Congestion Control in ATM Networks: Recent Results and Open Problems

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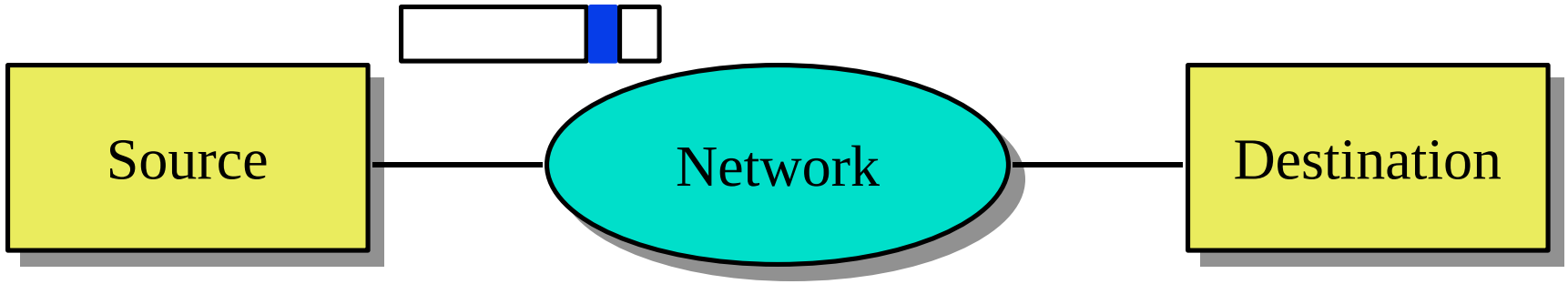
- Seven congestion management functions in ATM
- Five service classes
- Binary vs explicit rate feedback
- ERICA and ERICA+ Switch algorithms
- Outstanding issues

Congestion Control: Our Schemes

- 1986: Packet Loss ⇒ Timeout ⇒ Congestion
  ⇒ Slow Start in TCP/IP Networks
- 1989: DECbit Scheme:
  One bit in packet ⇒ Reduce/increase



- 1994: Explicit Rate

Computing Advertised Rate

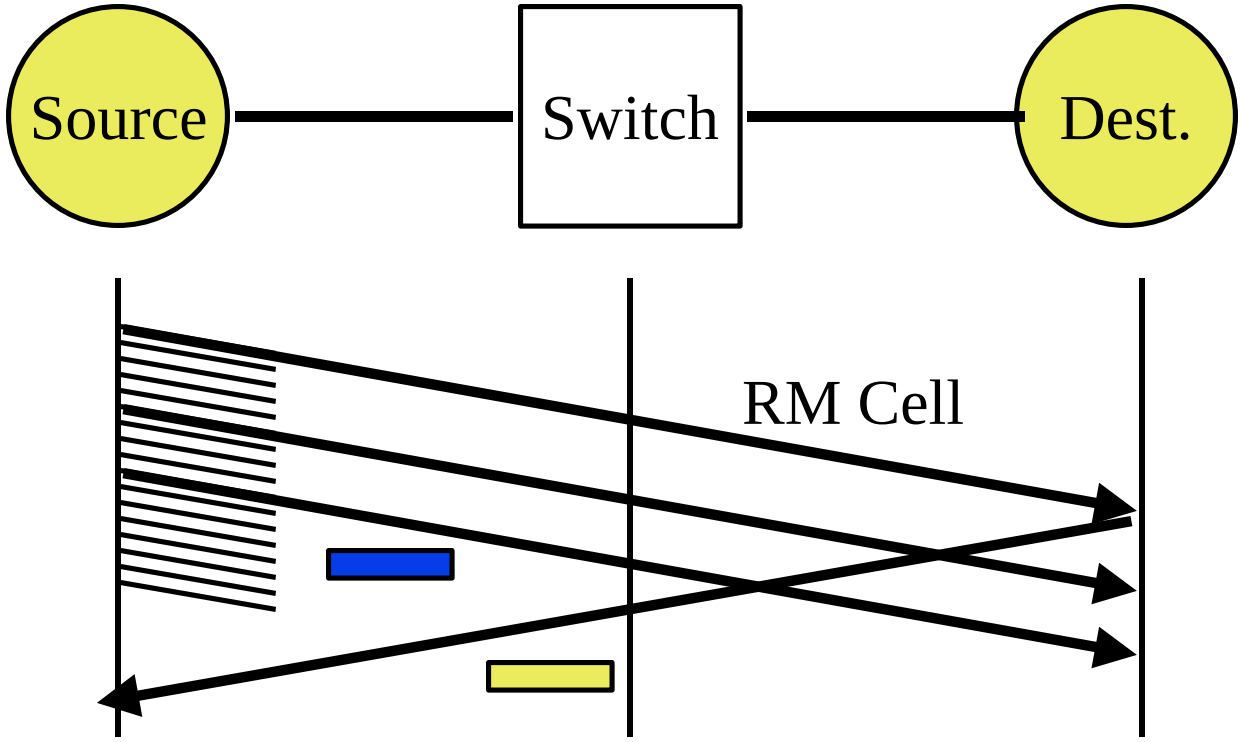
- Advertised Rate = Capacity/number of VCs
- Underloading VC = Rate < advertised

