

CISC452

Telecommunications Systems

Lesson 6

Frame Relay and ATM



Technology Comparison

	<u>Private Line</u>	<u>X.25</u>	<u>SMDS</u>	<u>Frame Relay</u>	<u>ATM</u>	<u>IP</u>
Speed	56K - 622M	9.6K - 2.048M	56K - 34M	Dial - 45M	1.5M - 622M	Dial - 45M
Traffic Type	Data/Voice/Video	Data	Data	Data/On Net Voice and Video	Data/Voice/Video	Data
Connection Oriented	Yes	Yes	No	Yes	Yes	No
Typical Topology	Star/Multi-point/Multi-Drop	Star	Any-to-Any	Mesh/Partial Mesh/Star	Mesh/Partial Mesh/Star	Any-to-Any
QoS Support	No	No	No	Proprietary	Yes	No



Benefits of Frame Relay

? Savings over Private Lines

Reduces number of dedicated devices which reduces equipment costs

Reduces complexity for network managers

? Greater Bandwidth Flexibility than Private Lines

? Higher Reliability and Resiliency than Private Lines

? Lower Cost of Ownership and Better Bandwidth Utilization

Growth of Branch Office Networks



Benefits of Frame Relay (cont'd)

? Consolidation of LAN, SNA, On-net Voice, and/or Packetized Video

Simplifies Network Architecture

Reduces Operations and Administrative Costs

Improves Application Performance and Network Efficiency

? Smooth migration to ATM

Service and Network Interworking with ATM (FRF.5 and FRF.8)



Frame Relay Terms And Definitions (cont'd)

? Committed Information Rate (CIR)

The bandwidth defined for a VC

? B_c = Committed Burst

Maximum number of committed bits to be transmitted over time interval

? B_e = Excess Burst

Number of Excess bits that will be transmitted over time

? T_c Time interval

Time measurement based how much bandwidth is available for data to burst on to the network



Frame Relay Terms And Definitions (cont'd)

- ? **FECN Forward Explicit Congestion Notification**
 - Bit set by the network node (FR Switch) that is experiencing congestion
 - Sent in the direction of the receiver (destination)

- ? **BECN Backward Explicit Congestion Notification**
 - Bit set by the network node that is experiencing congestion
 - Sent in the direction of the sender (source)

- ? **DE Discard Eligible bit**
 - Set by either the DTE (access device FRAD, router etc.) or the network nodes (switches)
 - May be set selectively by some DTE devices
 - May be set by network nodes in the event the user has exceeded CIR and the network is experiencing congestion



Service Comparison

Private Lines (TDM)

Engineer Network for Peak Traffic Needs

CSU/DSU per Leased Line per remote site

Time Division Multiplexing

Resiliency is Not Inherent

Frame Relay

Engineer Network for Average Traffic Needs

CSU/DSU per Leased Line that can access many remote sites

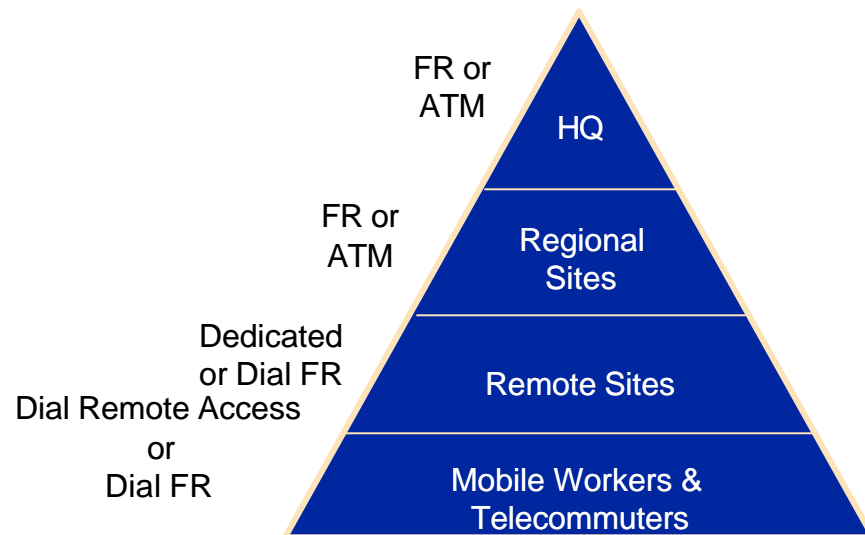
Statistical Multiplexing and Burst Capability

Resiliency is Inherent in Network

Frame Relay Complements Other Technologies

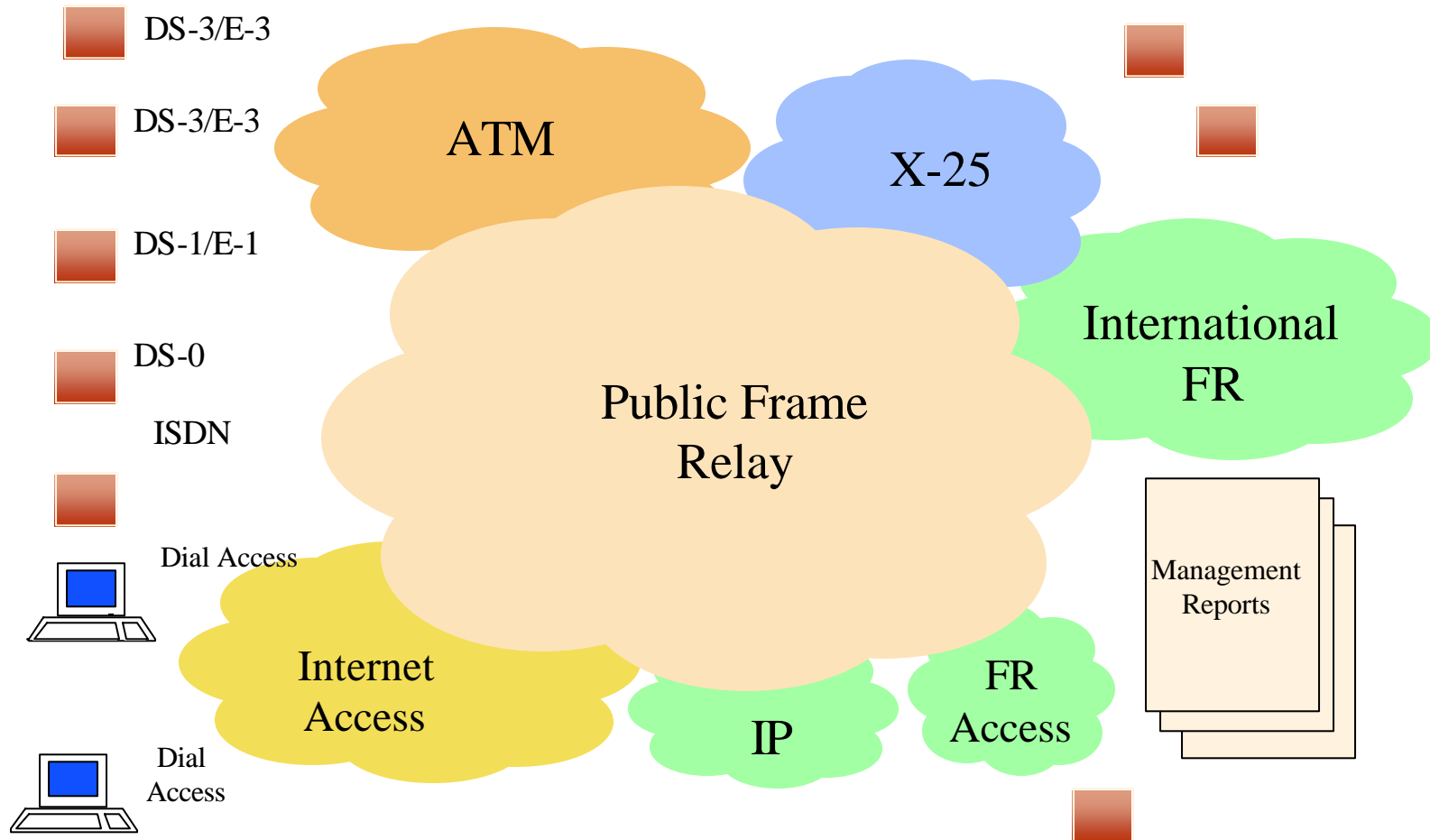
Application	Technology
<u>LAN</u>	<u>FR, SMDS, ATM</u>
<u>LAN & SNA</u>	<u>FR, ATM</u>
<u>Data & On-net Voice</u>	<u>FR, ATM</u>
<u>Data, On-net Voice & Packetized Video</u>	<u>FR, ATM</u>

Speeds	Technology
< 1.5 Mbps	FR
1.5 - 45 Mbps	FR, ATM
>45 Mbps	ATM



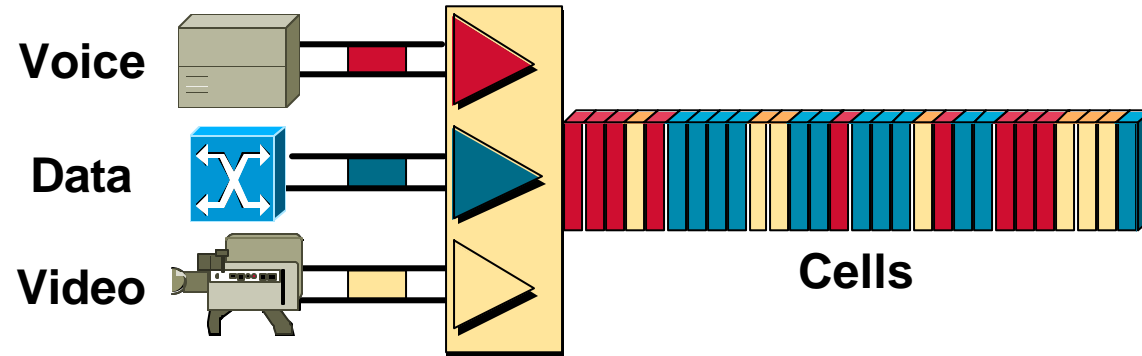
Interworking	Agreement
FR - ATM	FRF.5 and FRF.8
FR - SMDS	SIP

Understanding Public Frame Relay Services





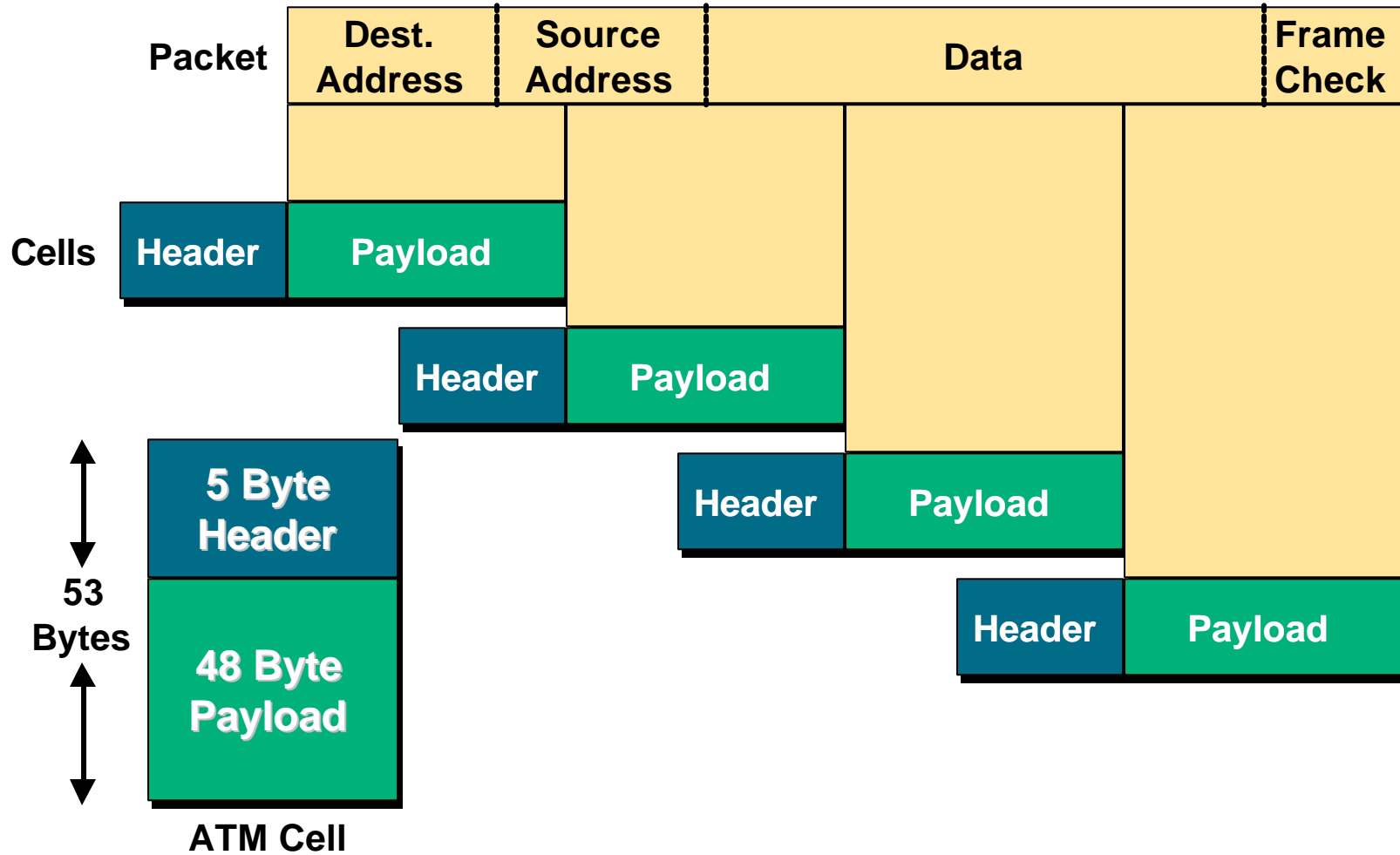
Characteristics of ATM



- ? Uses small, fixed-sized cells
- ? Connection-oriented
- ? Supports multiple service types
- ? Applicable to LAN and WAN

