAME INSTEAD OF OF INDIVIDUAL CELLS

RATE BASED CONGESTION CONTROL

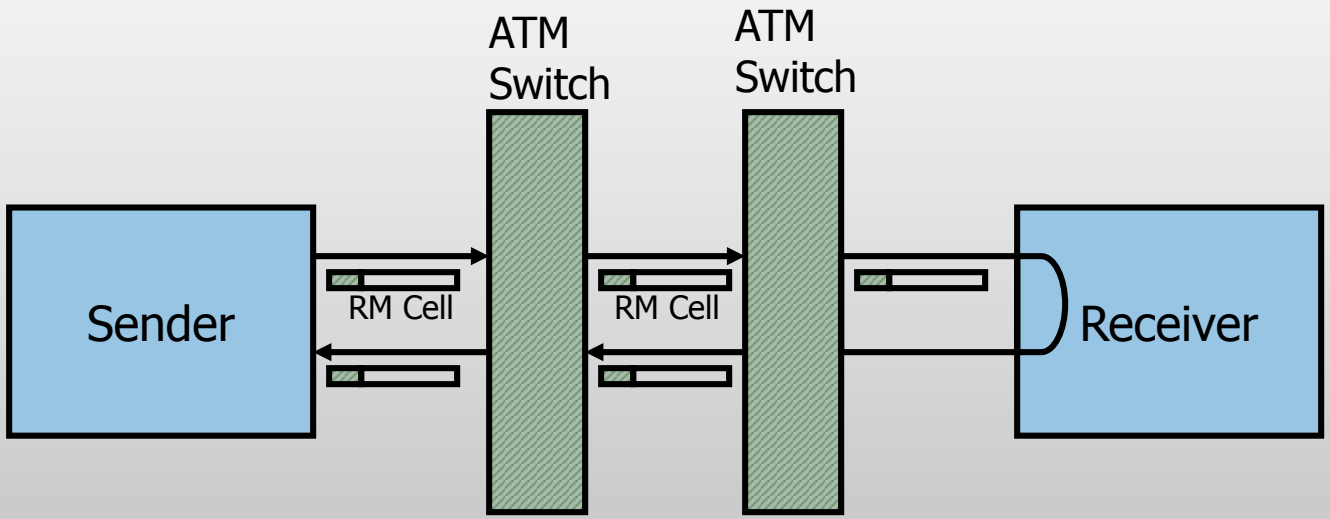
DURING CONGESTION

- CBR AND VBR TRAFFIC CAN NOT BE SLOWED DOWN
- ABR TRAFFIC CAN BE REDUCED
- UBR CELLS CAN BE DROPPED

RATE BASED CONGESTION CONTROL

- AFTER EVERY K DATA CELLS, EACH SENDER TRANSMITS A SPECIAL RM (RESOURCE MANAGEMENT) CELL
- THE RM CELL TRAVELS ALONG THE SAME VC AND GETS SPECIAL TREATMENT ALONG THE WAY
- ABSENCE OF BACKWARD RM CELL IS NOTICED BY THE SENDER (WITHIN EXPECTED TIME INTERVAL)
- THE SENDER REDUCES THE RATE

RATE BASED CONGESTION CONTROL



- SENDER TRANSMITS CELLS AT THE ACR (ACTUAL CELL RATE) WHERE MCR <= ACR <= PCR

RATE BASED CONGESTION CONTROL

- EACH RM CELL CONTAINS THE VALUE OF THE RATE AT WHICH SENDER WOULD LIKE TO TRANSMIT (SAY PCR OR LOWER); THIS RATE IS CALLED EXPLICIT RATE (ER)
- EACH INTERMEDIATE SWITCH ON THE WAY INSPECTS THE ER IN RM CELL. A SWITCH CAN REDUCE THE VALUE OF ER (IN CASE OF CONGESTION)

RATE BASED CONGESTION CONTROL

- ANY SWITCH CAN NOT INCREASE THE VALUE OF ER
- ON RECEIVING AN RM CELL, THE SENDER CAN ADJUST ACR DEPENDING ON THE VALUE OF ER

SUMMARY

- CALL ADMISSION CONTROL
- TRAFFIC DESCRIPTORS
- QOS PARAMETERS
- TRAFFIC SHAPING
- USAGE PARAMETER CONTROL

Module 9
Signaling in ATM Networks

OVERVIEW

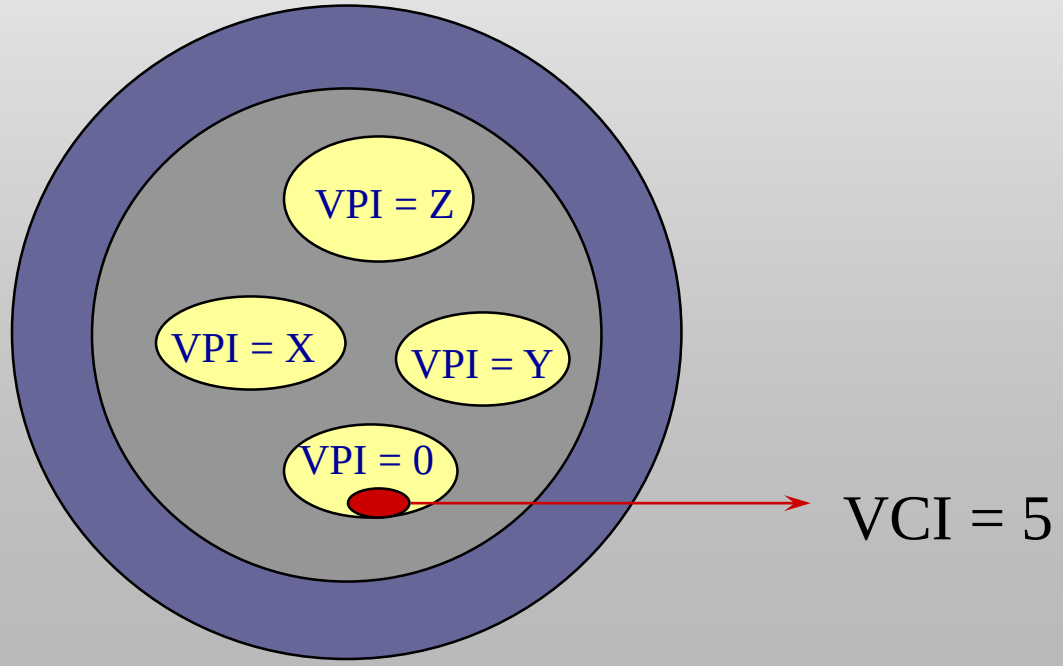
- SIGNALING :INTRODUCTION
- ASSOCIATED/NON-ASSOCIATED SIGNALING
- SIGNALING PROTOCOL STACK
- POINT-TO-POINT SIGNALING IN ATM
- POINT-TO-MULTIPOINT SIGNALING IN ATM

SIGNALING: INTRODUCTION

- ATM IS CONNECTION ORIENTED
- SIGNALING PROTOCOL IS REQUIRED FOR SETUP AND RELEASE OF CONNECTIONS
- PARAMETER AGREEMENT FOR EACH CONNECTION BETWEEN END USERS AND THE NETWORK
- SIGNALING FOR POINT-TO-POINT AND POINT-TO-MULTIPOINT CONNECTIONS

