Issues in Traffic Management on Satellite ATM Networks

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Why ATM?
ATM Service Categories: ABR and UBR
Binary and Explicit Feedback
ABR Vs UBR
4 Ways to improve ABR over Satellites
4 Ways to improve UBR over Satellites
Why ATM?

- ATM vs IP: Key Distinctions
  - Traffic Management: Explicit Rate vs Loss based
  - Signaling: Coming to IP in the form of RSVP
  - PNNI: QoS based routing
  - Switching: Coming soon to IP
  - Cells: Fixed size or small size is not important
Service Categories

Standby

Joy Riders

Guaranteed

Confirmed
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.
Our Goal

- Ensure that the new ATM Forum TM 4.0/5.0 specs are “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
- Develop optimal solutions for satellite networks

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DECbit scheme in many standards since 1986.

Forward explicit congestion notification (FECN) in Frame relay

Explicit forward congestion indicator (EFCI) set to 0 at source. Congested switches set EFCI to 1

Every nth cell, destination sends an resource management (RM) cell to the source
The Explicit Rate ABR

- Proposed in July 1994
- 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
Go
30 km East
35 km South

Go left
Why Explicit Rate Indication?

- Longer-distance networks
  ⇒ Can’t afford too many round-trips
  ⇒ More information is better

- Rate-based control
  ⇒ Queue length = ΔRate × ΔTime
  ⇒ Time is more critical than with windows
4 Ways to Improve ABR over Satellite

1. Increase the limit on the number of outstanding cells before decreasing ⇒ Large TBE
   The size of was increased from 8 bit to 24 bit to accommodate satellite paths.

2. Use larger increase factor
   ⇒ RIF=1 ⇒ Fast transient Response

3. Implement backward congestion notification (BECN)

4. Implement Virtual Source/Virtual Destination
Virtual source/virtual destinations (VS/VD) follow all notification/control rules.

Can be hop-by-hop.

Virtual dest/sources maintain per-VC queues.
VS/VD: Results

- Without VS/VD:

- With VSVD:

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

- Intelligent transport or not?
ABR vs UBR

**ABR**
- Queue in the source
- Pushes congestion to edges
- Good if end-to-end ATM
- Fair
- Good for the provider

**UBR**
- Queue in the network
- No backpressure
- Same end-to-end or backbone
- Generally unfair
- Simple for user
Improving Performance of TCP over UBR

TCP End System Policies

ATM Switch Drop Policies

TCP over UBR

Vanilla TCP: Slow Start and Congestion Avoidance

TCP Reno: Fast Retransmit and Recovery

Selective Acknowledgments

Minimum Rate Guarantees: per-VC queuing

Per-VC Accounting: Selective Drop/FBA

Early Packet Discard

Tail Drop
## Policies

<table>
<thead>
<tr>
<th>Switch Policies</th>
<th>End-System Policies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No FRR</td>
</tr>
<tr>
<td>No EPD</td>
<td></td>
</tr>
<tr>
<td>Plain EPD</td>
<td></td>
</tr>
<tr>
<td>EPD</td>
<td></td>
</tr>
<tr>
<td>Selective Drop</td>
<td></td>
</tr>
<tr>
<td>Fair Buffer Allocation</td>
<td></td>
</tr>
</tbody>
</table>
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 satellite networks, end-system improvements have more impact than switch-based improvements.

- FRR hurts in satellite networks.

- