ATM Networks

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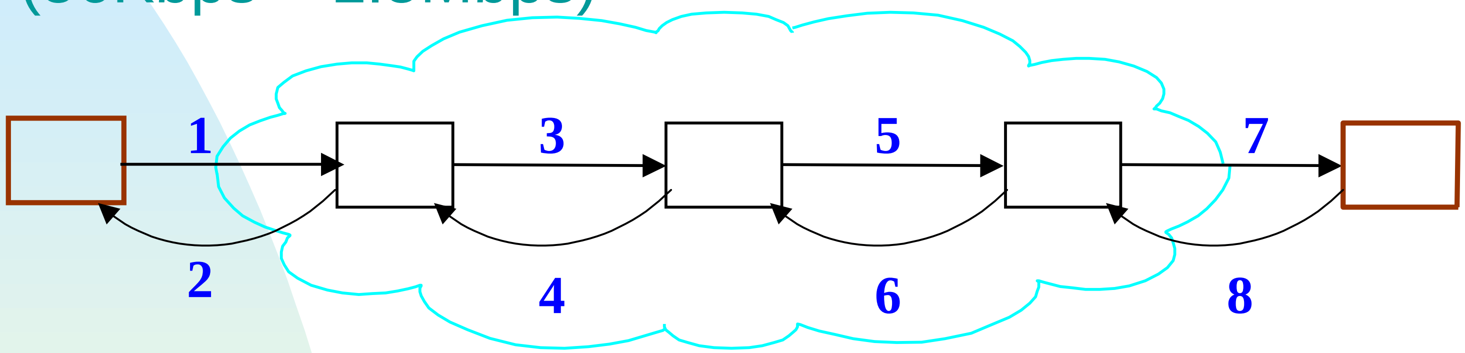
Cpsc 527 - Spring 2009

(adapted from Raj Jain)

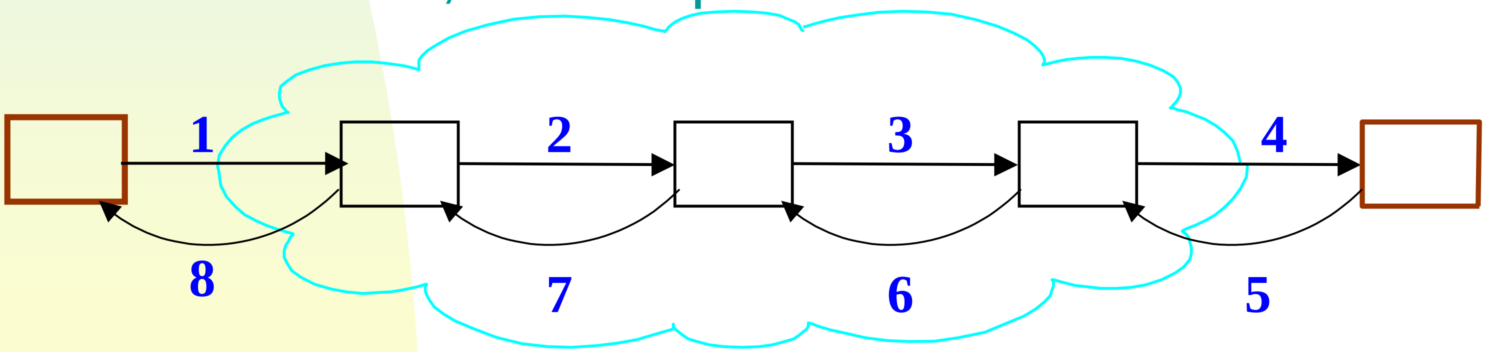
- ATM: Overview
- ATM Protocol Layers
- Network Interfaces
- Adaptation Layers
- Physical Layers

Cell Switching

- Packet switching: complex (error & flow control) slow (56Kbps < 1.5Mbps)



- Frame relay: simple (no error & flow control) variable frame, >1.5Mbps



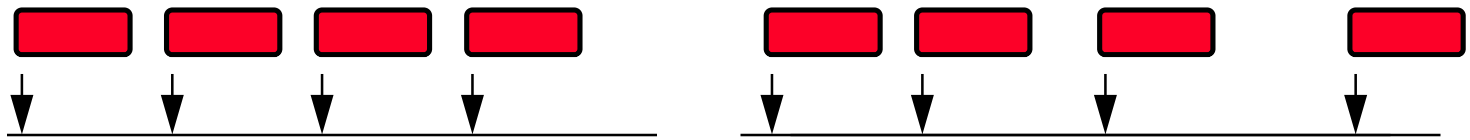
- Cell switching: small fixed size cell: 48B+5B header = 53B

Cell Switching (ATM)

- Connection-oriented packet-switched network
- Used in both WAN and LAN settings
- Signaling (connection setup) Protocol: Q.2931
- Specified by ATM forum
- Packets are called *cells*
  - 5-byte header + 48-byte payload
- Commonly transmitted over SONET
  - other physical layers possible

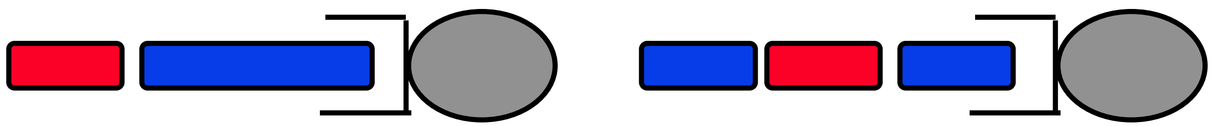
ATM Networks: Overview

- STM = Synchronous Transfer Mode,
  ATM = Asynchronous Transfer Mode

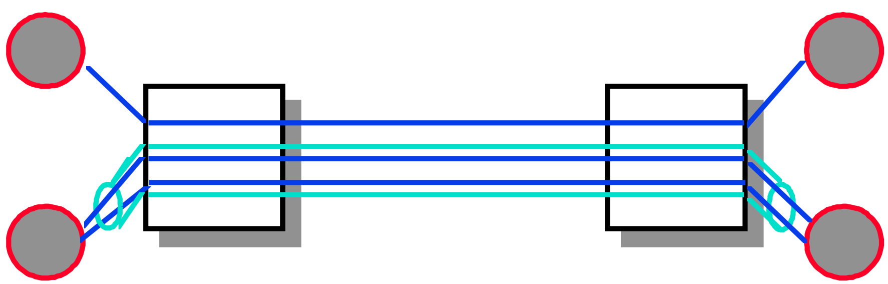


Allows any-speed and even variable rate connection

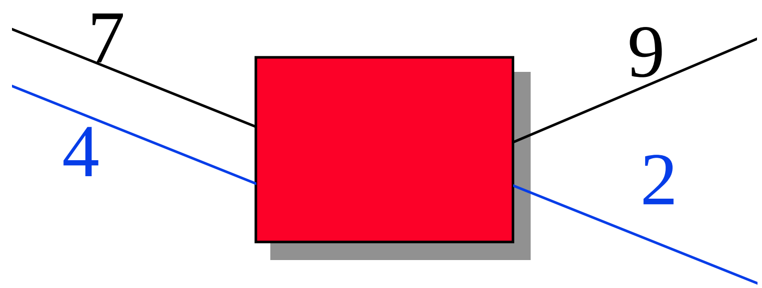
- ATM = Short fixed size 53-byte cells



- Connection oriented ⇒ Virtual Channels (VC)

