TCP/IP over ATM over Satellite Links

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Overview

- TCP over ABR over Satellites
- TCP over UBR over Satellites
- Improving TCP over UBR
- Improving TCP over ABR

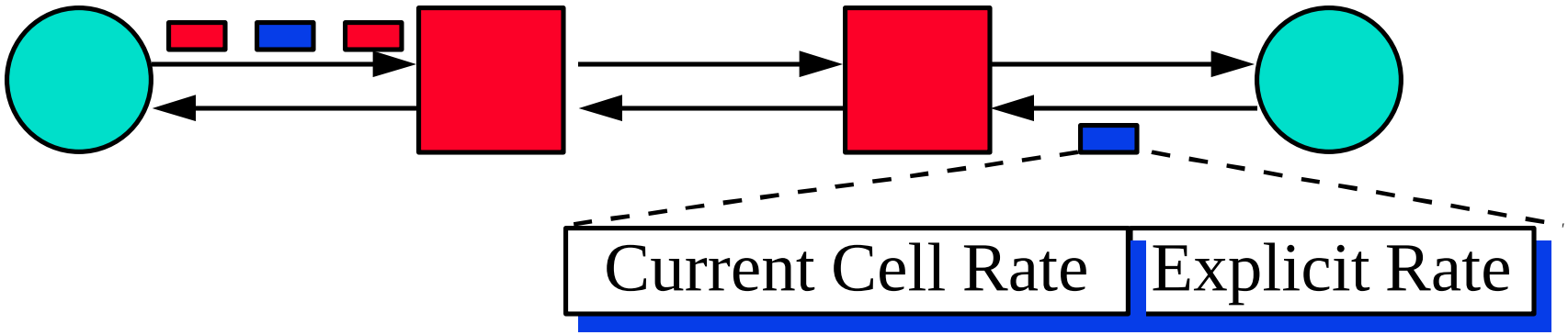
Our Goal in ATM Forum

- 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

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.

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
- Interoperates with all switch algorithms

UBR

- No specifications on switch or source behavior
- The sources send at peak rate.
- Switches drop cells if buffers full.
- Switch behavior similar to current routers.
- Intelligent protocols can use loss as implicit congestion indication and reduced load
- TCP is one such intelligent protocol Internet
  $\Rightarrow$ Engineering Task Force (IETF) prefers UBR
- UBR+:
  - Early packet discard (EPD)
  - EPD + Selective discard (Fair buffer allocation)

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

Issues Studied

- What is the performance of TCP over UBR over Satellites?
  - Performance with limited buffers
  - Buffer requirements for zero loss
- What is the performance of TCP over ABR over Satellites?
  - Performance with limited buffers
  - Buffer Requirement for zero loss
  - Performance with ABR only in the backbone

Issues Studied (Cont)

- How can we improve the performance of UBR?
  - Early Packet Discard in switches?
  - Fast Retransmit Recovery in end systems?
  - Fair buffer allocation in switches?
- How can we improve the performance of ABR over satellites?
  - Better switch Algorithms
  - VS/VD

TCP over UBR over Satellites

- No loss for TCP if Buffers = Σ TCP receiver window
- Each receiver window ≥ RTT for full throughput
- Required buffering does not scale well with the number of sources.
- Unfairness in many cases.
- 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 but not for long delay paths.

