TCP/IP over ATM using ABR, UBR, and GFR Services

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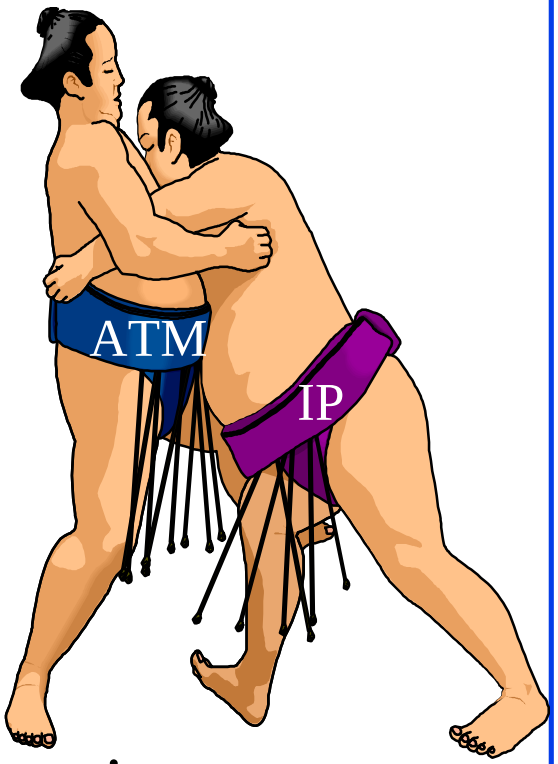
Overview

- Why ATM?
- ABR: Binary and Explicit Feedback
- ABR Vs UBR
- TCP/IP over UBR
- TCP/IP over GFR

Why ATM?



ATM vs IP: Key Distinctions

1. Traffic Management:
   Explicit Rate vs Loss based
2. Signaling: Coming to IP in the form of RSVP
3. QoS: PNNI routing, Service categories. Integrated/Differentiated services
4. Switching: Coming to IP as MPLS
5. Cells: Fixed size or small size is not important

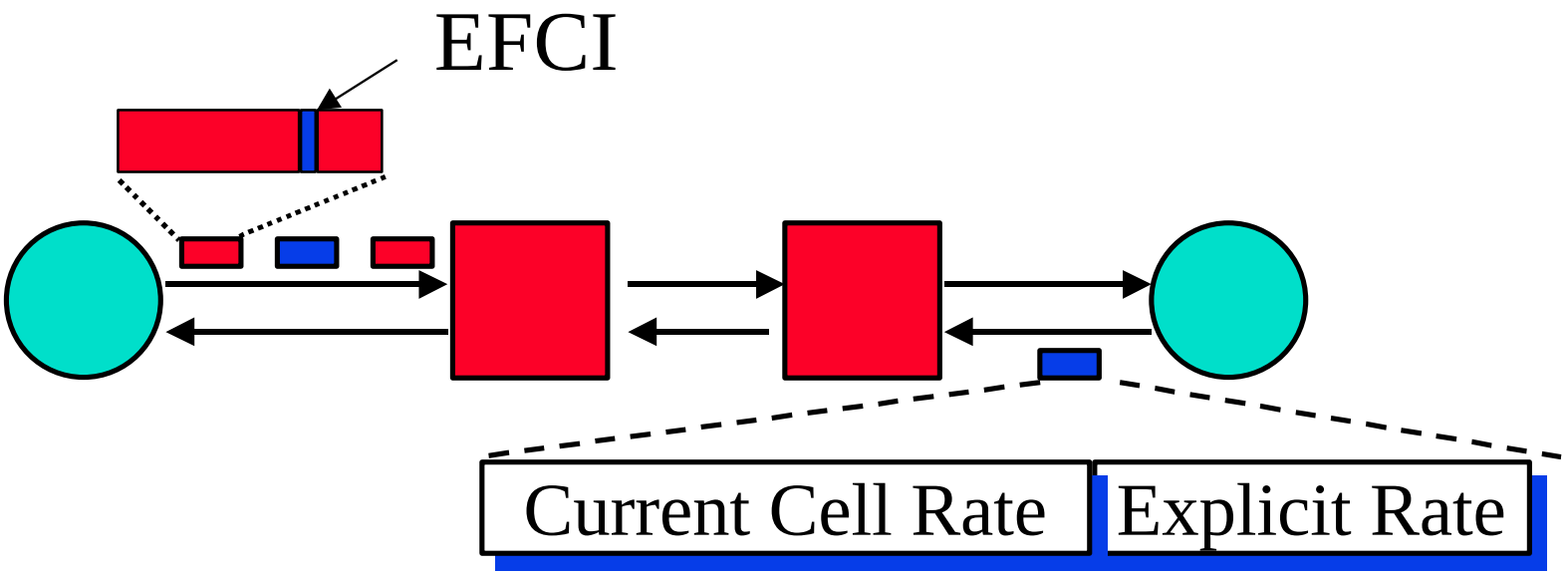
Traffic Mgmt Functions

- Connection Admission Control (CAC):
  Can 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, 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.

