

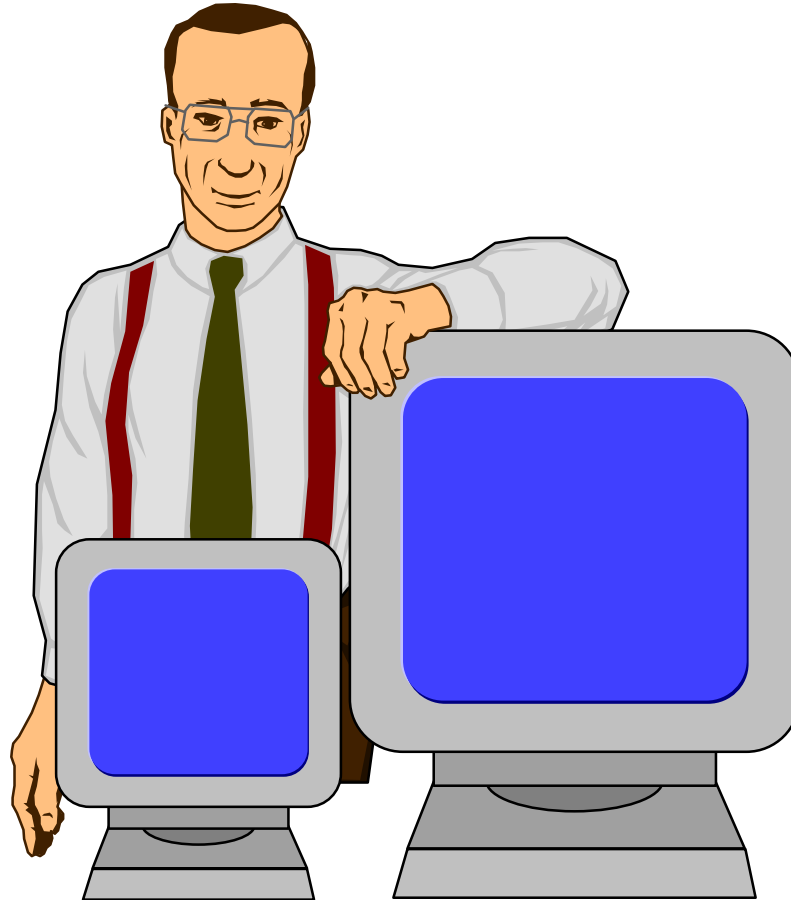
# ATM

# Traffic Management

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# Dime 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



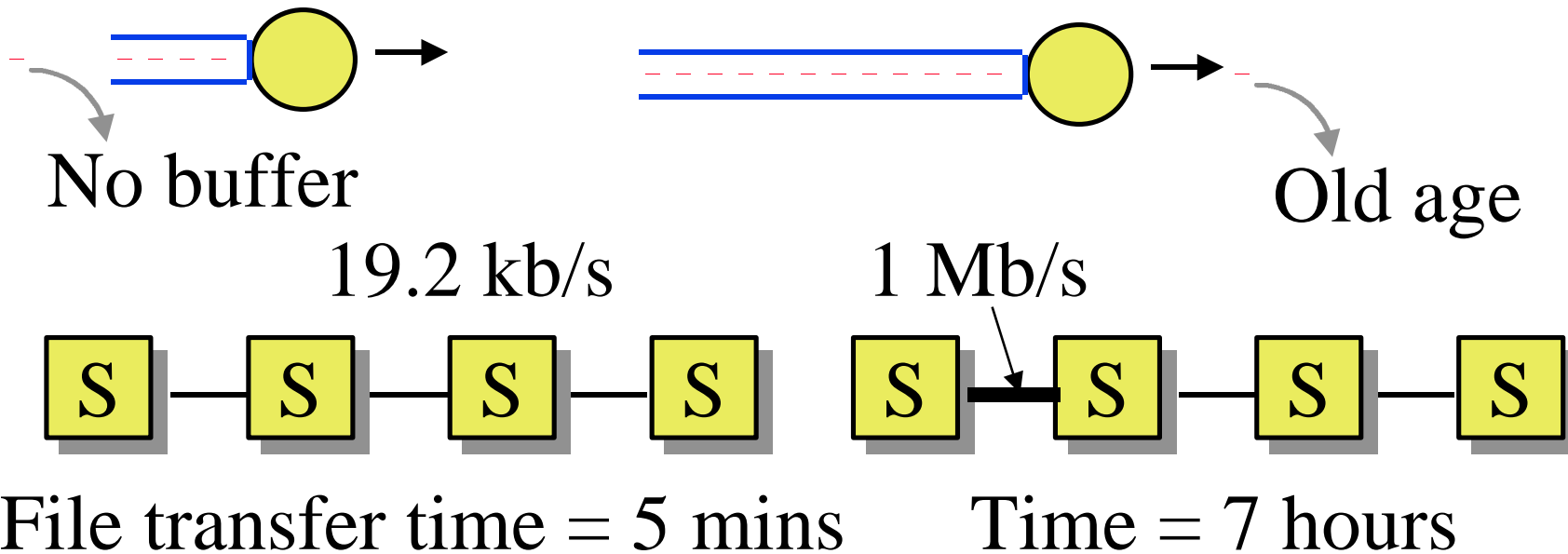
In 1990, the memory will be so cheap that you will not have to worry about paging, swapping, virtual memory, memory hierarchy, and....

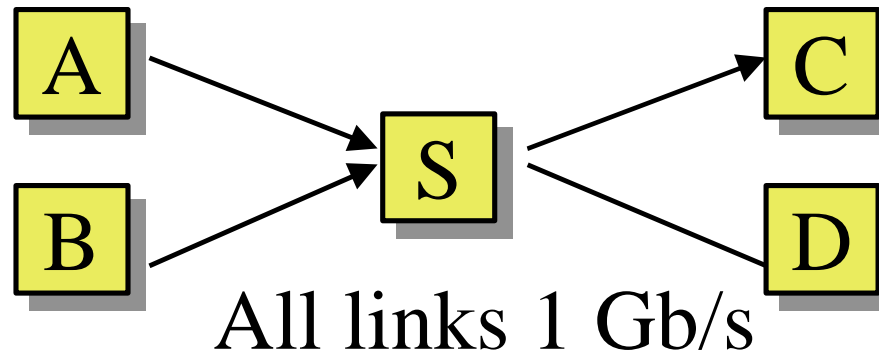
# Why Worry About Congestion?

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  
⇒ More unbalanced networks
- ❑ Buffer shortage is a symptom not the cause.

# Economic Reasons

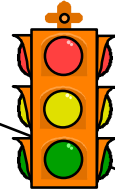
- ❑ Network is a shared resource  
Because it is expensive and needed occasionally  
(Like airplanes, emergency rooms)
- ❑ Most costs are fixed.  
Cost for fiber, switches, laying fiber and maintaining them does not depend upon usage  
⇒ Underutilization is expensive
- ❑ But overutilization leads to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

# Traffic Management on the Information Superhighway

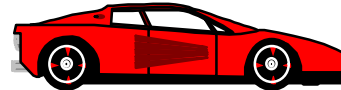
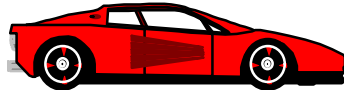
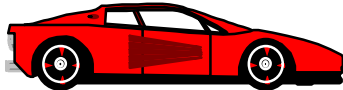
① CAC



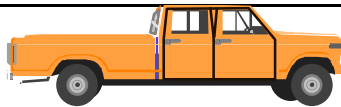
② Shaping



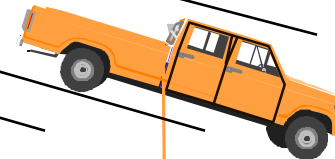
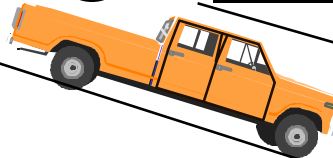
③ UPC



Scheduling ④

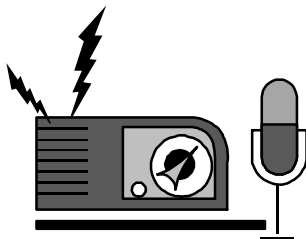


⑤ Selective



⑥

Frame Discard



⑦

Traffic Monitoring and feedback



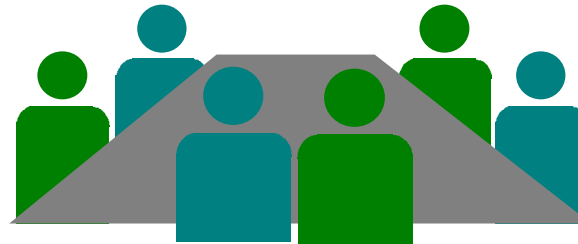
# Traffic Management Functions

- ❑ 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

# Service Categories



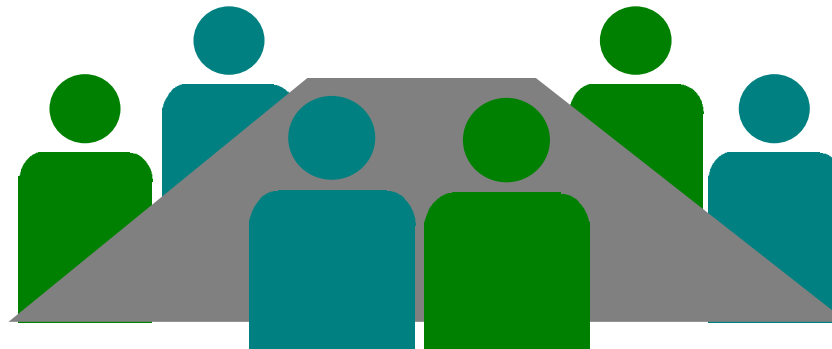
Standby



Guaranteed



Joy Riders



Confirmed

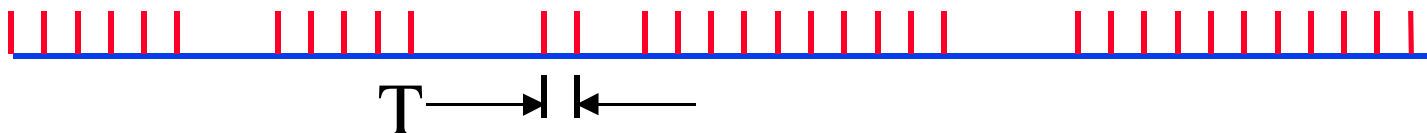


Raj Jain

# Service Categories

- ❑ **ABR** (Available bit rate):  
Source follows network feedback.  
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 guaranteed.
  - **nrt-VBR** (non-real time): Stored video.

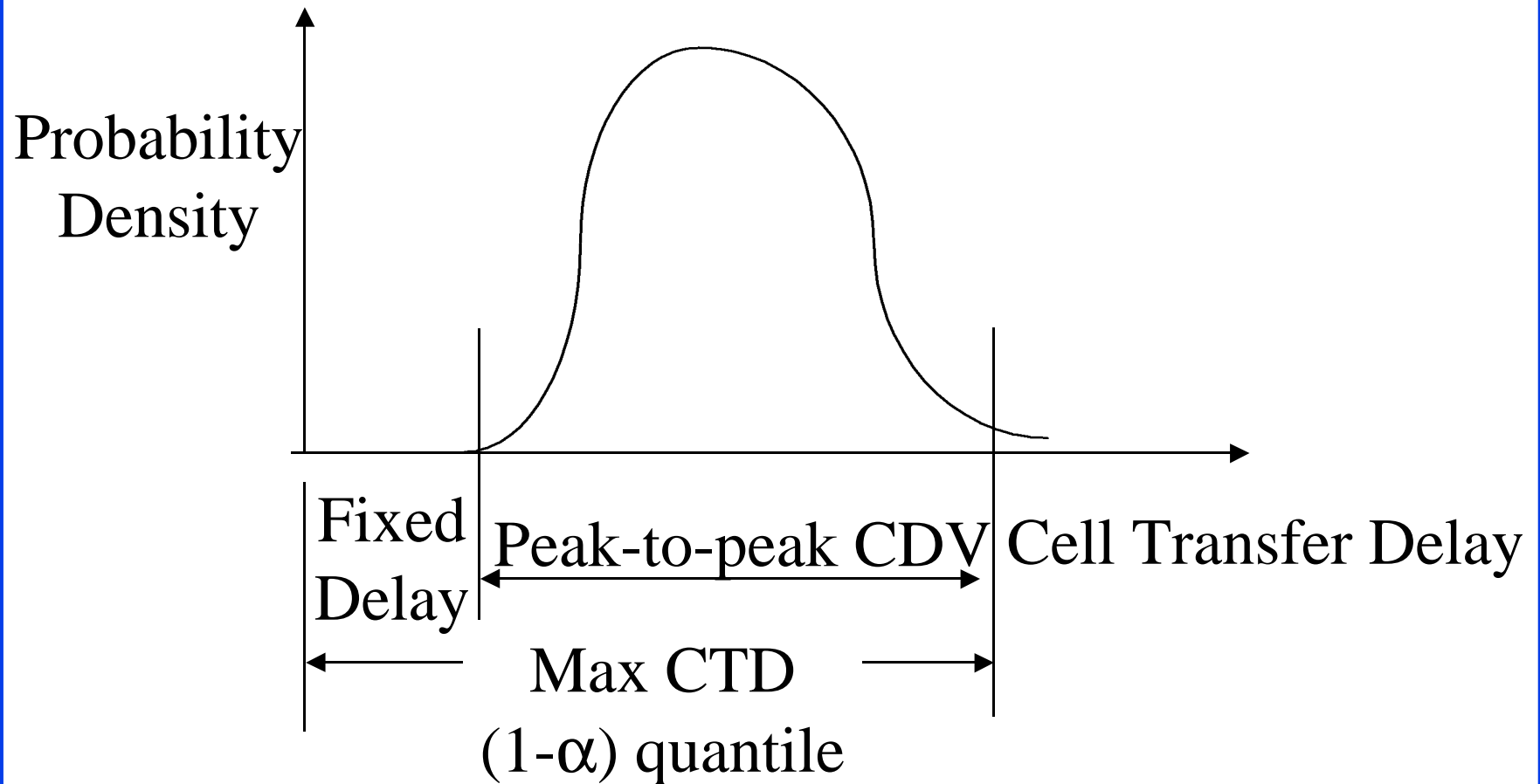
# Traffic Contract Parameters



- ❑ Peak Cell Rate (PCR):  $1/T$
- ❑ Cell Transfer Delay (CTD): First bit in to last bit out
- ❑ Cell Delay Variation (CDV):  $\sim \text{Max CTD} - \text{Min CTD}$ 
  - Peak-to-peak CDV
- ❑ Cell Delay Variation Tolerance (CDVT)  $\tau$   
= GCRA limit parameter wrt PCR  $\Rightarrow \text{GCRA}(T, \tau)$

- ❑ Sustained Cell Rate (SCR): Average over a long period
- ❑ Burst Tolerance (BT)  $\tau_s$  : GCRA limit parameter wrt SCR GCRA( $1/T_s, \tau_s$ )  
Maximum Burst Size:  
$$MBS = \lfloor 1 + BT / (1/SCR - 1/PCR) \rfloor$$
$$BT \in [(MBS - 1)(1/SCR - 1/PCR), MBS(1/SCR - 1/PCR)]$$
- ❑ Cell Loss Ratio (CLR): Cells lost / Totals cells sent
- ❑ Minimum cell rate (MCR)

# Peak-to-Peak CDV



# Service Categories

Attribute	CBR	rt-VBR	nrt-VBR	UBR	ABR
PCR, CDVT <sup>4,5</sup>	Specified	Specified	Specified	Specified <sup>2</sup>	Specified <sup>3</sup>
SCR,MBS, CDVT <sup>4,5</sup>	N/A	Specified	Specified	N/A	N/A
MCR <sup>4</sup>	N/A	N/A	N/A	N/A	Specified
Peak-to-peak CDV	Specified	Specified	Unspecified	Unspecified	Unspecified
Max CTD	Specified	Specified	Unspecified	Unspecified	Unspecified
CLR <sup>4</sup>	Specified	Specified	Specified	Unspecified	Specified <sup>1</sup>
Feedback	Unspecified	Unspecified	Unspecified	Unspecified	Specified <sup>6</sup>

<sup>1</sup>Network specific

<sup>2</sup>Not subject to CAC/UPC

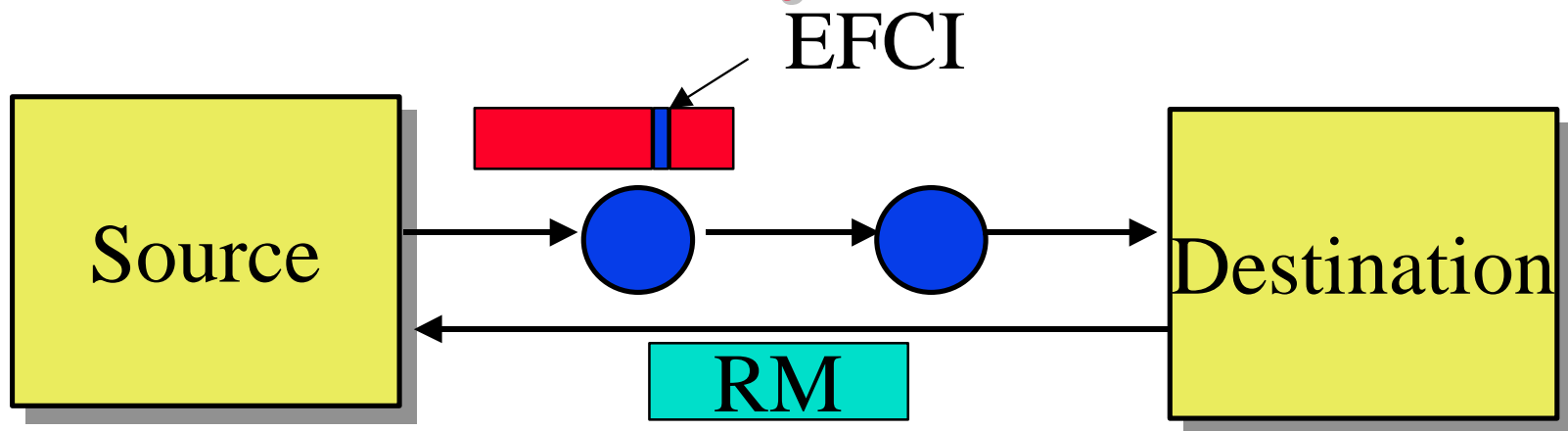
<sup>3</sup>PCR  $\Rightarrow$  Max ACR

<sup>4</sup>Explicitly/implicitly  
specified for PVC/SVC

<sup>5</sup>Not signaled. Different values may  
apply at different interfaces along  
the path.

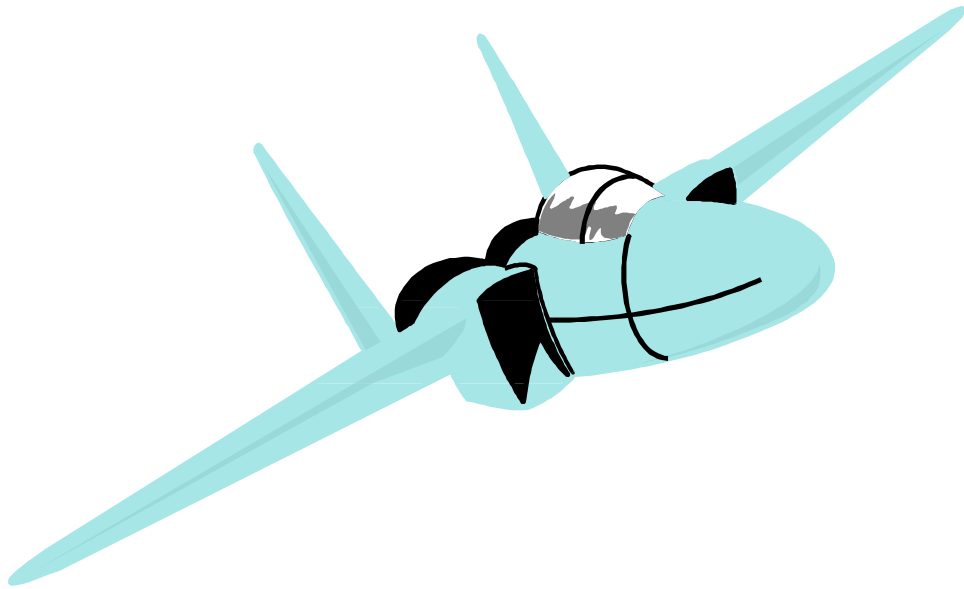
<sup>6</sup>Follow ABR rules

# ABR: 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  $n$ th cell, destination sends an resource management (RM) cell to the source