TCP Over ABR over Satellites

- EFCI (binary feedback) requires many (10s) of RTT to stabilize ⇒ Not good for satellites
- Need explicit rate (ER) feedback in switches
- ER performance depends upon the switch algorithm ⇒ Need switch algorithms with fast transient response
- Explicit Rate Indication for Congestion Avoidance (ERICA) is one such example.
  (See http://www.cis.ohio-state.edu/~jain/)

TCP over ABR (Cont)

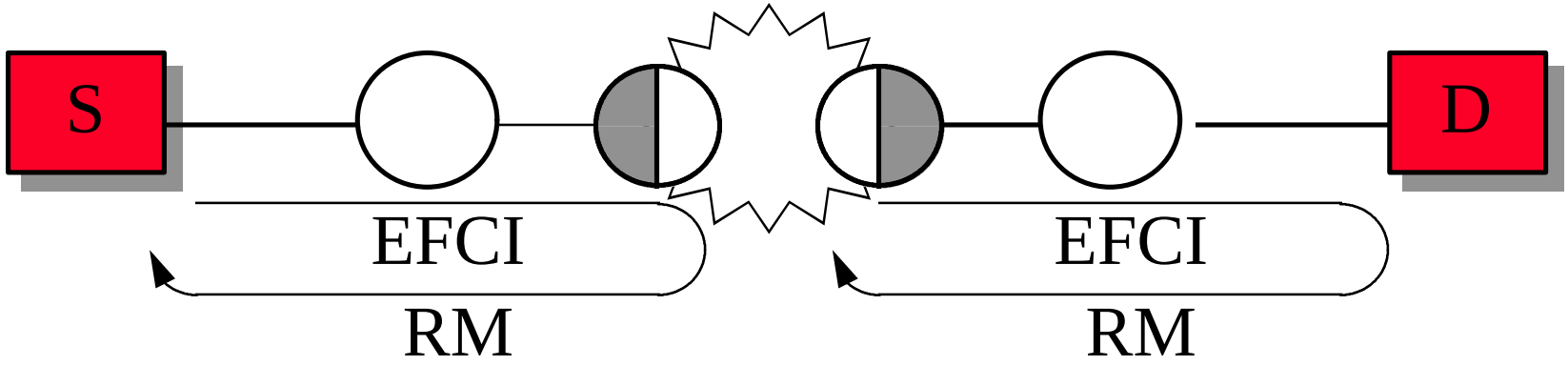
Following statements are based on *ERICA* algorithm.

- No cell loss for *TCP* if switch has Buffers = 4 × RTT.
- No loss for any number of TCP sources with 4 × RTT buffers.
- No loss even with VBR.
  W/o VBR, 3×RTT buffers will do.
  Tried with various VBR patterns and video traffic.
- Under many circumstances, 1× RTT buffers may do.
- Required buffers depend upon RTT, feedback delay, switch parameters, and characteristics of VBR.

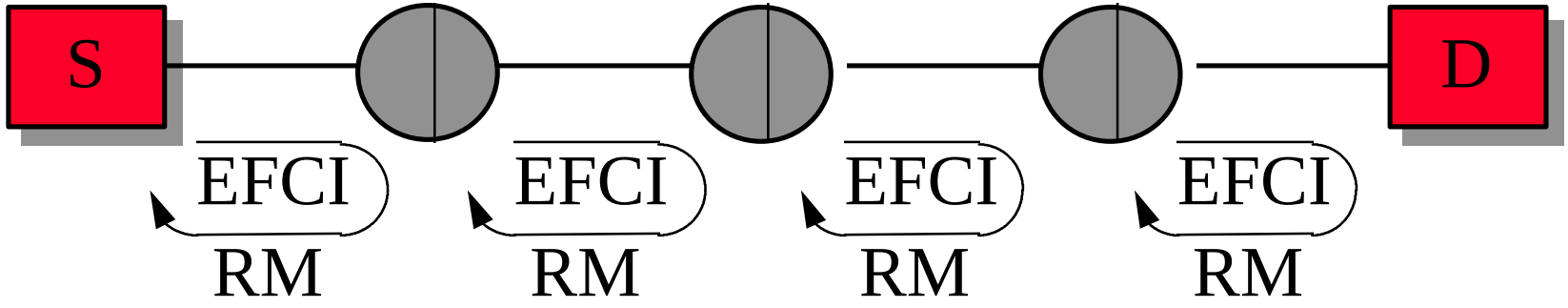
Improving TCP over UBR

- EPD: Helps improve the efficiency.
  But does not improve fairness.
- Fast Retransmit/Recovery:
  Helpful only if single packet loss.
  Hurts if multiple packets are lost.
  $\Rightarrow$ Improves efficiency in LANs
  Reduces efficiency in WANs and Satellites
- Fair Buffer Allocation/Selective Drop:
  Improves fairness and efficiency in WANs and Satellites
  Improvement in LANs is small.

