Traffic Mangement in ATM Networks

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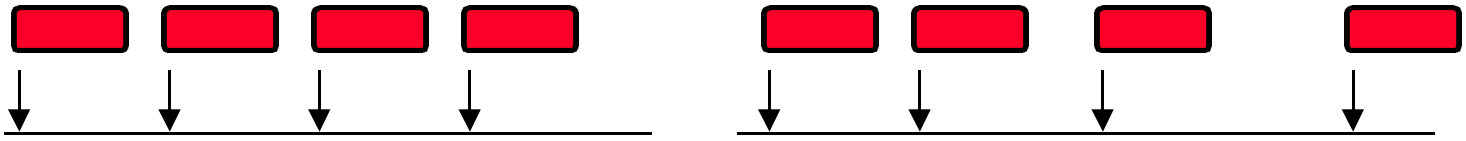
- Why worry about traffic Mangement
- ATM Traffic Management
- Switch Algorithms
- Issues Specific to Satellites
- ABR Vs UBR
- Internet protocols over ATM

Economic Reasons

- Network is a shared resource
  Because it is expensive and needed occasionally
  (Like airplanes, emergency rooms)
- Most costs are fixed.
  Cost for making, launching, and maintaining satellites, switches, 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 managemnt is required even with underload

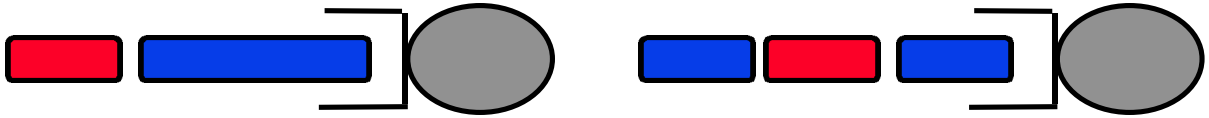
ATM Networks: Overview

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

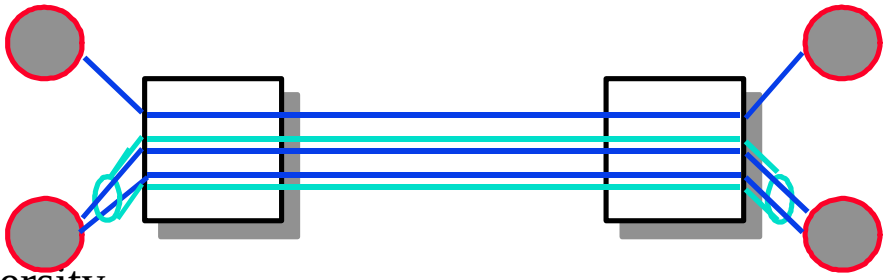


Allows any-speed and even variable rate connection

- ATM = Short fixed size 53-byte cells



- Connection oriented ⇒ Virtual Channels (VC)