$$\text{Advertised rate} = \frac{\text{Capacity} - \Sigma \text{ BW of Underloading VCs}}{\text{\# of flows - \# of underloading flows}}$$

- If change, go to Step 2
- Two iterations are sufficient.
- Switches keep a table of stamped rates of all VCs
- Order (n) computation for n VCs

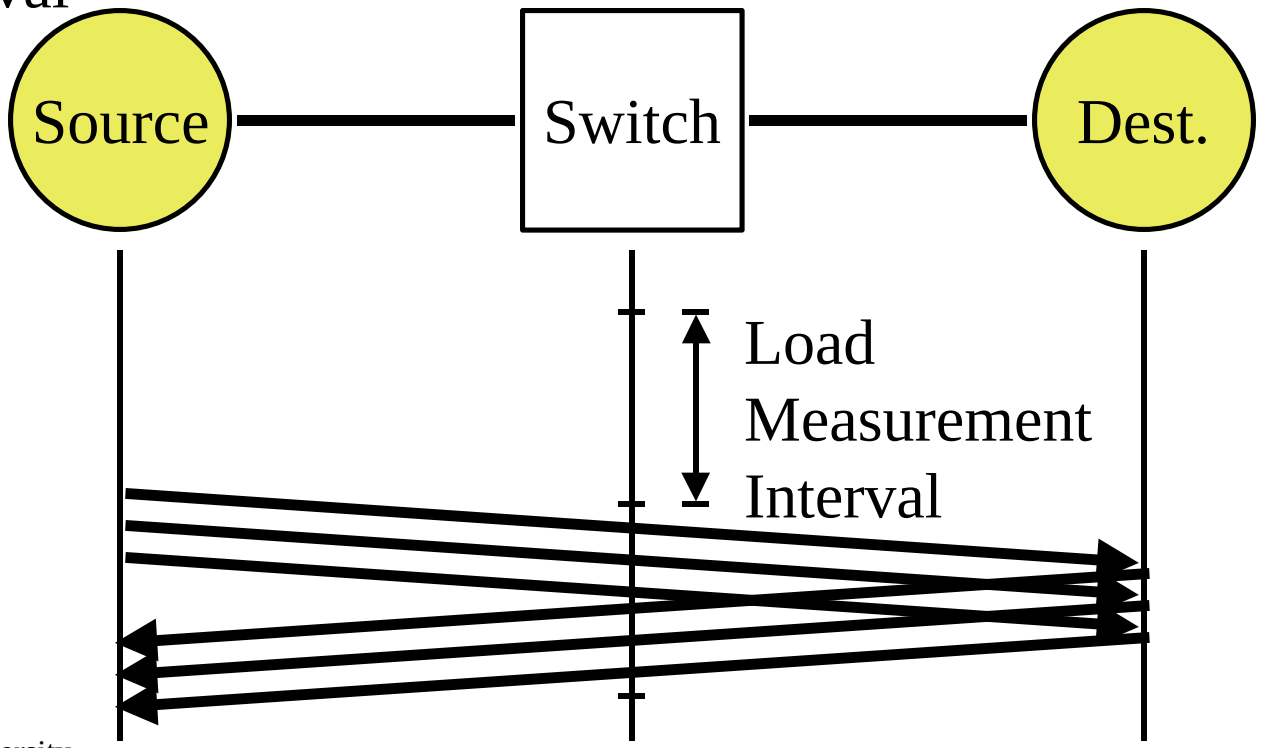
Innovation 1: Most Recent Info

- Use the latest CCR from the forward direction (more recent information) and not that in the reverse RM cell



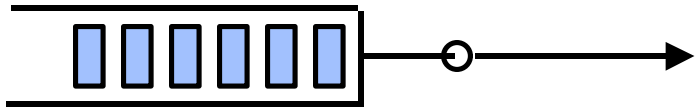
Innovation 2: Same Feedback in one Interval

- No new feedback if no new measurement
- Same feedback in all RM cells of a VC in one averaging interval



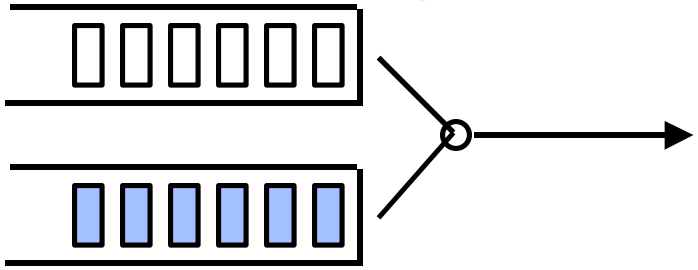
ABR-Only Systems

- Most simulations have assumed
  - Infinite sources
  - ABR only



- With ABR only:
  - Link capacity is known
  - Link capacity is fixed
  - Only traffic is random
  - Only traffic has to be measured, predicted, and allocated fairly