Segment-by-Segment Control



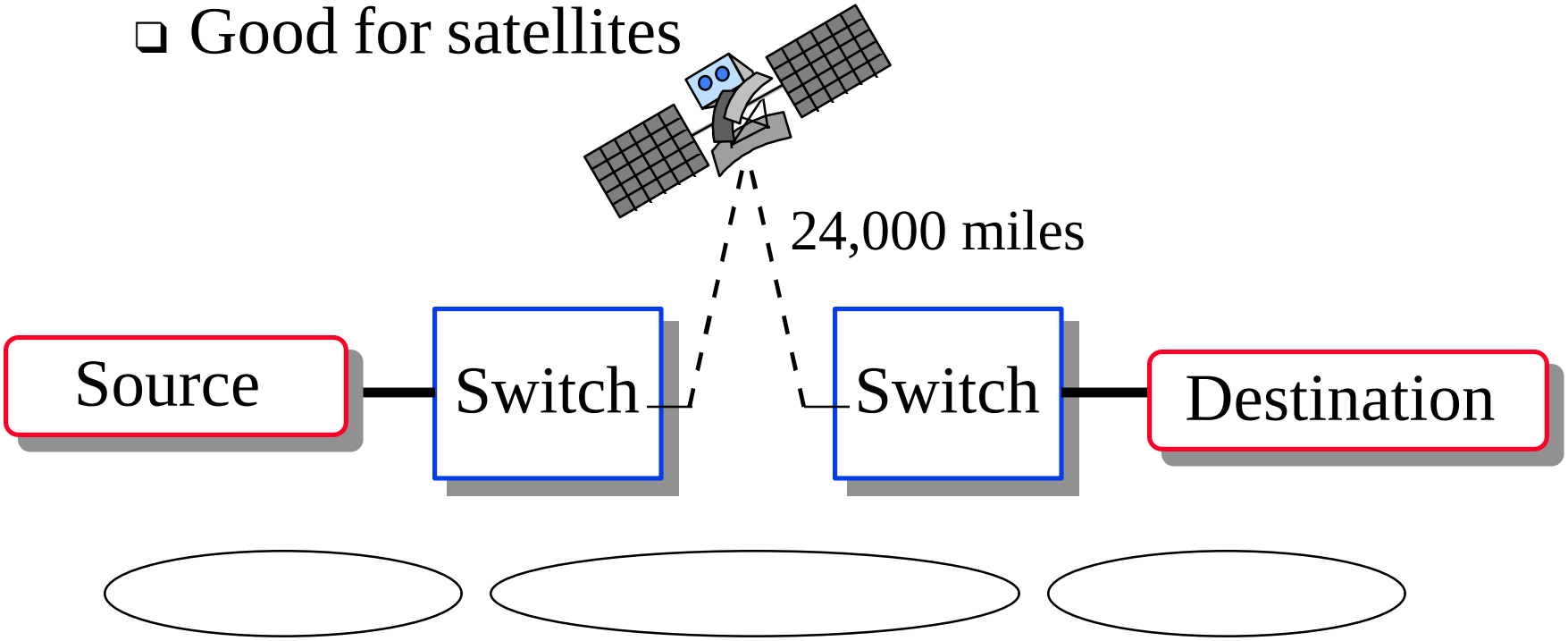
- Virtual source/virtual destinations (VS/VD) follow all notification/control rules
- Can be hop-by-hop



- Virtual dest/sources maintain per-VC queues.