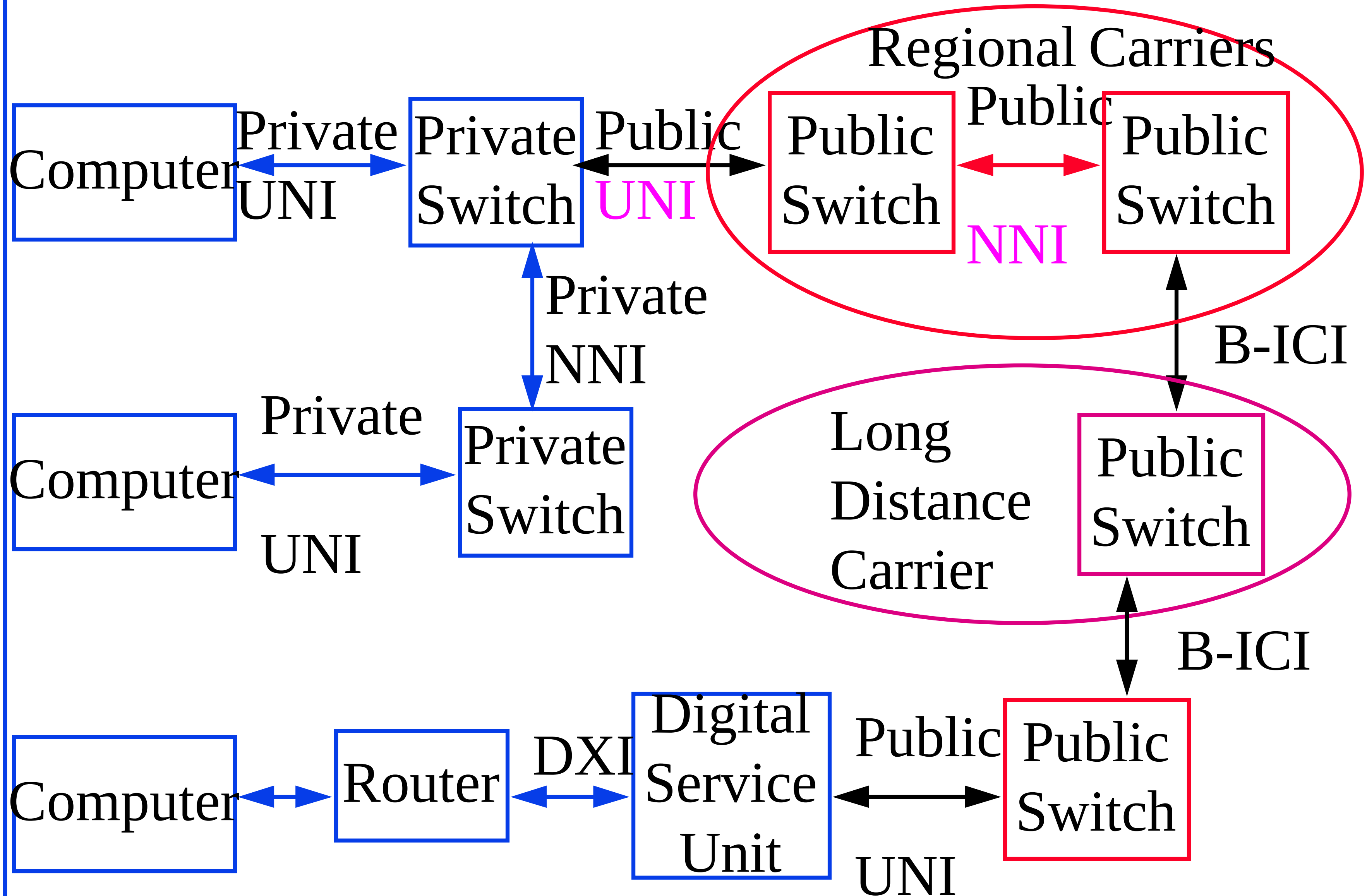


- Labels vs addresses
  ⇒ Better scalability in number of nodes



- Switches vs routers
  ⇒ Faster due to fixed size, short address, simplicity
- Seamless ⇒ Same technology for LAN, MAN,WAN
- Data, voice, video integration
- Everyone else is doing it

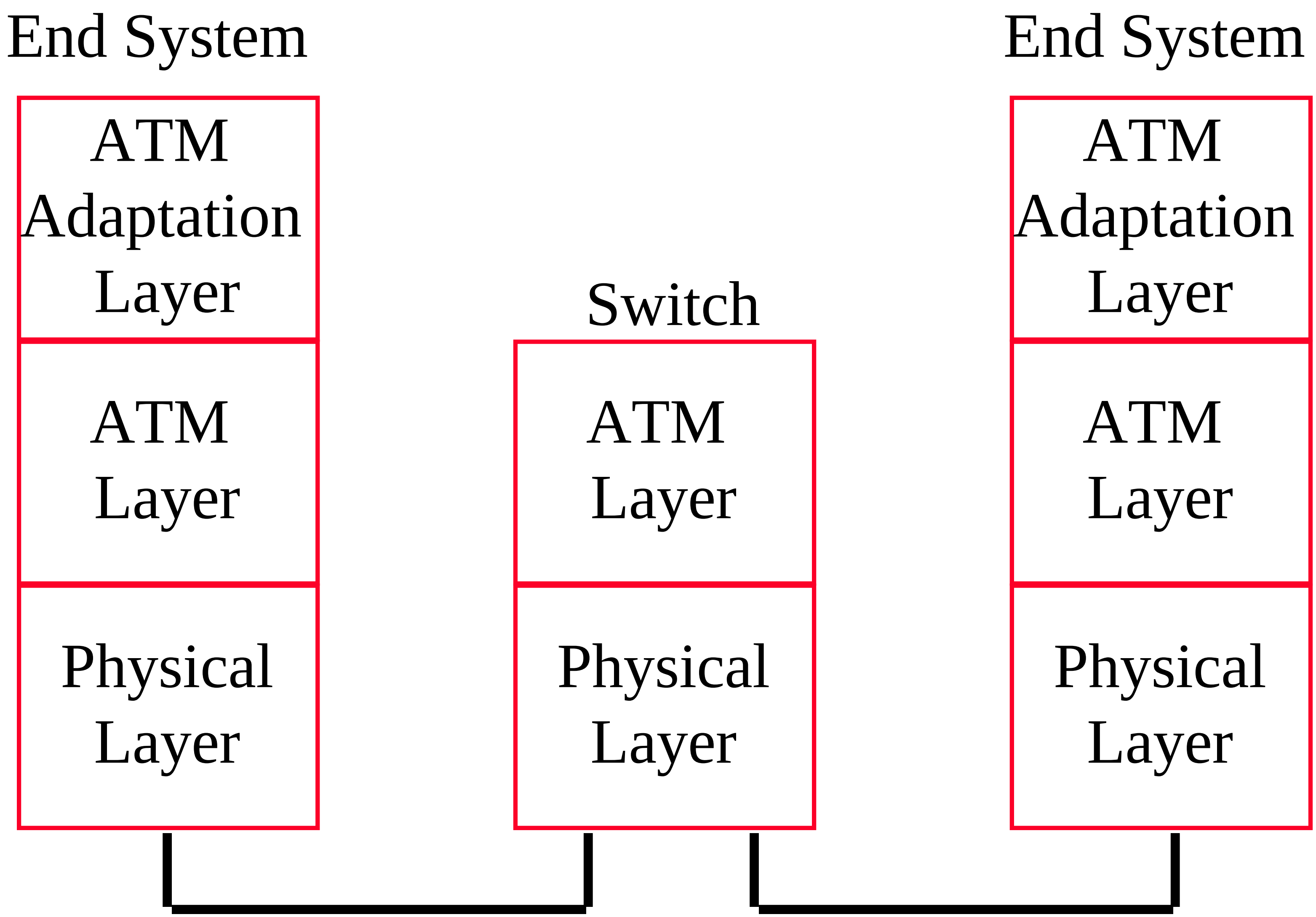
ATM Network Interfaces



ATM Network Interfaces

- User to Network Interface (UNI):
  Public UNI, Private UNI
- Network to Node Interface (NNI):
  - Private NNI (P-NNI)
  - Public NNI =Inter-Switching System Interface (ISSI)
    Intra-LATA ISSI (Regional Bell Operating Co)
  - Inter-LATA ISSI (Inter-exchange Carriers)
    $\Rightarrow$ Broadband Inter-Carrier Interface (B-ICI)
- Data Exchange Interface (DXI)
  Between routers and ATM Digital Service Units (DSU)