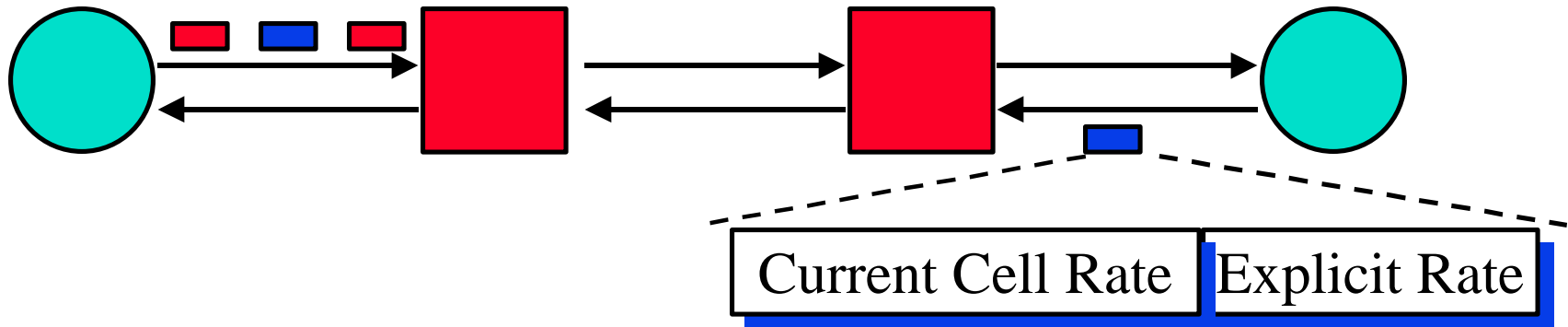


Go  
30 km East  
35 km South



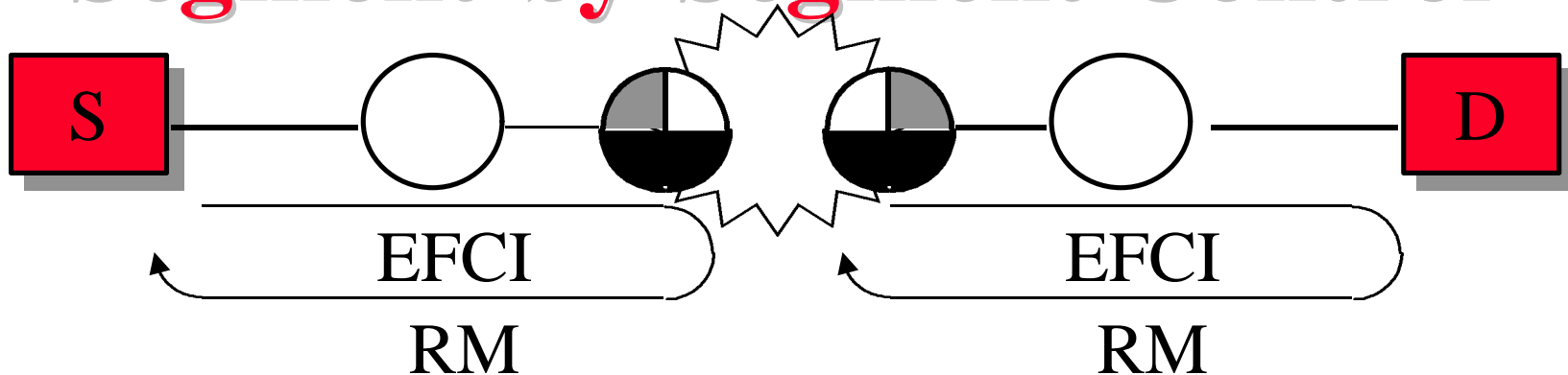
Go left

# ABR: The Explicit Rate Scheme

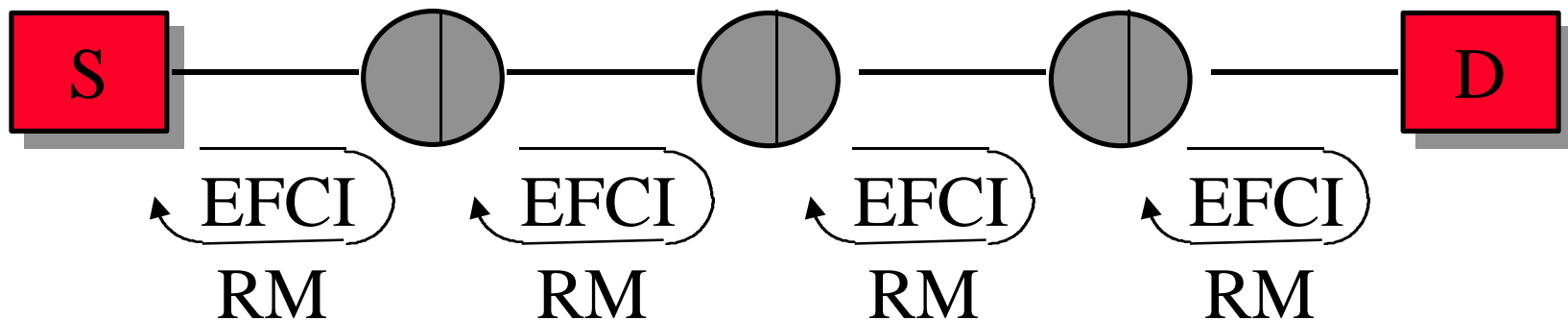


- ❑ Sources send one **RM cell** every  $n$  cells
- ❑ The RM cells contain “**Explicit rate**”
- ❑ Destination returns the RM cell to the source
- ❑ The switches adjust the rate **down**
- ❑ Source adjusts to the specified rate

# Segment-by-Segment Control



- Virtual source/virtual destinations follow all notification/control rules
- Can be hop-by-hop



- Virtual dest/sources maintain per-VC queues.

# Guaranteed Frame Rate (GFR)

- ❑ UBR with minimum cell rate (MCR)  $\Rightarrow$  UBR+
- ❑ Frame based service
  - Complete frames are accepted or discarded in the switch
  - Traffic shaping is frame based.  
All cells of the frame have the same cell loss priority (CLP)
  - All frames below MCR are given CLP =0 service.  
All frames above MCR are given best effort (CLP =1) service.

# 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.

# References

- ❑ Read Chapters 21-23 of McDysan's book
- ❑ R.Jain, "Congestion Control and Traffic Management in ATM Networks: Recent Advances and A Survey", Computer Networks and ISDN Systems, November 1996, <http://www.cis.ohio-state.edu/~jain/>
- ❑ K. Siu and R. Jain, "A Brief Overview of ATM: Protocol Layers, LAN Emulation, and Traffic Management," Computer Communications Review (ACM SIGCOMM), April 1995, <http://www.cis.ohio-state.edu/~jain/>

# References (Cont)

- ❑ User-Network Interface Specifications, V4.0, <ftp://ftp.atmforum.com/pub/approved-specs/af-sig-0061.000.ps>
- ❑ “ATM Forum Traffic Management Specification, Version 4.0,” <ftp://ftp.atmforum.com/pub/approved-specs/af-tm-0056.000.ps>
- ❑ Stallings’ ISDN and BISDN book, Chapter 16