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.

ABR: Binary vs Explicit Rate



- DECbit scheme in 1986: Bit ⇒ Go up/Down
  - Used in Frame Relay (FECN) and ATM (EFCI)
- In July 1994, we proposed Explicit Rate Approach.
  Sources send one RM cell every n cells.
  The switches adjust the explicit rate field down.

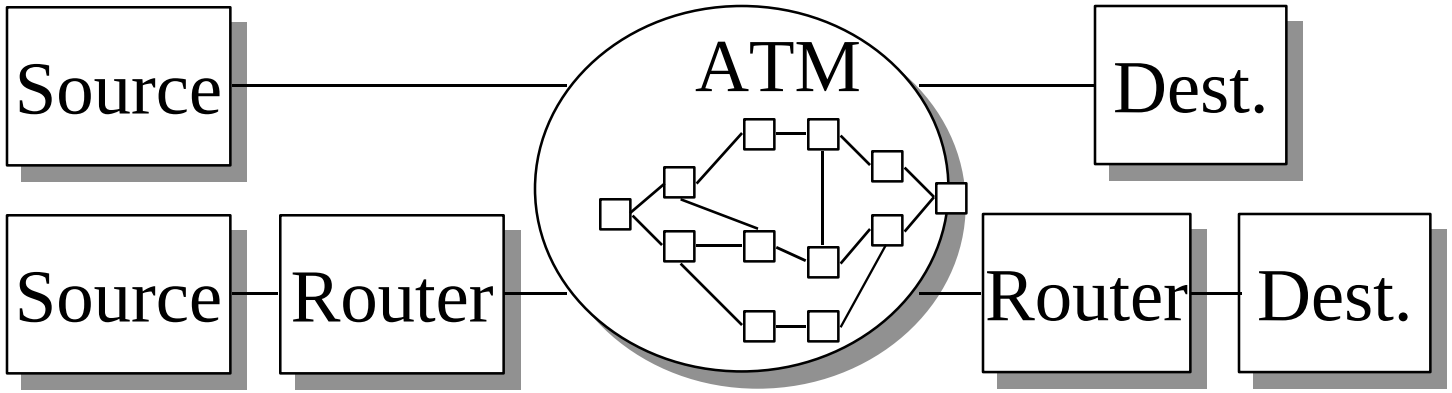
Why Explicit Rate Indication?

- Longer-distance networks
  $\Rightarrow$ Can't afford too many round-trips
  $\Rightarrow$ More information is better
- Rate-based control
  $\Rightarrow$ Queue length = ΔRate $\times$ ΔTime
  $\Rightarrow$ Time is more critical than with windows
- NOTE: Explicit congestion notification (ECN) in IP is binary and applies only to TCP.