Protocol Layers



Protocol Layers

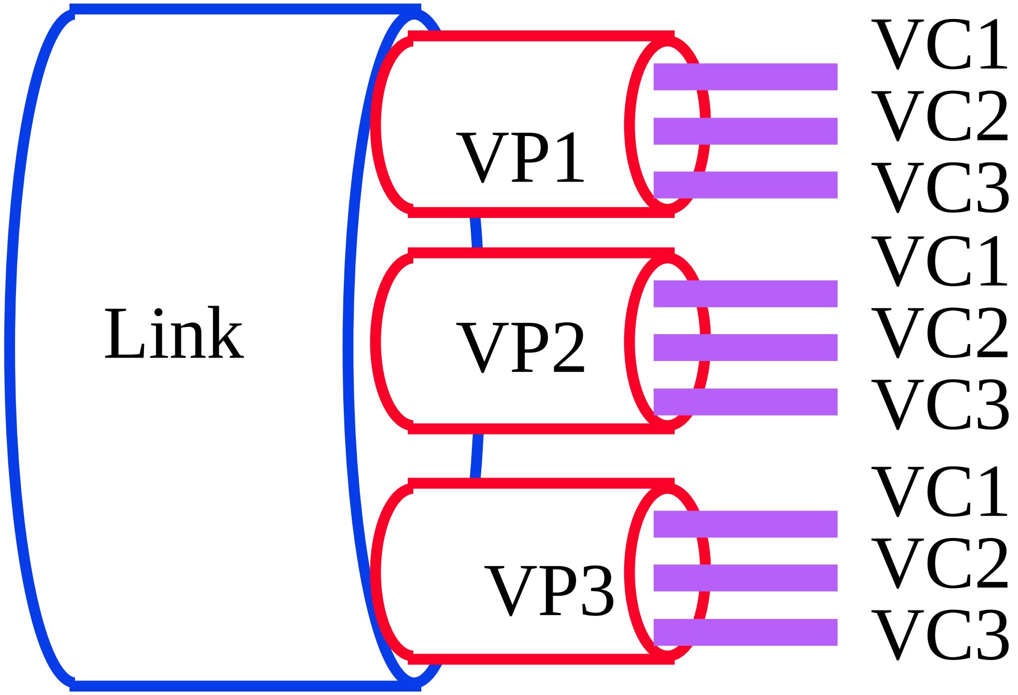
- The ATM Adaptation Layer
  - How to break application messages to cells
- The ATM Layer
  - Transmission/Switching/Reception
  - Congestion Control/Buffer management
  - Cell header generation/removal at source/destination
  - Cell address translation
  - Sequential delivery

ATM Cell Header Format

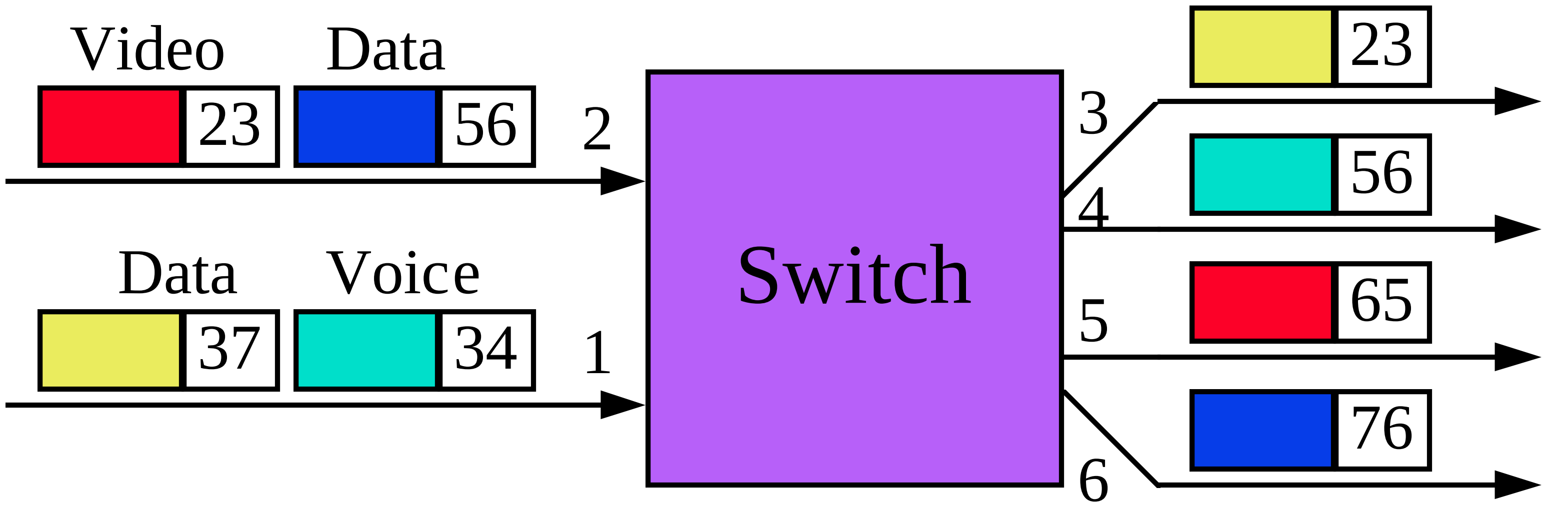
- GFC = Generic Flow Control
  - (Was used in UNI but not in NNI)
- VPI/VCI = 0/0 $\Rightarrow$ Idle cell; 0/n $\Rightarrow$ Signaling
- HEC: $1 + x + x^2 + x^8$

GFC/VPI	VPI	
VPI	VCI	
VCI		
VCI	PTI	CLP
Header Error Check (HEC)		
Payload		

Connection Identifiers

- Each cell contains a 24/28-bit connection identifier
  First 8/12 bits: Virtual Path,
  Last 16 bits: Virtual Circuit
- VP service allows new VC's w/o orders to carriers
- 