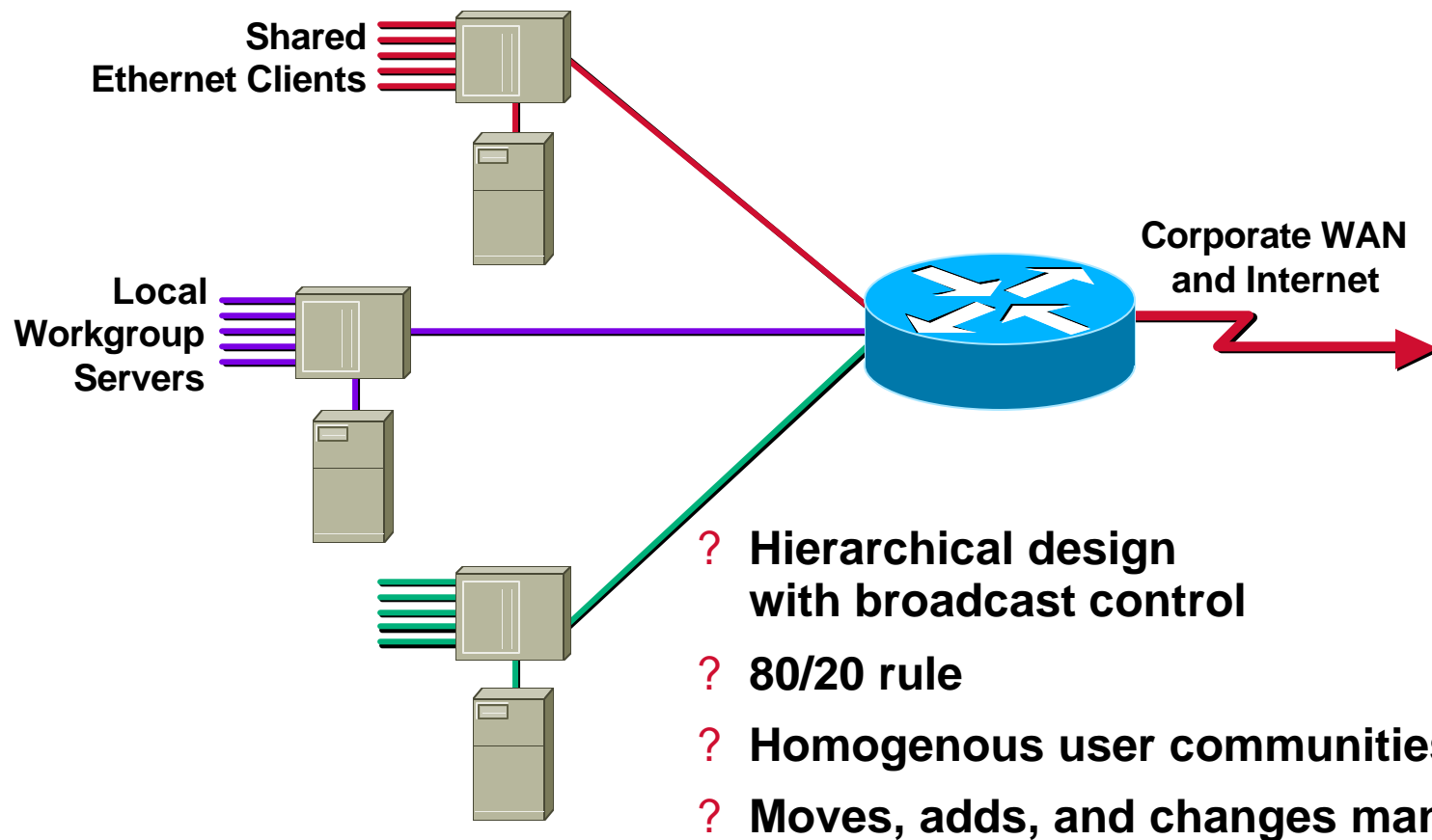


Creating Cells from Packets



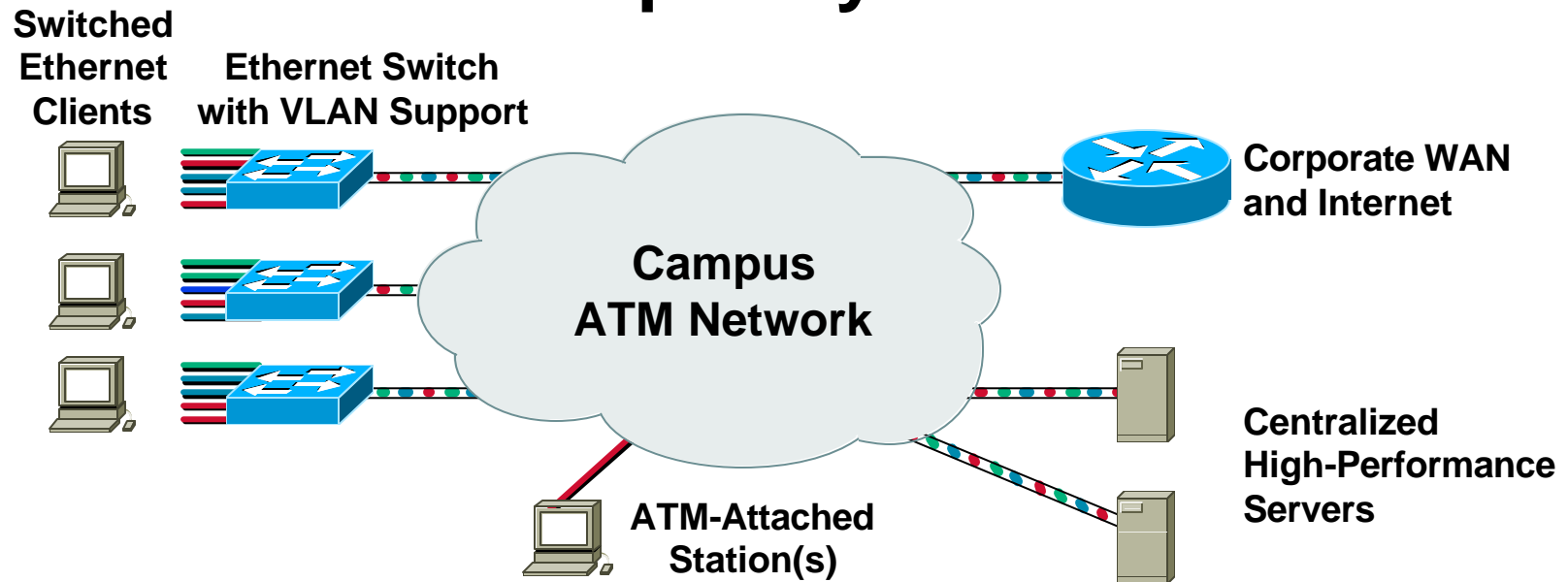
Campus Networking Evolution

Traditional Network



Campus Networking Evolution

Contemporary Network



- ? Network hierarchy maintained
- ? Traffic patterns migrating
- ? Client and server performance increases
- ? Moves, adds, and changes automated

Rudimentary ATM Concepts

- ? **Physical layer**
- ? **Signaling**
- ? **Cell format**
- ? **Connection types**



ATM Transmission Media

ATM SDH/SONET Rates Chart

SDH	SONET	Rate—Mbps
	STS-1/OC-1	51.84
STM-1	STS-3/OC-3	155.52
STM-4	STS-12/OC-12	622.08
STM-8	STS-24/OC-24	1,244.16
STM-16	STS-48/OC-48	2,488.32

- ? CCITT (Consultative Committee for International Telephony and Telegraph)
- ? ITU (International Telecommunications Union)



ATM Physical Interface Rates

Framing	Data Rate (Mbps)	Media					
		Multi-Mode Fiber	Single-Mode Fiber	Coaxial Cable	UTP-5	UTP-3	STP
DS1	1.544						(TP)
E1	2.048			✓			
J2	6.23						(TP)
DS3	45			✓			
E3	34			✓			
E4	139			X			
ATM25	25.6					✓	
STS 1	51.8					✓	
STS3c/STM1	155	✓	✓		✓	X	
STS 12c/STM4	622	✓	✓				
4B/5B (TAXI)	100	✓					
8B/10B (Fiberchannel)	155	✓					✓

✓ = Standardized X = Proposed/In Progress

Rudimentary ATM Concepts

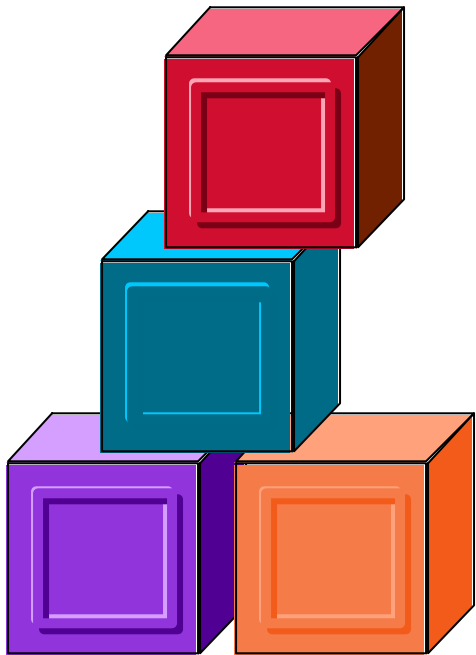
? **Physical layer**

? **Signaling**

? **Cell format**

? **Connection types**

ATM Building Blocks



? **ATM signaling**

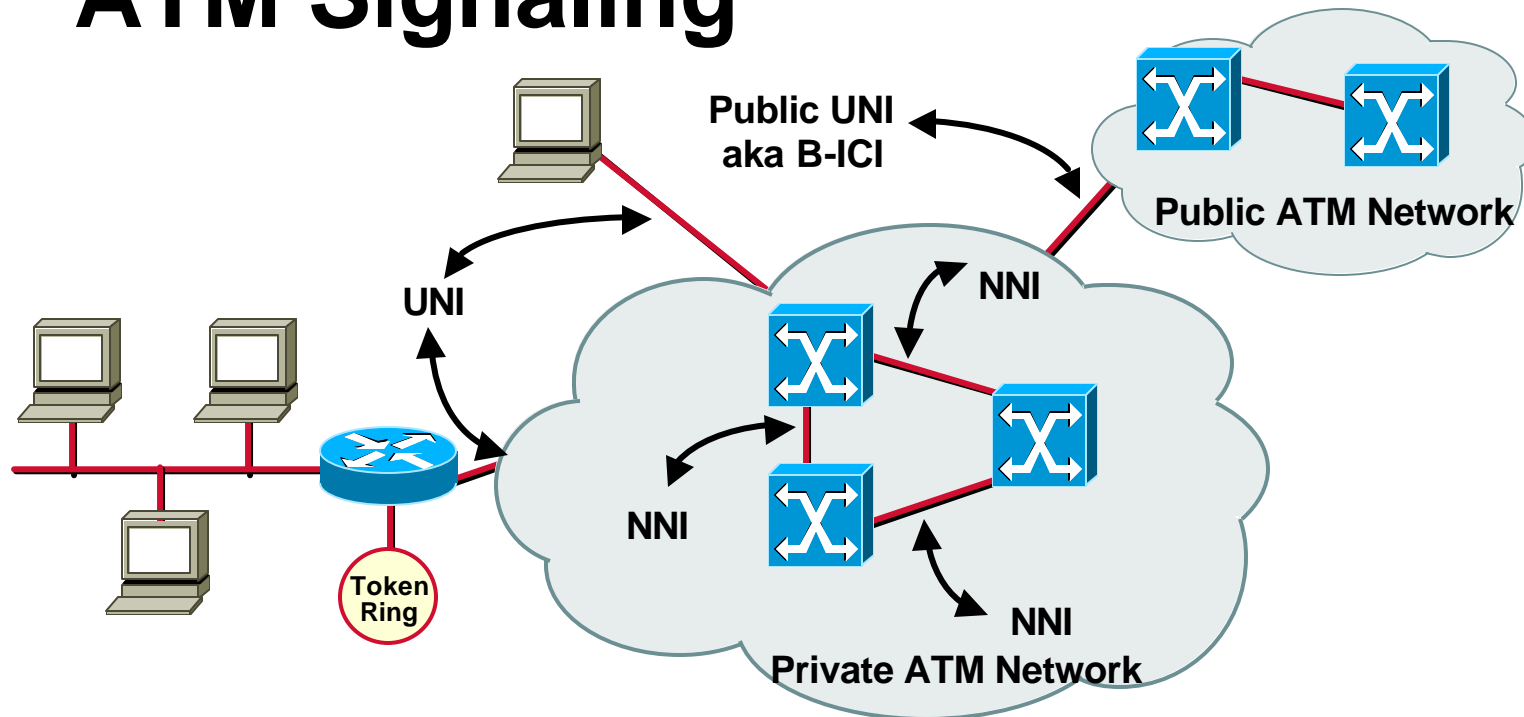
UNI and NNI

? **Virtual connections**

VCC, VP, and VC



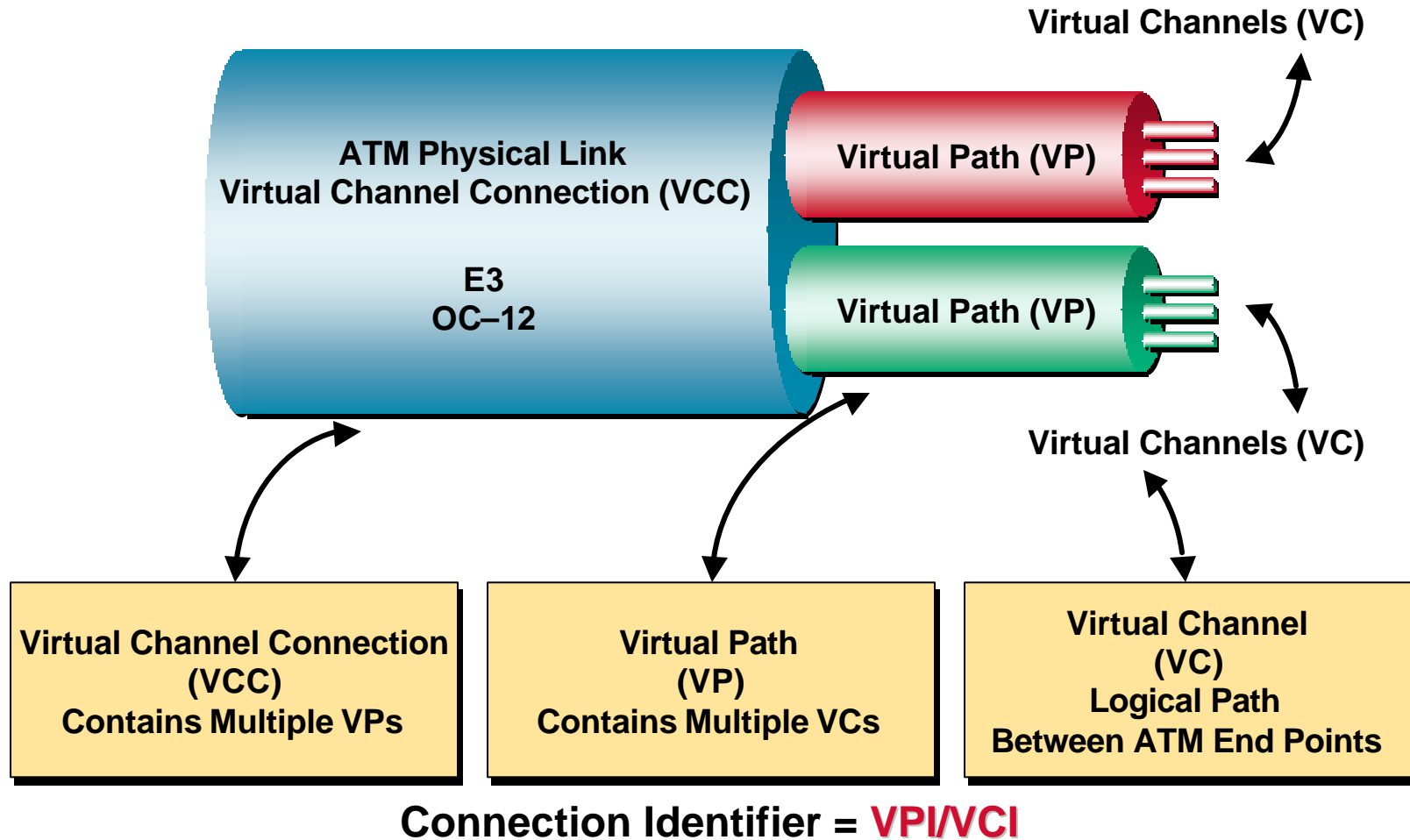
ATM Signaling



- ? UNI = User-to-Network Interface
- ? NNI = Network-to-Network Interface
- ? Cell header content varies depending on who's talking to whom



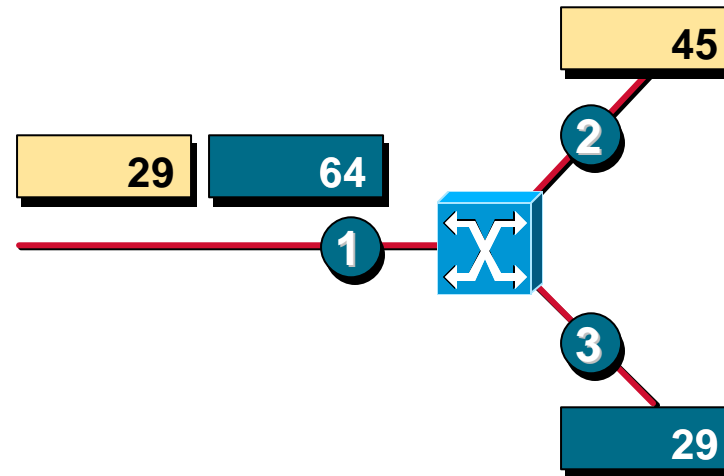
Virtual Path and Virtual Channels





ATM Switches

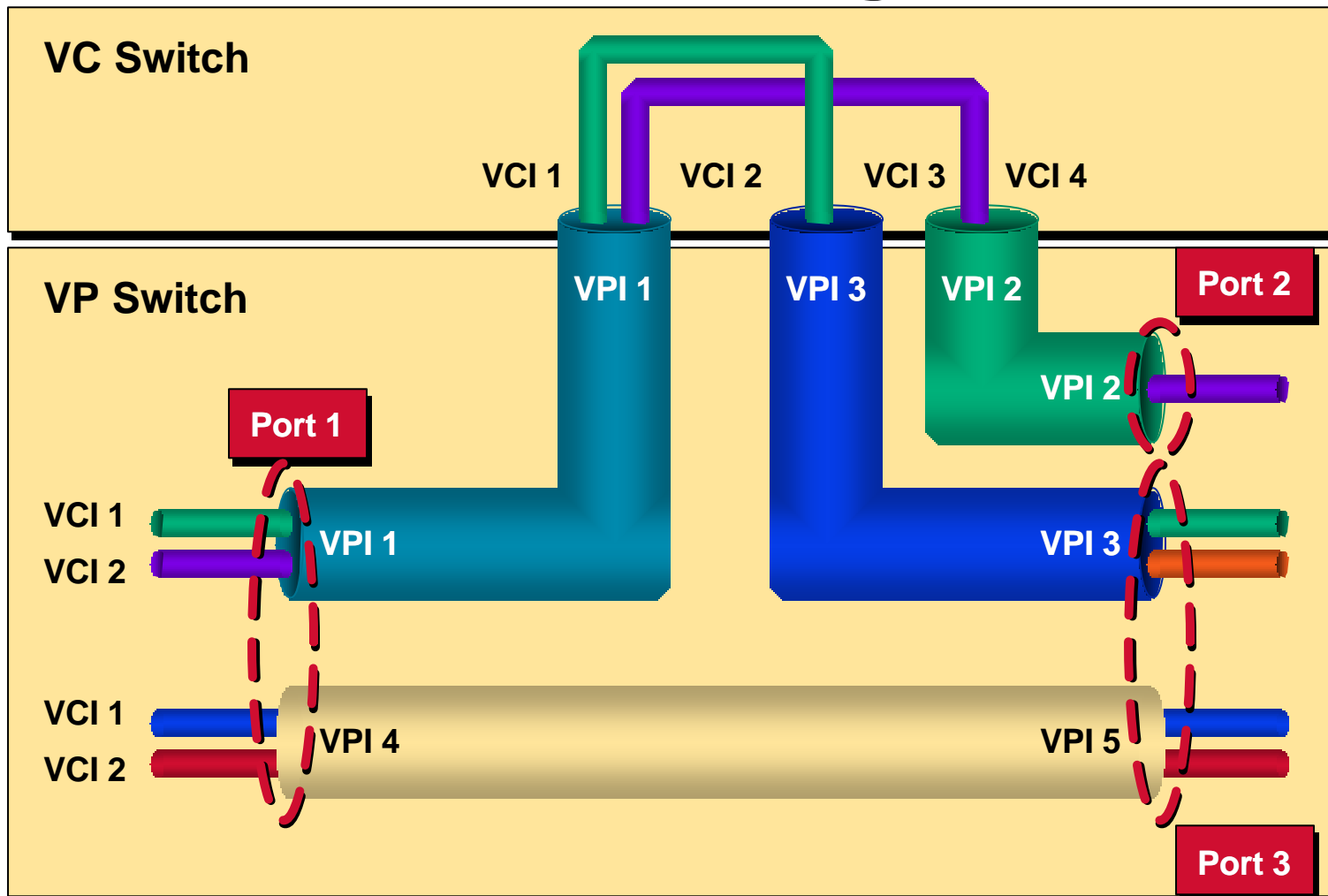
Input		Output	
Port	VPI/VCI	Port	VPI/VCI
1	29	2	45
2	45	1	29
1	64	3	29
3	29	1	64