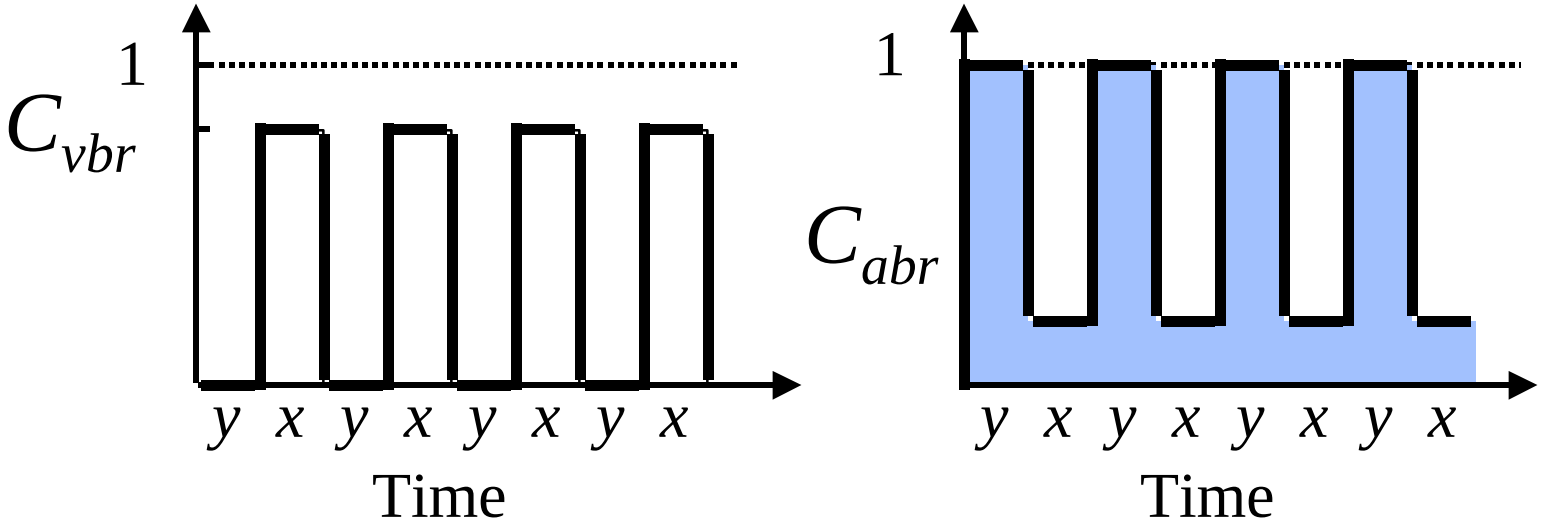
VBR+ABR Systems



- VBR gets a preferential treatment
- ABR gets only left-overs
- ABR capacity is a random variable
  It has to be measured, forecasted, and allocated
- Sometimes, there may not be any left-overs
- Sometimes, even VBR may be overbooked

A Simple VBR Model

- On for x ms and off for y ms
- When on, VBR uses up C_{vbr} bandwidth
- In practice, x, y, C_{vbr} are random variables. We assumed constants.



Problem with Current Congestion Avoidance Schemes

- Link utilization is 95% or below
  May not be acceptable for high-cost WAN links.
- Queue length is close to 1.
  Not good if available bit rate changes fast