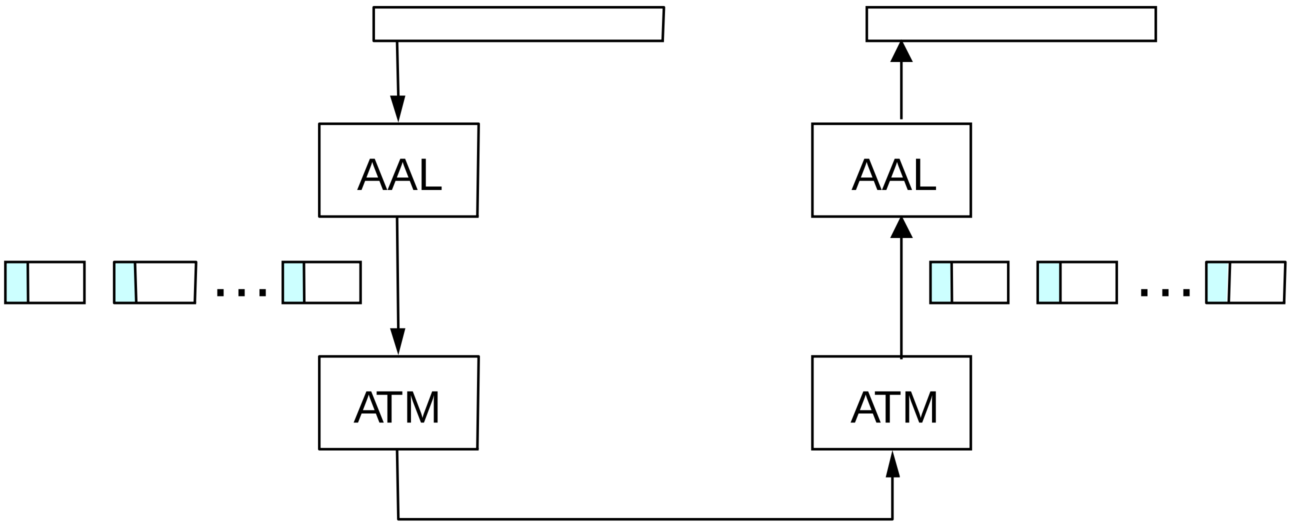
VP/VC Assignment/Use



In		Out	
Port	VPI/VCI	Port	VPI/VCI
1	0/37	3	1/23
1	0/34	4	0/56
2	0/23	5	0/65
2	0/56	6	4/76

Segmentation and Reassembly

- ATM Adaptation Layer (AAL)
  - AAL 1 and 2 designed for applications that need guaranteed rate (e.g., voice, video)
  - AAL 3/4 designed for packet data
  - AAL 5 is an alternative standard for packet data



AAL 3/4 - CS

- Convergence Sublayer Protocol Data Unit (CS-PDU)

8	8	16	< 64 KB	0– 24	8	8	16
CPI	Btag	BASize	User data	Pad	0	Etag	Len

– CPI: comm part indicator (version field)

– Btag/Etag:beginning and ending tag

– BAsize: hint on amount of buffer space to allocate

– Length: size of whole PDU

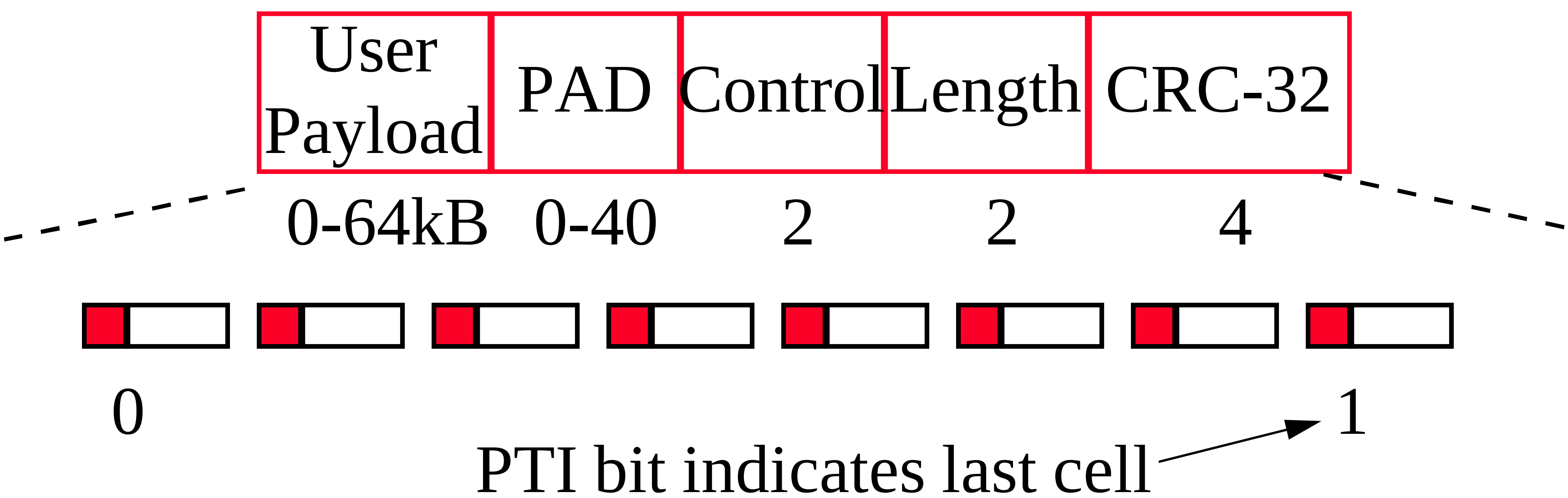
AAL 3/4 - SAR (Cell Format)

40	2	4	10	352 (44 bytes)	6	10
ATM header	Type	SEQ	MID	Payload	Length	CRC-10

- Type
  - BOM: beginning of message
  - COM: continuation of message
  - EOM end of message
- SEQ: sequence of number
- MID: message id
- Length: number of bytes of PDU in this cell

AAL 5

- Designed for data traffic
- Less overhead bits than AAL 3/4
  ⇒ Simple and Efficient AAL (SEAL)
- No per cell length field, No per cell CRC



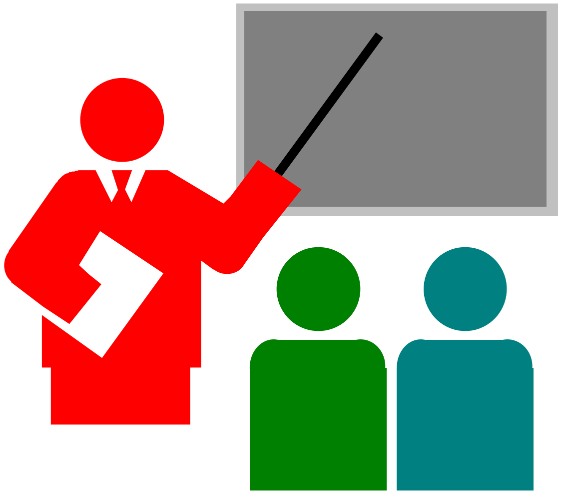
Classes of Service

- ABR (Available bit rate): Follows feedback
  Network gives max throughput with minimum loss.
- UBR (Unspecified bit rate):
  User sends whenever it wants. No feedback. No guarantee. Cells may be dropped during congestion.
- CBR (Constant bit rate): User declares required rate. Throughput, delay and delay variation guaranteed.
- VBR (Variable bit rate): Declare avg and max rate.
  - rt-VBR (Real-time): Conferencing.
    Max delay and delay variation guaranteed.
  - nrt-VBR (non-real time): Stored video.