- ? ATM switches translate VPI/VCI values
- ? VPI/VCI value unique only per interface—
eg: locally significant and may be re-used
elsewhere in network

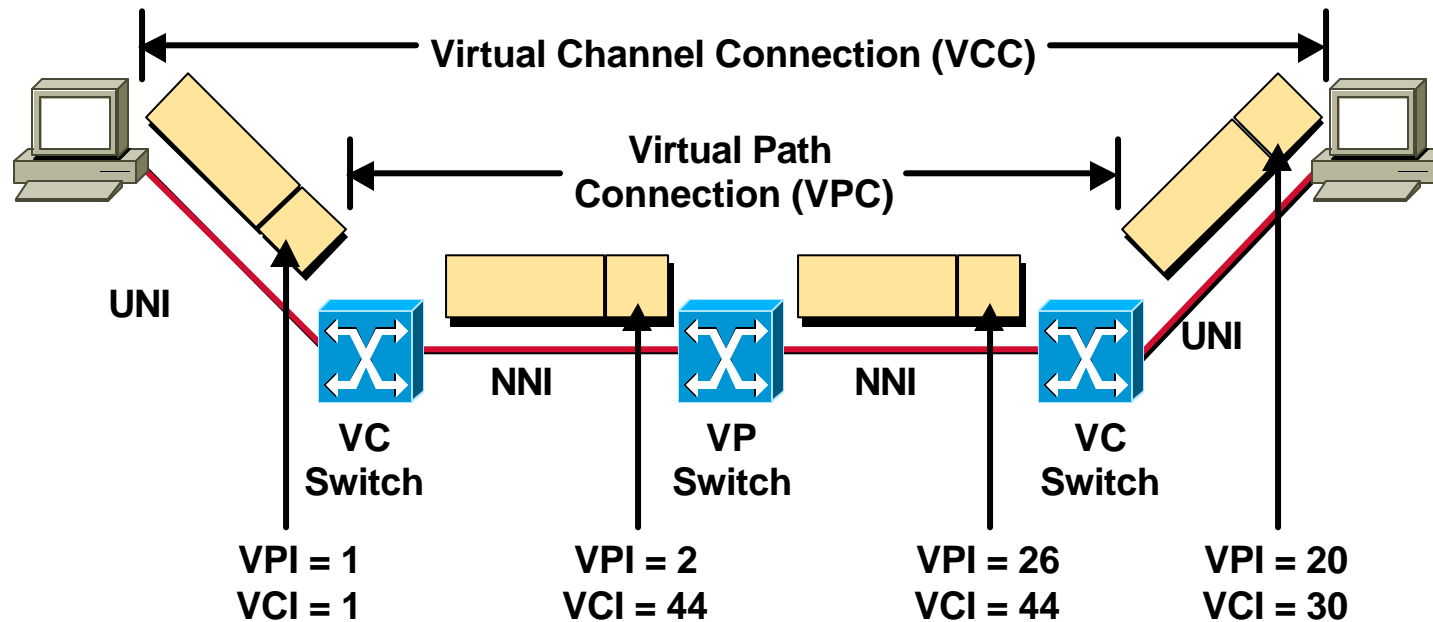


VP and VC Switching





Virtual Channels and Virtual Paths

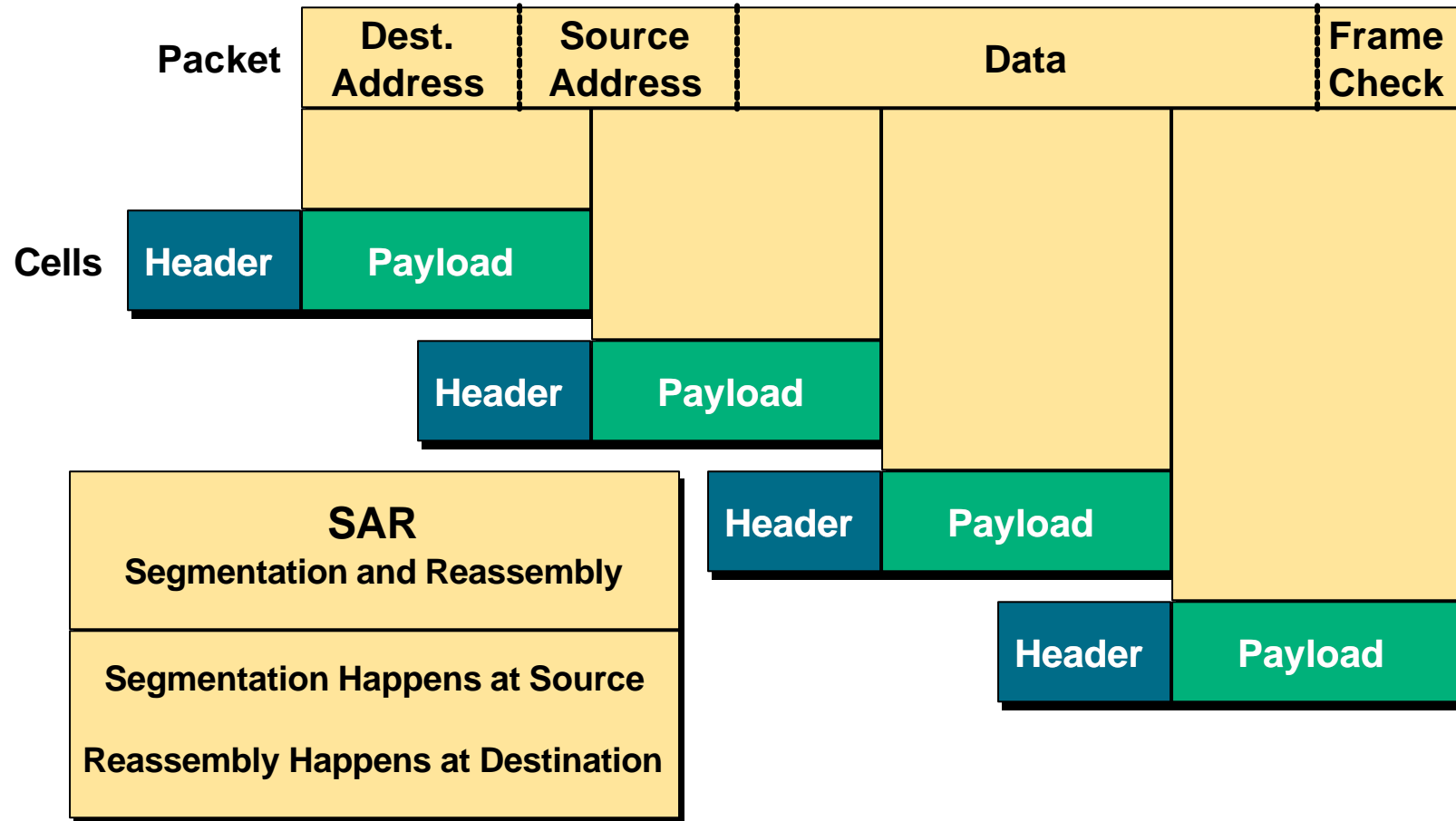


? This hop-by-hop forwarding is known as cell relay

Rudimentary ATM Concepts

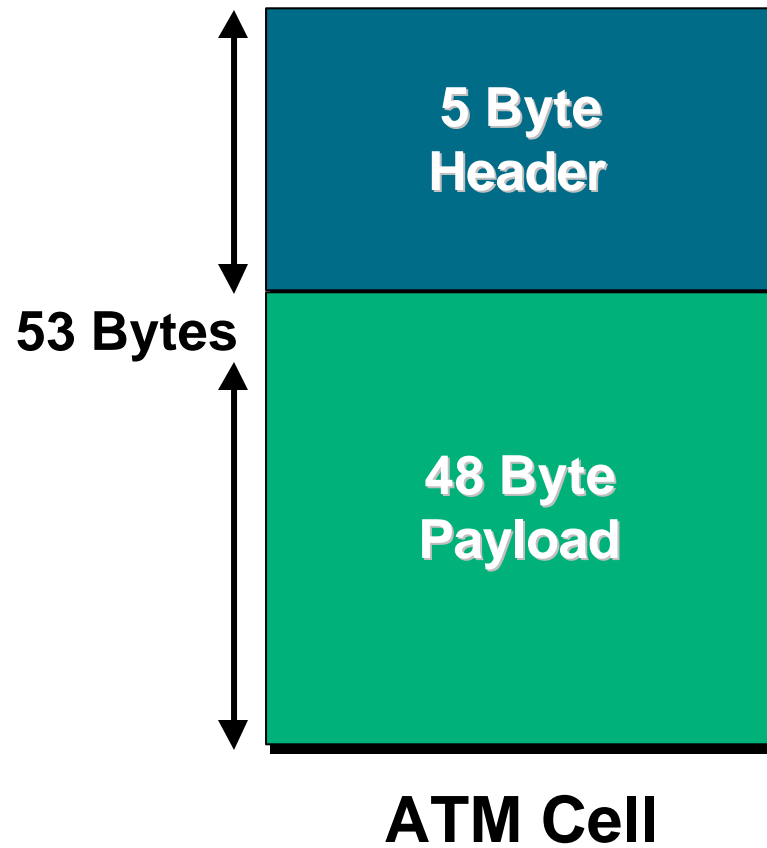
- ? **Physical layer**
- ? **Signaling**
- ? **Cell format**
- ? **Connection types**

Creating Cells from Packets



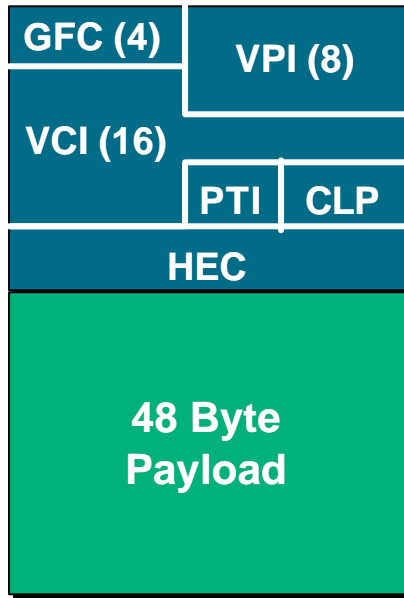


ATM Cell Header

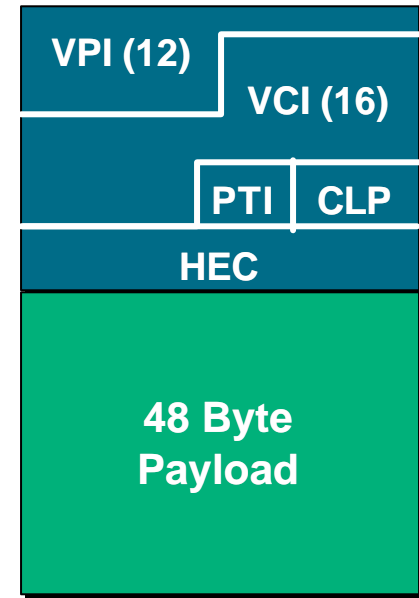
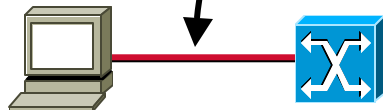




ATM Cell Header Details



ATM **UNI** Cell



ATM **NNI** Cell



- GFC** Generic Flow Control
UNI Cells Only!
- VPI/VCI** Identifies Virtual Paths and Channels
- PTI** Payload Type Identifier
3 Bits:
 - 1. User/Control Data
 - 2. Congestion
 - 3. Last Cell
- CLP** Cell Loss Priority Bit
- HEC** Header Error Check
8 Bit CRC

Rudimentary ATM Concepts

- ? **Physical layer**
- ? **Signaling**
- ? **Cell format**
- ? **Connection types**

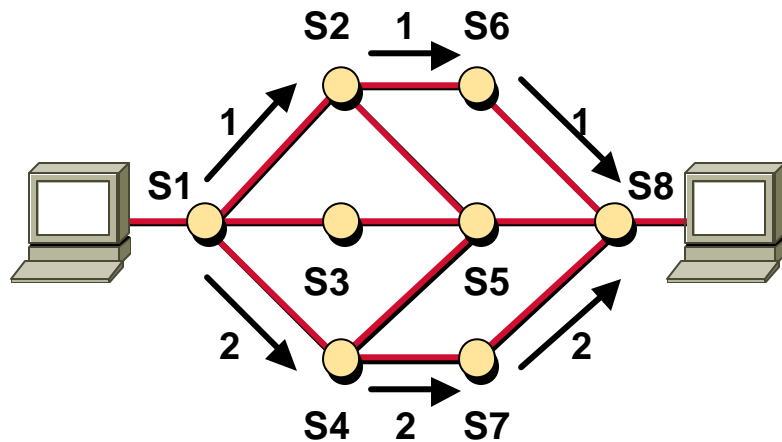
ATM Connection Types

? PVC

? SVC

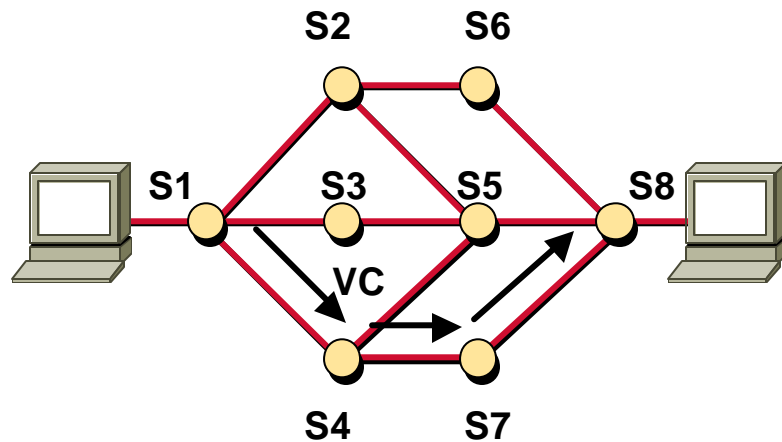
? Soft PVC

Connection Types



Connectionless: Packet Routing

- ? Path 1 = S1, S2, S6, S8
- ? Path 2 = S1, S4, S7, S8
- ? Data can take different path and can arrive out of order