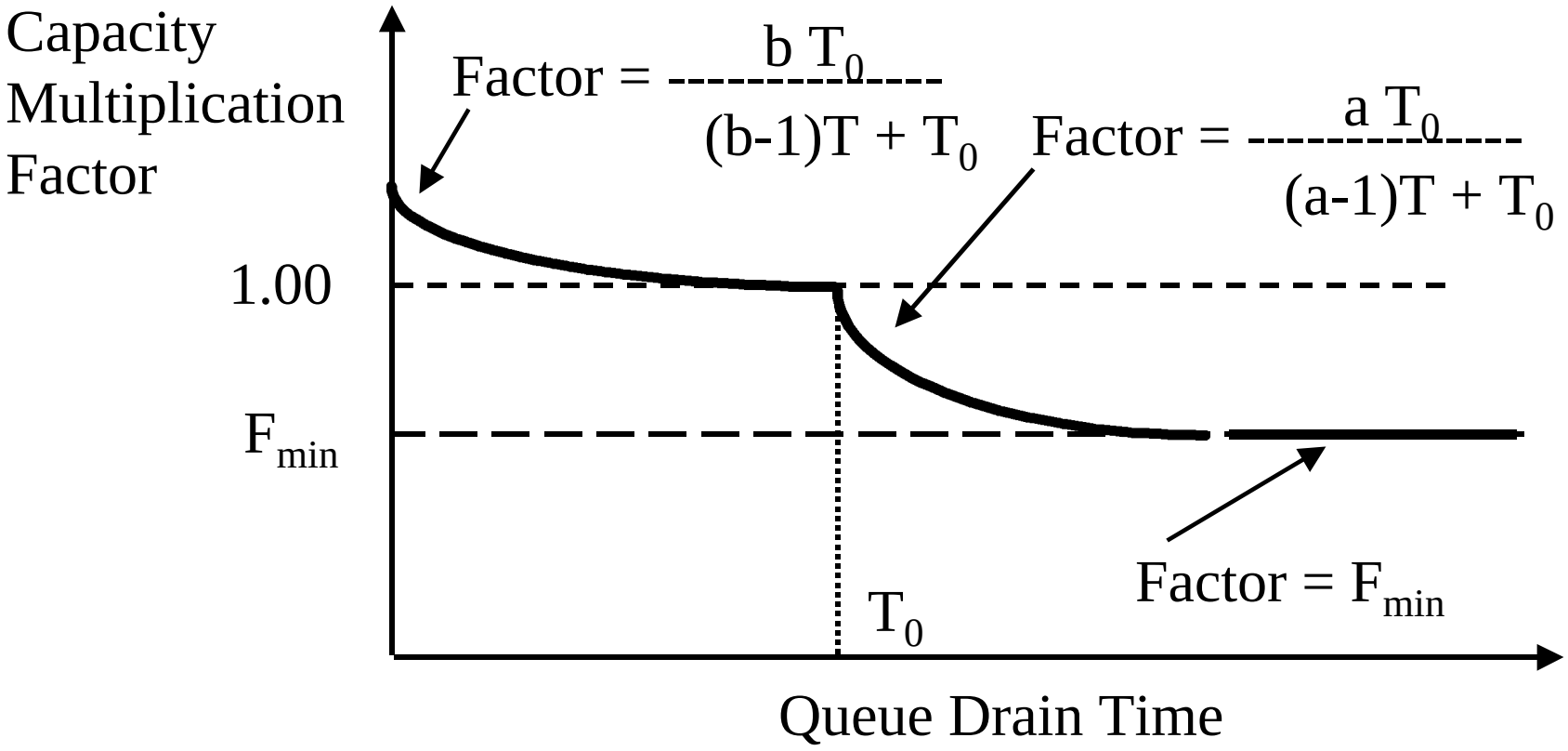
ERICA+: Switch Algorithm

- Available rate = fn(Unused bandwidth, Queue length, Queue drain time goal)
- Rest is similar to ERICA
- New Parameters:
  - Queue drain time goal = T_0
  - Queue drain rate = a
  - Queue fill rate = b
  - Capacity allocation for queue control = 20%

Features (Continued)

- Compatible with current ATM Forum TM agreements
- No changes to source operation required
- No changes to destination operation required
- No changes to RM cell format required
- Follows all switch requirements