Physical Media Dependent Layers (PMDs)

- Multimode Fiber: 100 Mbps using 4b/5b (TAXI), 155 Mbps SONET STS-3c, 155 Mbps 8b/10b
- Single-mode Fiber: 155 Mbps STS-3c, 622 Mbps
- Shielded Twisted Pair (STP): 155 Mbps 8b/10b
- Coax: 45 Mbps, DS3, 155 Mbps
- Unshielded Twisted Pair (UTP)
  - UTP-3 (phone wire) at 25.6 Mbps, 51.84 Mbps
  - UTP-5 (Data grade UTP) at 155 Mbps
- DS1, DS3, STS-3c, STM-1, E1, E3, J2, n × T1

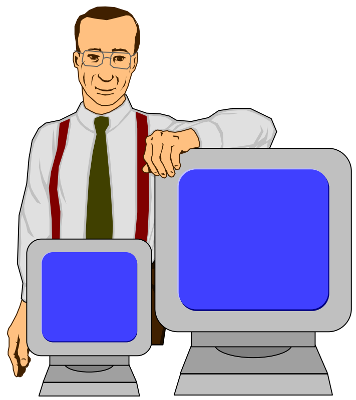
Summary



- ATM Overview: History, Why and What
- Protocol Layers: AAL, ATM, Physical layers, Cell format
- Interfaces: PNNI, NNI, B-ICI, DXI

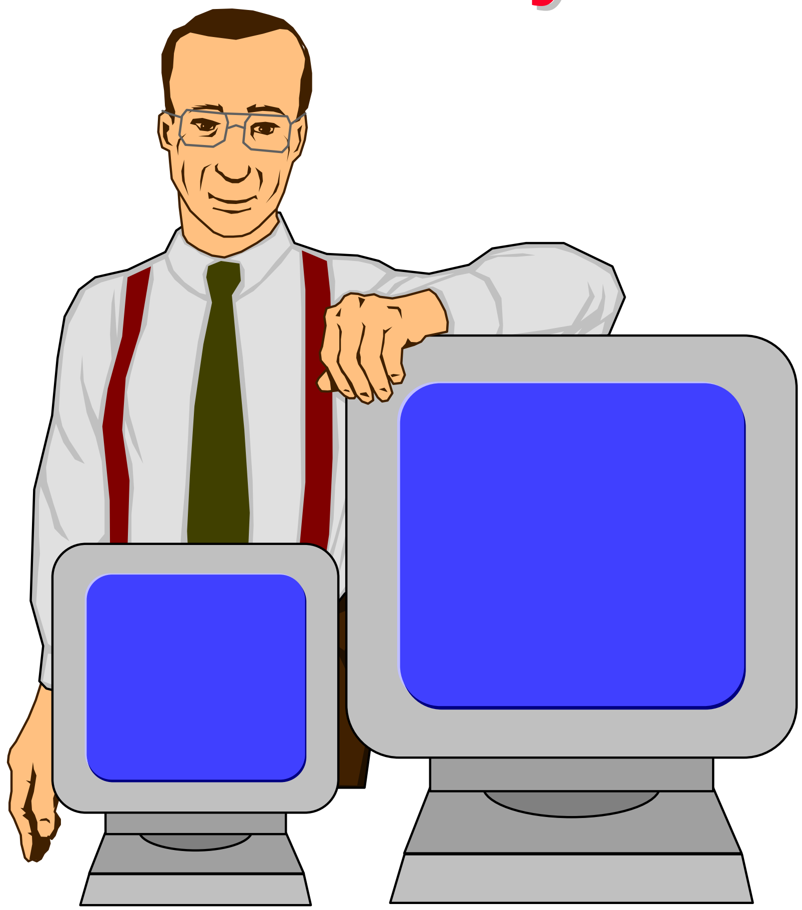
ATM Traffic Management

Dollar Day Sale



One Megabit memory, One Megabyte disk, One Mbps link, One MIP processor, one dollar each.....

Dollar Day Sale



One Megabit memory, One Megabyte disk, One Mbps link, One MIP processor, 10 cents each.....

- Why worry about congestion?
- Congestion schemes for ATM
- Explicit Rate-based Control
- ABR Traffic Management

Future

Year

1980

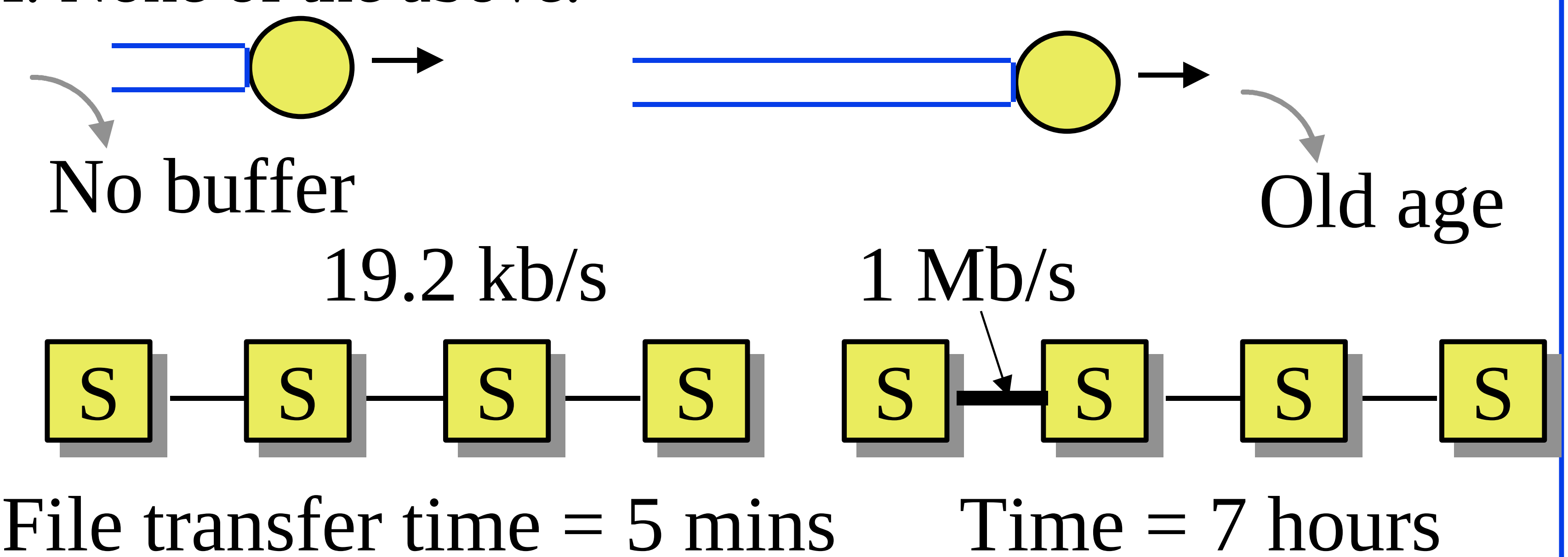
In 1990, the memory will be so cheap that you will not have to worry about paging, swapping, virtual memory, memory hierarchy, and....

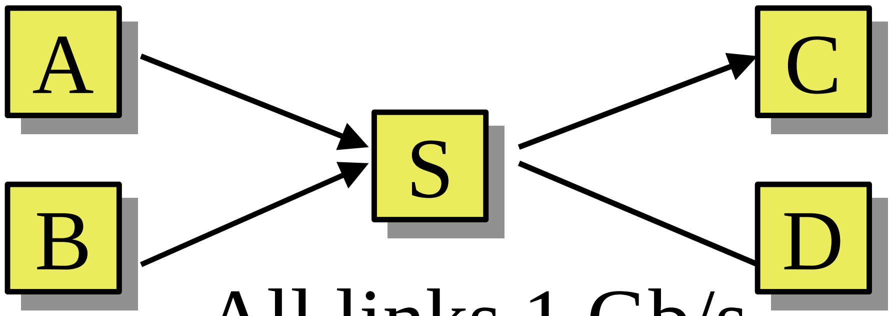
Why Worry About Congestion?

Q: Will the congestion problem be solved when:

- Memory becomes cheap (infinite memory)?
- Links become cheap (very high speed links)?
- Processors become cheap?

A: None of the above.