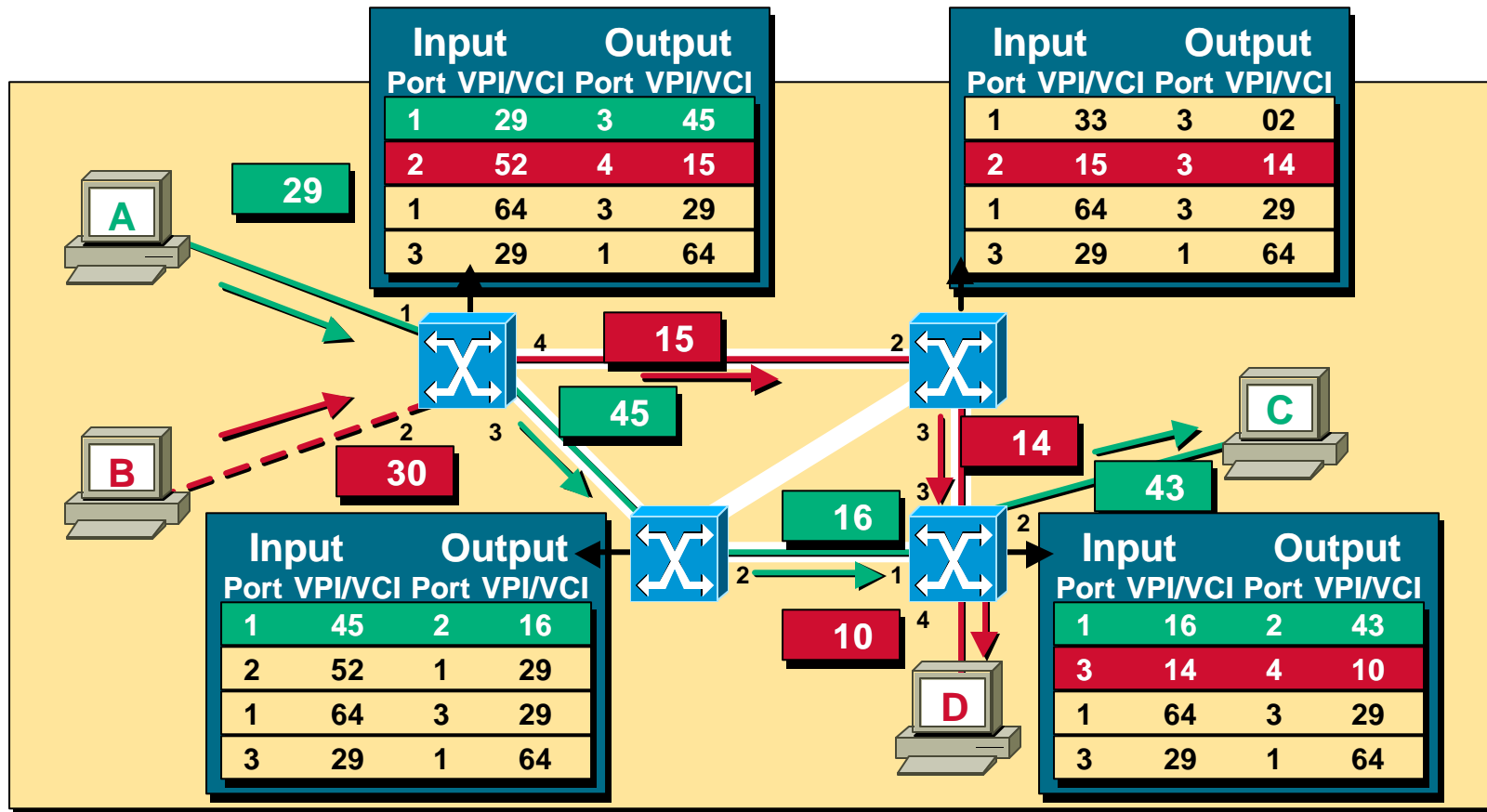


Connection Oriented: Cell Switching

- ? VC = S1, S4, S7, S8
- ? Data takes the same path and arrives in sequence



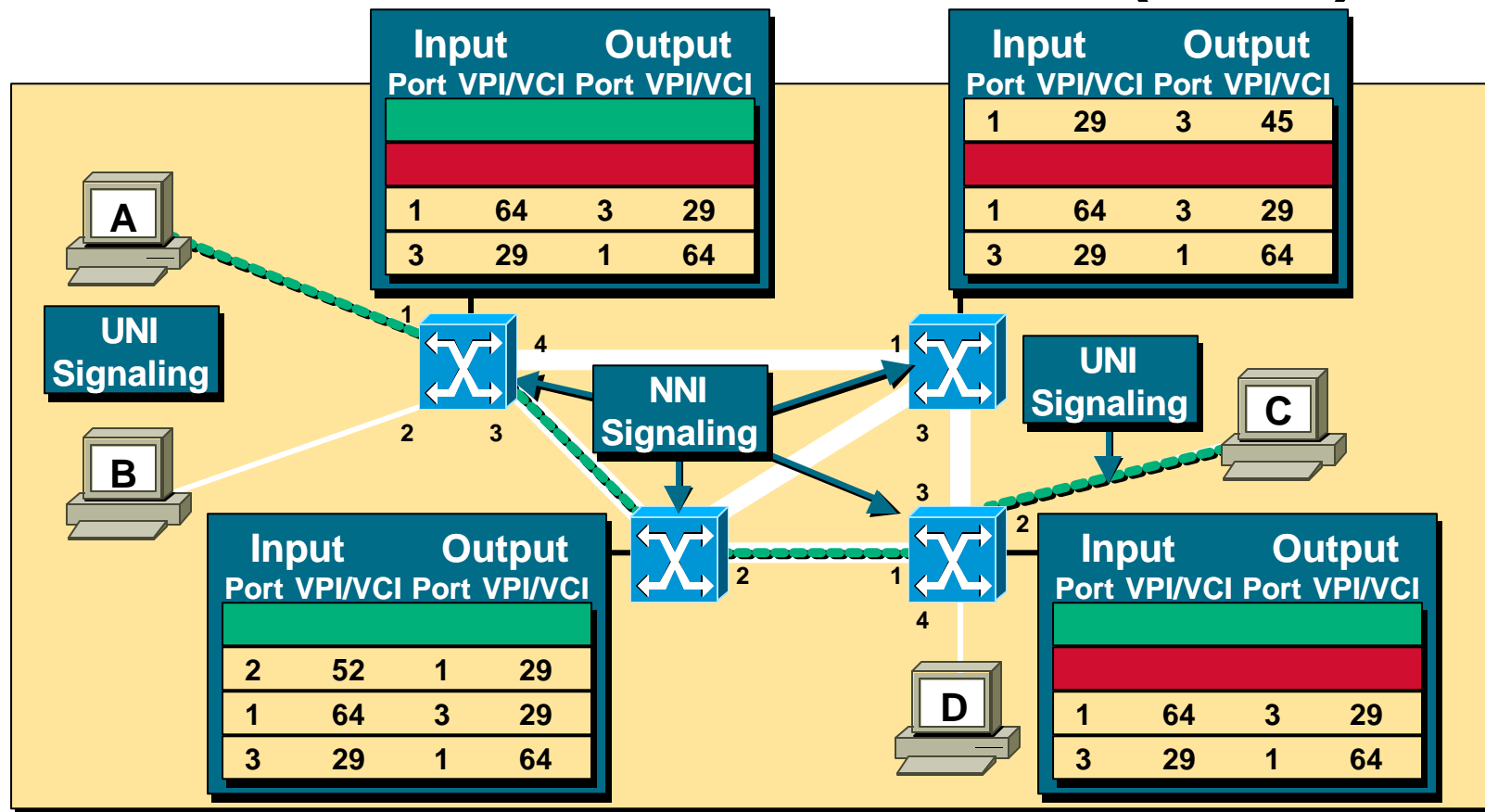
Permanent Virtual Circuit (PVC)



? VPI/VCI tables in network equipment updated by administrator



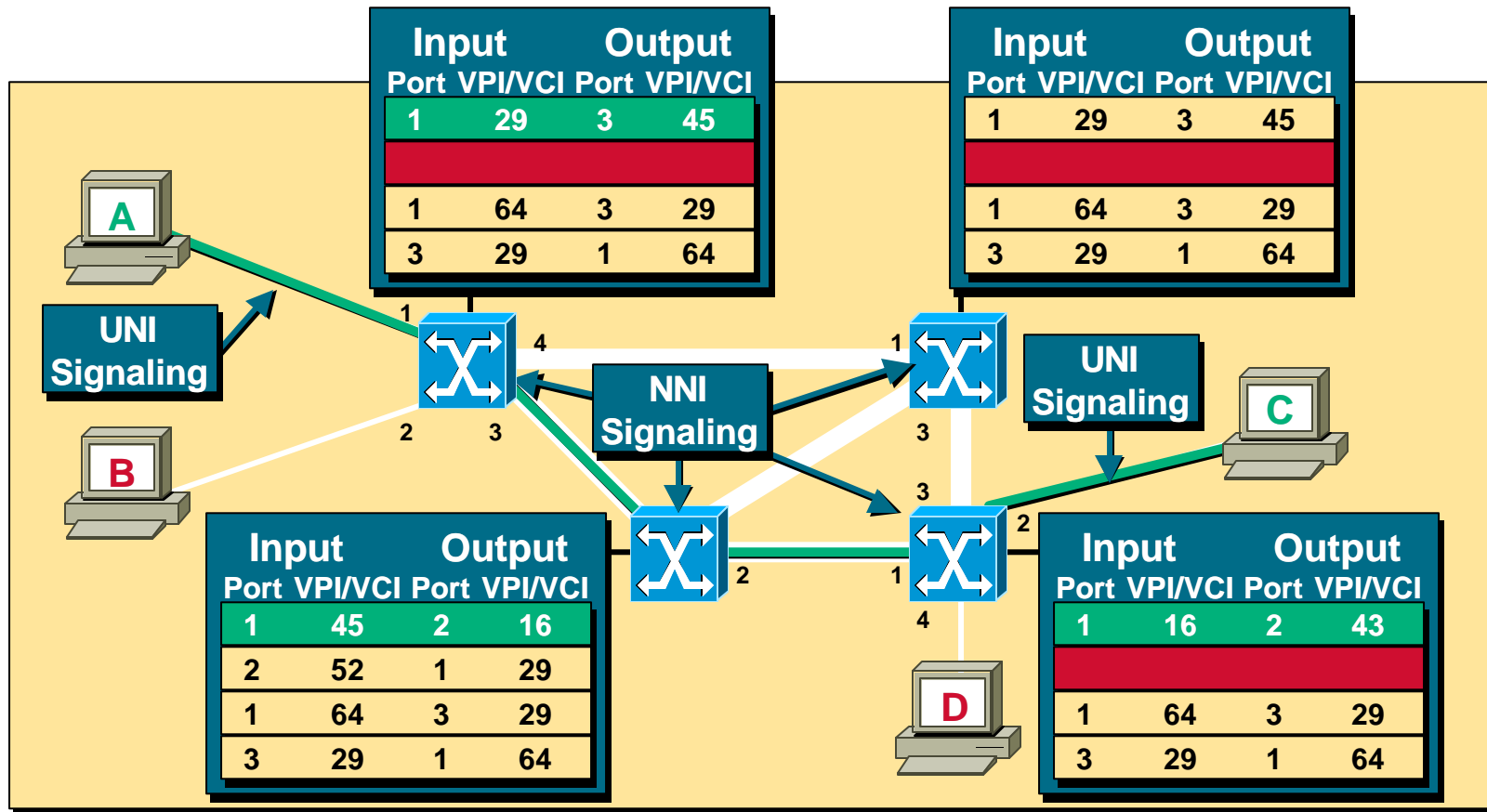
Switched Virtual Circuit (SVC)



? Dynamically set up connections via signaling

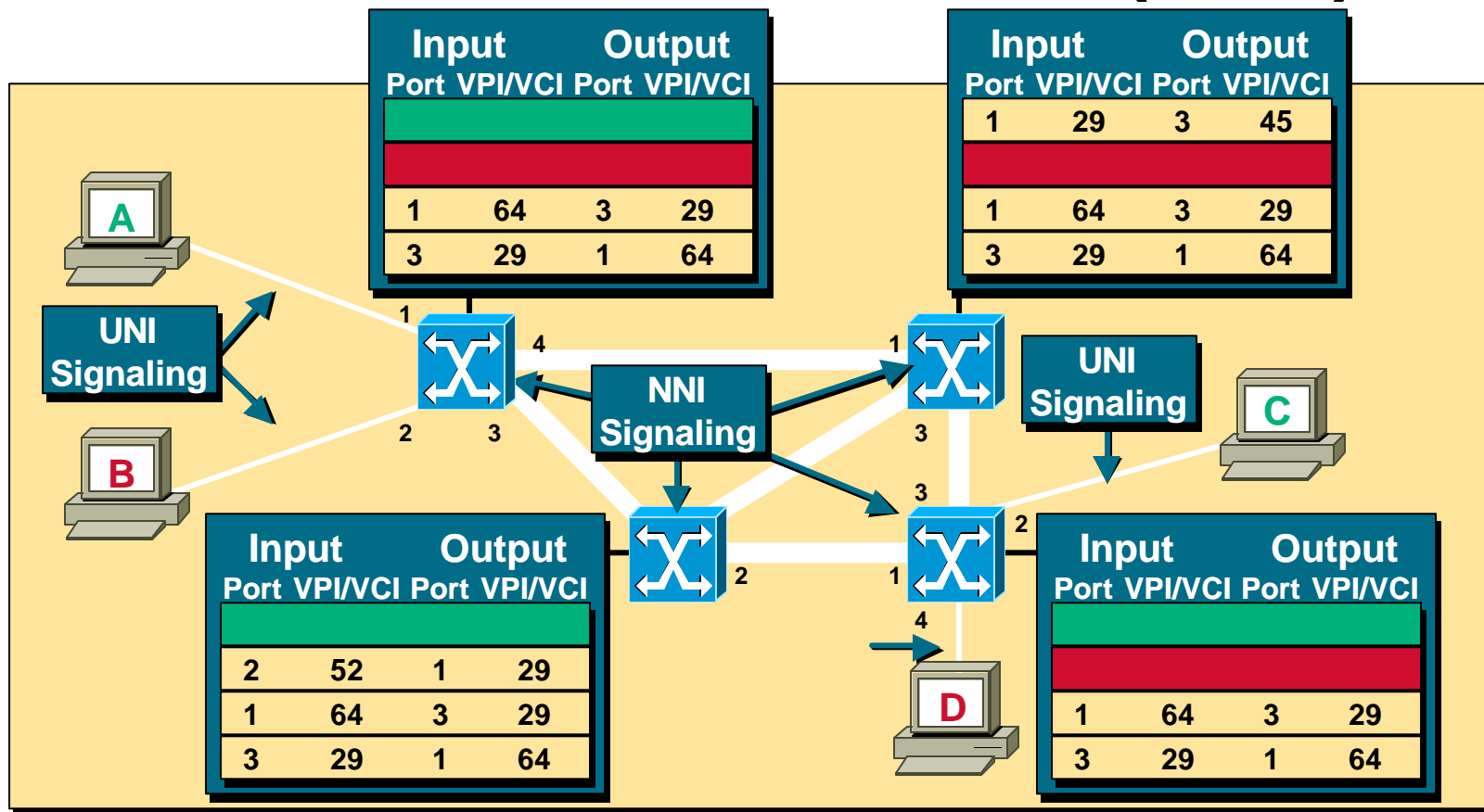


Switched Virtual Circuit (SVC)



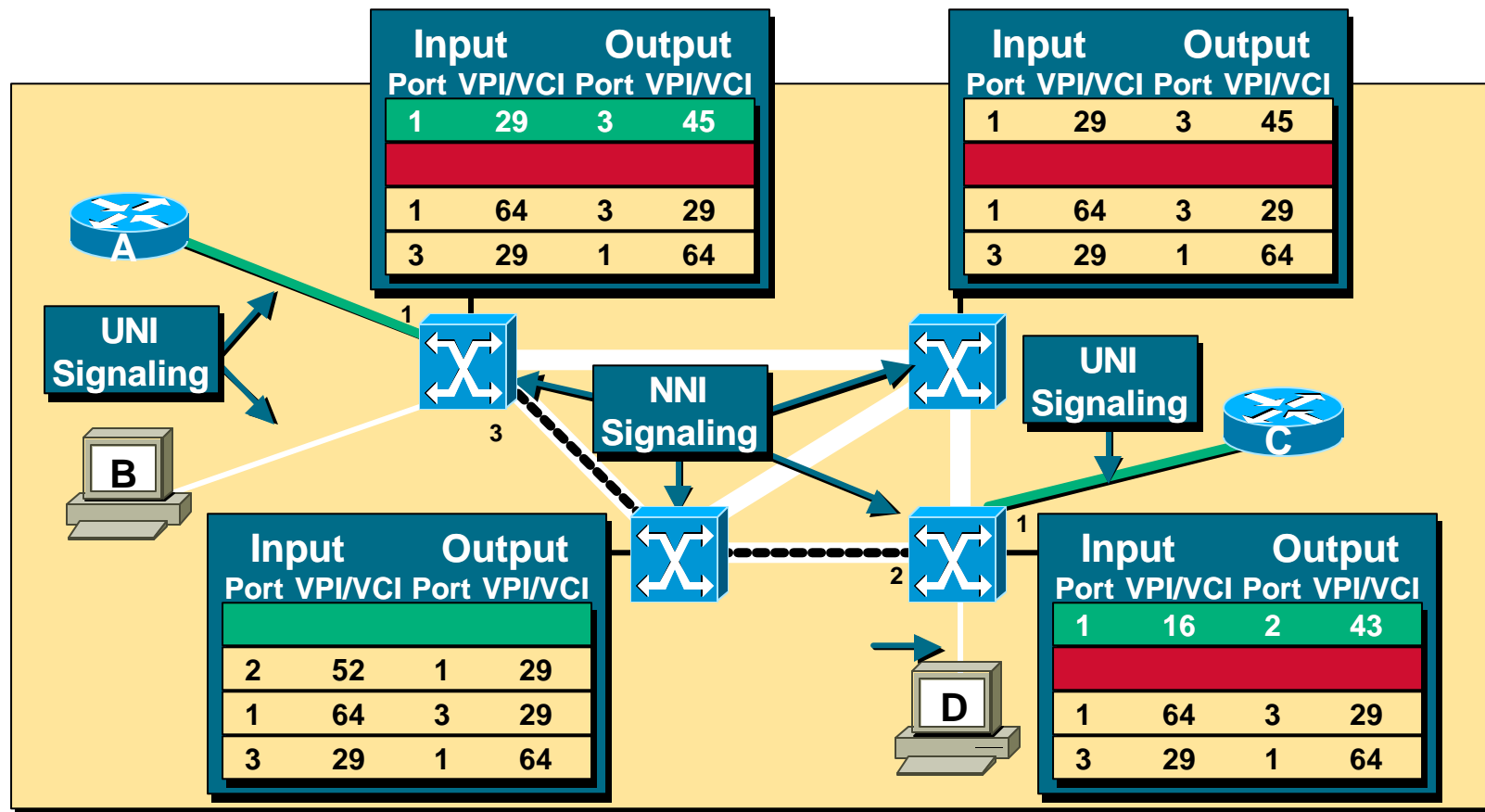
? Transfer data over newly established link