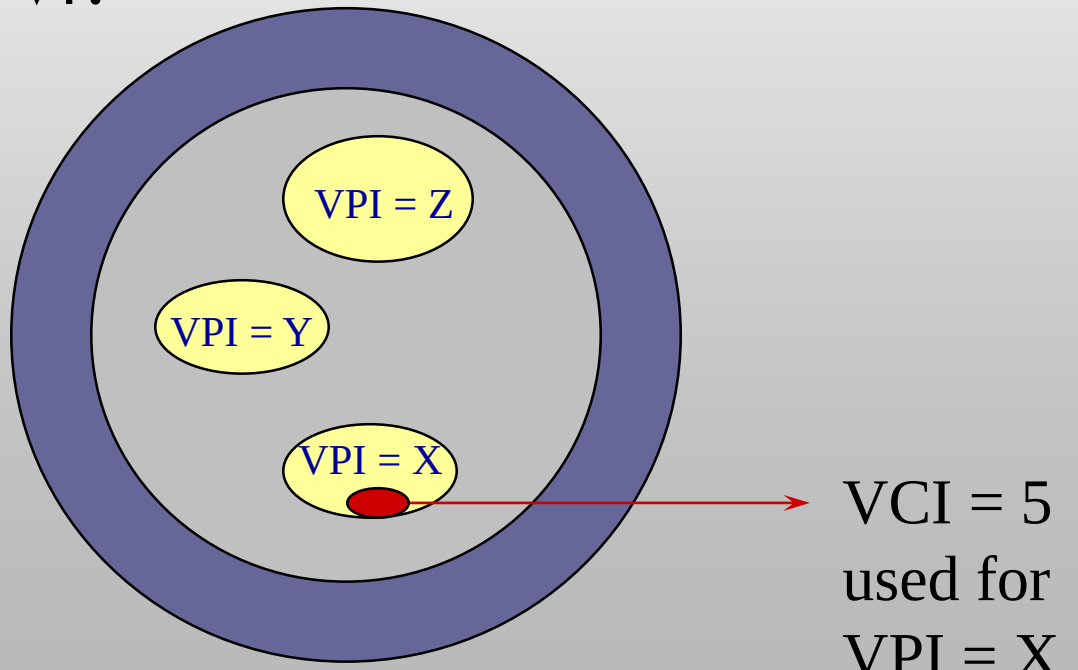
NON-ASSOCIATED SIGNALING

- NON-ASSOCIATED SIGNALING : ALL VCS IN ALL VPS CONTROLLED BY ONE SIGNALING VIRTUAL CHANNEL

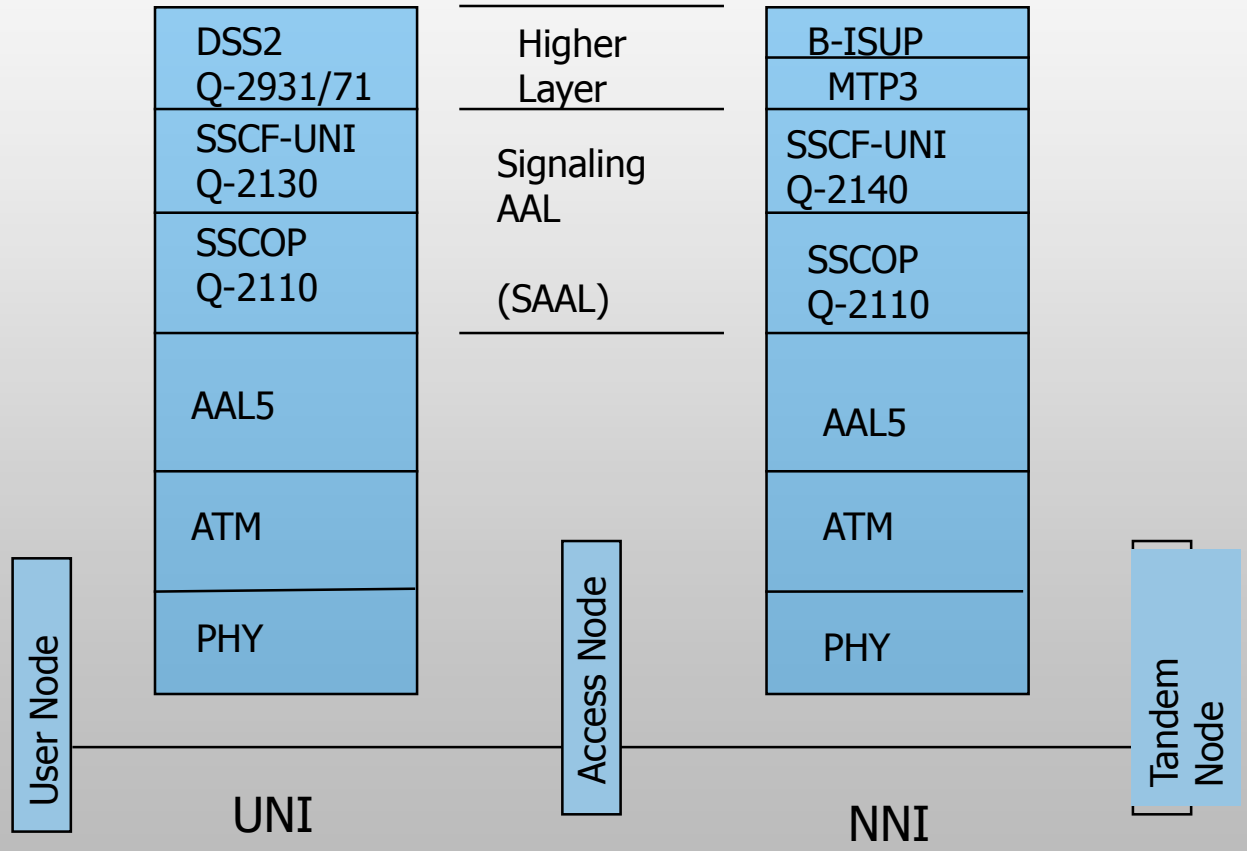


ASSOCIATED SIGNALING

- ASSOCIATED SIGNALING : ALL VCS IN A VP CONTROLLED BY A PARTICULAR VC IN THAT VP.



PROTOCOL STACK FOR SIGNALING



ATM Point-to-Point Signaling

STANDARDS

- ITU-T Q.2931 DEFINES PROCEDURES FOR POINT-TO-POINT SIGNALING.
- IT USES SAAL AS THE LOWER LAYER FOR RELIABLE DELIVERY OF PROTOCOL MESSAGES.

POINT-TO-POINT MESSAGES

- SETUP
- CALL PROCEEDING
- ALERTING
- CONNECT
- CONNECT ACKNOWLEDGE
- RELEASE
- RELEASE COMPLETE

POINT-TO-POINT MESSAGES

- SETUP
  - USED TO INITIATE A CALL/CONNECTION ESTABLISHMENT.
- CALL PROCEEDING
  - USED TO INDICATE TO THE CALLING USER THAT THE CALL ESTABLISHMENT HAS BEEN INITIATED.
- ALERTING
  - USED TO INDICATE THAT THE CALLED USER ALERTING HAS BEEN INITIATED.

POINT-TO-POINT MESSAGES

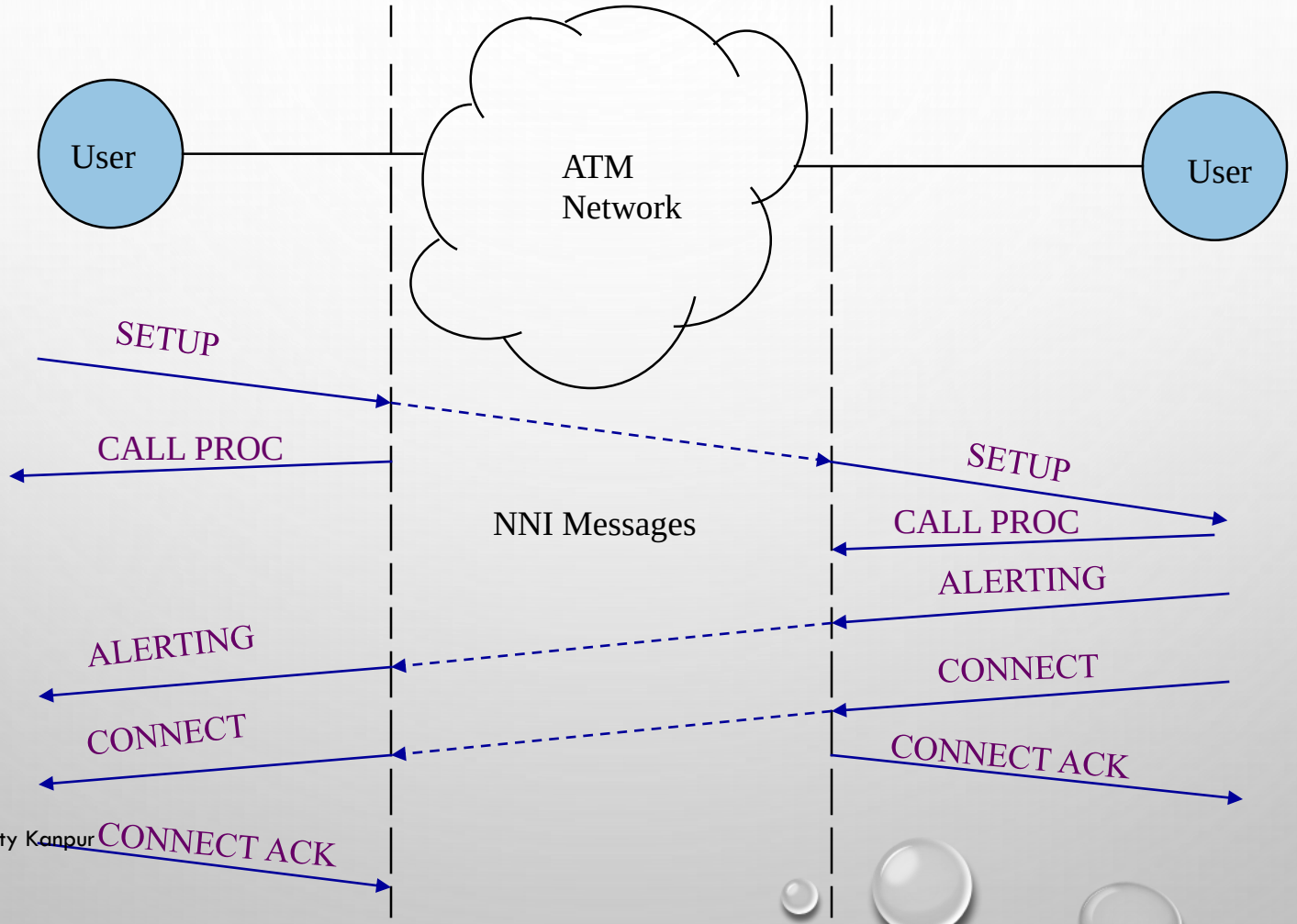
- CONNECT
  - USED TO INDICATE THAT THE CALL/CONNECTION REQUEST HAS BEEN ACCEPTED BY THE CALLED USER.
- CONNECT ACKNOWLEDGE
  - USED TO CONFIRM THE RECEIPT OF THE CONNECT MESSAGE AND THE ACCEPTANCE OF THE CALL.

POINT-TO-POINT MESSAGES

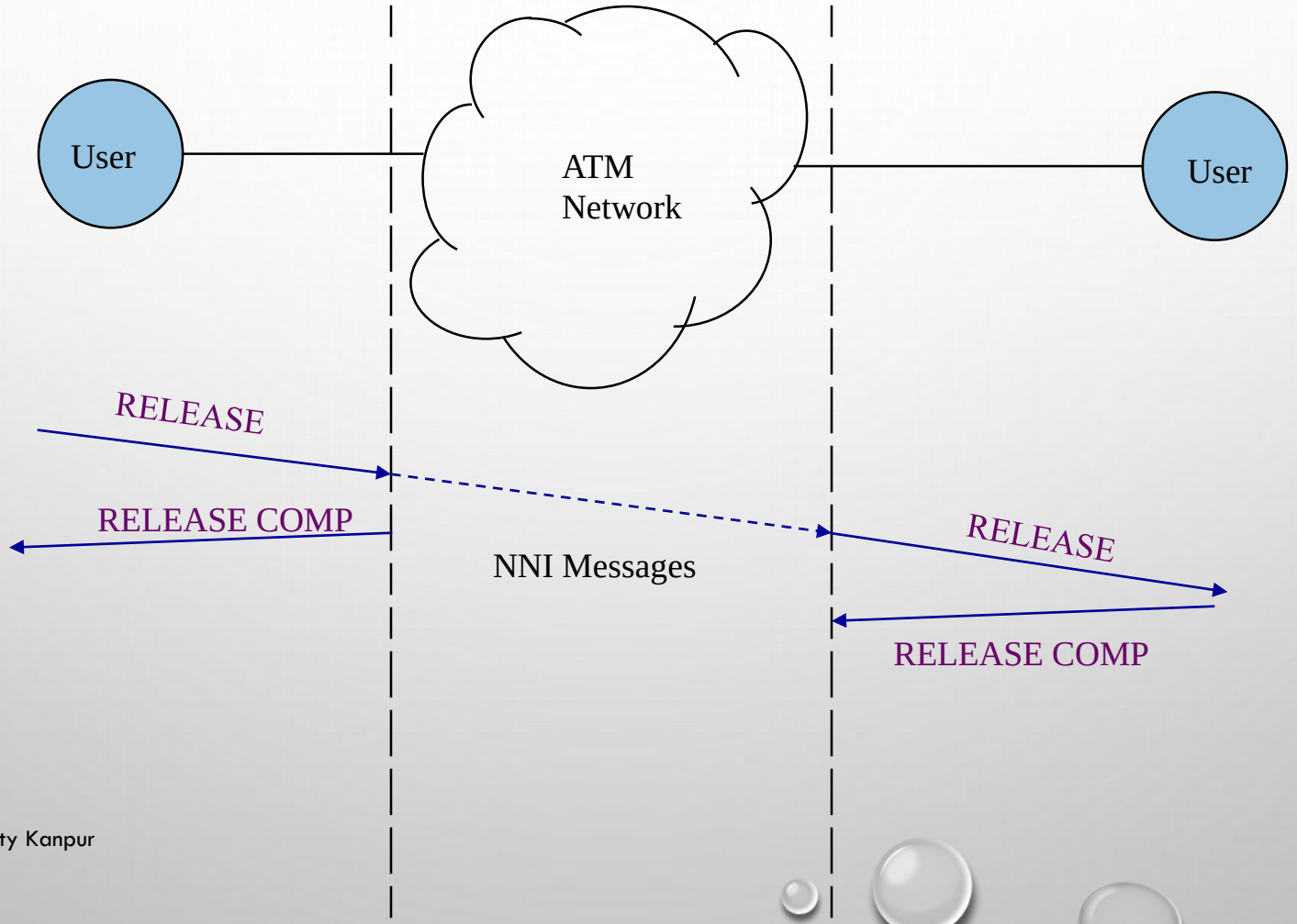
- RELEASE
  - USED TO INITIATE CLEARING OF THE CALL/CONNECTION.
- RELEASE COMPLETE
  - USED TO CONFIRM THAT THE CALL/CONNECTION HAS BEEN CLEARED.