Conclusions:

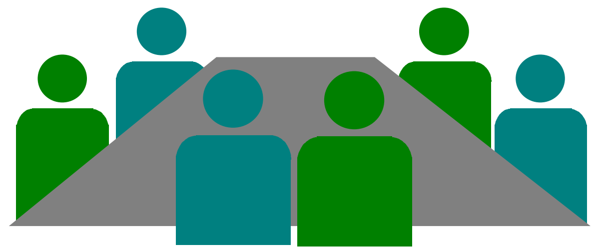
- Congestion is a dynamic problem.
  Static solutions are not sufficient
- Bandwidth explosion
  $\Rightarrow$ More unbalanced networks
- Buffer shortage is a symptom not the cause.

Economic Reasons

- Network is a shared resource
  Because it is expensive and needed occasionally
  (Like airplanes, emergency rooms)
- Most costs are fixed.
  Cost for fiber, switches, laying fiber and maintaining them does not depend upon usage
  $\Rightarrow$ Underutilization is expensive
- But overutilization leads to user dissatisfaction.
- Need a way to keep the network maximally utilized

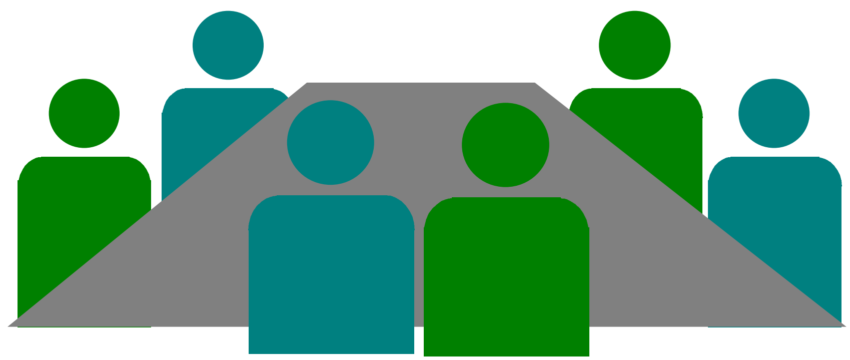
Service Categories

Standby



Guaranteed

Joy Riders



Confirmed

Service Categories

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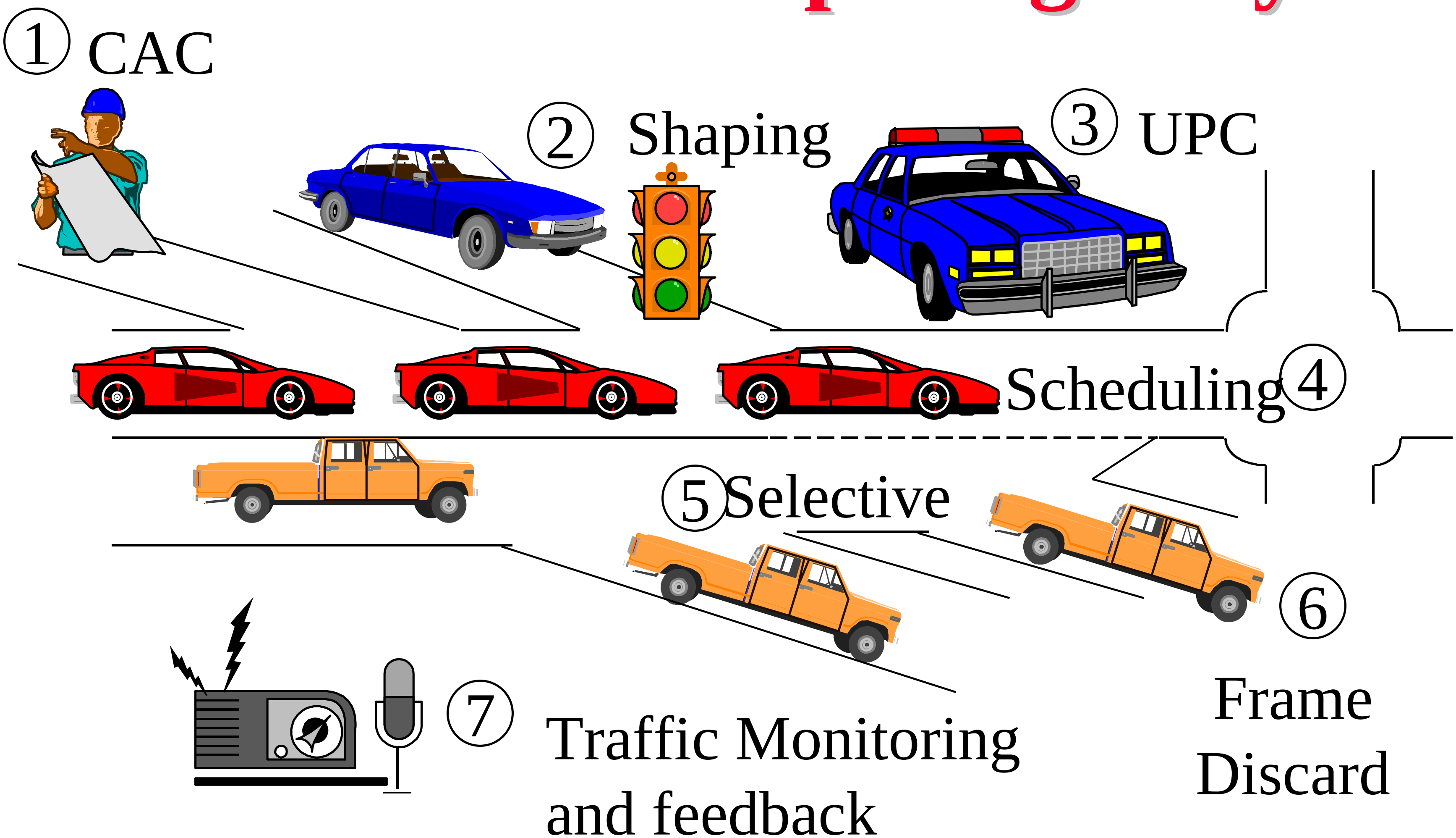
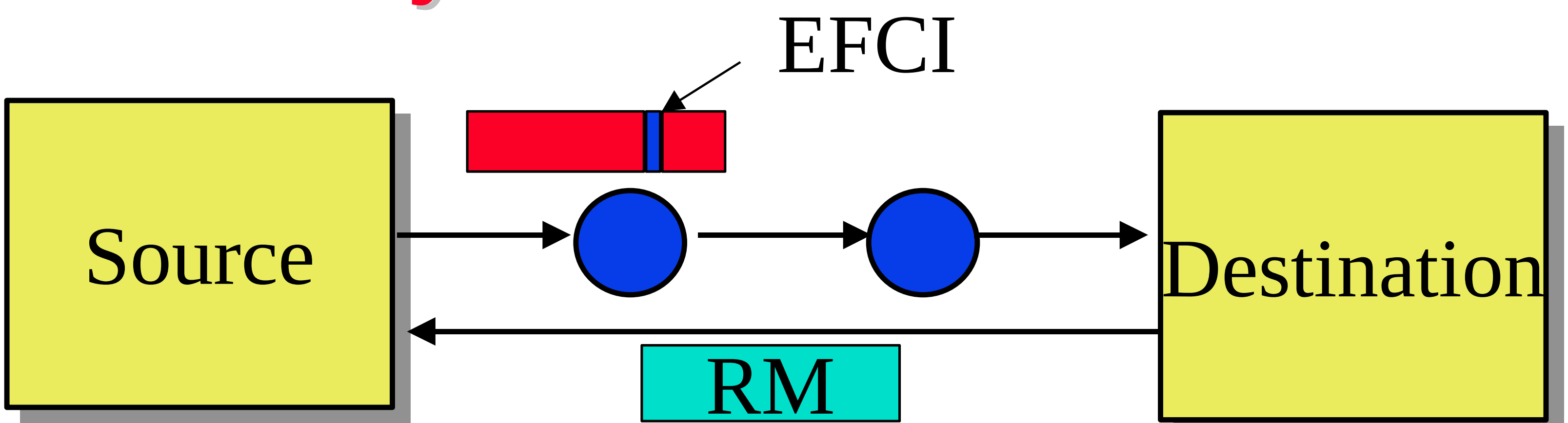
Traffic Management on the Information Superhighway