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

ABR vs UBR



ABR

Queue in the source

Pushes congestion to edges

If ATM not end-to-end: intelligent Q mgmt in routers

Works for all protocols

UBR

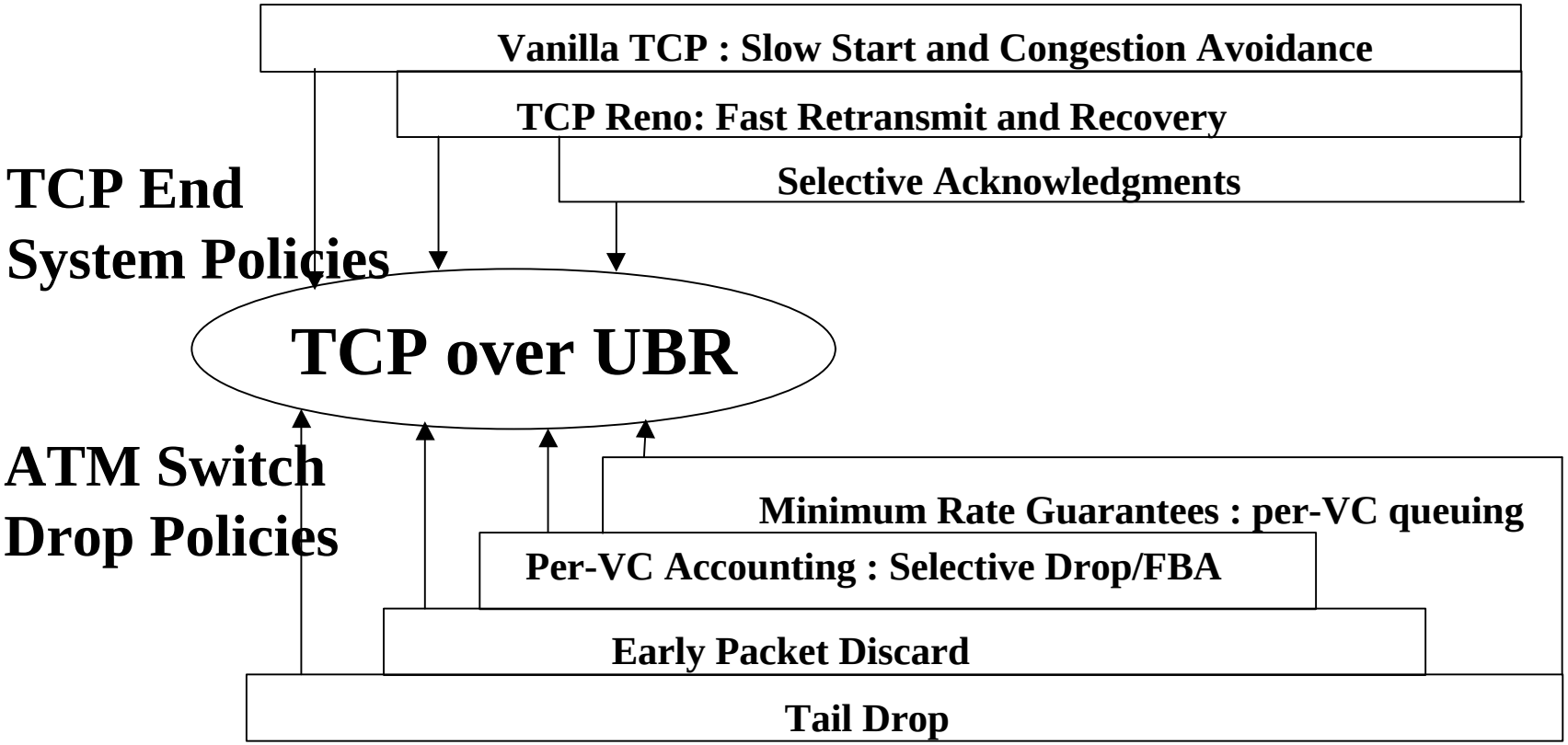
Queue in the network

No backpressure

Same end-to-end or backbone

Works with TCP

Improving Performance of TCP over UBR



Policies

Switch Policies		End-System Policies: No FRR	FRR	New Reno	SACK + New Reno
No EPD					
	Plain EPD				
EPD	Selective Drop				
	Fair Buffer Allocation				

Policies: Results

- In LANs, switch improvements (PPD, EPD, SD, FBA) have more impact than end-system improvements (Slow start, FRR, New Reno, SACK). Different variations of increase/decrease have little impact due to small window sizes.
- In large bandwidth-delay networks, end-system improvements have more impact than switch-based improvements
- FRR hurts in large bandwidth-delay networks.

Policies (Continued)

- Fairness depends upon the switch drop policies and not on end-system policies
- In large bandwidth-delay networks:
  - SACK helps significantly
  - Switch-based improvements have relatively less impact than end-system improvements
  - Fairness is not affected by SACK
- In LANs:
  - Previously retransmitted holes may have to be retransmitted on a timeout
    $\Rightarrow$ SACK can hurt under extreme congestion.

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 CLP =0 or CLP =1
  - All frames below MCR are given CLP =0 service.
    All frames above MCR are given best effort (CLP =1) service.

Guaranteed Rate Service

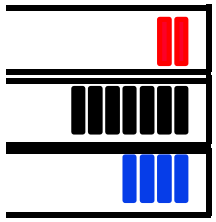
- Guaranteed Rate (GR): Reserve a small fraction of bandwidth for UBR class.