Queue Control Function

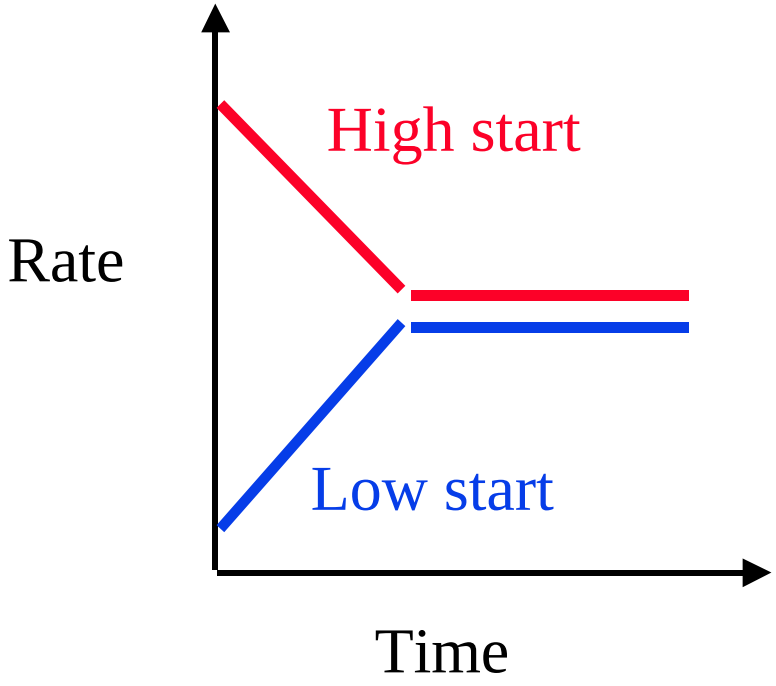


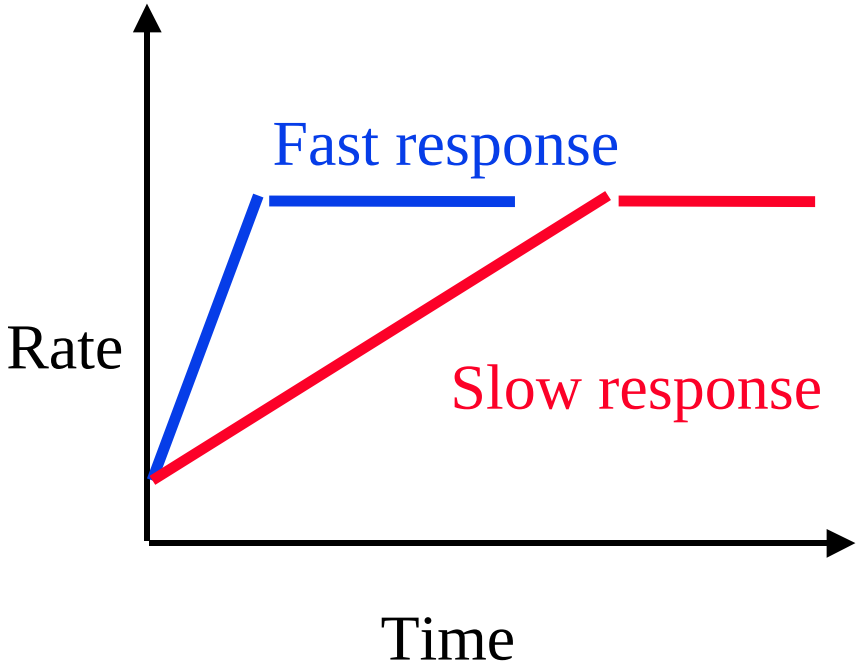
Available Capacity = Unused Capacity × Factor

How Much to Allocate?

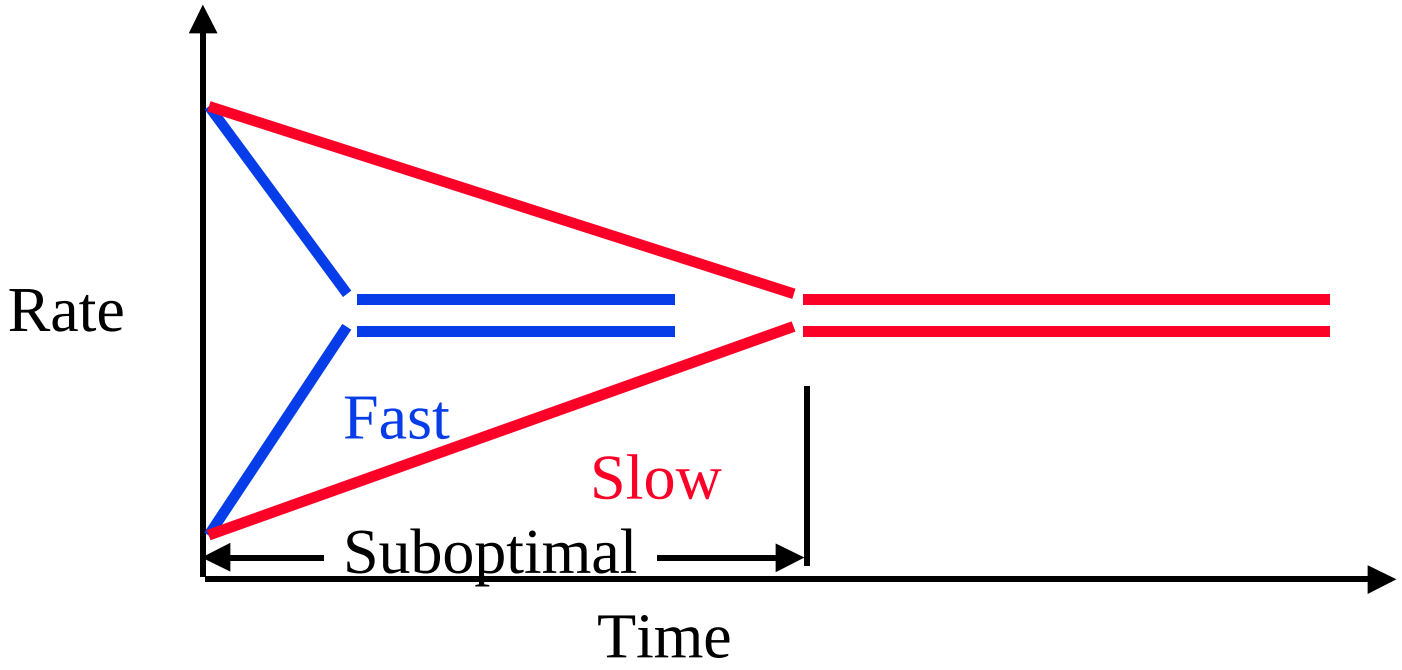
- Two Allocation Philosophies: Pessimistic vs Optimistic
- Starting point: Low vs High
- Going up: Slow vs Fast
- Going down: Slow vs Fast
- Transient Response time: Slow vs Fast