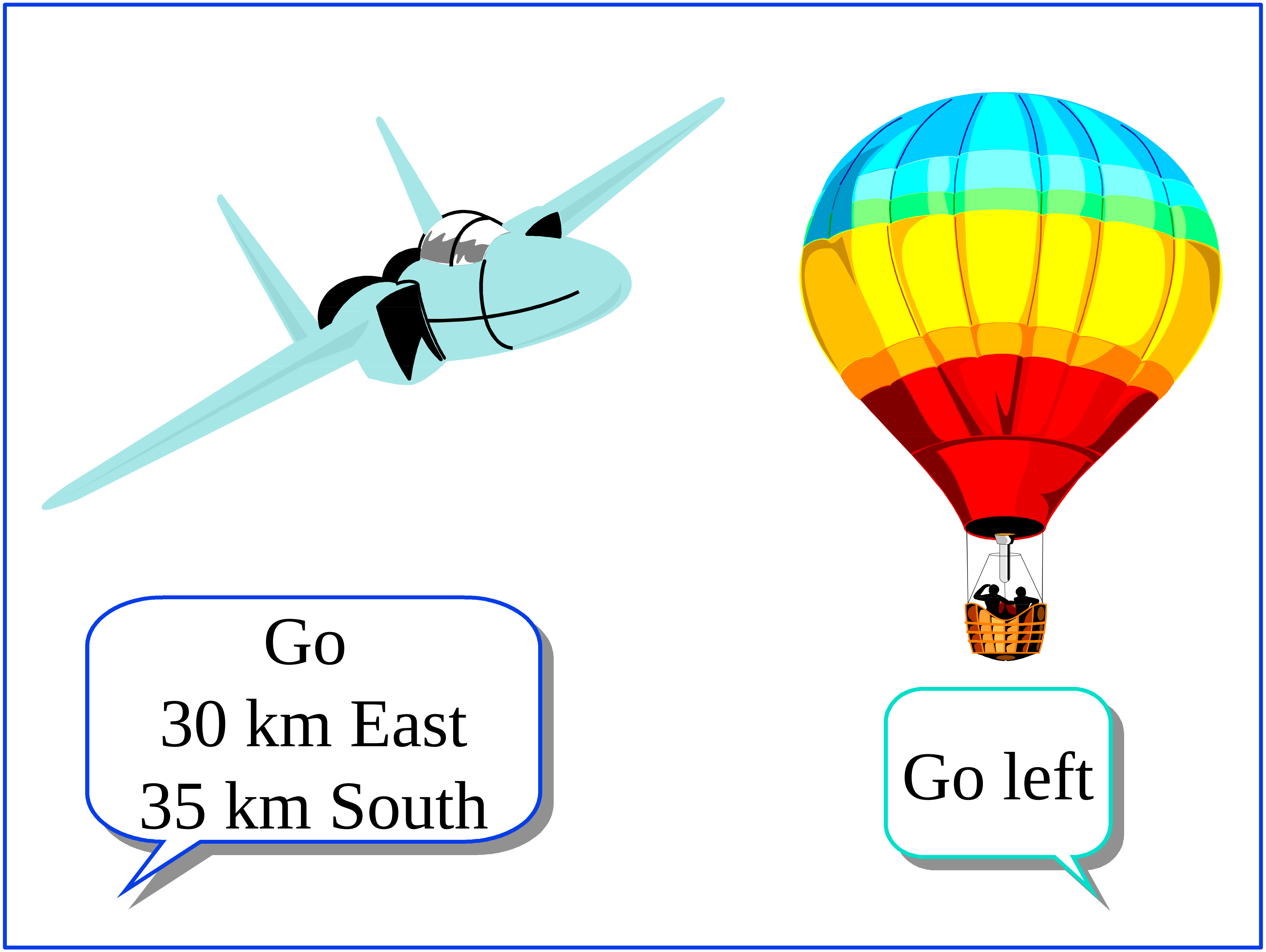
Traffic Management Functions

- Connection Admission Control (CAC): Can requested bandwidth and quality of service be supported?
- Traffic Shaping: Limit burst length. Space-out cells.
- Usage Parameter Control (UPC):
  Monitor and control traffic at the network entrance.
- Network Resource Management: Scheduling, Queueing, virtual path resource reservation
- Selective cell discard:
  Cell Loss Priority (CLP) = 1 cells may be dropped
  Cells of non-compliant connections may be dropped
- Frame Discarding
- Feedback Control

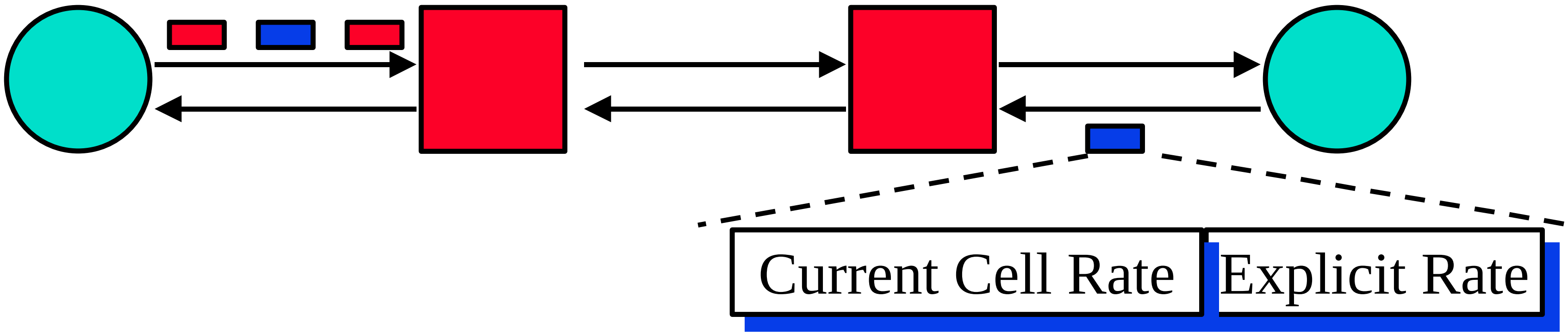
Binary Rate Scheme



- DECbit scheme in many standards since 1986.
- Forward explicit congestion notification (FECN) in Frame relay
- Explicit forward congestion indicator (EFCI) set to 0 at source. Congested switches set EFCI to 1
- Every nth cell, destination sends an resource management (RM) cell to the source


Go
30 km East
35 km South
Go left

The Explicit Rate Scheme



- Sources send one RM cell every n cells
- The RM cells contain “Explicit rate”
- Destination returns the RM cell to the source
- The switches adjust the rate down
- Source adjusts to the specified rate