Procedures:
Message Flows

ESTABLISHING A CALL



RELEASING A CALL



ATM PMP Signaling

STANDARDS

- Q.2971 DEFINES THE BASIC PROCEDURES FOR PMP.
- Q.2971 IS AN EXTENSION OF Q.2931.
- ATM PMP USES SAAL AS THE LOWER LAYER FOR RELIABLE DELIVERY OF PROTOCOL MESSAGES

ADDITIONAL PMP MESSAGES

- ADD PARTY
- ADD PARTY ACKNOWLEDGE
- PARTY ALERTING
- ADD PARTY REJECT
- DROP PARTY
- DROP PARTY ACKNOWLEDGE

ADDITIONAL PMP MESSAGES

- ADD PARTY
  - USED TO ADD A NEW LEAF TO A POINT-TO-MULTIPOINT CONNECTION
- ADD PARTY ACKNOWLEDGE
  - USED TO ACKNOWLEDGE THAT THE ADD PARTY FOR A PARTICULAR LEAF WAS SUCCESSFUL

ADDITIONAL PMP MESSAGES

- PARTY ALERTING
  - USED TO NOTIFY THAT PARTY ALERTING FOR A PARTICULAR LEAF HAS BEEN INITIATED
- ADD PARTY REJECT
  - USED TO NOTIFY THAT THE ADD PARTY FOR A PARTICULAR LEAF WAS UNSUCCESSFUL

ADDITIONAL PMP MESSAGES

- DROP PARTY
  - USED TO DROP A PARTY FROM A PMP CONNECTION
- DROP PARTY ACKNOWLEDGE
  - USED TO ACKNOWLEDGE THAT THE CONNECTION TO A PARTICULAR LEAF HAS BEEN CLEARED SUCCESSFULLY

Procedures:
Message Flows

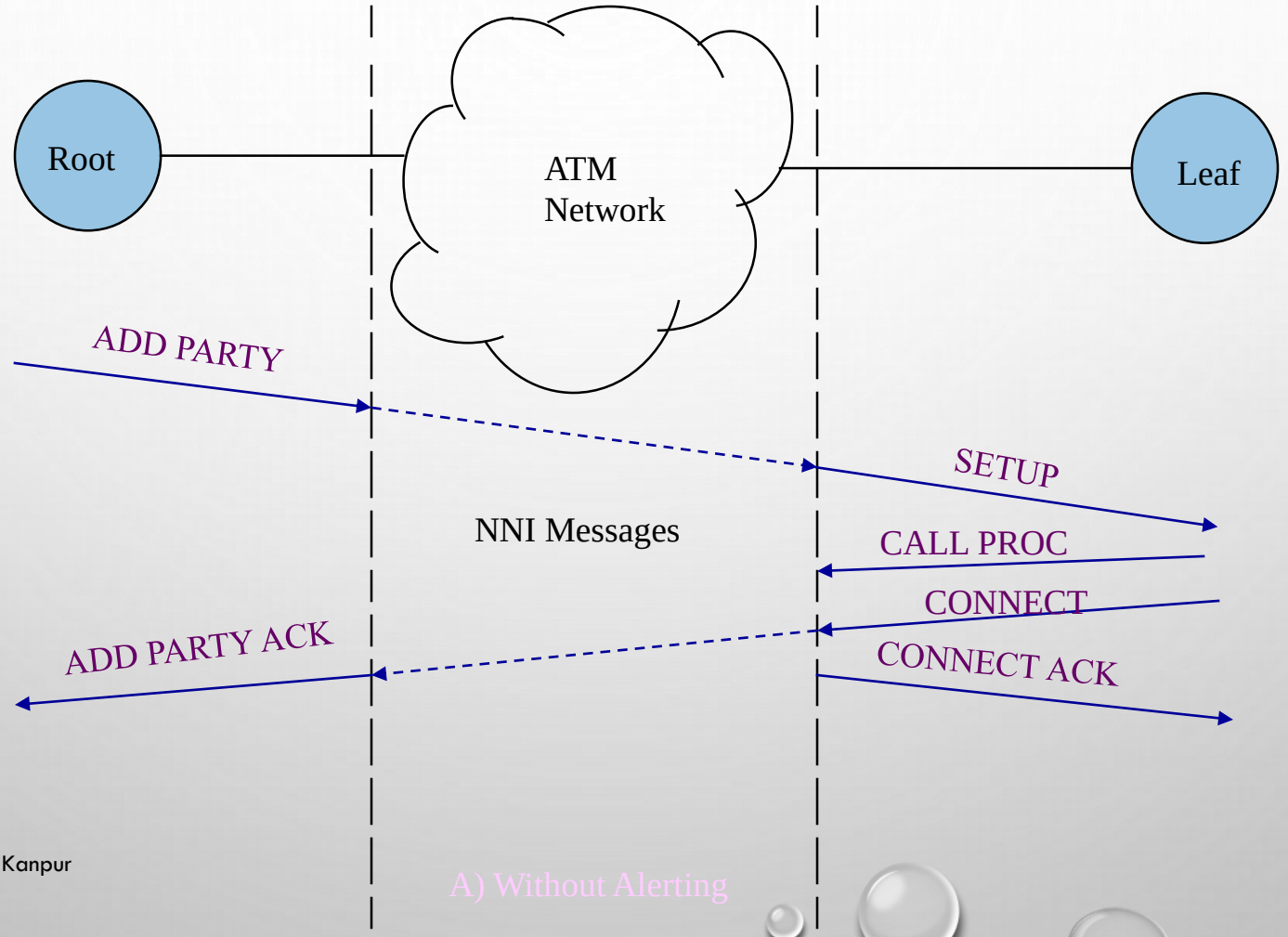
ESTABLISHING A PMP CONNECTION

- A TWO-STEP PROCESS
- SET UP A POINT-TO-POINT UNIDIRECTIONAL CONNECTION FROM ROOT TO A LEAF
  - USES MODIFIED POINT-TO-POINT SIGNALLING PROCEDURES
  - MESSAGES HAVE THE INDICATION THAT THE CONNECTION IS PMP

ESTABLISHING A PMP CONNECTION..

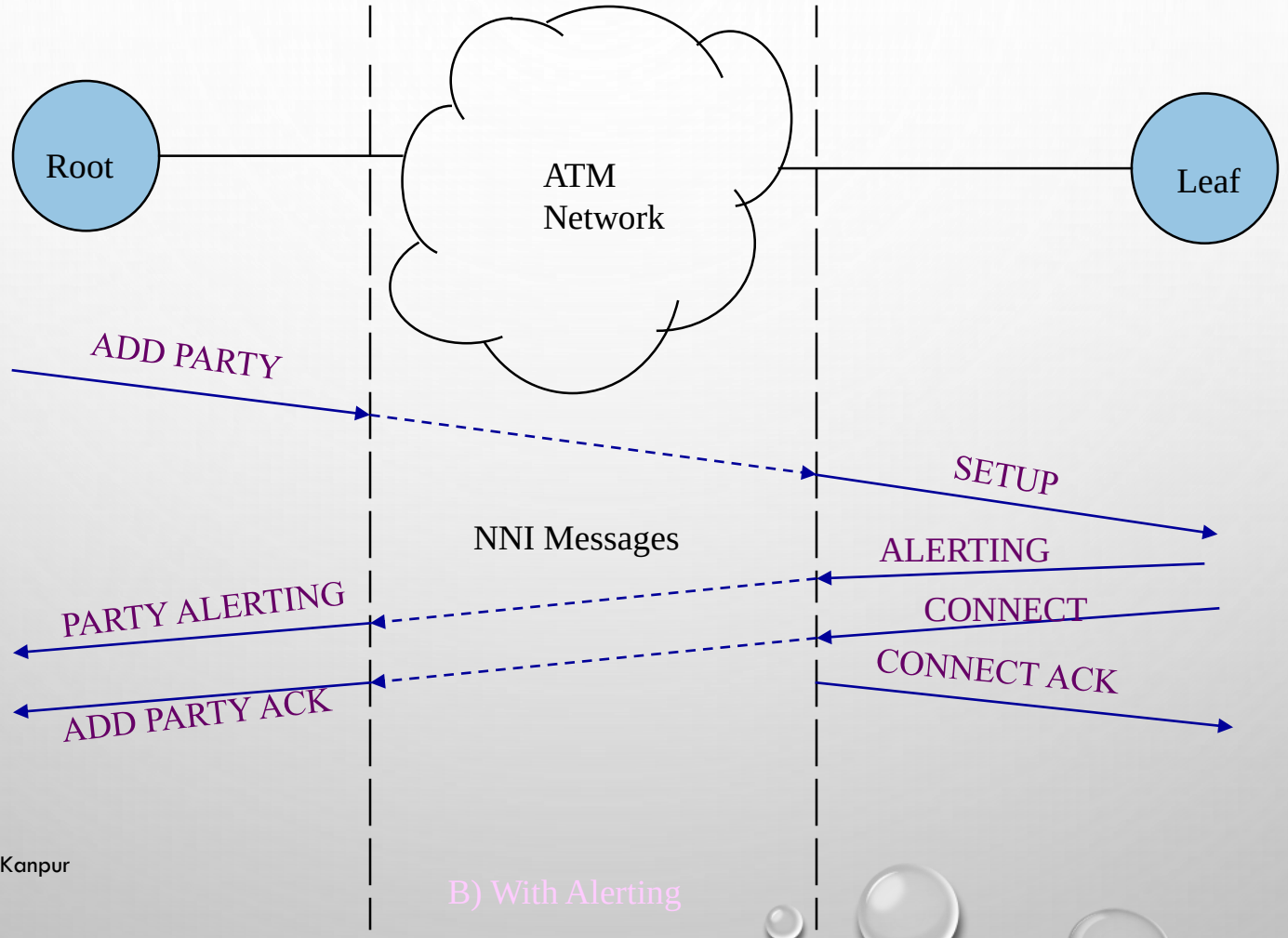
- WHEN THE FIRST CONNECTION HAS BEEN ESTABLISHED
  - ROOT CAN ADD ONE OR MORE LEAVES USING PMP SIGNALLING
  - ONE REQUEST PER PARTY REQUIRED
- LEAF NEED NOT SUPPORT PMP SIGNALLING, POINT-TO-POINT SIGNALLING AT LEAF WILL DO!

ADDING A NEW LEAF



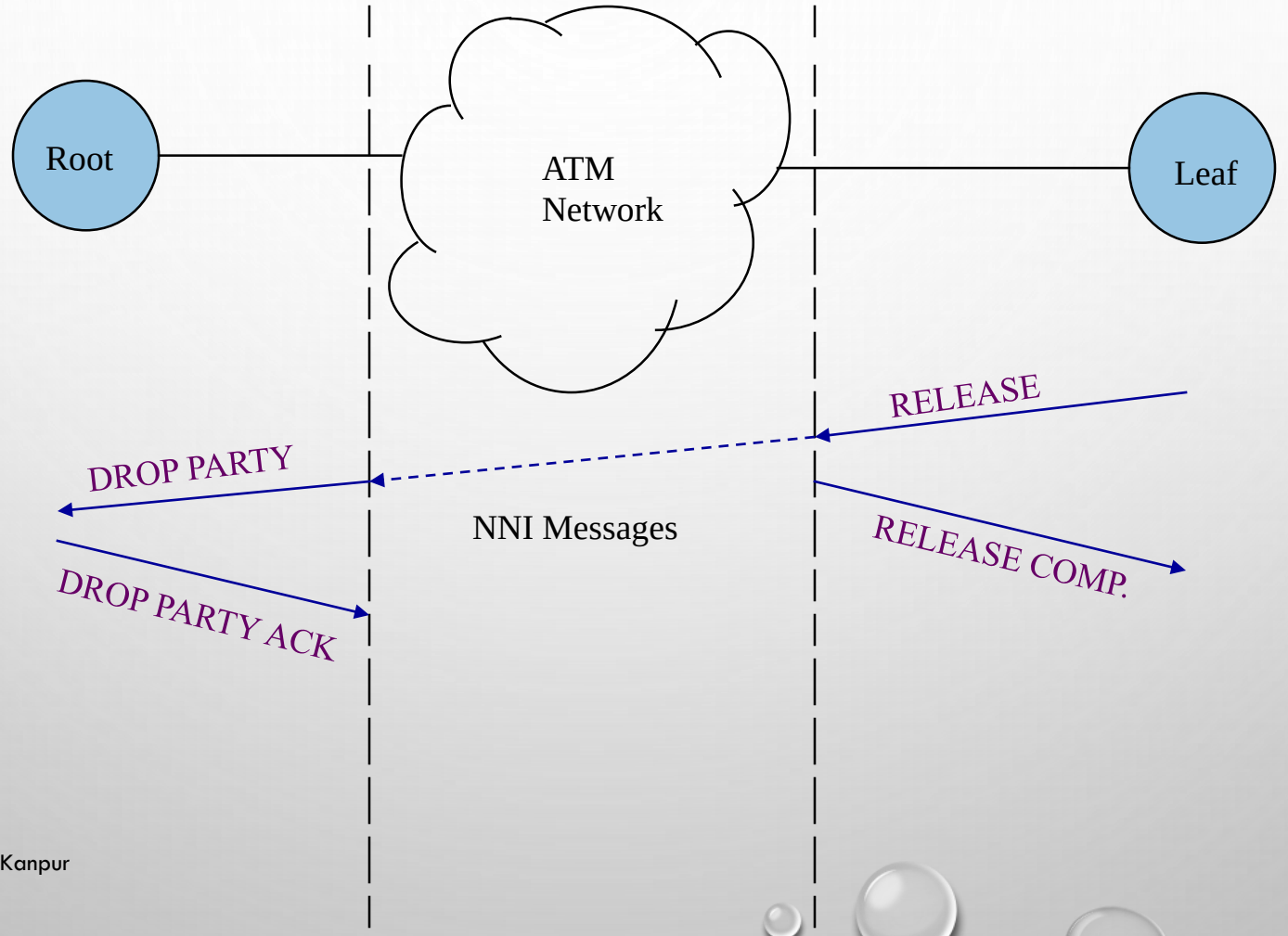
A) Without Alerting

ADDING A NEW LEAF

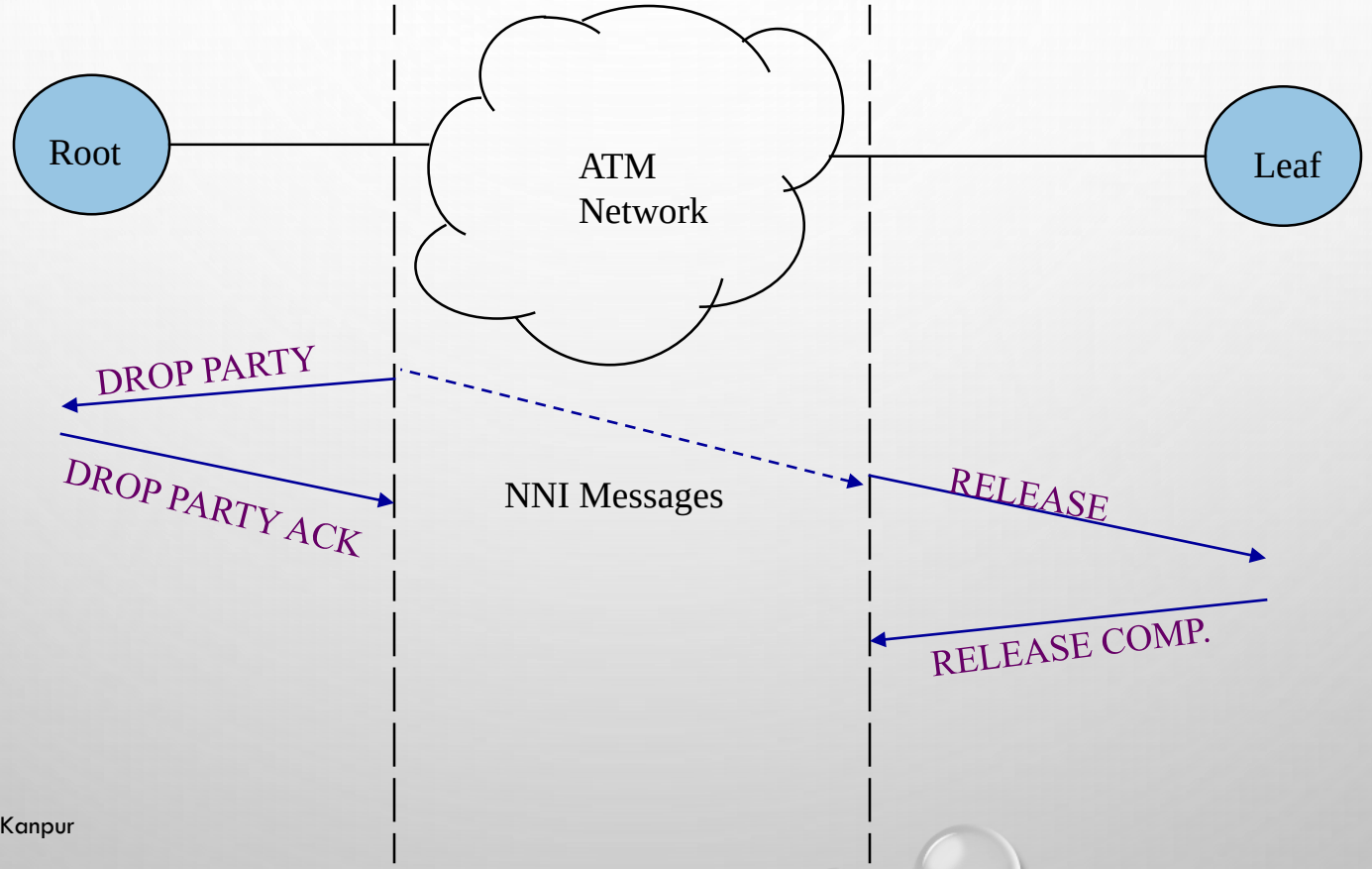


B) With Alerting

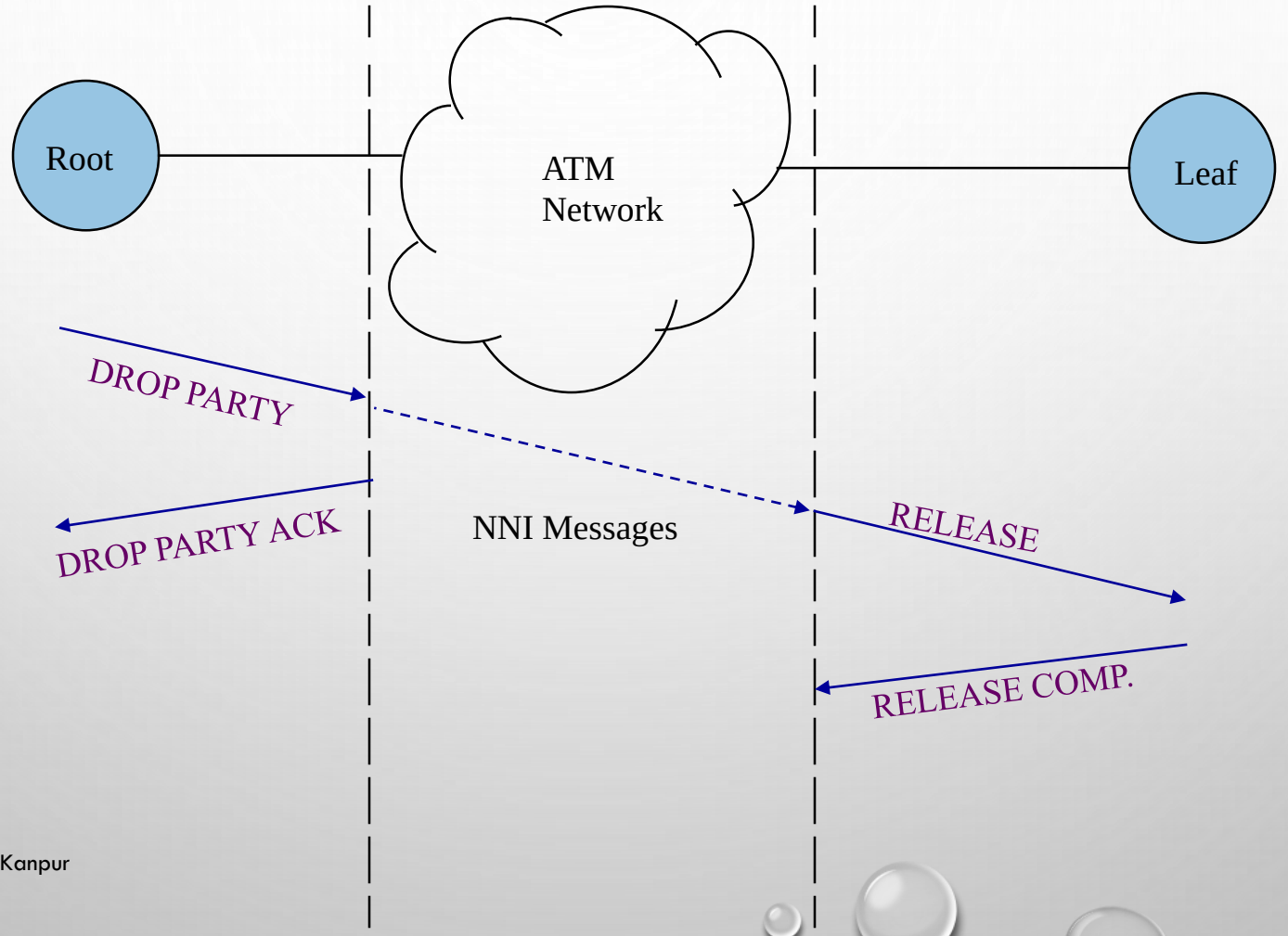
LEAF INITIATED DROPPING



NETWORK INITIATED DROPPING



ROOT INITIATED DROPPING



LEAF INITIATED JOIN (LIJ)

- ADDED BY ATM FORUM IN UNI 4.0