Switched Virtual Circuit (SVC)



? Dynamically tear down connections via signaling

Soft PVC



? PVC established manually across **UNI**
and dynamically across **NNI**

ATM Reference Model

? Physical layer

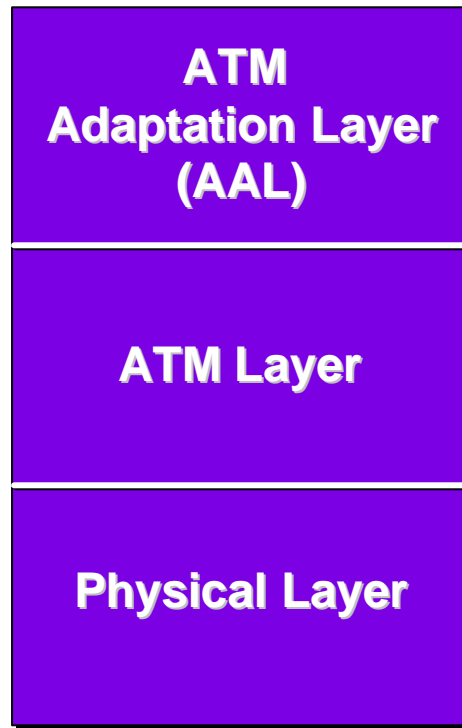
? ATM layer

? ATM adaptation layer

? A day in the life of a cell

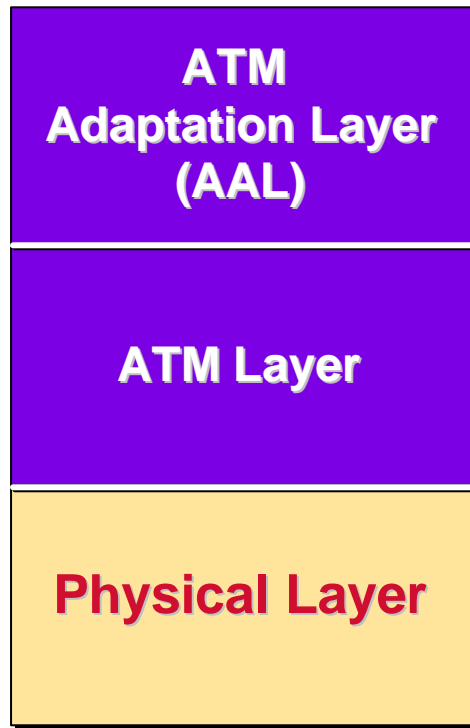


ATM Reference Model





ATM Reference Model



Physical Layer

Two Sublayers:

? Transmission Convergence (TC)

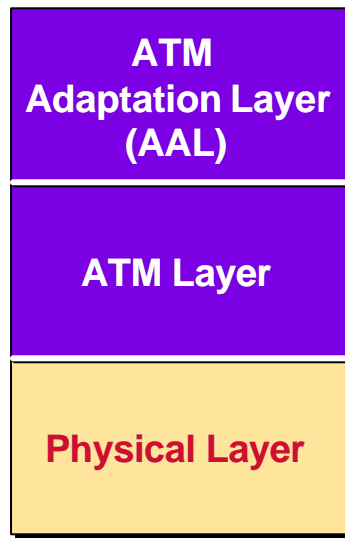
Framing

HEC

? Physical Media Dependent (PMD)

Physical media coding

Physical Layer

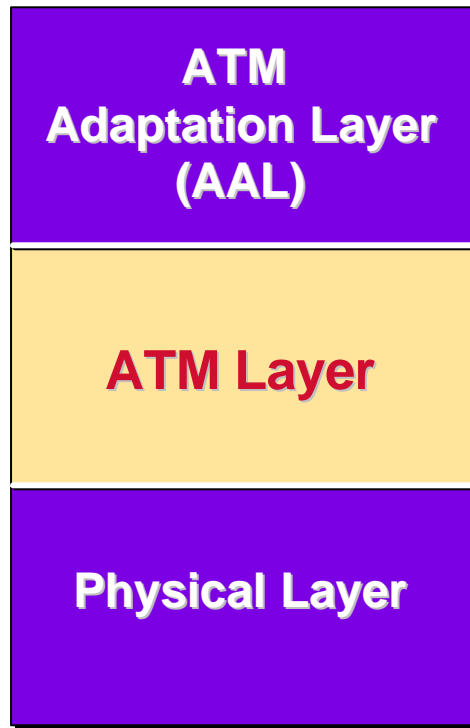


Framing	Data Rate (Mbps)	Media					
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ATM25	25.6					✓	
STS 1	51.8					✓	
STS3c/STM1	155	✓	✓		✓	X	
STS 12c/STM4	622	✓	✓				
4B/5B (TAXI)	100	✓					
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✓ = Standardized X = Proposed/In Progress



ATM Reference Model

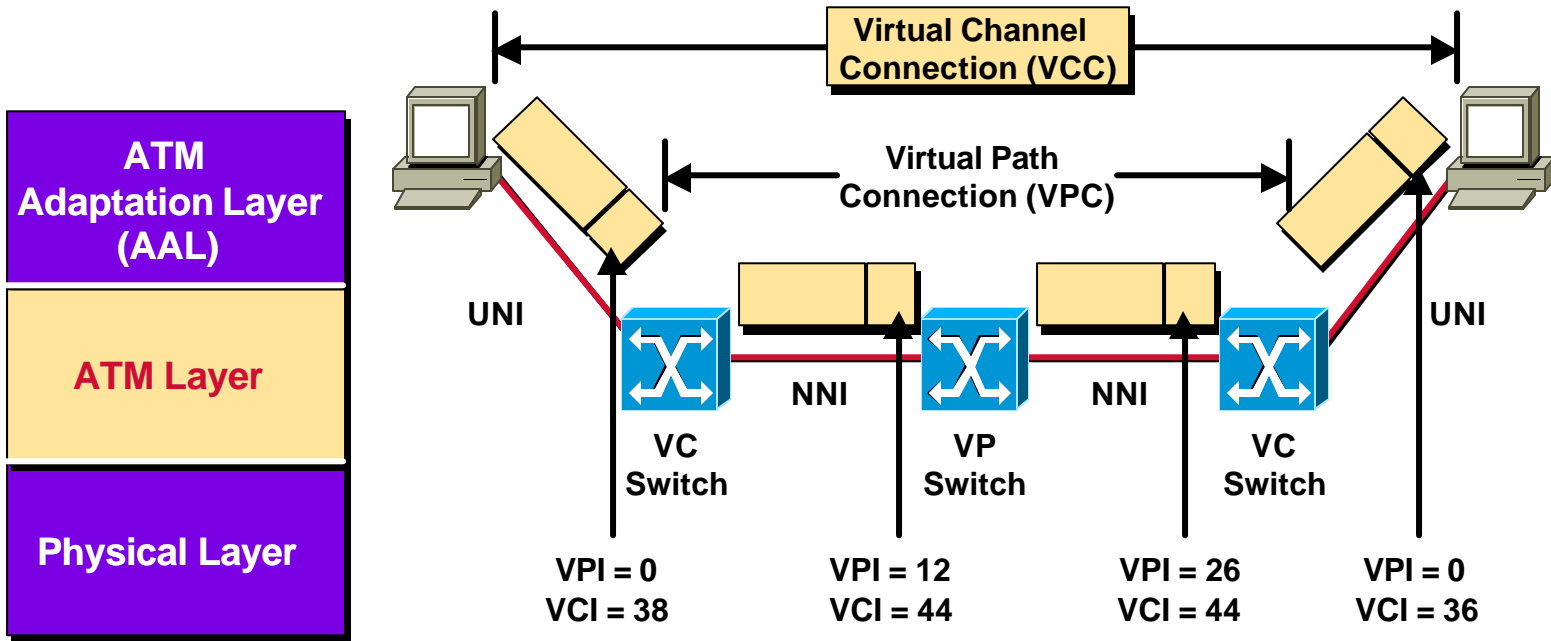


ATM Layer

- ? Cell header insertion/removal
- ? Cell Relay
- ? Multiplexes/demultiplexes cells of different connections



ATM Layer



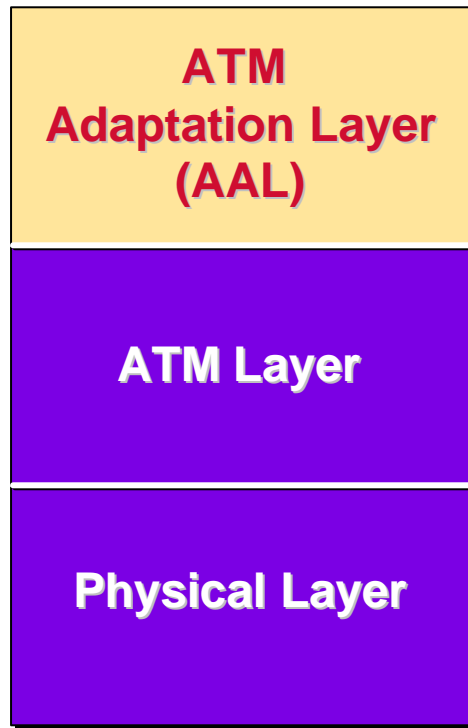
? Provides VPI/VCI values in header

? Ensures that cells stay in the correct order



ATM Reference Model

ATM Adaptation Layer (AAL)



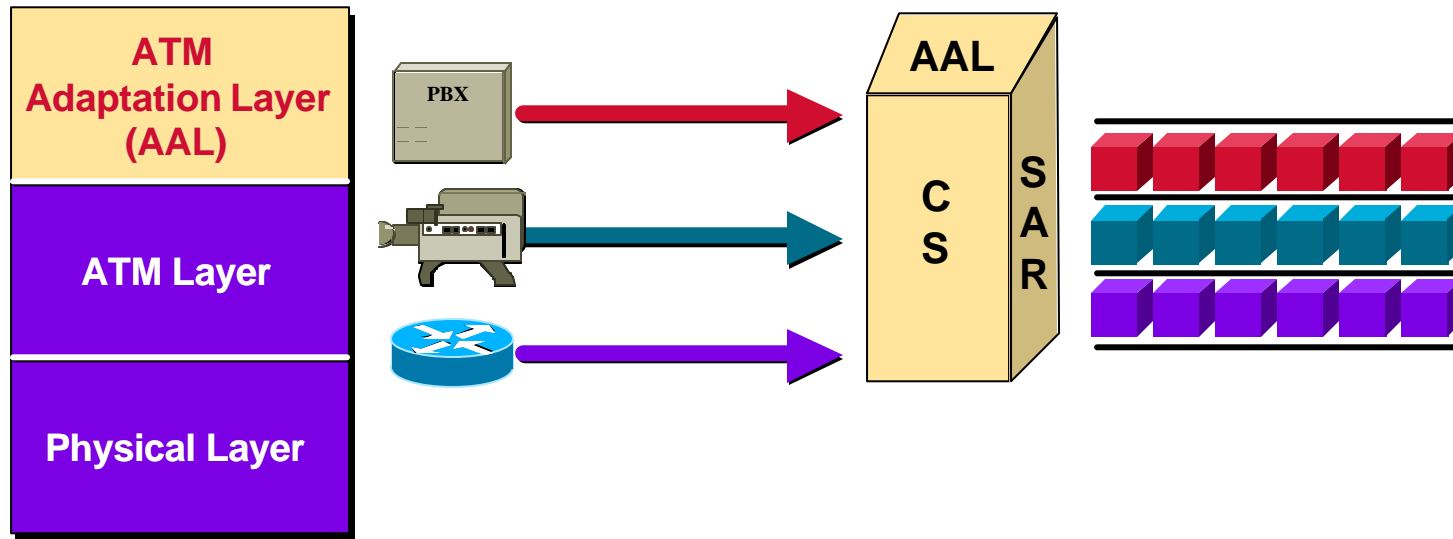
Two Sublayers:

? **Convergence Sublayer (CS)**

? **Segmentation and Reassembly (SAR)**



ATM Adaptation Layer—AAL

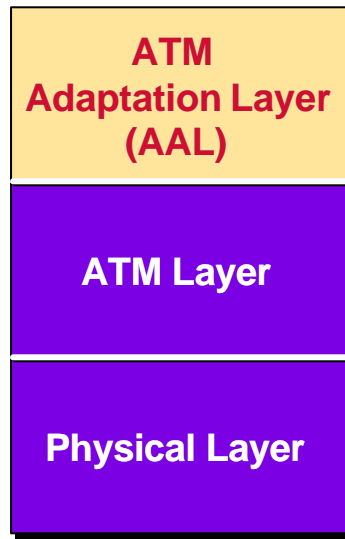


AAL = QoS + SAR

- ? CS—assigns different AAL's/QoS for different traffic types
- ? SAR—cell <-> packet



ATM Adaptation Layer



Class	Service Categories	Bit Rate	Connection Mode	Timing Concern	Application Examples
A	AAL1	CBR (Constant)	Connection-Oriented	Yes	<ul style="list-style-type: none">• Bandwidth and throughput guaranteed• Good for voice and video
B	AAL2	VBR (Variable) VBR-AT and VBR-NRT	Connection-Oriented	Yes	<ul style="list-style-type: none">• Best effort bandwidth and throughput• Good for live video, multimedia, LAN-to-LAN
C	AAL5	ABR (Available)	Connection-Oriented	No	<ul style="list-style-type: none">• Best effort with congestion feedback• Reliable delivery of bursty traffic if latency okay
D	AAL3/4	UBR (Un-specified)	Connection-less	No	<ul style="list-style-type: none">• No guarantee• For SMDS/LAN