GR	GFR
per-class reservation	per-VC reservation
per-class scheduling	per-VC accounting/scheduling
No new signaling	Need new signaling
Can be done now	In TM4+

Guaranteed Rate: Results

- Guaranteed rate is helpful in WANs.
- For WANs, the effect of reserving 10% bandwidth for UBR is more than that obtained by EPD, SD, or FBA
- For LANs, guaranteed rate is not so helpful. Drop policies are more important.

GFR: Results

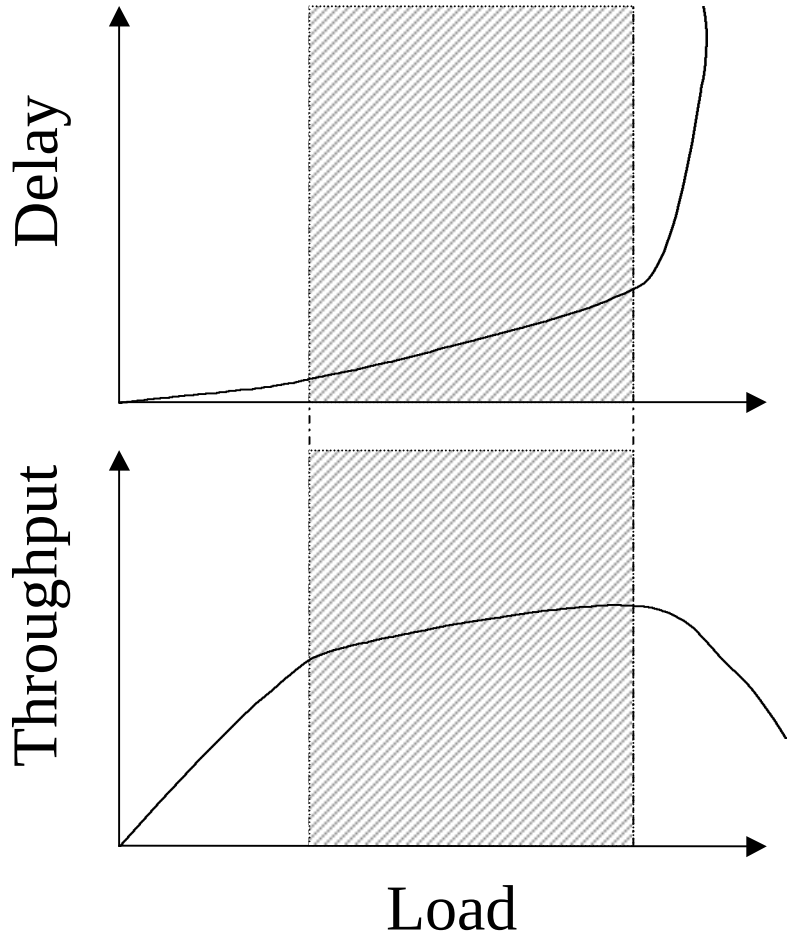


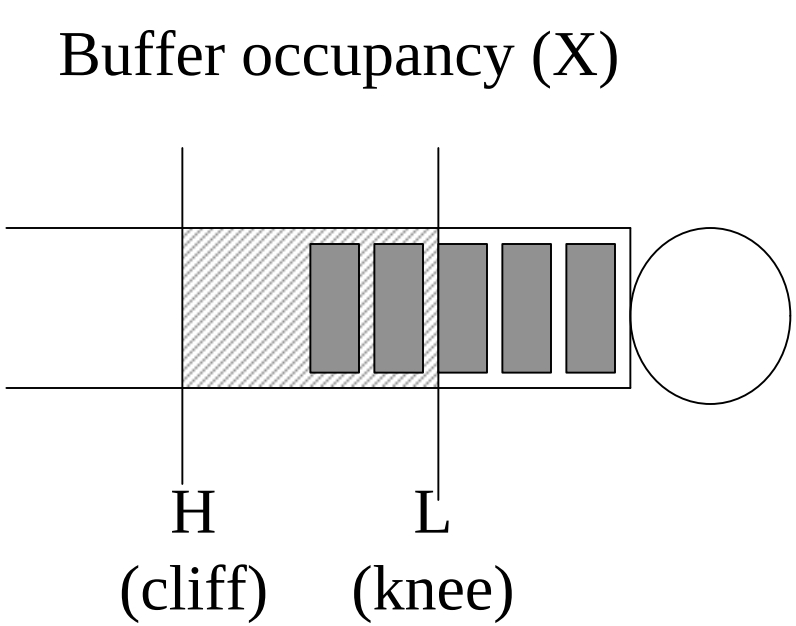
Per-VC Q

Single FIFO

- Per-VC queuing and scheduling is sufficient for per-VC MCR.
- FBA and proper scheduling is sufficient for fair allocation of excess bandwidth
- Questions:
  - How and when can we provide MCR guarantee with FIFO?
  - What if each VC contains multiple TCP flows?