- ALLOWS LEAF TO REQUEST JOINING A PMP CONNECTION
- INDEPENDENT OF WHETHER THE CALL IS ACTIVE/INACTIVE
- MAY NOT REQUIRE INTERVENTION FROM ROOT

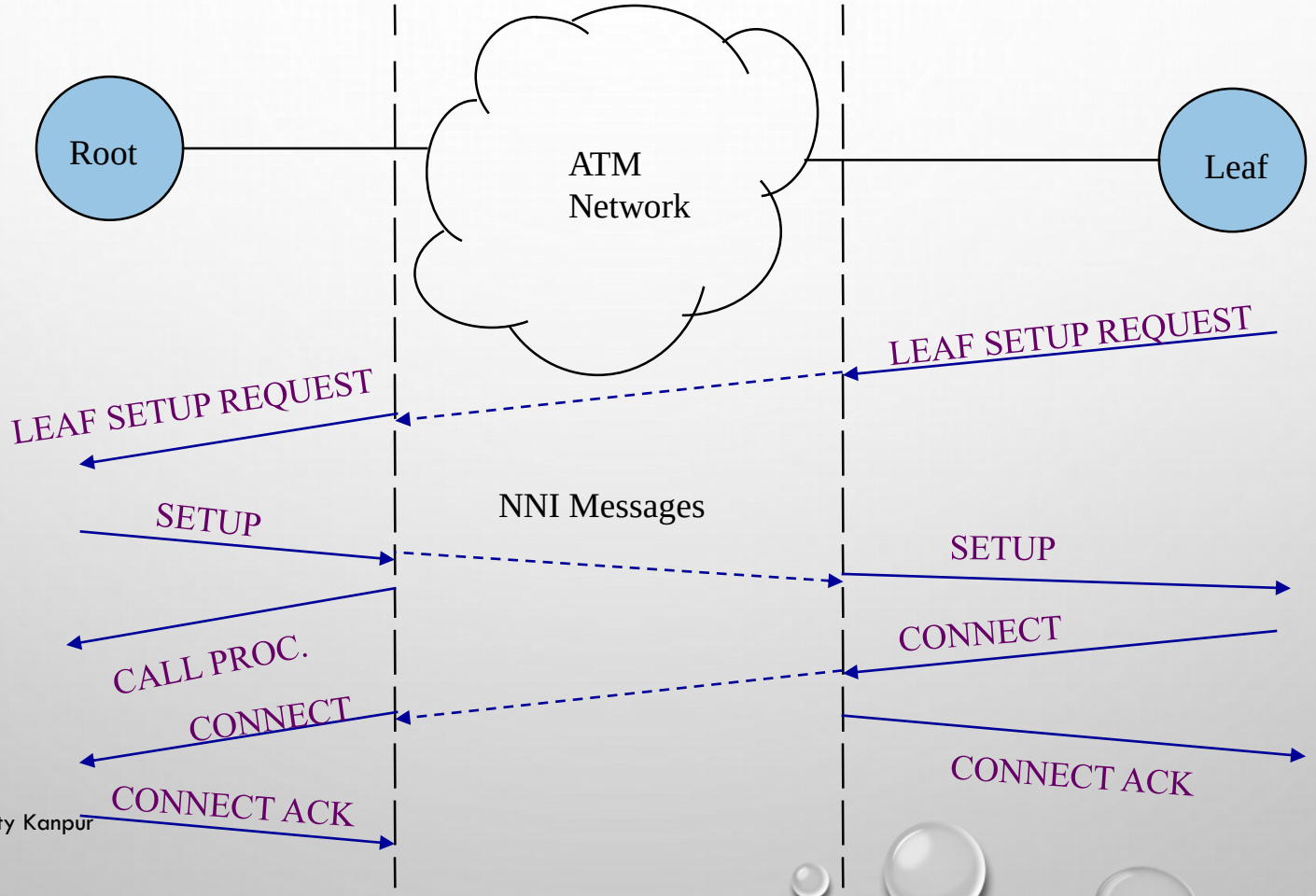
LEAF INITIATED JOIN (LIJ)

- ADDITIONAL MESSAGES REQUIRED :

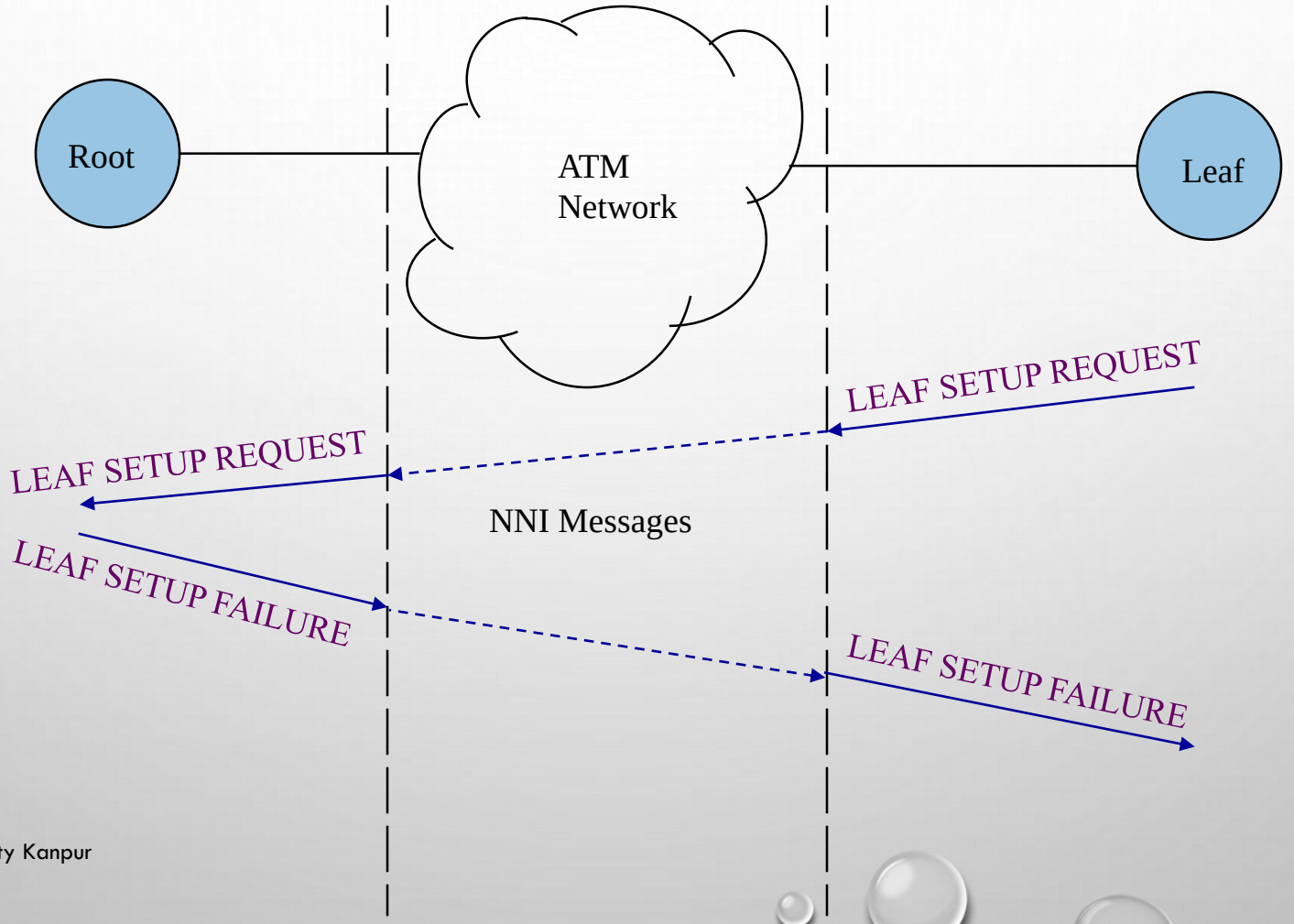
- **LEAF SETUP REQUEST** : SENT BY LEAF TO INITIATE LEAF JOINING PROCEDURES.

  - **LEAF SETUP FAILURE** : SENT TO THE LEAF BY THE ROOT OR THE NETWORK TO INDICATE THAT THE REQUEST TO JOIN THE CALL FAILED.

LEAF JOINED TO INACTIVE CALL



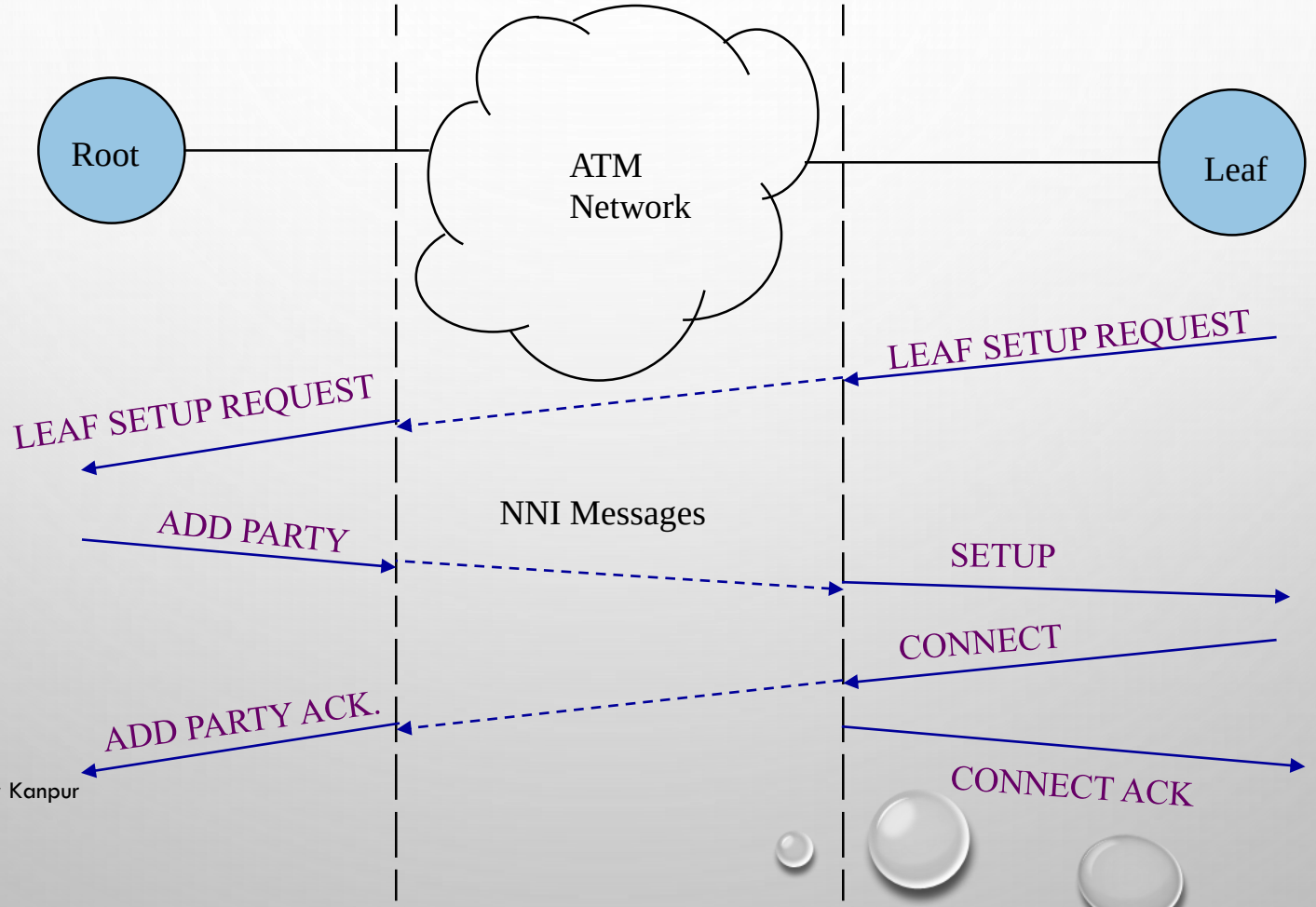
UNSUCCESSFUL LEAF JOIN



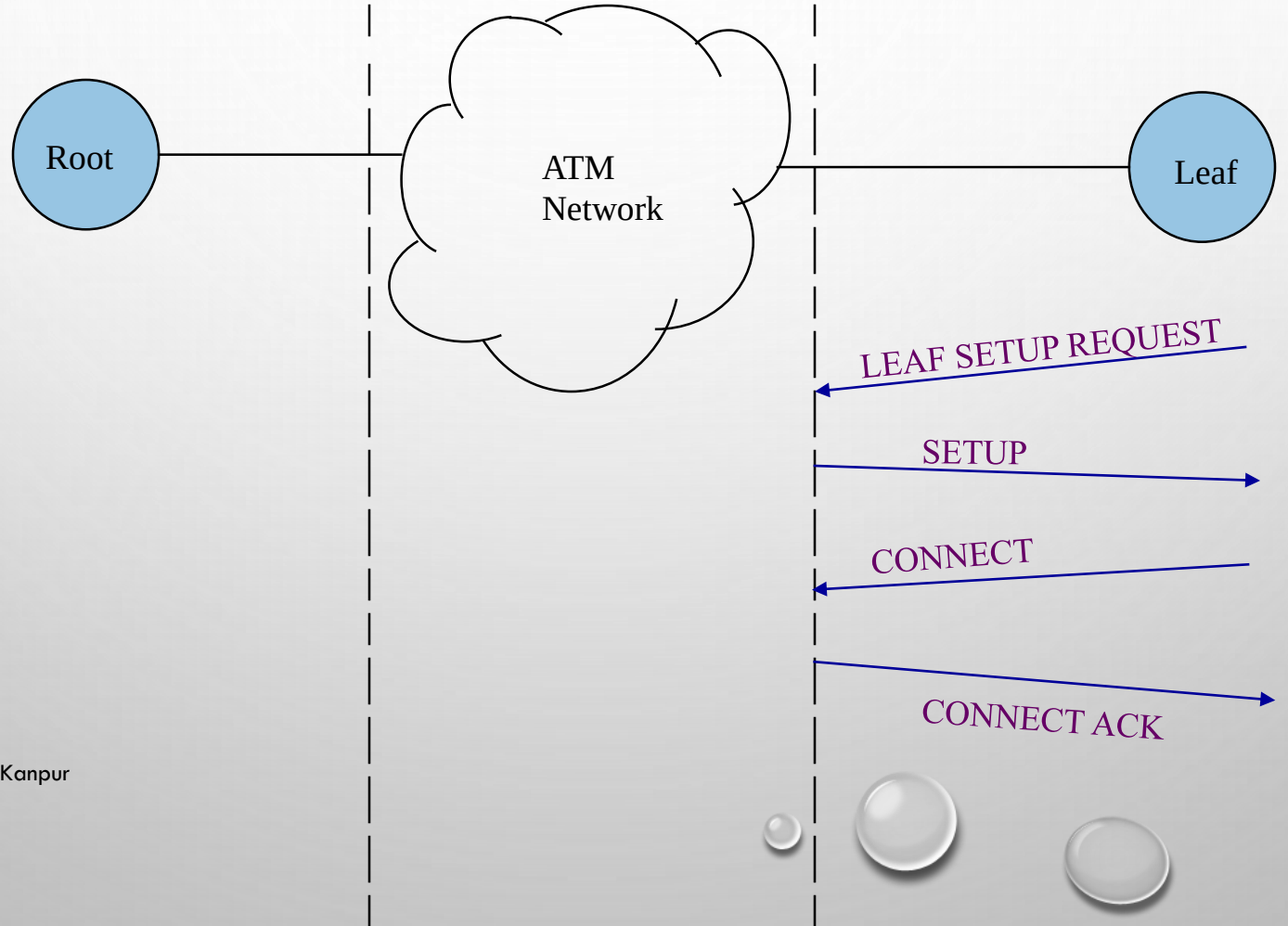
Leaf Initiated Join (LIJ)

- TWO TYPES OF LIJ CALLS :
  - **NETWORK LIJ** : NETWORK IS RESPONSIBLE FOR ADDING LEAVES THAT REQUEST TO JOIN A CALL.
  - **ROOT LIJ** : ALL LEAVES ARE ADDED AND REMOVED BY THE ROOT.

LEAF JOINED TO ACTIVE ROOT LIJ CALL



LEAF JOINED TO ACTIVE NETWORK LIJ CALL

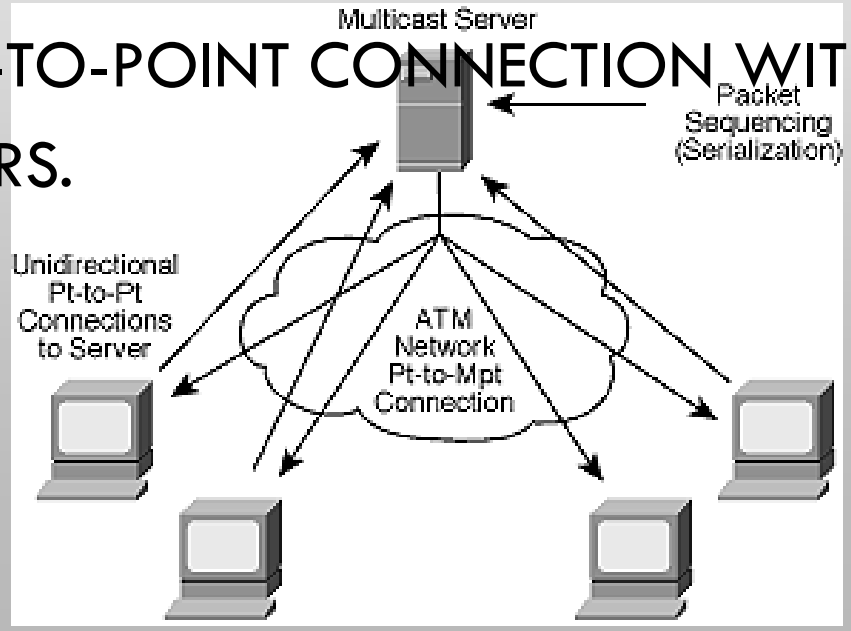


ISSUES

- UNIDIRECTIONAL PMP CONNECTIONS
  - CELL INTERLEAVING IN AAL5 NOT POSSIBLE
  - ADDITIONAL COMPLEXITIES IN USING AAL3/4
- CONNECTION CHARACTERISTICS NEGOTIATION POSSIBLE FOR FIRST PARTY ONLY
- LIJ NOT SUPPORTED IN PNNI 1.0
- ABR PMP CONNECTIONS INVOLVE FEEDBACK CONSOLIDATION PROBLEMS

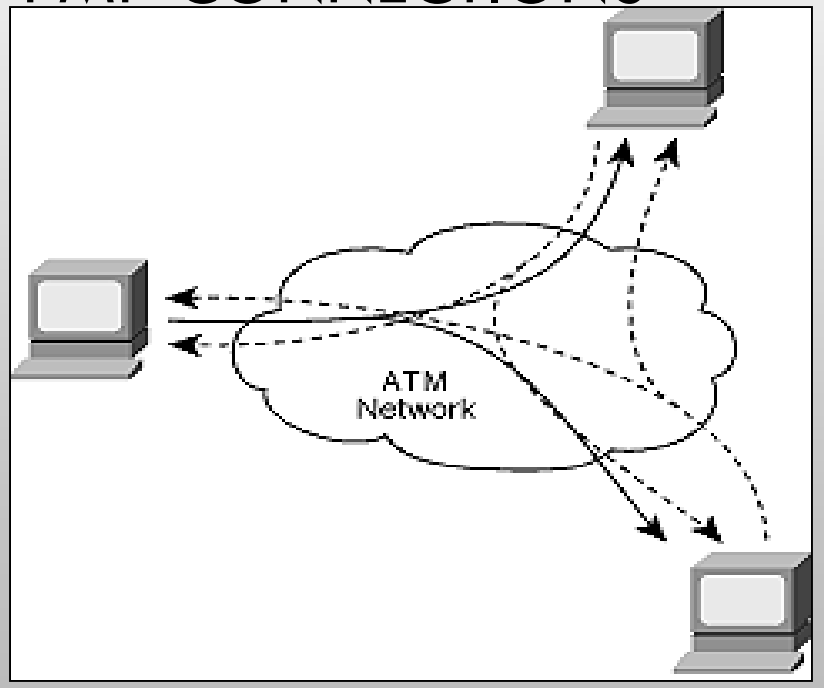
PROVIDING BI-DIRECTIONAL CONNECTIONS

- MULTICAST SERVER
  - SERVER WITH PMP CONNECTION WITH ALL LEAVES
  - POINT-TO-POINT CONNECTION WITH ALL SENDERS.



PROVIDING BI-DIRECTIONAL CONNECTIONS

- OVERLAID PMP CONNECTIONS



PROVIDING BI-DIRECTIONAL CONNECTIONS

- VP MULTICASTING
  - MULTIPOINT-TO-MULTIPOINT VP LINKS ALL NODES
  - UNIQUE VCI VALUE FOR EACH NODE
  - INTERLEAVED PACKETS IDENTIFIED BY UNIQUE VCI.

REQUIRES A PROTOCOL TO UNIQUELY ALLOCATE VCI VALUES TO NODES.

CONCLUSIONS

- ATM HAS NO IMPLICIT BROADCAST MECHANISMS
- NO IDEAL SOLUTION WITHIN ATM FOR MULTICAST
- PMP CONNECTIONS HAVE A WIDE RANGE OF APPLICATIONS
- IN PMP CONNECTIONS, ONLY ROOT CAN ADD PARTIES AS OF NOW.
- MECHANISMS TO WORK AROUND ABOVE PROBLEMS BEING EVOLVED

SIGNALING REFERENCES

- ITU-T Q.2931: B-ISDN UNI LAYER 3 SPECIFICATION FOR BASIC CALL/CONNECTION CONTROL
- ITU-T Q.2971: B-ISDN UNI LAYER 3 SPECIFICATION FOR POINT-TO-MULTIPOINT CALL/CONNECTION CONTROL
- ATM FORUM UNI 4.0

SIGNALING REFERENCES

- SIGNALING IN ATM NETWORKS : ONVURAL
- ATM INTERNETWORKING : ANTHONY ALLES
- DESIGN AND EVALUATION OF FEEDBACK CONSOLIDATION FOR ABR PMP CONNECTIONS IN ATM NETWORKS : FAHMY, RAJ JAIN ET AL.

Module 10
Related Topics

RELATED TOPICS

- ROUTING IN ATM NETWORKS (PNNI)
- LANE
- MPOA
- VTOA

PNNI

- PRIVATE “NETWORK-TO-NETWORK” OR “NETWORK-TO-NODE” INTERFACE
- TWO KEY PROTOCOLS:
  - PNNI ROUTING : HIERARCHICAL, STATE-OF-THE-ART ROUTING PROTOCOL.
  - PNNI SIGNALING : BASED ON Q.2931, EXTENDED AS NECESSARY.

TOPOLOGY STATE ROUTING

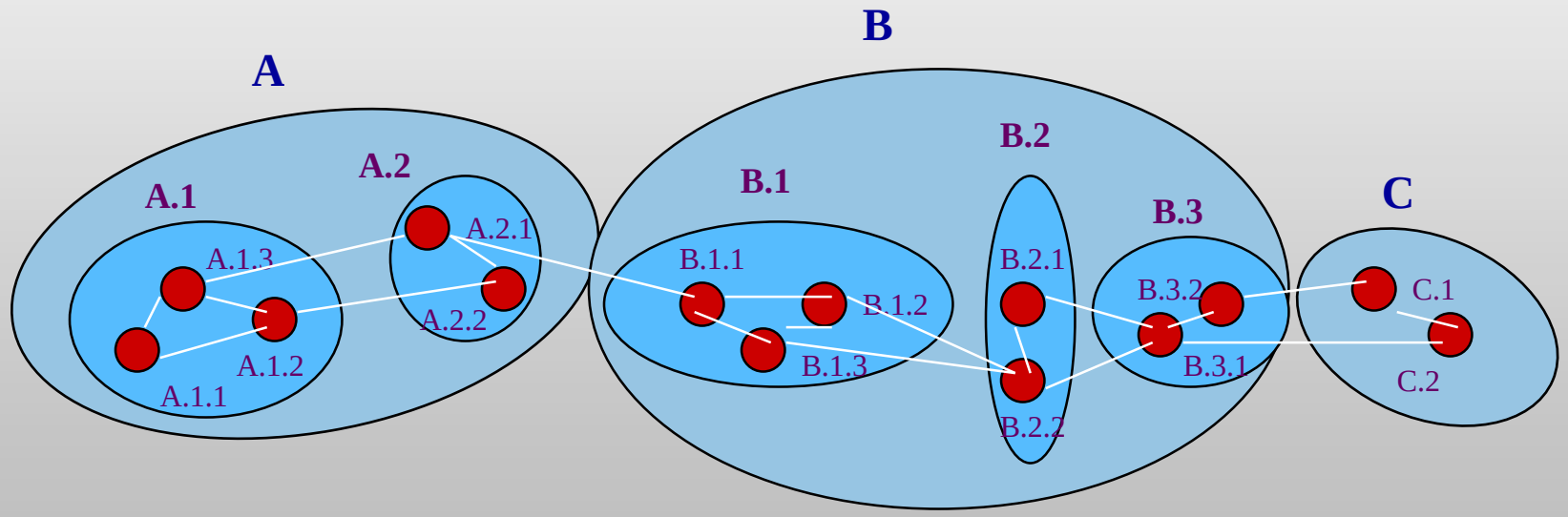
- EACH NODE PERIODICALLY:
  - EXCHANGES “HELLO” PACKETS WITH DIRECTLY NEIGHBORING NODES.
  - CONSTRUCTS A “TOPOLOGY STATE UPDATE” (TSU) DESCRIBING THE NODE AND LISTING LINKS TO DIRECT NEIGHBORS.
  - FLOODS TSUS TO ALL OTHER NODES.
- NODES THEN CAN COMPUTE COMPLETE TOPOLOGY.

CONCEPT OF “SOURCE ROUTES”

- INGRESS NODES CHOOSE A COMPLETE PATH TO THE DESTINATION.
- INGRESS NODE THEN ADDS FULL PATH TO THE MESSAGE ITSELF.
- TRANSIT NODES SIMPLY FOLLOW THE GIVEN PATH.

PNNI ROUTING HIERARCHY

- AGGREGATING INFORMATION “UP” THE HIERARCHY.

