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

- **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.
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
  ⇒ 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 = $4 \times$ RTT.
- No loss for any number of TCP sources with $4 \times$ RTT buffers.
- No loss even with VBR.
  - W/o VBR, $3 \times$RTT buffers will do.
  - Tried with various VBR patterns and video traffic.
- Under many circumstances, $1 \times$ 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. ⇒ 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.
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

Source: 24,000 miles

Switch

Switch

Destination
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!