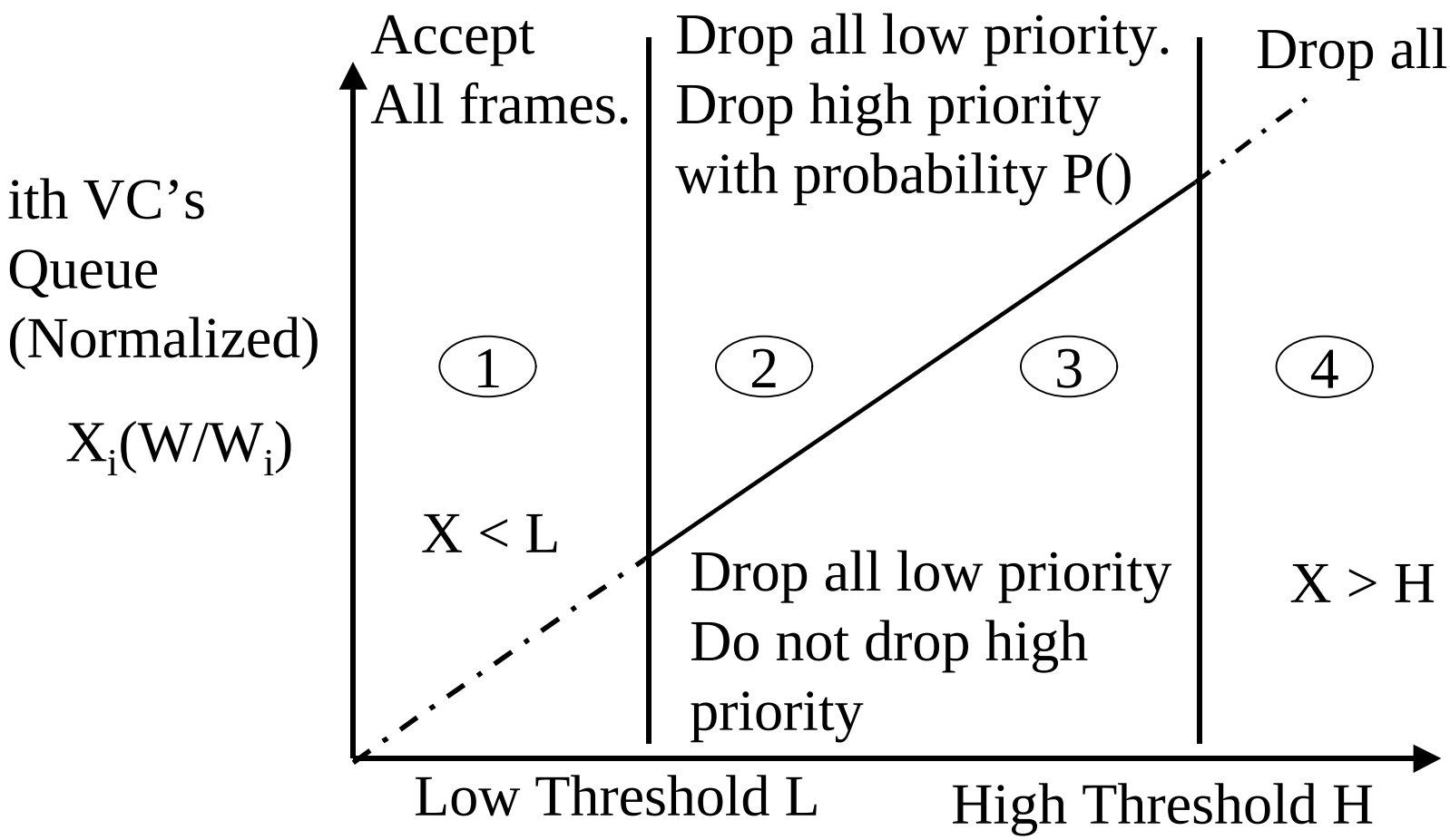
Differential Fair Buffer Allocation





Desired operating region

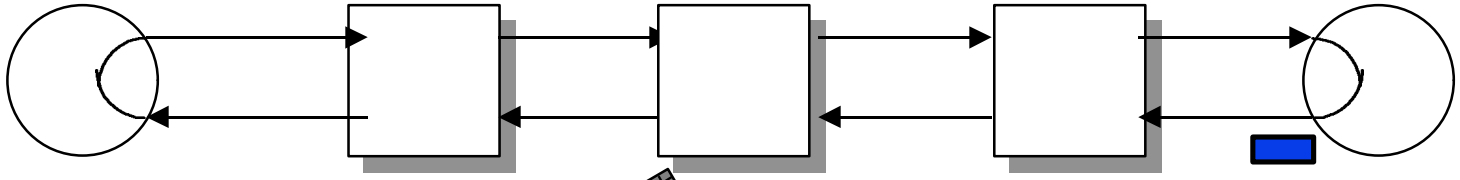
DFBA (contd.)



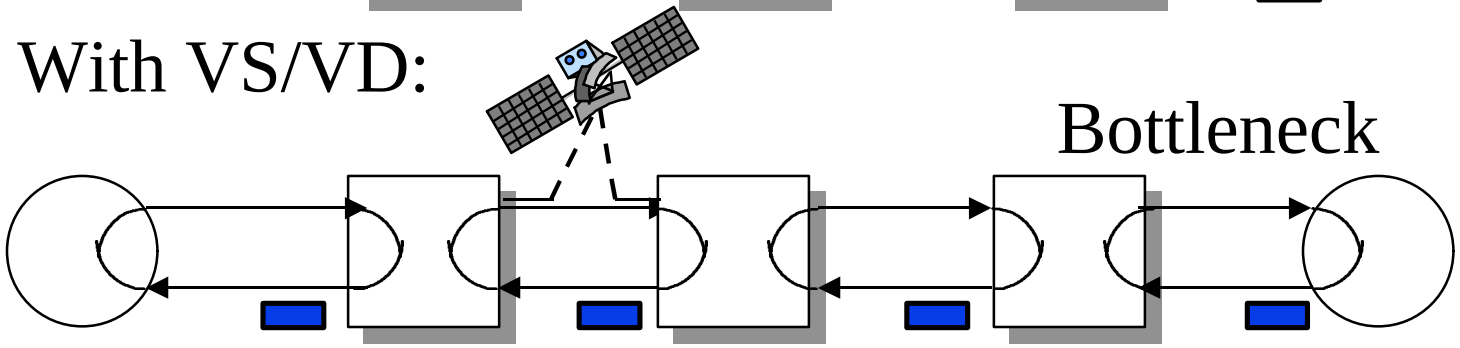
TCP Rate $D \propto \frac{MSS}{RTT \times \sqrt{P(drop)}}$

VS/VD

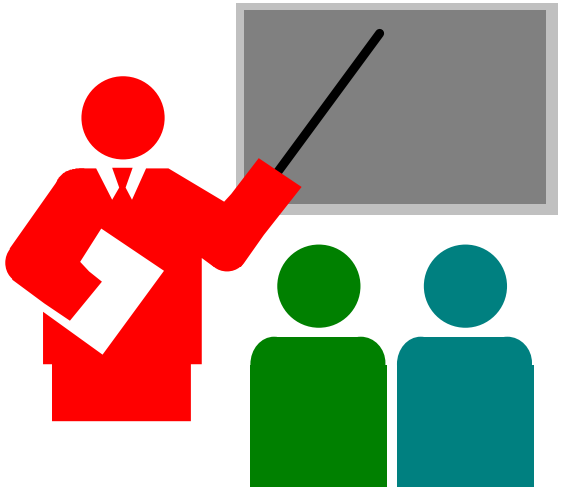
- Without Virtual Source/Virtual Destination:



- With VS/VD:



- With VSVD, the buffering is proportional to the delay-bandwidth of the previous loop
  ⇒ Good for satellite networks



Summary

- Traffic management distinguishes ATM from its competition
- Binary feedback too slow.
  ER switches better for high bandwidth-delay paths.
- ABR pushes congestion to edges.
  UBR+ may be OK for LANs but not for large bandwidth-delay paths.

Summary (Cont)

- Reserving a small fraction of bandwidth for the entire UBR class improves its performance considerably.
- It may be possible to do GFR with FIFO

Our Contributions and Papers

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