Low/High Start vs Slow/Fast Response



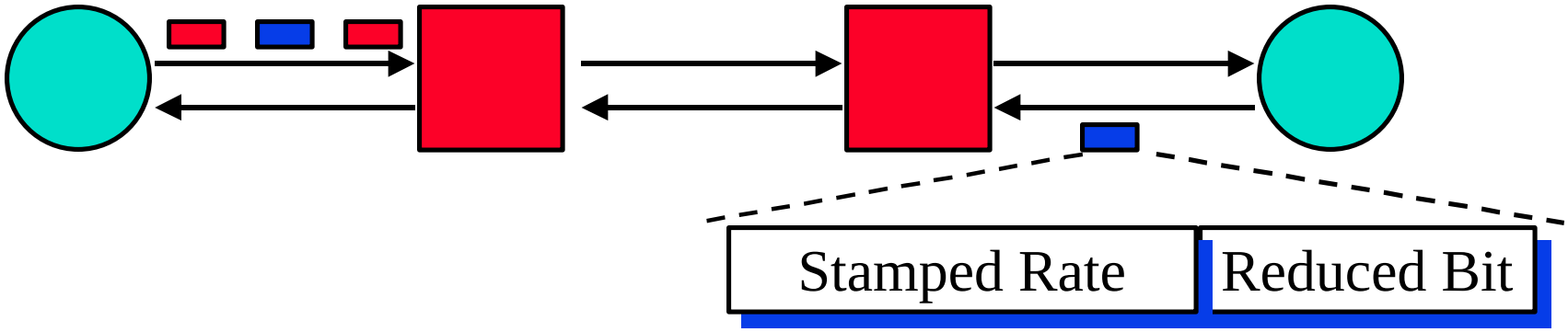


Is Fast Response Good for WAN?



- Yes, schemes with fast response, if designed properly, give lower queue length and better throughput than those with slow response
- With fast response, starting point doesn't matter that much.