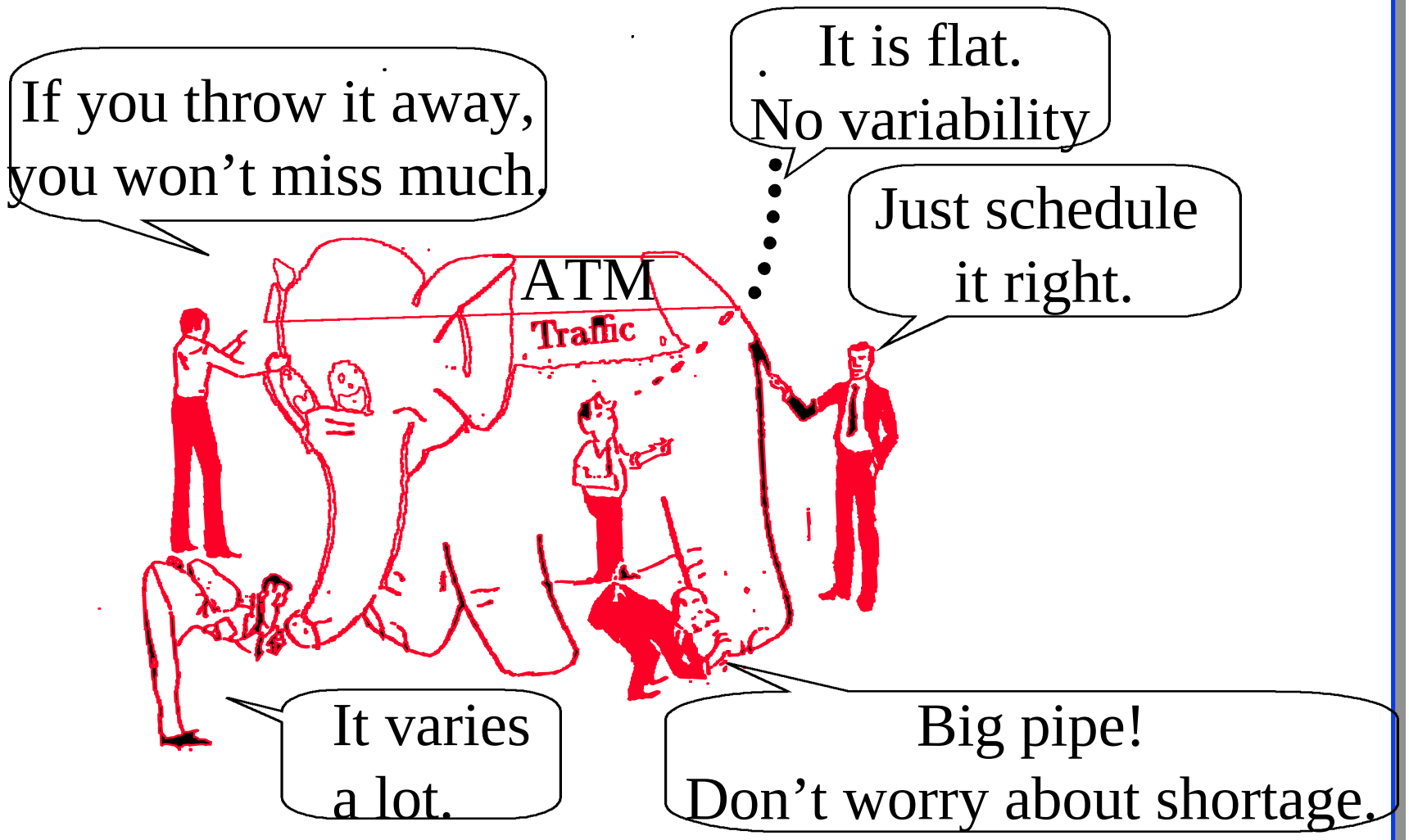
Classes of Service

- 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.
    Mean delay guaranteed.

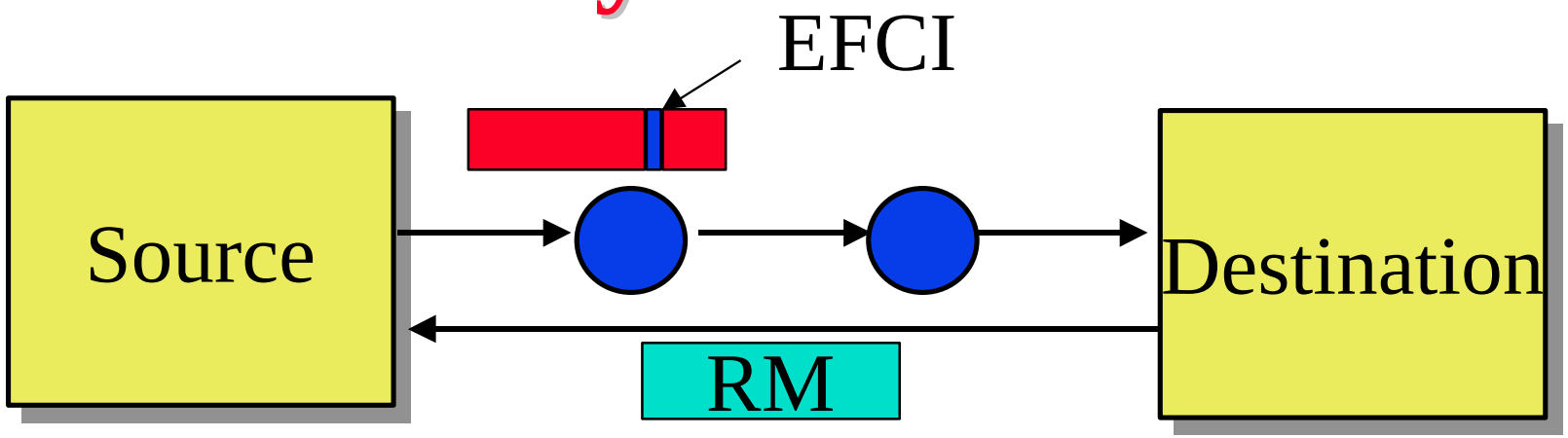
Traffic Management Functions

- Connection Admission Control (CAC):
  Verify that the requested bandwidth and quality of service (QoS) can 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, resource reservation
- Priority Control: Cell Loss Priority (CLP)
- Selective Cell Discarding: Frame Discard
- Feedback Controls: Network tells the source to increase or decrease its load.

ATM Traffic

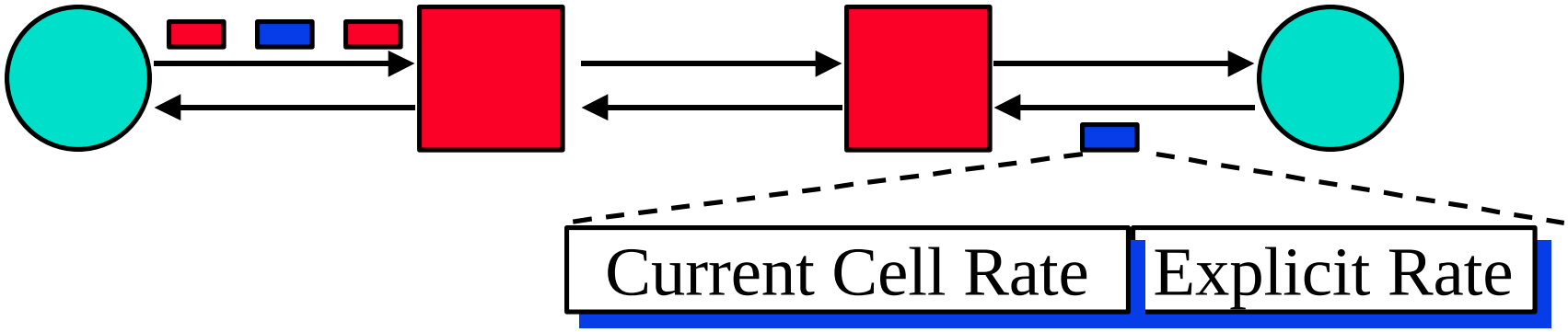

If you throw it away, you won't miss much.
It is flat. No variability
Just schedule it right.
ATM
Traffic
It varies a lot.
Big pipe! Don't worry about shortage.

Initial Binary Rate-based Scheme



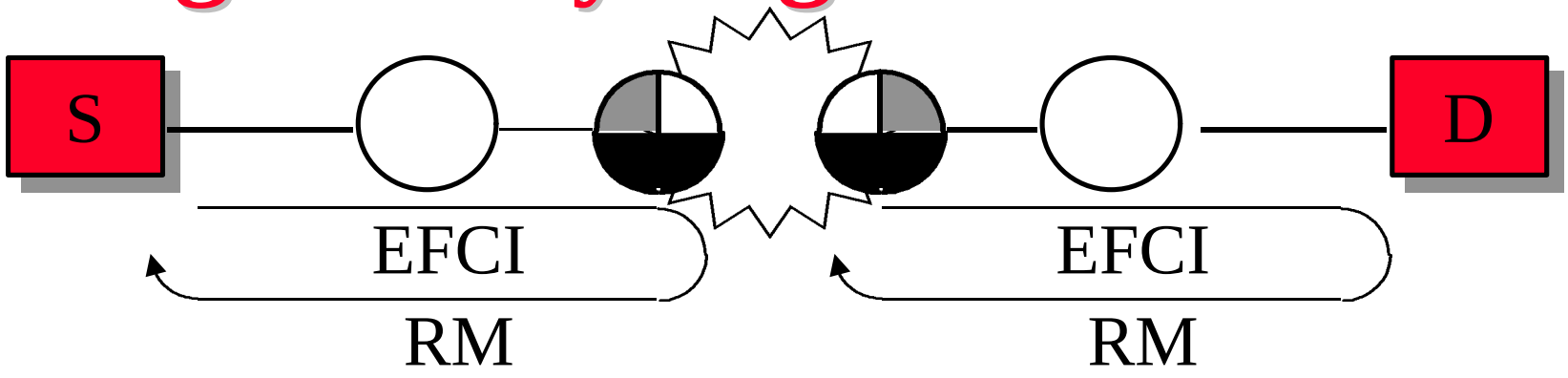
- Explicit forward congestion indicator (EFCI) set to 0 at source
- Congested switches set EFCI to 1
- Every *n*th cell, destination sends an resource management (RM) cell to the source indicating increase amount or decrease factor