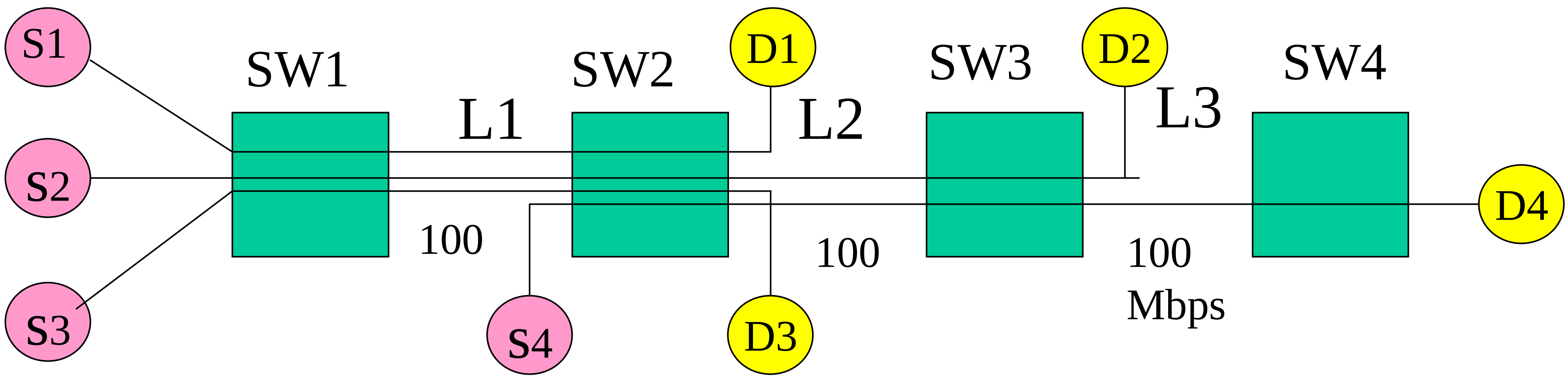
ERICA Switch Algorithm

- Explicit Rate Indication for Congestion Avoidance
- Set target rate, say, at 95% of link bandwidth
- Monitor input rate and number of active VC s *k*
  Overload = Input rate/Target rate
- This VC's Share = VC's Current Cell Rate/Overload
- Fairshare = Target rate / *k*
- ER = ***Max(***Fairshare, This VC's share)
- ER in Cell = Min(ER in Cell, ER)
- Ref: R. Jain, et al, "A Simple Switch Algorithm," AF-TM 95-0179R1, February 1995.

ERICA Features

- Measured overload/load at switch
- Insensitive to source not using their allocated rates
- Small queue lengths during steady state
- Fast response due to optimistic design
- Parameters: Few, insensitive, easy
- Several options: Backward Explicit Congestion Notification
- Simplified switch algorithm
- Optimized all steps. Eliminated unncessary steps. Eliminated many parameters

ATM Congestion Control - ERICA Example



- FairAlloc-MaxMin = <33.3, 33.3, 33.3, 66.7>
- UnfairAlloc = <20, 50, 30, 50>

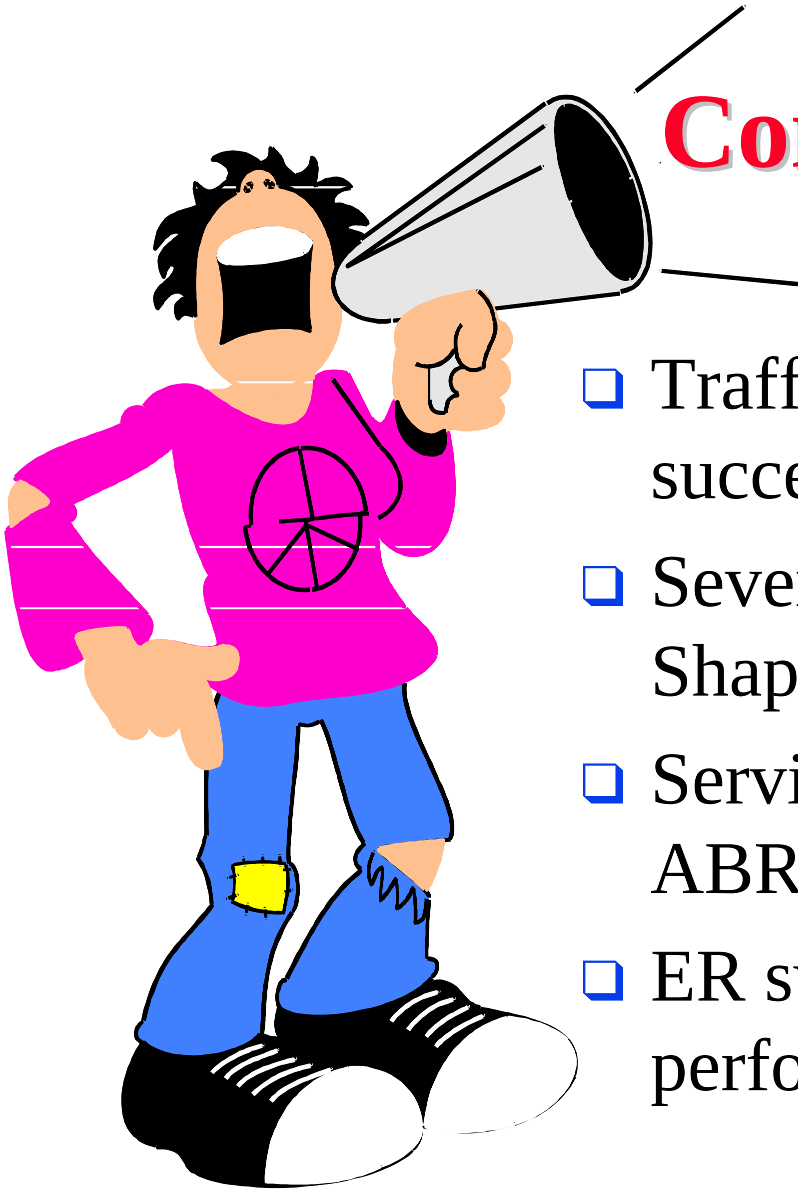
- Given CurrentR = <20,25,30,50>

Q1. Would S1's request <CR, ER> = <20,35> be granted ?

•Fairshare = 100/3 = 33.3 => underload = (20+25+30)/100 = 75%

•VC Share = 20/75% = 26.7 => ER = max (33.3, 26.7) = 33.3 Mbps

Q2: What if S2 request <CR,ER> = <25, 40> ? Q3: Repeat Q2, assuming S1 terminated



Congestion: Summary

- Traffic Management is key to success of ATM
- Several different methods: CAC, Shaping, UPC, Scheduling, ...
- Service categories:CBR, VBR, ABR, UBR
- ER switches provide much better performance than EFCI.

ATM vs. The Internet

- **ATM** supported by Telco
- **ATM** inherently designed to support highspeed, multimedia communications, e.g., VOD (Video on Demand)
- Complete, scalable ATM networking solution: LAN, MAN, and WAN
- **Internet** has huge infrastructure and large user population
- New Internet protocols (IPv6, RSVP, RTP)
- Conclusion:
  - Internet
  - TCP/IP over ATM
  - Wireless ATM

ATM vs. The Internet

- Connection oriented
- Constant-size cells
- Switching, thus scalable
- Quality of Service (QoS) guarantee (negotiable during VC setup)
- Support different classes of traffic (CBR, NRT-VBR, RT-VBR, ABR, UBR)- multimedia apllication
- Scalable
- Congestion control in ATM
  - rate-based
  - reservation / expl. Feedback
  - router / host centric
- Homogeneous (LAN, MAN, WAN) - by Telco

- Connectionless
- Variable-size packet
- Use routing
- Best effort (no QoS guarantee, RVSP supports dynamic resource reserv.
- No inherent support for different classes, but issues addressed in new protocols (RTP, RSVP, Mbone)
- Not easily scalable
- Congestion control in TCP
  - credit (window)-based
  - implicit feedback
  - host centric
- Heterogeneous (via gateways/routers)