ATM Reference Model

? Physical layer

? ATM layer

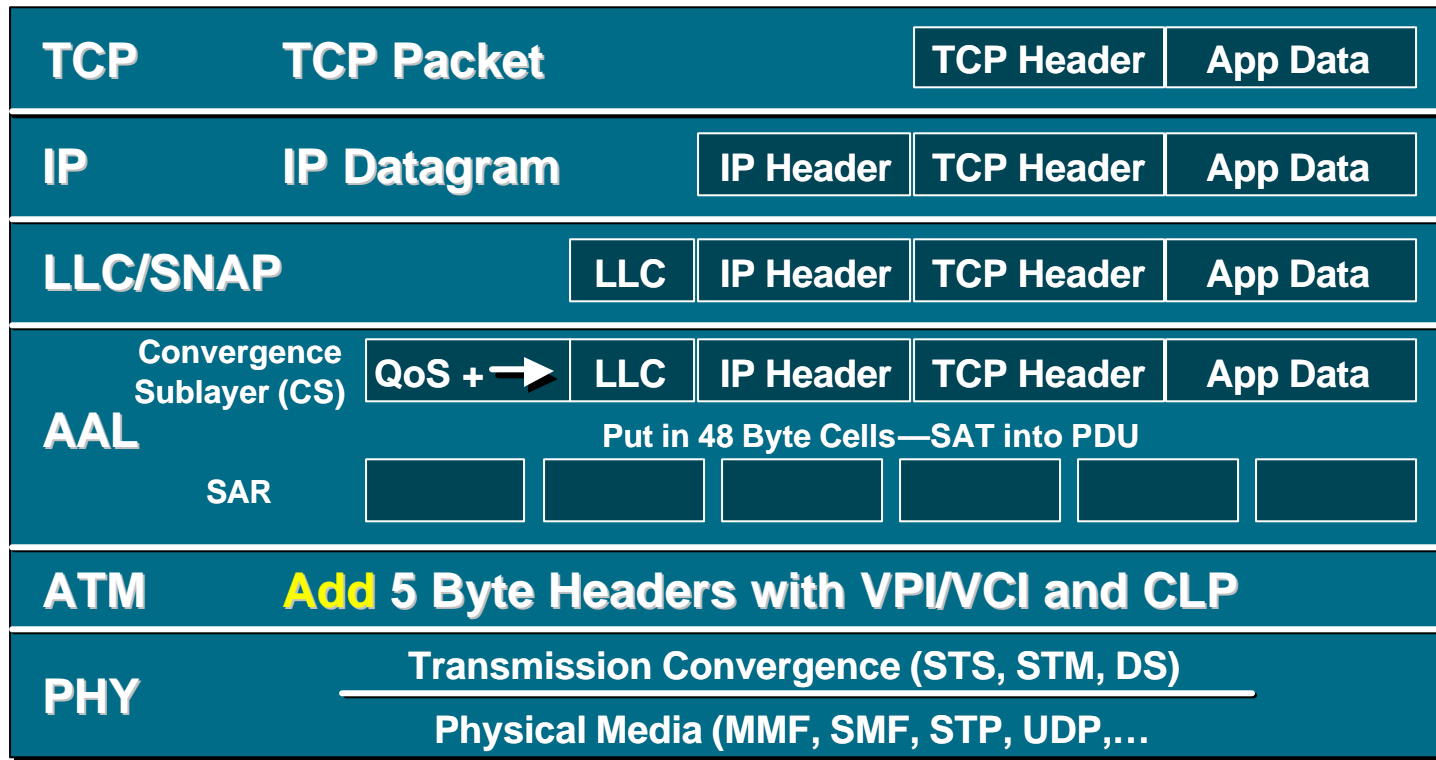
? ATM adaptation layer

? A day in the life of a cell



A Day in the Life of a Cell

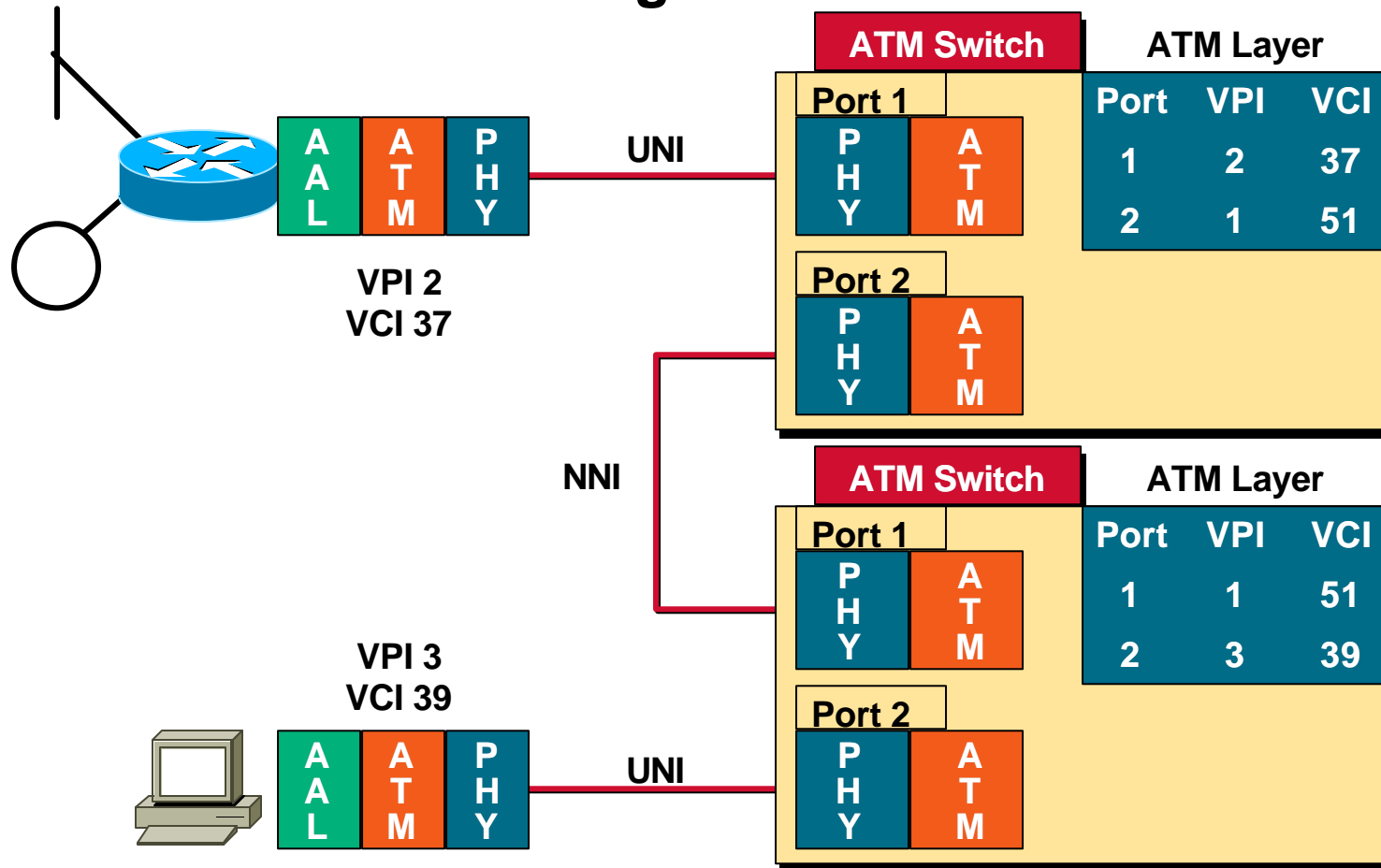
ATM Payload Processing





A Day in the Life of a Cell

Traversing the Network



Agenda

? Introduction

? ATM Fundamentals

Rudimentary ATM Concepts

ATM Reference Model

ATM Adaptation Layer (AAL)

Traffic Management

? ATM Transport Standards

? Campus ATM Internetworking

? Wrap Up

AAL

? AAL criteria

Traffic parameters

QoS parameters

? The AAL's

AAL1—CBR

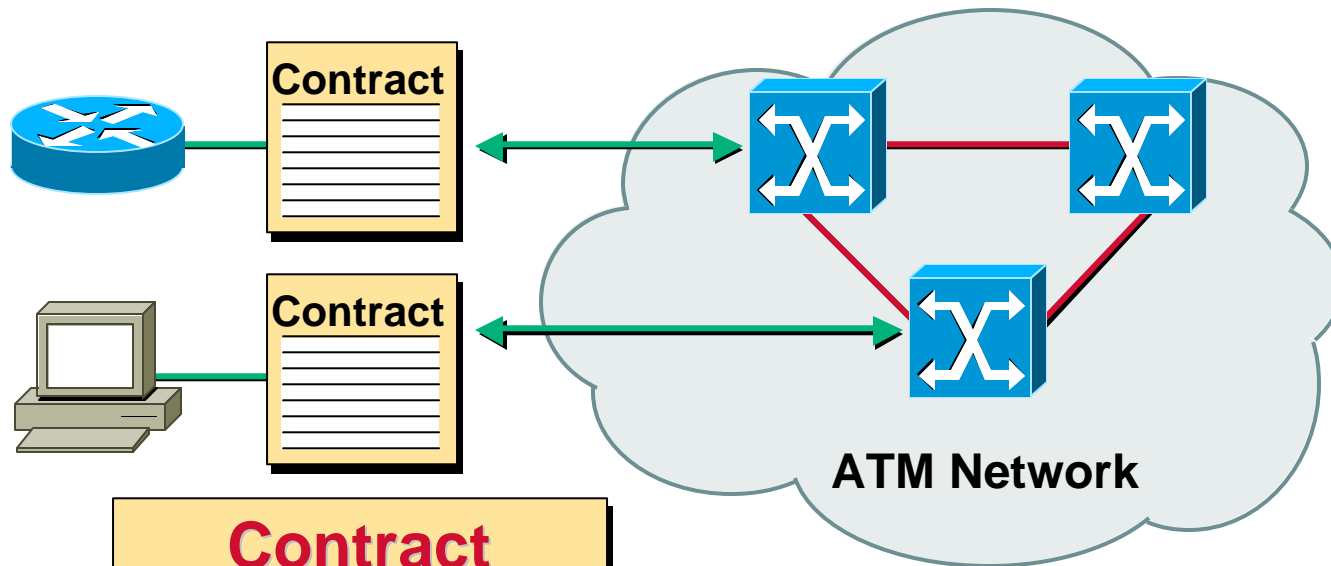
AAL2—VBR

AAL3/4—UBR

AAL5—ABR



AAL Criteria



Contract

? Traffic Parameters

- Peak cell rate
- Sustainable cell rate
- Maximum burst size
- Minimum Cell Rate

? Quality of Service

- Delay
- Cell loss

AAL Criteria

Traffic Parameters

- ? **Peak Cell Rate—PCR—Maximum data rate a connection can handle without losing data**
- ? **Sustainable Cell Rate—SCR—Average ATM cell throughput the application is permitted**
- ? **Maximum Burst Size—MBS—Size of the maximum burst of contiguous cells that can be transmitted**
- ? **Minimum Cell Rate—MCR—Rate of an application's ability to handle latency**

AAL Criteria

QoS—Delay

- ? **Maximum Cell Transfer Delay—MCTD**
How long the network can take to transmit a cell from one endpoint to another
- ? **Cell Delay Variation Tolerance—CDVT**
Line distortion caused by change in interarrival times between cells aka jitter

AAL Criteria

QoS—Cell Loss

? Cell Loss Ratio—**CLR**

Acceptable percentage of cells that the network can discard due to congestion

Quality of Service—QoS

? AAL criteria

Traffic parameters

QoS parameters

? The AAL's

AAL1—CBR

AAL2—VBR

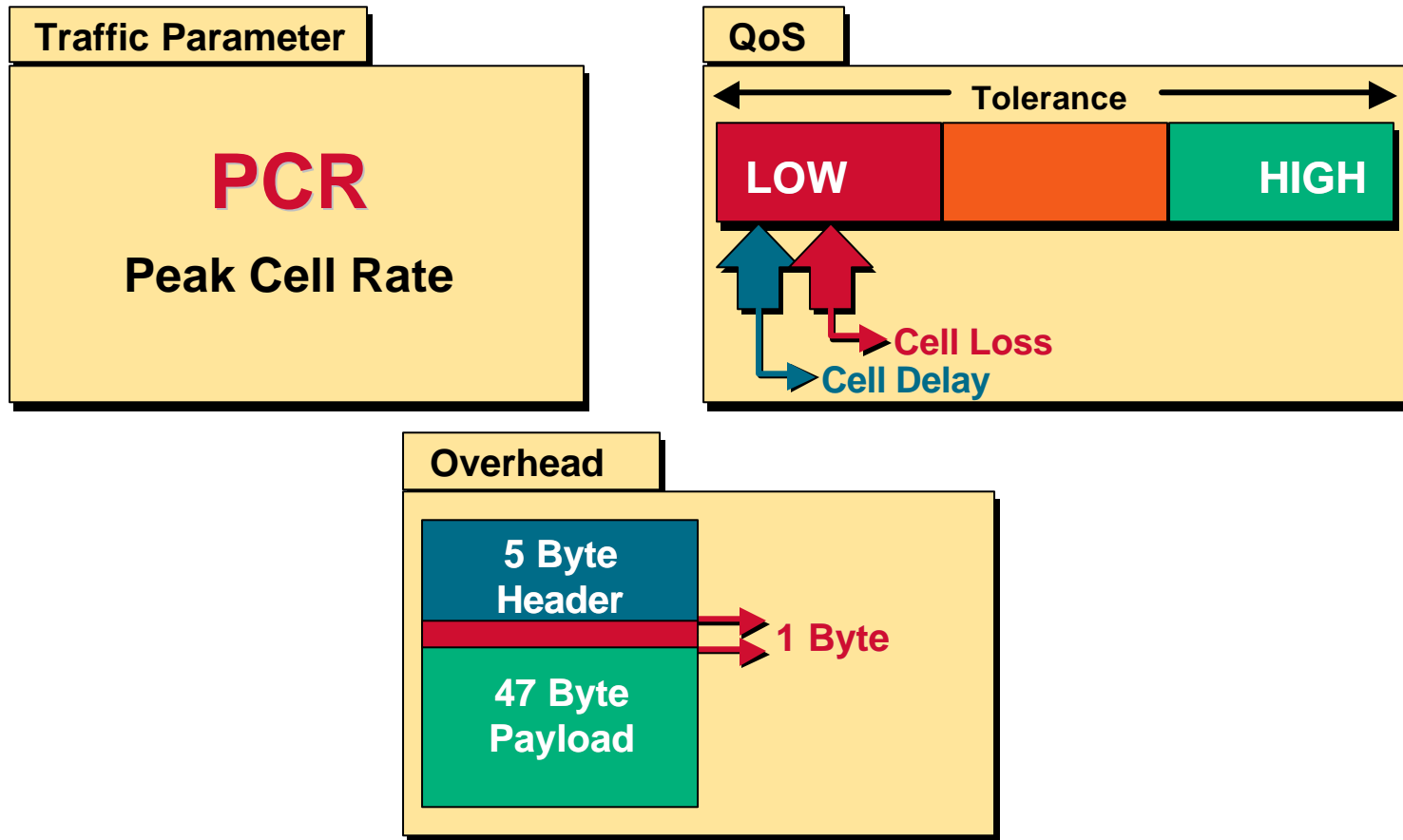
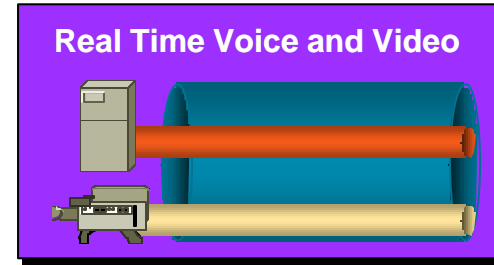
AAL3/4—UBR

AAL5—ABR



The AAL's

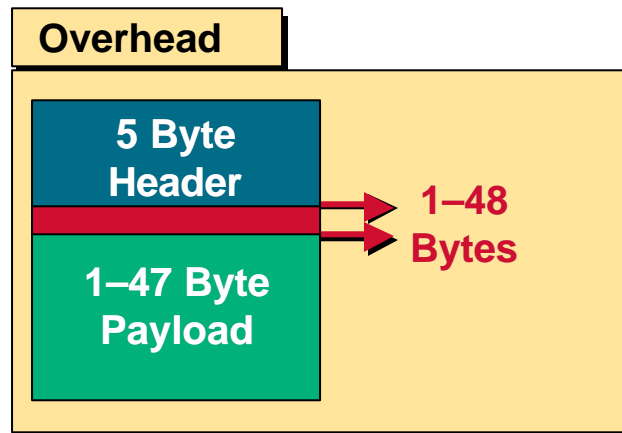
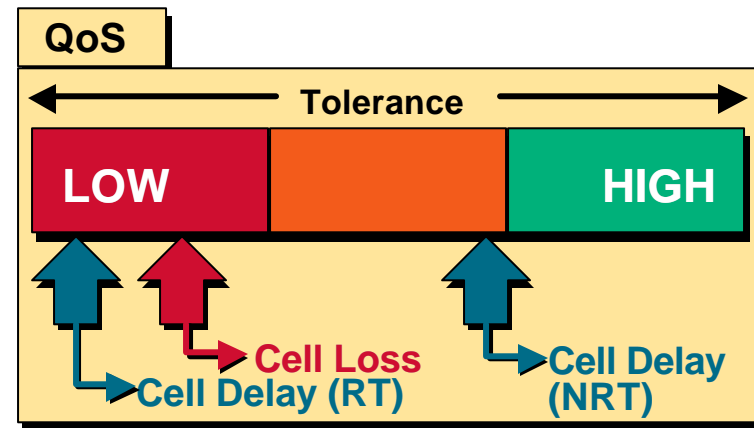
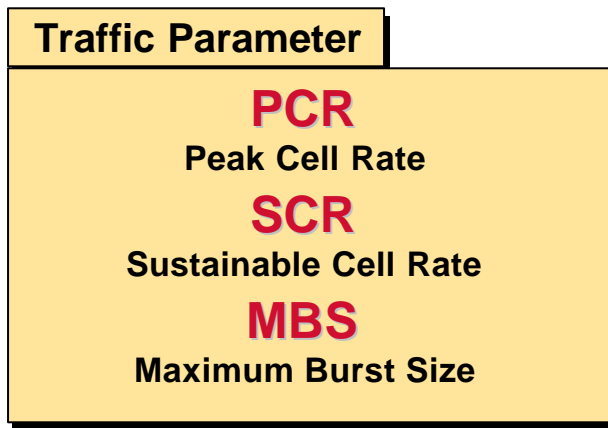
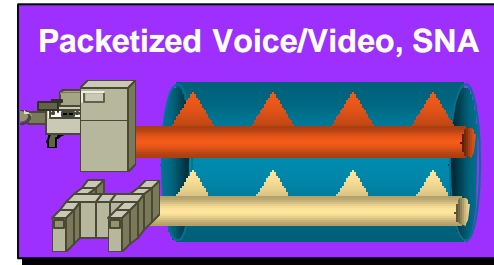
AAL1—Constant Bit Rate (CBR)





The AAL's

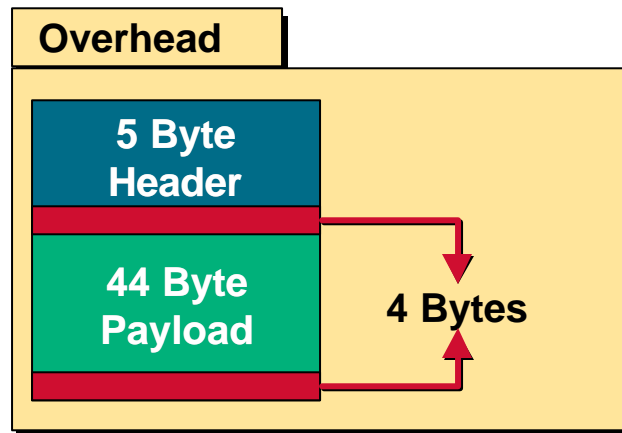
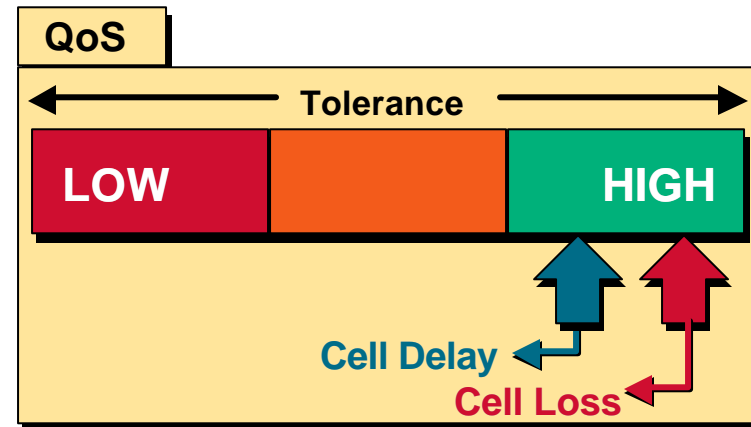
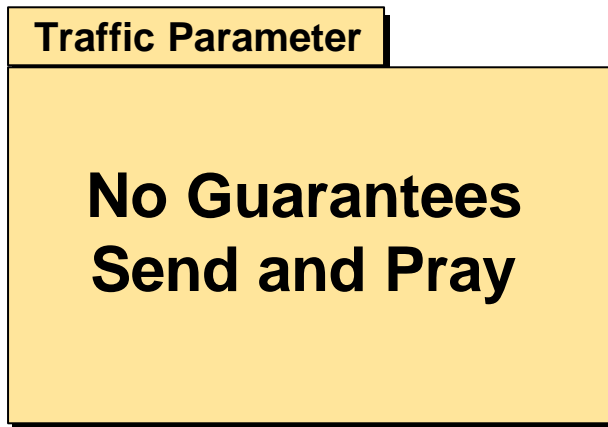
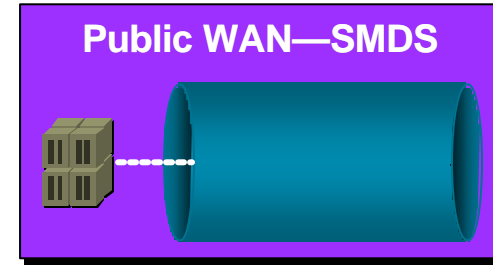
AAL2—Variable Bit Rate (VBR-RT/VBR-NRT)





The AAL's

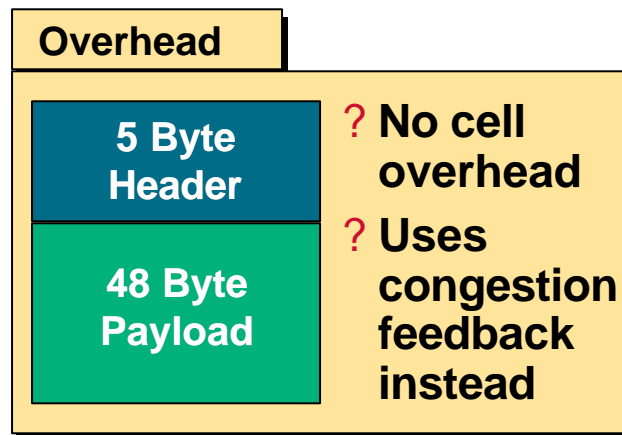
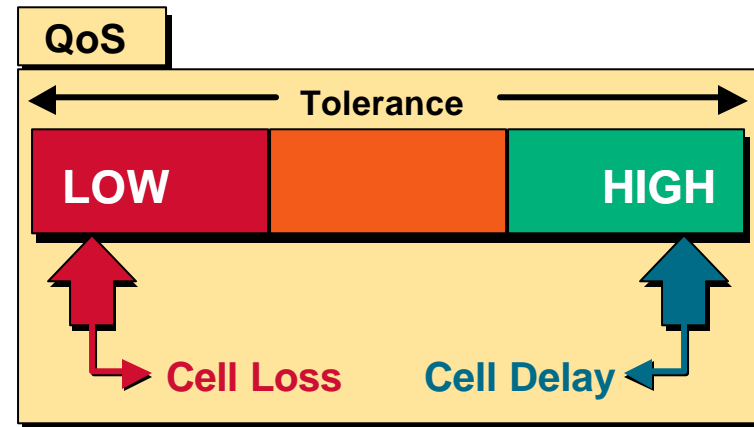
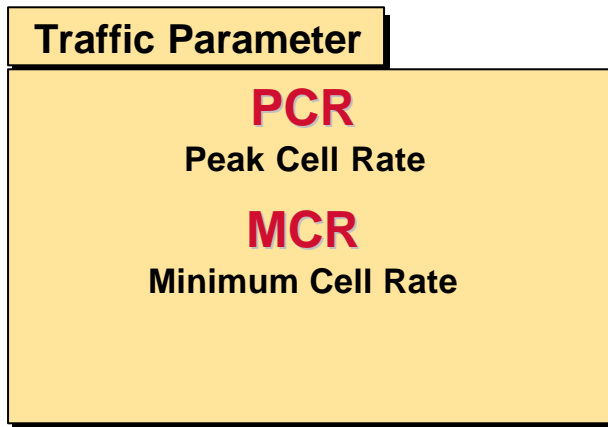
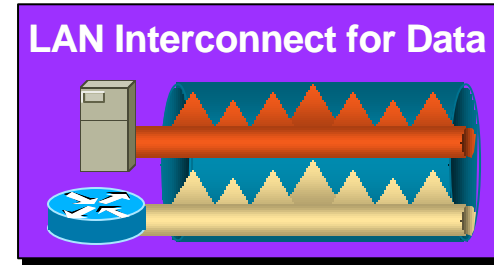
AAL3/4—Unspecified Bit Rate (UBR)





The AAL's

AAL5—Available Bit Rate (ABR)



Traffic Management

- ? Why traffic management?**
- ? Traffic control techniques**
- ? AAL5/ABR congestion feedback**
- ? Buffers are your friend**



Why Traffic Management?

- ? Proactively combat congestion**
- ? Provision for priority control**
- ? Maintain well-behaved traffic**



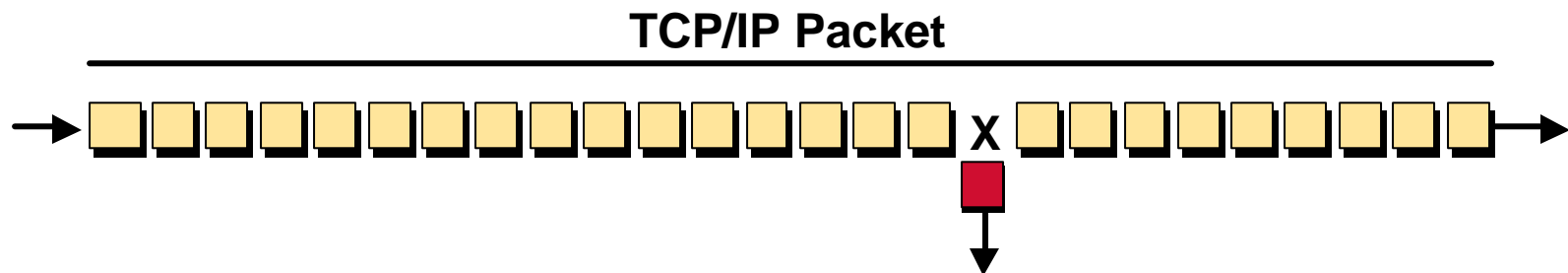
Why Traffic Management?

Cell Loss—Data's Critical Enemy

Ethernet (1500 Bytes) = 32 Cells

FDDI (4470 Bytes) = 96 Cells

IP over ATM-1577 (9180 Bytes) = 192 Cells



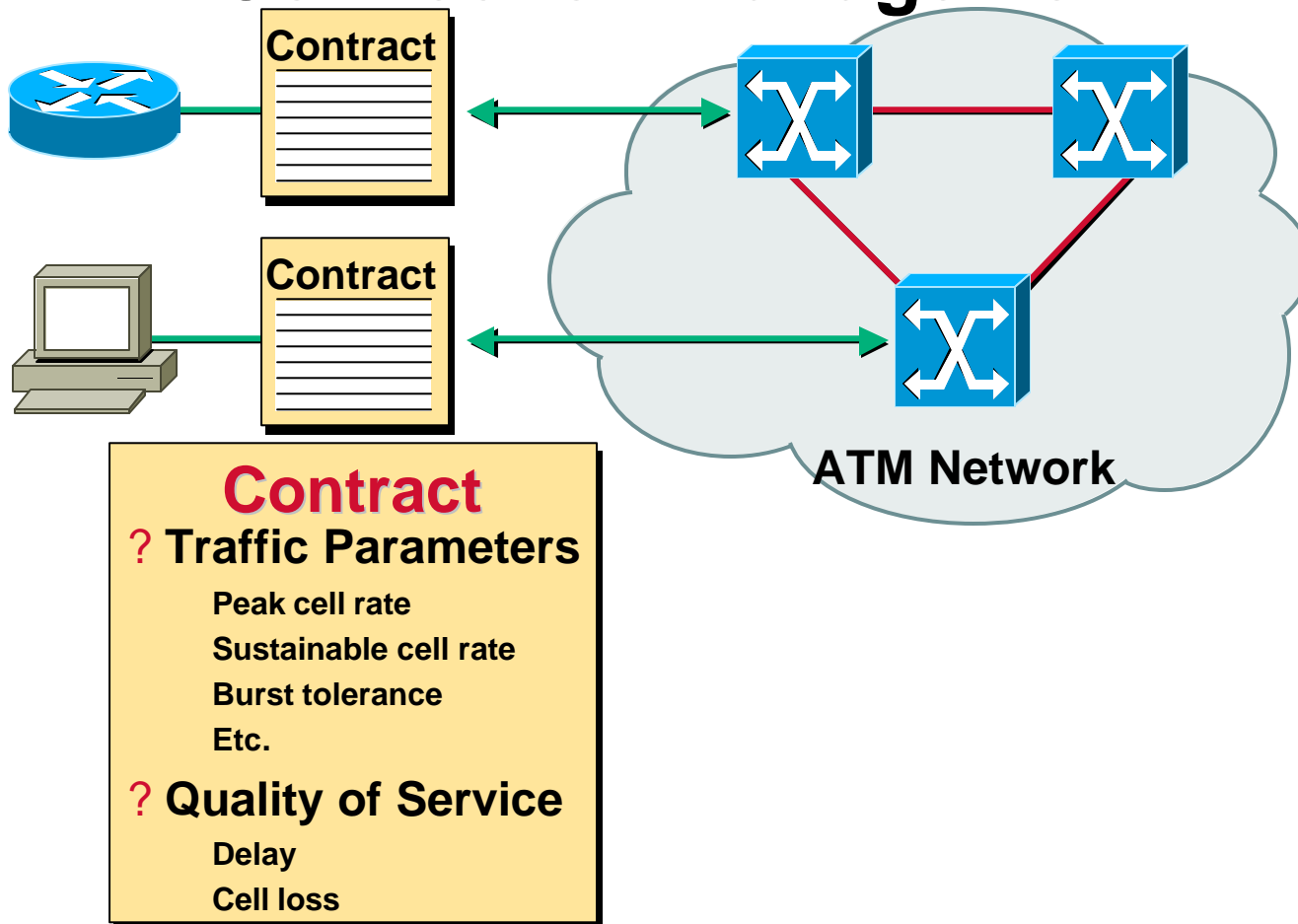
- ? Lose one cell and the rest are useless
- ? Need to re-transmit 32+ cells for one cell lost
- ? **Congestion collapse** is the result

Traffic Control Techniques

- ? **Connection management—Acceptance**
- ? **Traffic management—Policing**
- ? **Traffic smoothing—Shaping**

Traffic Control Techniques

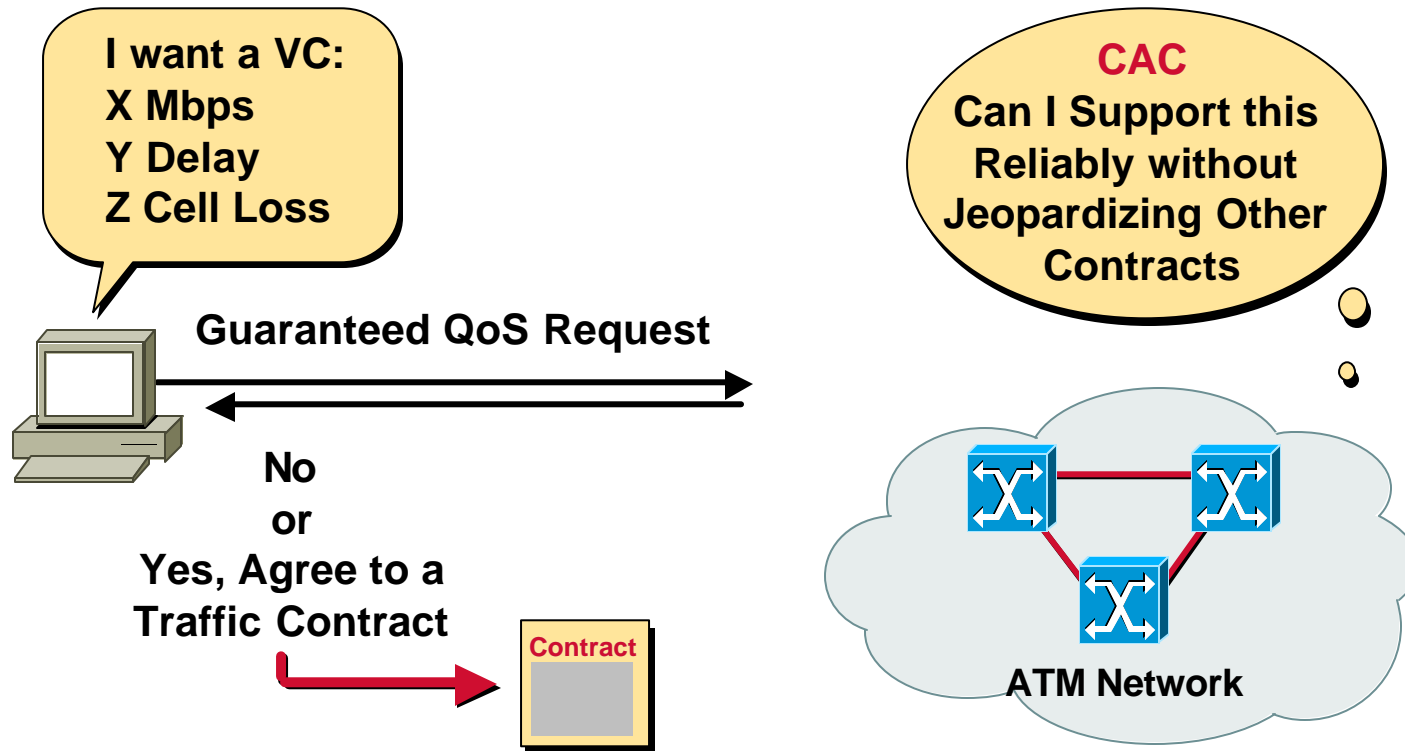
Connection Management





Traffic Control Techniques

Connection Management Connection Admission Control (CAC)

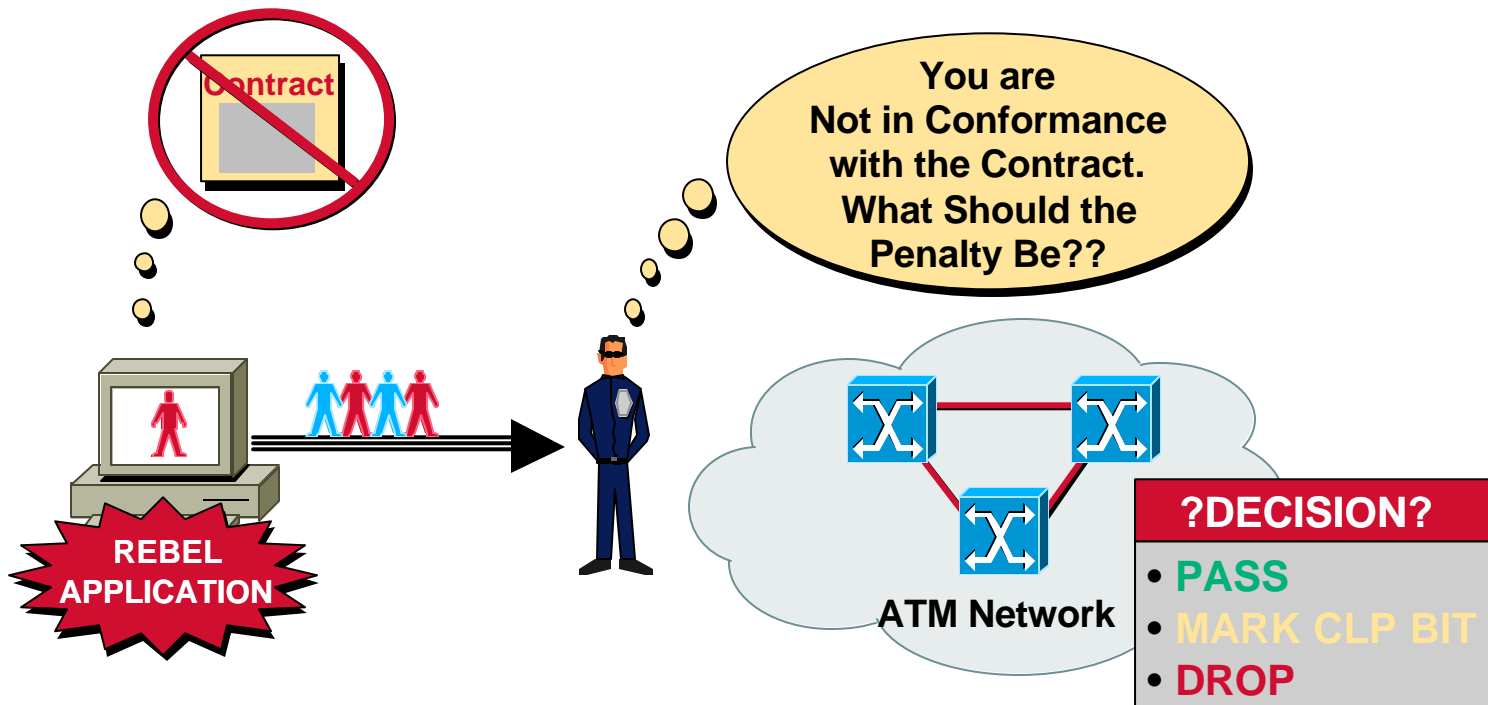




Traffic Control Techniques

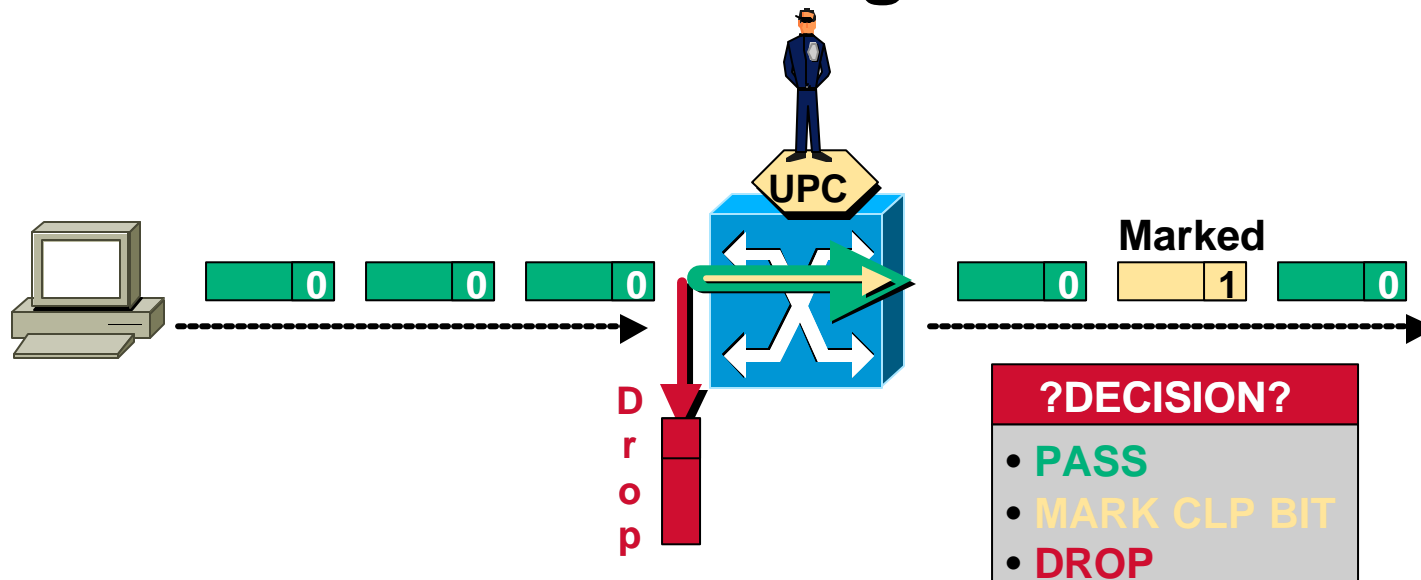
Traffic Management

Usage Parameter Control (UPC) aka **Policing**



Traffic Control Techniques

Traffic Management

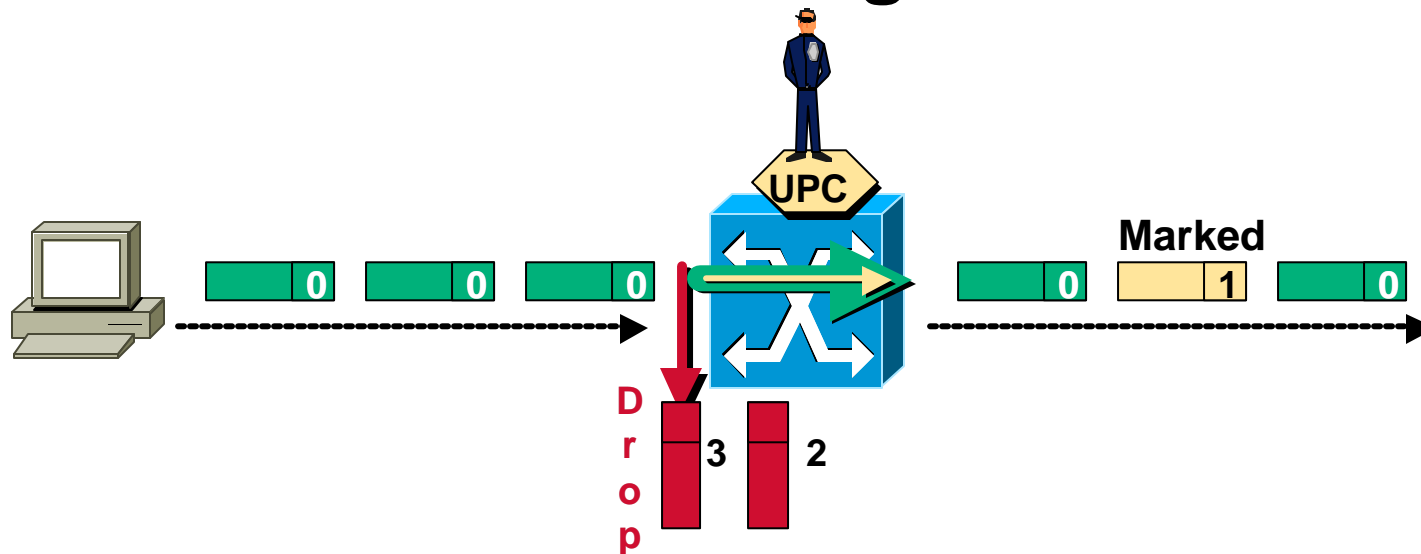


- ? CLP Control—When congested **drop** marked cells
- ? Public UNI—Generic Cell Rate Algorithm (GCRA)



Traffic Control Techniques

Traffic Management

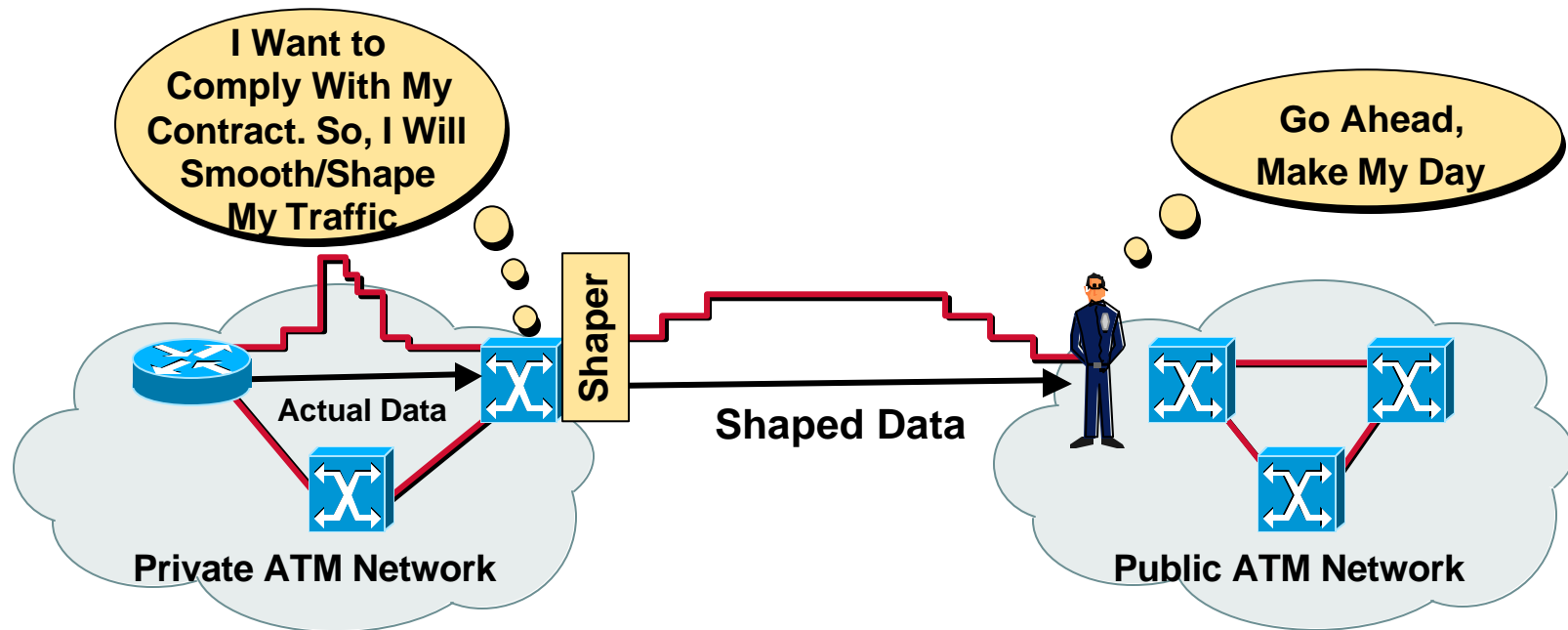


- ? Intelligent Packet Discard—**IPD**
- ? Discard cells from same 'bad' packet
- ? Tail packet discard
- ? Maximize “**Goodput**”



Traffic Control Techniques

Traffic Smoothing



- ? Traffic shaper at customer site
- ? Changes traffic characteristics
- ? Leaky bucket algorithm



Traffic Control Techniques

Buffers Are Your Friend

- ? Absorb traffic bursts from simultaneous connections
- ? Switches schedule traffic based on priority of traffic according to QoS
- ? Switch must reallocate buffers as the traffic mix changes
- ? **Effective buffering** maximizes throughput of usable cells as opposed to raw cells (aka goodput)

ATM Internetworking

? Challenges

? RFC1483

? RFC1577

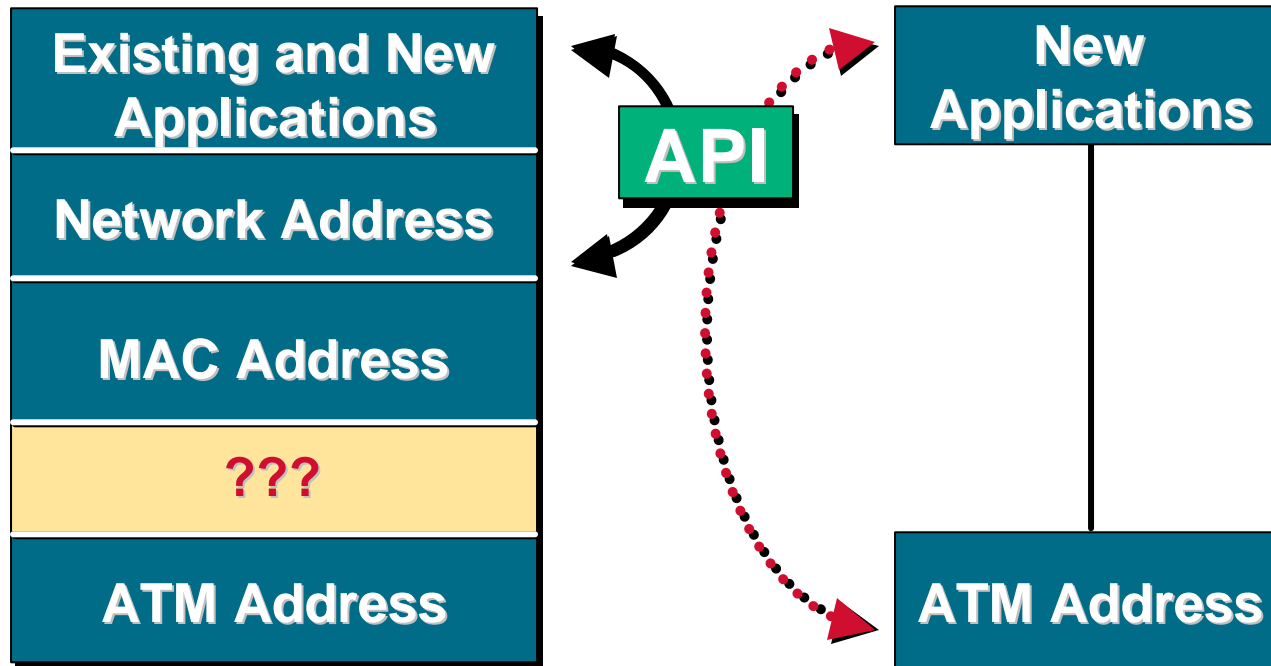
? LANE

? MPOA



ATM Internetworking

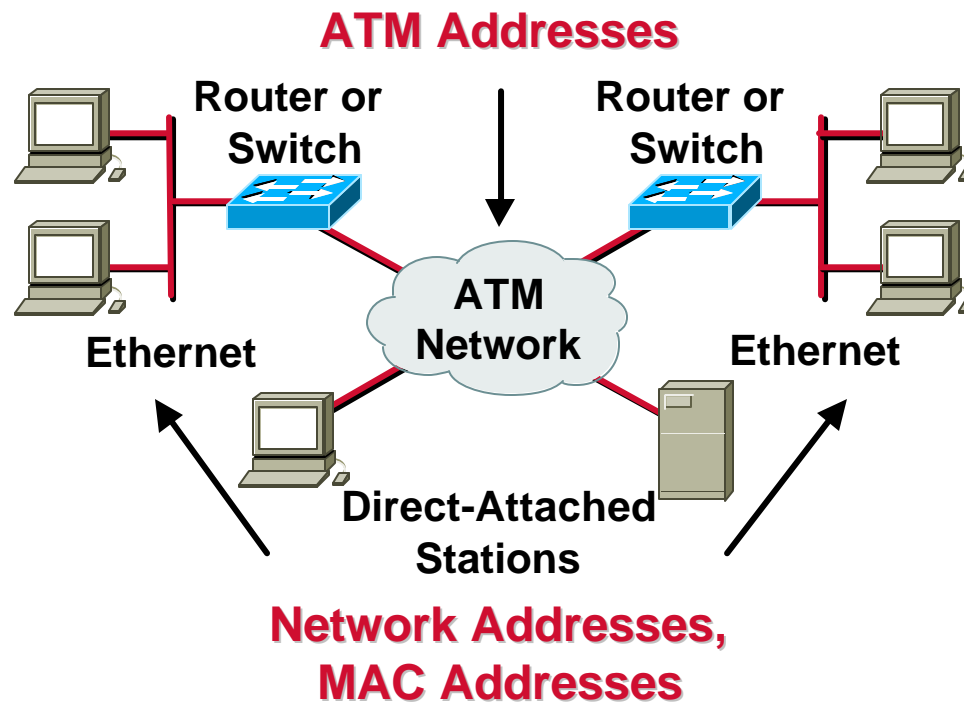
The Challenges



? MAC address to ATM address resolution

? No Standard ATM API

ATM Internetworking Overlay Model



? Multiple layers of addressing