The Explicit Rate Scheme

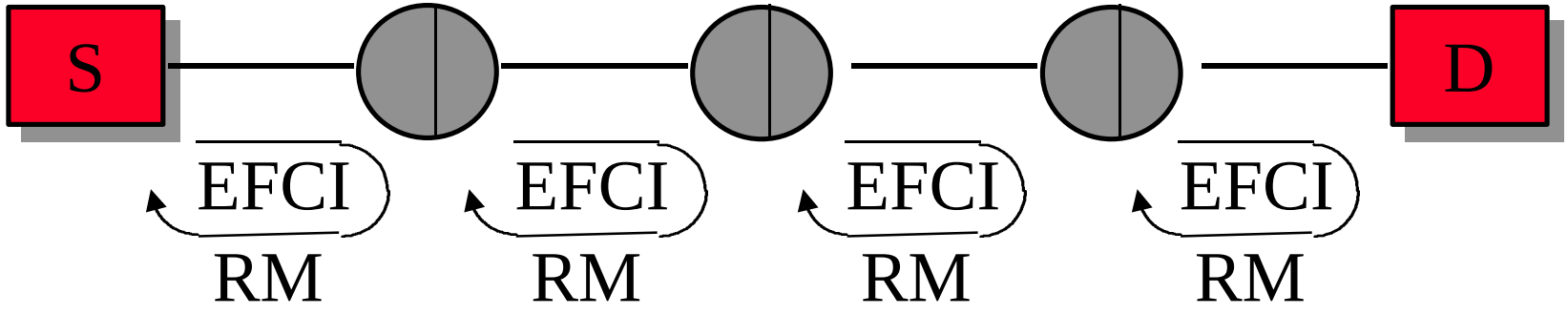


- Sources send one RM cell every n cells
- The RM cells contain "Explicit rate"
- Destination returns the RM cell to the source
- The switches adjust the rate down
- Source adjusts to the specified rate

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.

ERICA Switch Algorithm

- Each manufacturer will have its own explicit rate switch algorithm
- Explicit Rate Indication for Congestion Avoidance (ERICA) is the most thoroughly analyzed algorithm among disclosed algorithms
- Shown to be efficient, fair, fast transient response, able to handle bursty TCP traffic
- ERICA+ allows low delay even at 100% utilization and provides stability in the presence of high frequency VBR background traffic
- Being implemented by several vendors

Our Goal in ATM Forum

- Ensure that the new ATM Forum TM 4.0 spec is "Satellite-friendly"
- There are no parameters or requirement that will perform badly in a long-delay satellite environment
- Users can use paths going through satellite links without requiring special equipment

Effect of Crm

- CRM limits the number of cells lost if the link is broken
- Source Rule (6):
  If you have not received feedback from the network after Crm×Nrm cells, reduce your ACR:

$$ACR = \max\{MCR, ACR - ACR \times CDF\}$$

Here,

CDF = Crm Decrease Factor

MCR = Minimum Cell Rate

ACR = Allowed Cell Rate

Effect of CDF

- After Crm×Nrm cells:

$$ACR = ACR(1 - CDF)$$

- After Crm(1 + Nrm) cells:

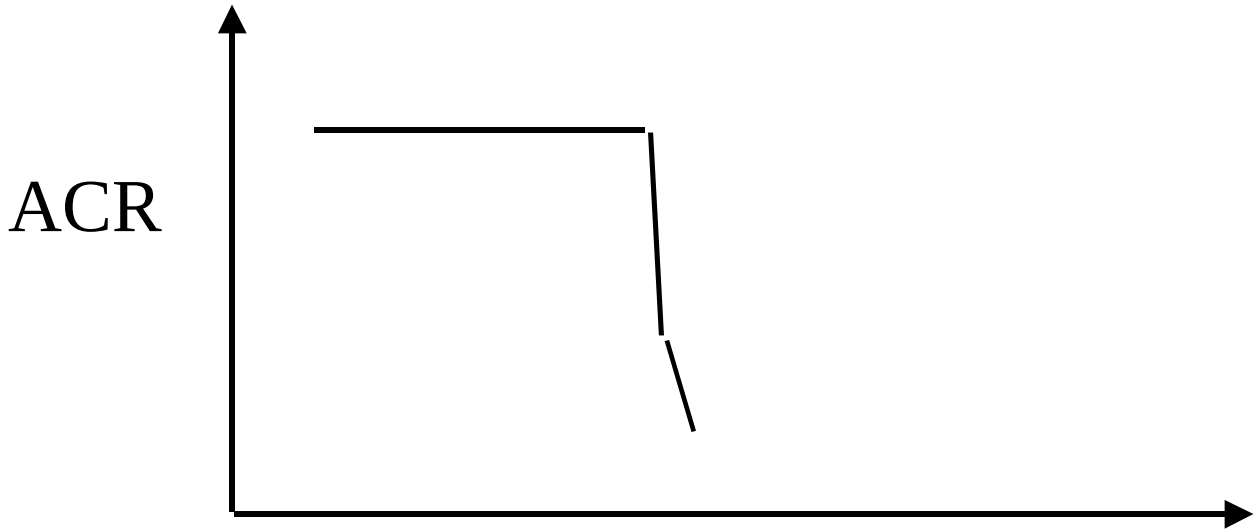
$$ACR = ACR(1 - CDF)^2$$

- After Crm(k + Nrm) cells:

$$ACR = ACR(1 - CDF)^k$$

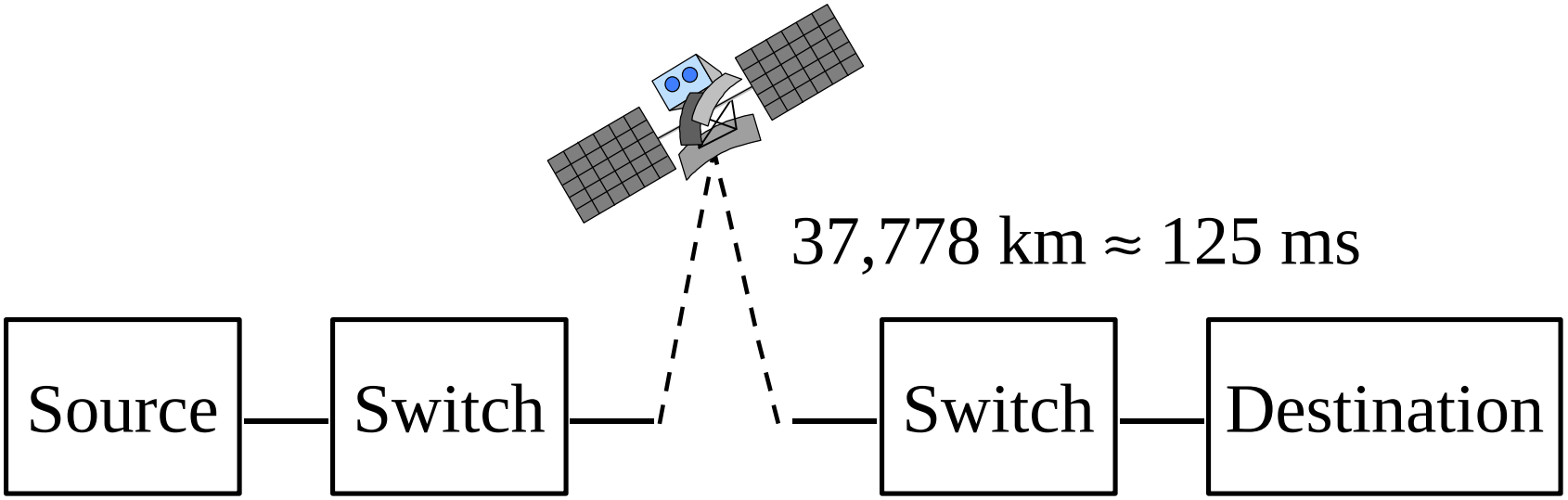
Effect of CDF

- There is an almost vertical drop after Crm:



- The value of CDF has very little effect
- The source becomes a "Low Rate Source"
- Initially Crm was a 8-bit quantity with a default of 32

Satellite Links



- One-way delay = Up-down = 250 ms
  Round-trip delay = 550 ms (measured)
- Crm = 32
  ⇒ Maximum 32×32 = 1024 cells in flight before ACR starts coming down

Required Crm

- For full throughput
  Crm $\geq$ RTTQ/(Nrm×ACR)
  Where RTTQ = Round Trip Time
  including Queueing
- For 155 Mbps, Crm $\geq$ 6,144
- For 622 Mbps, Crm $\geq$ 24,576
- For two satellite hops: Crm $\geq$ 49,152
- For *n* satellite hops: Crm $\geq$ 24,576*n*
  $\Rightarrow$ Need 32 bits for Crm
- Compromise: Crm is now a 24 bit quantity.

Internet Protocols over ATM

- ATM Forum has designed ABR service for data
- UBR service provides no feedback or guarantees
- Internet Engineering Task Force (IETF) prefers UBR for TCP

Observations About ABR

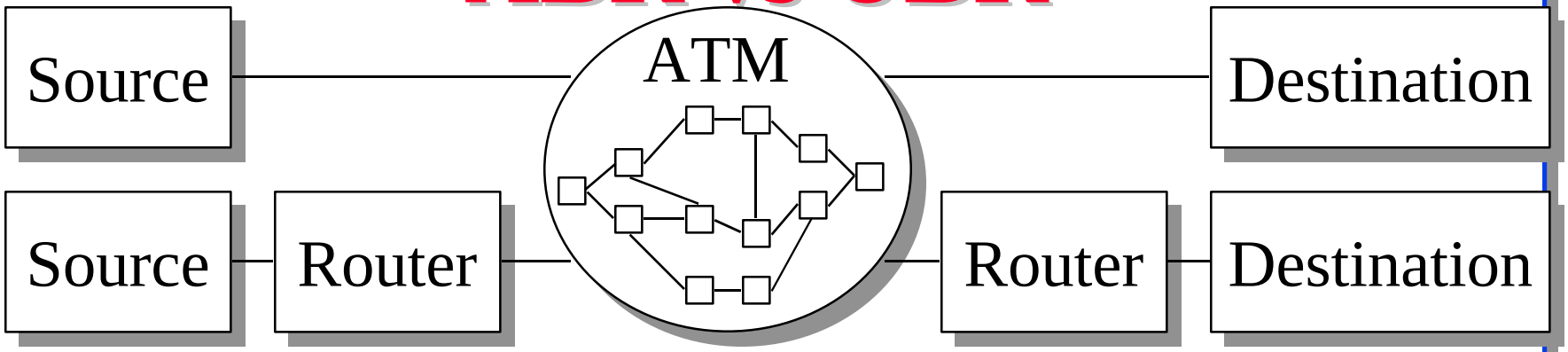
- ABR performance depends upon the switch algorithm. Following statements are based on *ERICA* algorithm. (For ERICA, see http://www.cis.ohio-state.edu/~jain/)
- No cell loss for *TCP* if switch has Buffers = 4 × RTT.
- No loss for any number of TCP sources w 4 × RTT buffers.
- No loss even with VBR.
  W/o VBR, 3×RTT buffers will do.
- Under many circumstances, 1× RTT buffers may do.
- Required buffers depend upon RTT, feedback delay, switch parameters, and characteristics of VBR.

Observations about UBR

- No loss for TCP if Buffers = Σ TCP receiver window
- Required buffering depends upon number of sources.
- Receiver window ≥ RTT for full throughput
- Unfairness in many cases.
- Fairness can be improved by proper buffer allocation, selective drop policies, and scheduling.
- No starvation ⇒ Lower throughput shows up as increased file transfer times = Lower capacity

Conclusion: UBR may be OK for: LAN, w/o VBR, Small number of sources, AND cheap implementation

ABR vs UBR

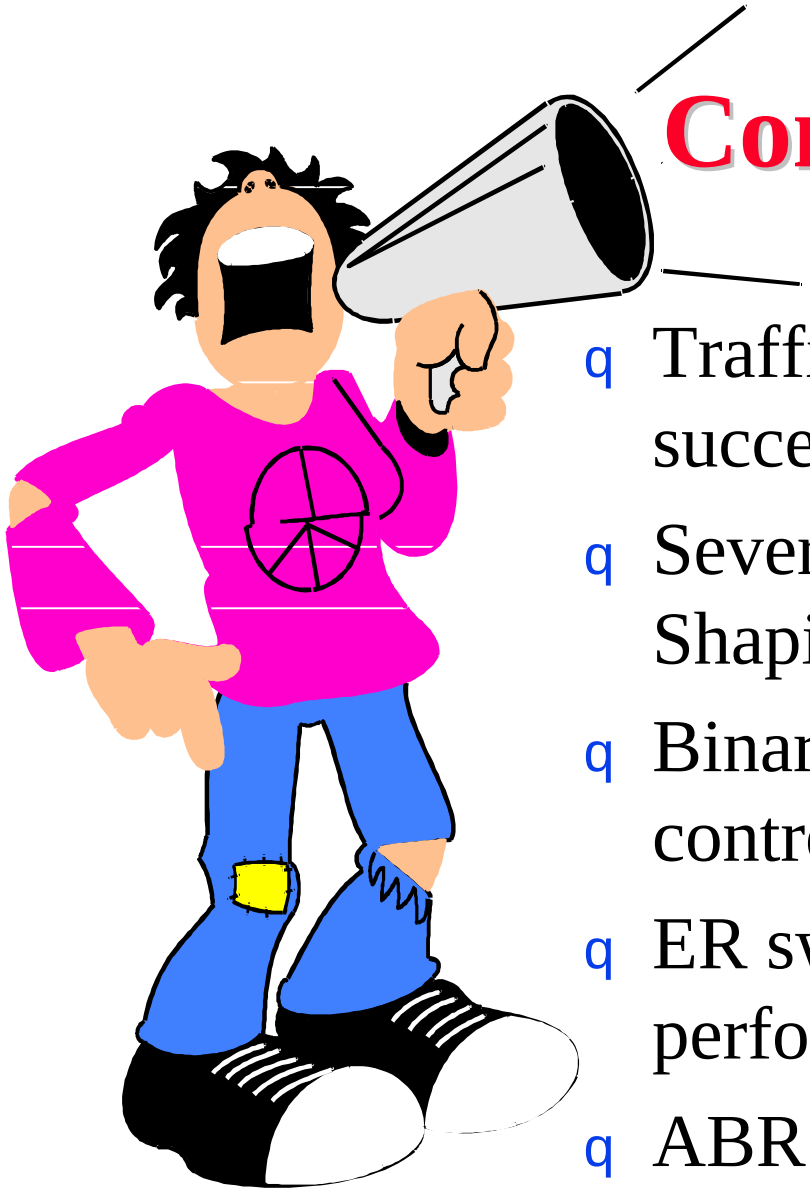


ABR	UBR
Queue in the source	Queue in the network
Pushes congestion to edges	No backpressure
Good if end-to-end ATM	Same end-to-end or backbone
Fair	Generally unfair
Good for the provider	Simple for user

ATM Over Satellite: Issues

- Switch algorithms for satellite networks
- Optimization of performance of TCP/IP over satellite ATM networks
- Multi-satellite networks
- QoS models for ATM service over satellites
- Suitability of commercial switches for on-board switching
- Buffer sizing for switches

Congestion: Summary



- Traffic Management is key to success of ATM Service
- Several different methods: CAC, Shaping, UPC, Scheduling, ...
- Binary feedback too slow for rate control. Especially for satellites.
- ER switches provide much better performance than EFCI.
- ABR service required for long-delay or high-speed networks.

Our ATM Forum Contributions

All our contributions are available on-line at
http://www.cis.ohio-state.edu/~jain/

Our Papers

- Most of our papers are available on-line at *http://www.cis.ohio-state.edu/~jain/*
- See Recent Hot Papers for tutorials.