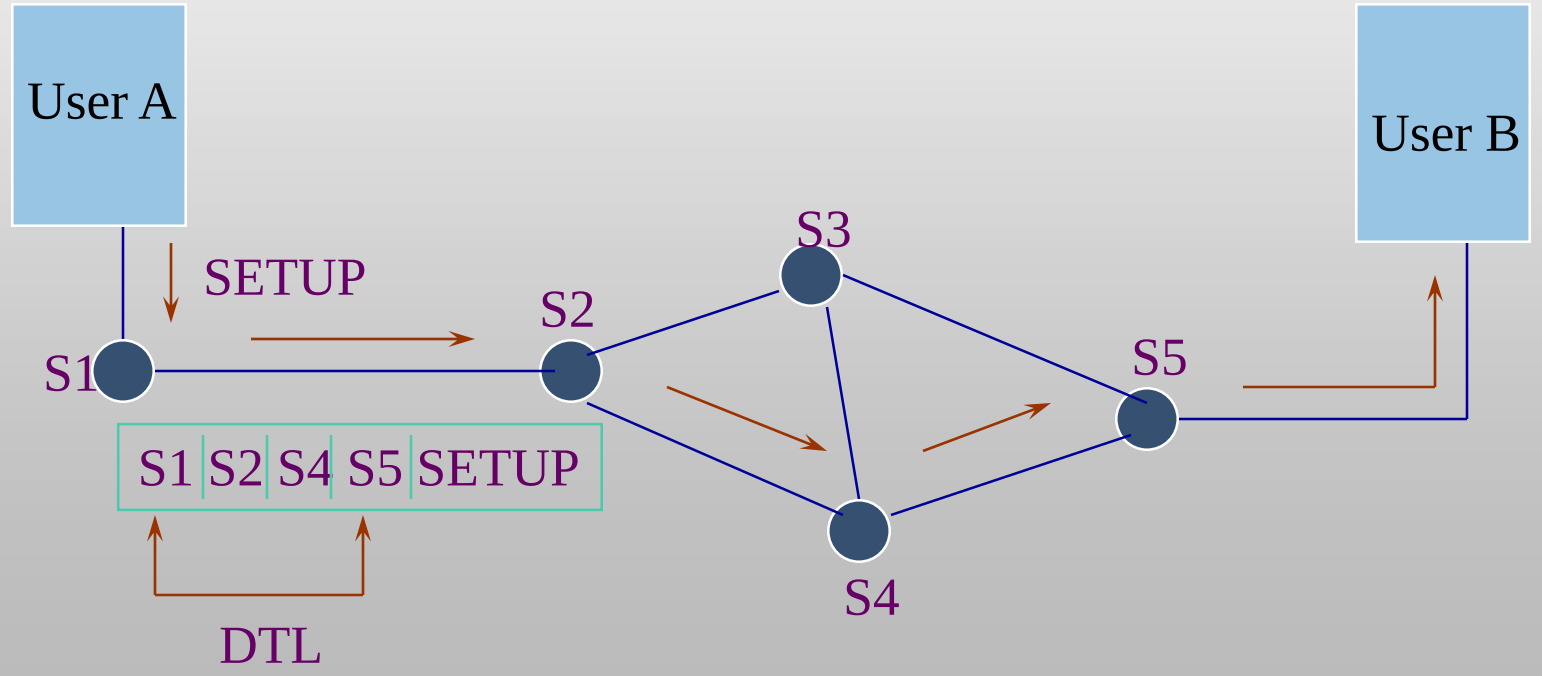


PNNI SIGNALING (KEY CONCEPTS)

- COMPLETE SOURCE ROUTING ACROSS EACH LEVEL OF HIERARCHY
- USE OF DESIGNATED TRANSIT LISTS
- “CRANKBACK” AND ALTERNATE PATH ROUTING

PNNI SIGNALING

- DTL : IMPLEMENTED AS “PUSH-DOWN/POP-OFF STACK”

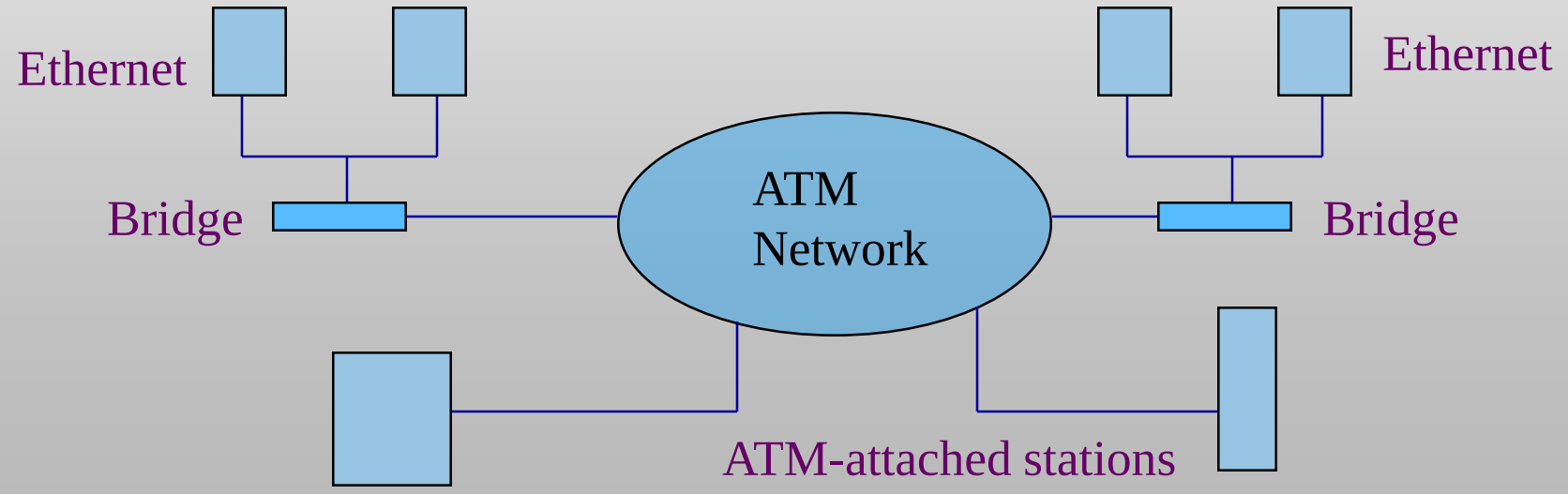


LANE

- LANE STANDS FOR LAN EMULATION
- LANE PROVIDES FOR:
  - ALL EXISTING LAN APPLICATIONS TO RUN OVER ATM
  - THE USE OF ATM AS A BACKBONE TO INTERCONNECT EXISTING “LEGACY” LANS
  - THE INTERCONNECTION OF ATM-ATTACHED SERVERS/WORKSTATIONS TO EACH OTHER AND TO THOSE ON “LEGACY” LANS

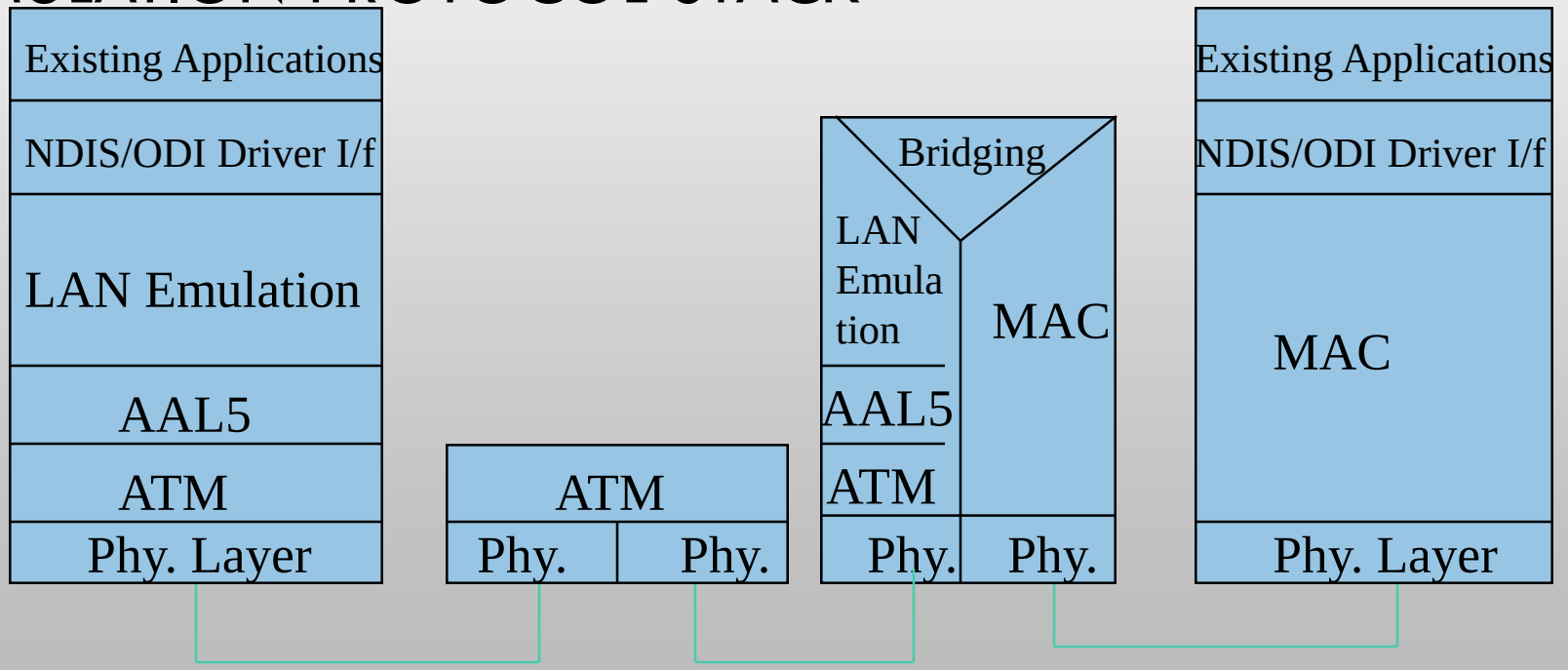
LANE

- AN ATM NETWORK INTERCONNECTING MULTIPLE ETHERNET SEGMENTS AND ATM-ATTACHED END-SYSTEMS



LANE

- LAN EMULATION PROTOCOL STACK



MPOA

- MULTIPROTOCOL OVER ATM
- MPOA IS AN EVOLUTION OF LANE
- LANE OPERATES AT LAYER 2 (BRIDGING)
- MPOA OPERATES AT BOTH LAYER 2 (BRIDGING) AND LAYER 3 (ROUTING)
- MPOA WILL USE LANE FOR ITS LAYER 2 FORWARDING

BENEFITS OF MPOA

- PROVIDES THE CONNECTIVITY OF A FULLY ROUTED ENVIRONMENT
- EASES INTRODUCTION OF ATM IN CAMPUS ENVIRONMENT
- PROVIDES DIRECT ATM CONNECTIONS BETWEEN MPOA DEVICES.
- PRESENTS UNIFIED APPROACH TO LAYER-3 PROTOCOLS OVER ATM

VTOA

- VOICE AND TELEPHONY OVER ATM
- OBJECTIVE : TO ALLOW THE INTERCONNECTION OF PRIVATE NARROWBAND NETWORKS THROUGH AN ATM BROADBAND NETWORK IN ORDER TO :
  - INTEGRATE SERVICE SPECIFIC NETWORKS
  - REDUCE COMMUNICATION COSTS
  - SIMPLIFY THE OPERATIONAL ENVIRONMENT
  - SIMPLIFY NETWORK MANAGEMENT