Improving TCP over ABR

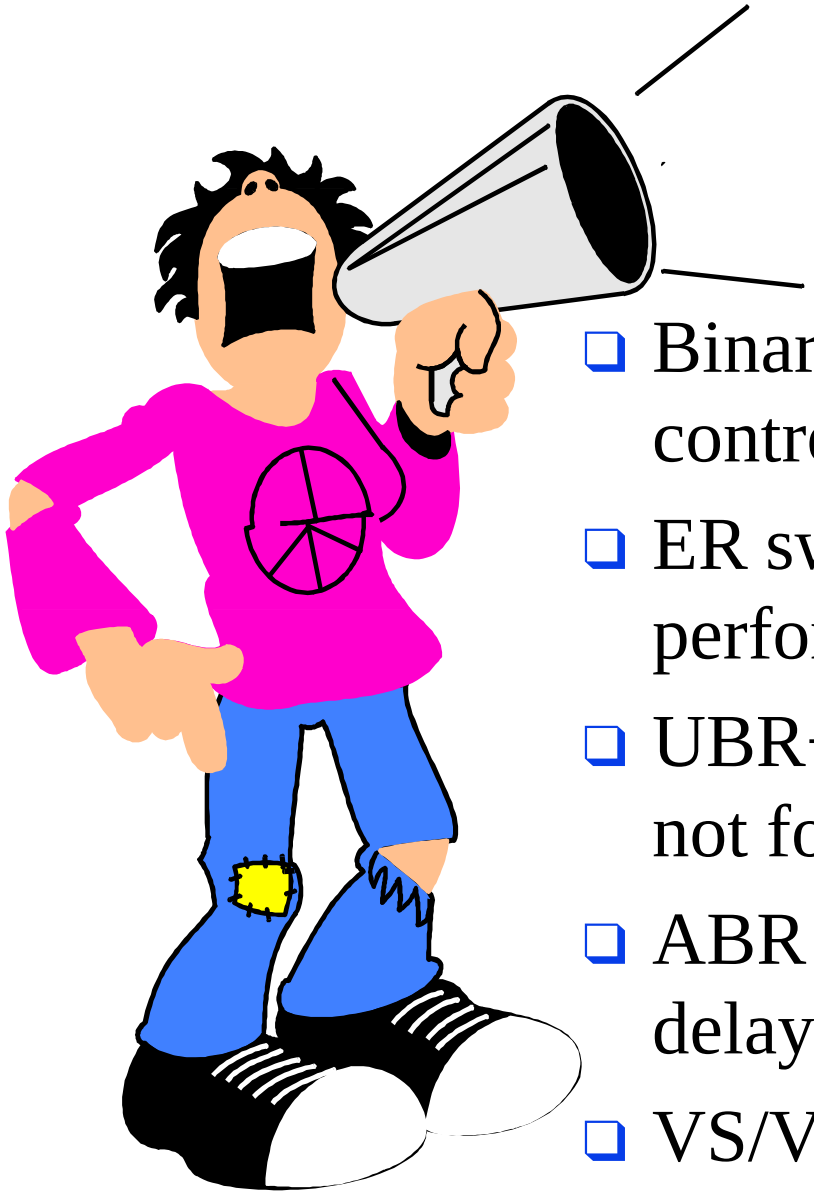
- Virtual Source/Virtual destination:
  - Reduces response time during first round-trip
  - Good for satellites



ATM Over Satellites: Open Issues

- Effect of on-board switching
- Multipoint connections
- Buffer sizing for on-board switches
- 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

Summary



- Binary feedback too slow for rate control. Especially for satellites.
- ER switches provide much better performance than EFCI.
- UBR+ may be OK for LANs but not for long delay paths.
- ABR service required for long-delay or high-speed networks.
- VS/VD may help in satellite paths.

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.

Thank You!