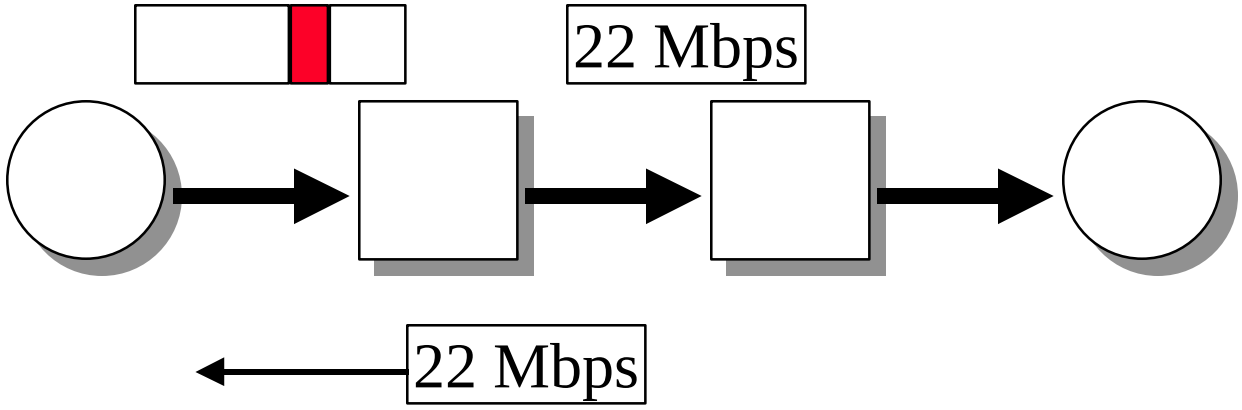
Explicit Rate Feedback: The MIT Scheme



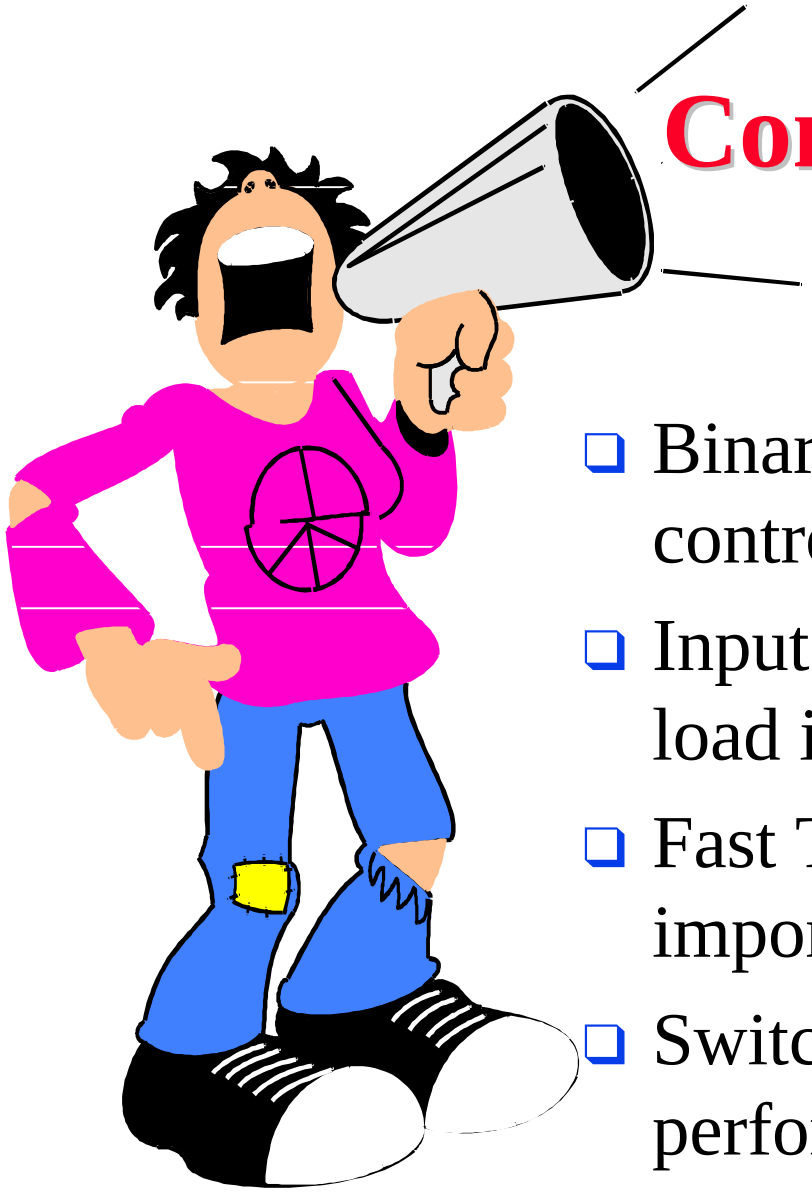
- MS Thesis of Anna Charny at MIT under Clark and Jain
  Presented to ATM Forum in July 1994
- Sources send one RM cell every *N* cells
- The RM cells contain "Stamped (Explicit) rate" and a "reduced-bit"
- The switches adjust the rate down and set the reduced bit
- Destination returns the RM cell to the source
- Source adjusts to the specified rate
- Order *n* complexity in switch algorithm. *n* = # of VCs.

Traffic Management Fns (Cont)

- Feedback Controls: Network tells the source to increase or decrease its load.
  - Explicit forward congestion indication (EFCI)
  - Explicit rate (ER)
  - Backward explicit congestion notification (BECN)



Congestion: Summary



- Binary feedback too slow for rate control
- Input rate (not queue length) is a load indicator for rate
- Fast Transient performance is important
- Switch scheme affects the performance