ATM Traffic Management

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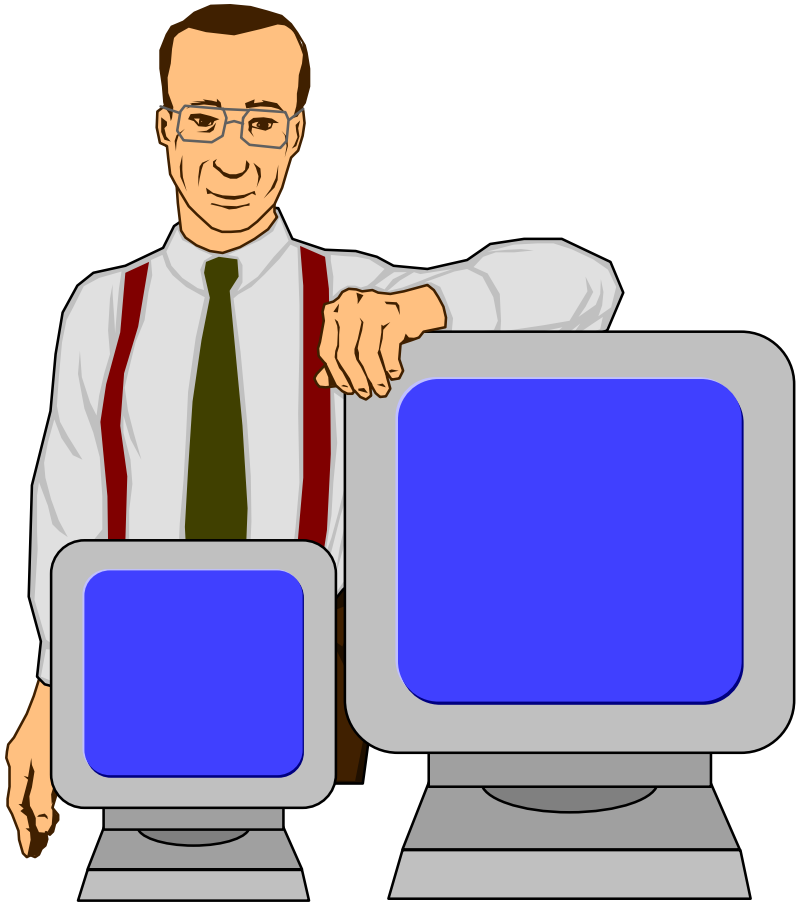
Dime Sale



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

Overview

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

Future

Year

1980

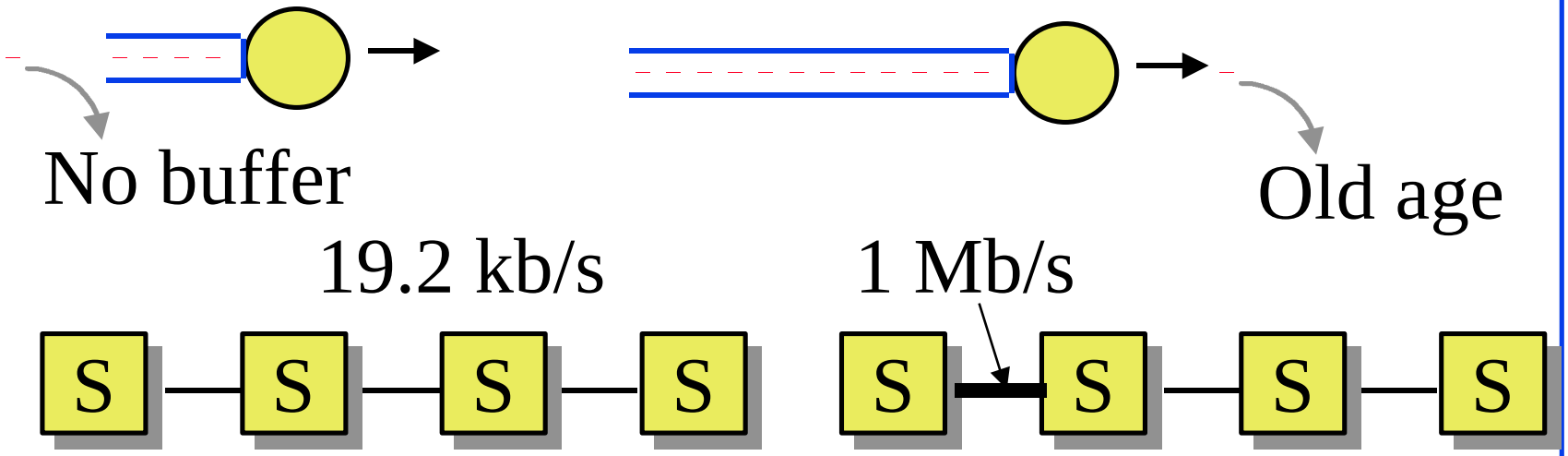
In 1990, the memory will be so cheap that you will not have to worry about paging, swapping, virtual memory, memory hierarchy, and....

Why Worry About Congestion?

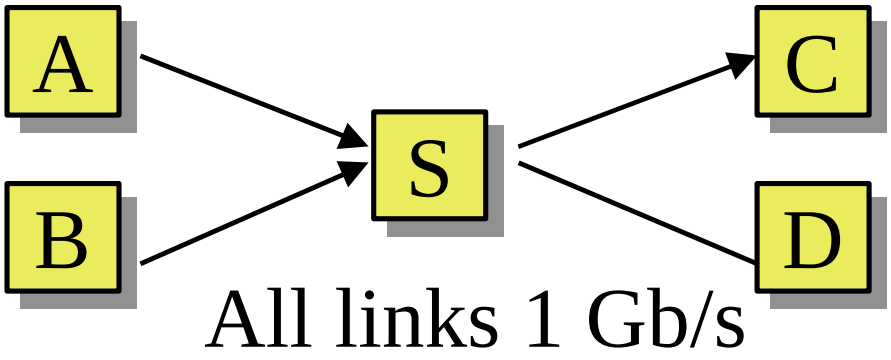
Q: Will the congestion problem be solved when:

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

A: None of the above.



File transfer time = 5 mins Time = 7 hours



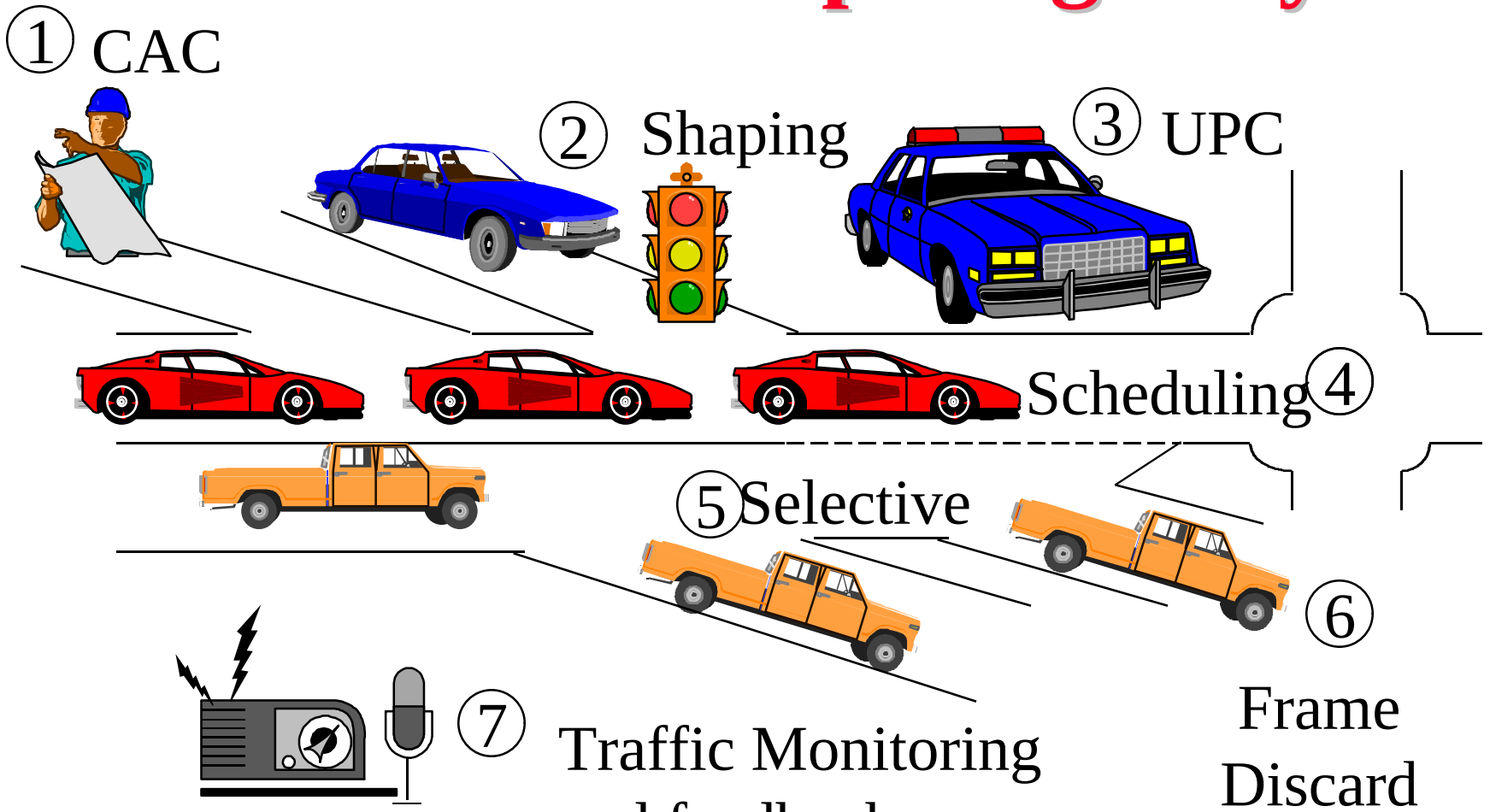
Conclusions:

- 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

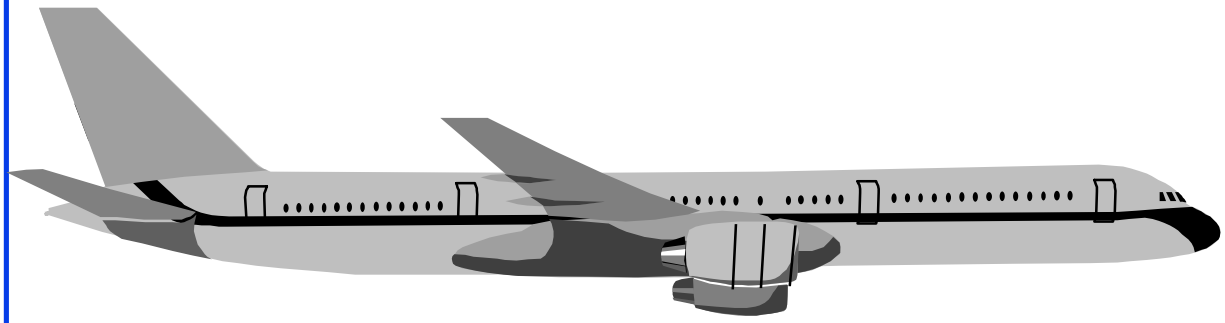
- Network is a shared resource
  Because it is expensive and needed occasionally
  (Like airplanes, emergency rooms)
- Most costs are fixed.
  Cost for fiber, switches, laying fiber and maintaining them does not depend upon usage
  $\Rightarrow$ Underutilization is expensive
- But overutilization leads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

Traffic Management on the Information Superhighway



Traffic Management Functions

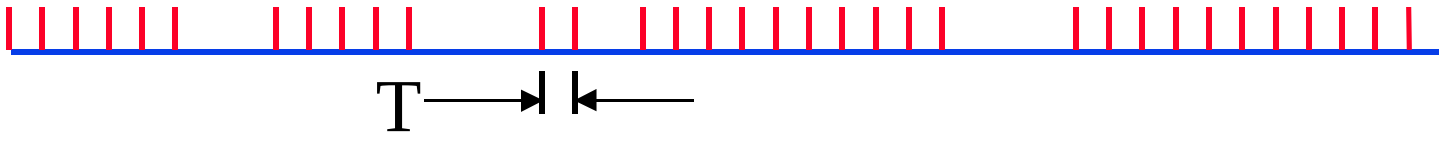
- Connection Admission Control (CAC): Can requested bandwidth and quality of service be supported?
- Traffic Shaping: Limit burst length. Space-out cells.
- Usage Parameter Control (UPC):
  Monitor and control traffic at the network entrance.
- Network Resource Management: Scheduling, Queueing, virtual 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



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.

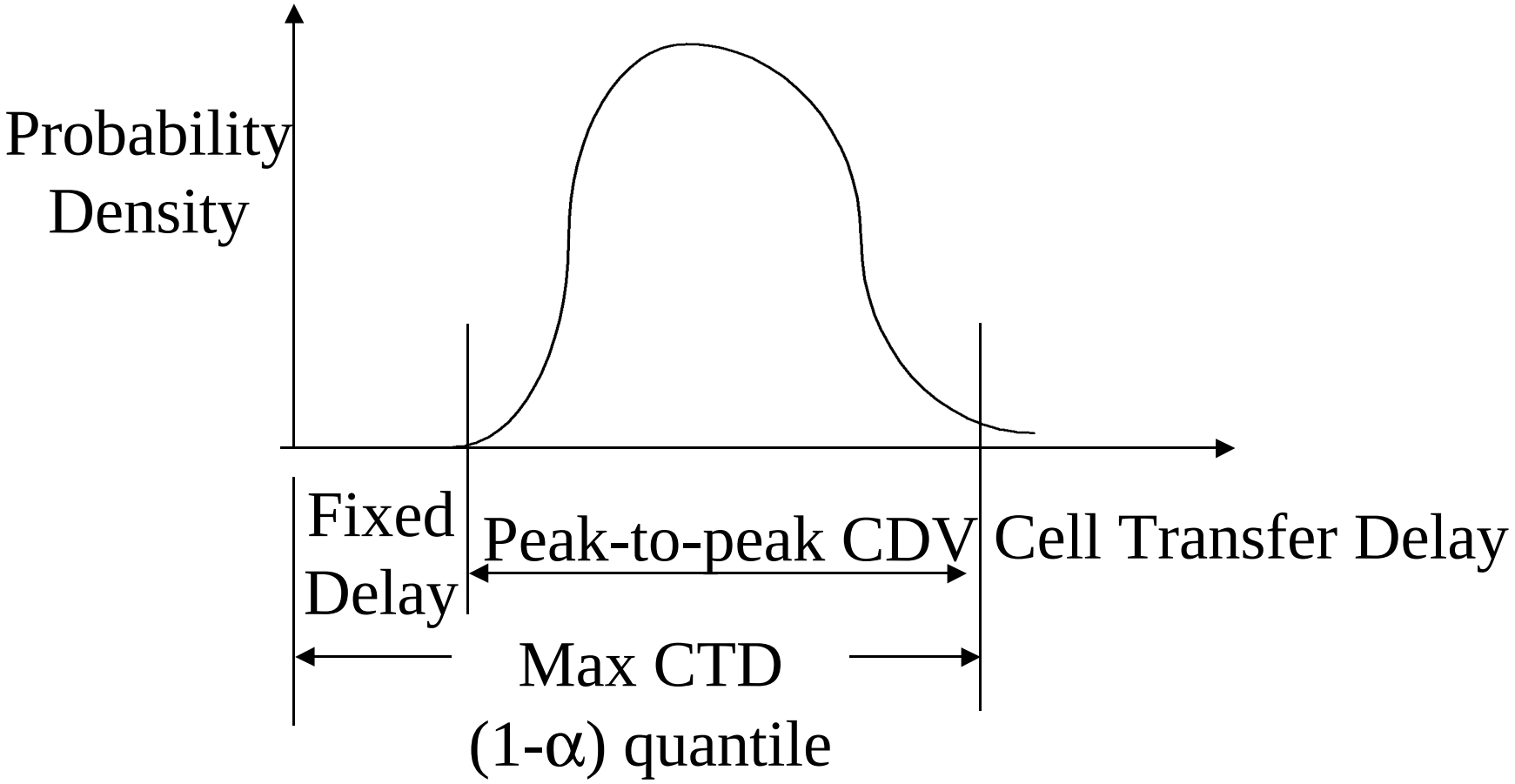
Traffic Contract Parameters



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

- Sustained Cell Rate (SCR): Average over a long period
- Burst Tolerance (BT) τ_s : GCRA limit parameter wrt SCR GCRA($1/T_s$, τ_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[4,5]	Specified	Specified	Specified	Specified[2]	Specified[3]
SCR,MBS, CDVT[4,5]	N/A	Specified	Specified	N/A	N/A
MCR[4]	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[4]	Specified	Specified	Specified	Unspecified	Specified[1]
Feedback	Unspecified	Unspecified	Unspecified	Unspecified	Specified[6]

[1]Network specific

[2]Not subject to CAC/UPC

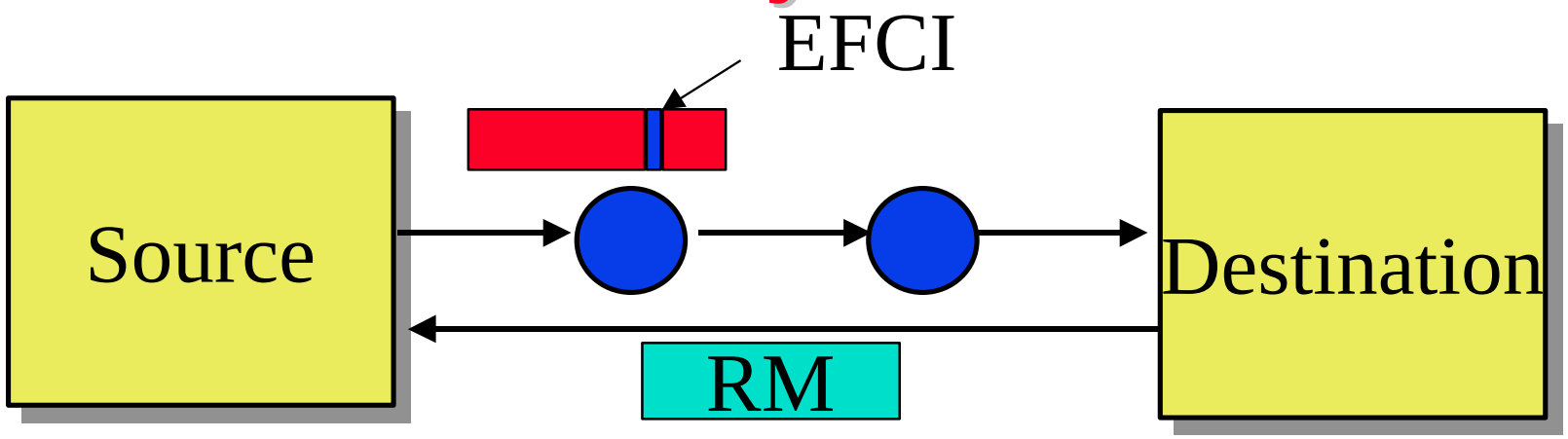
[3]PCR $\Rightarrow$ Max ACR

[4]Explicitly/implicitly specified for PVC/SVC

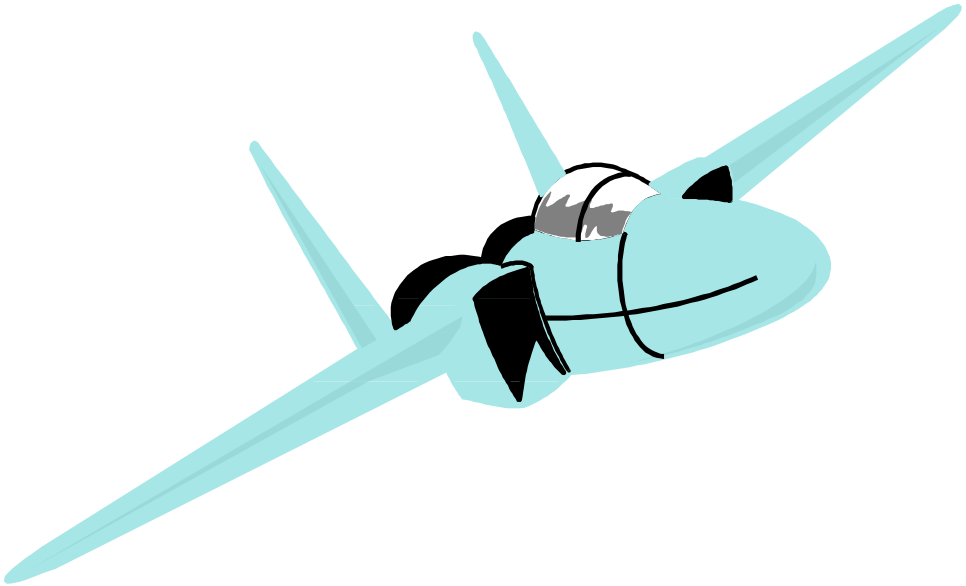
[5]Not signaled. Different values may apply at different interfaces along the path.

[6]Follow ABR rules

ABR: Binary Rate Scheme



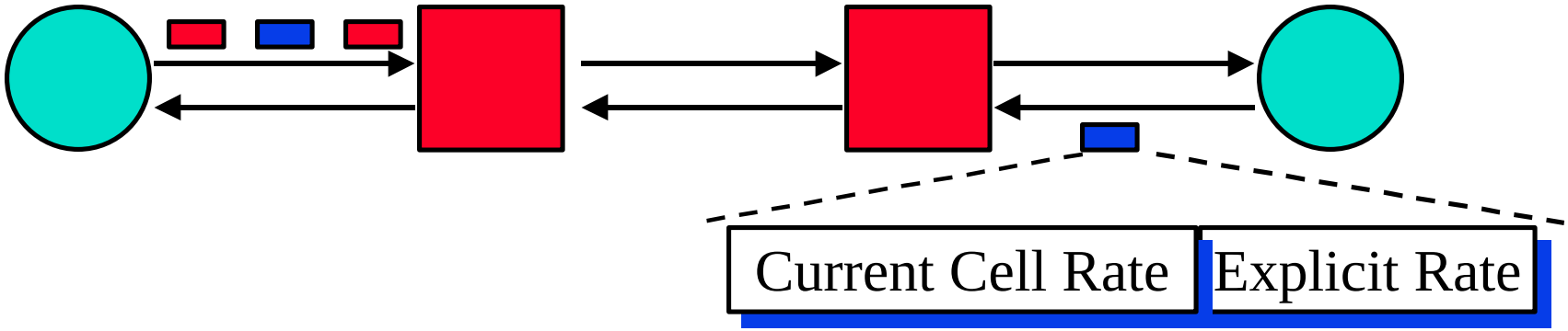
- DECbit scheme in many standards since 1986.
- Forward explicit congestion notification (FECN) in Frame relay
- Explicit forward congestion indicator (EFCI) set to 0 at source. Congested switches set EFCI to 1
- Every nth cell, destination sends an resource management (RM) cell to the source



Go
30 km East
35 km South

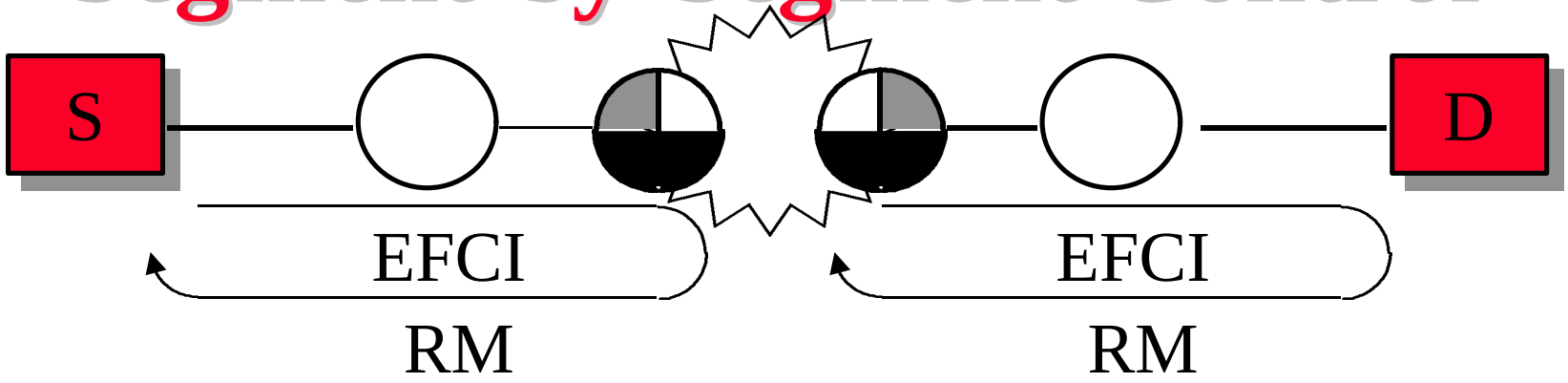
Go left

ABR: The Explicit Rate Scheme

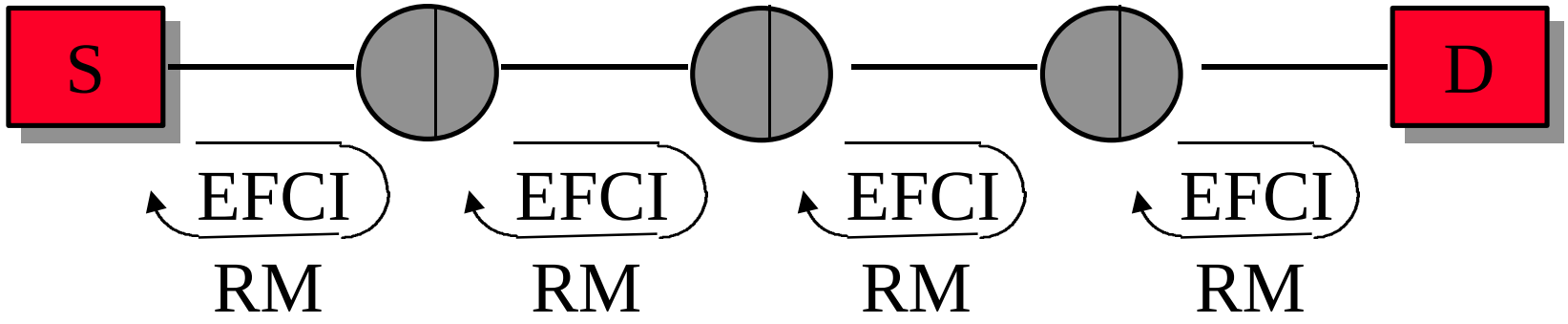


- Sources send one RM cell every n cells
- The RM cells contain "Explicit rate"
- Destination returns the RM cell to the source
- The switches adjust the rate down
- Source adjusts to the specified rate

Segment-by-Segment Control



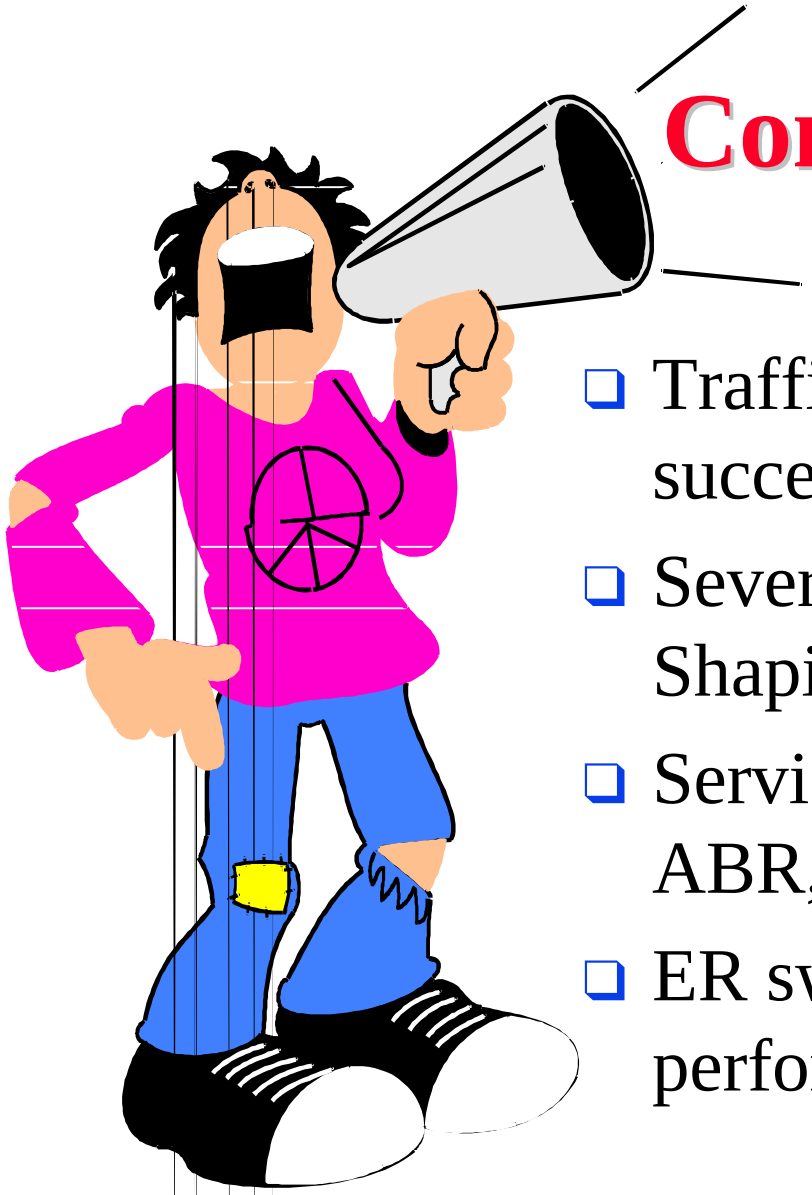
- Virtual source/virtual destinations follow all notification/control rules
- Can be hop-by-hop



- Virtual dest/sources maintain per-VC queues.

Guaranteed Frame Rate (GFR)

- UBR with minimum cell rate (MCR) ⇒ 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

- Stallings' ISDN and BISDN book, Chapter 16
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- 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/*

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- 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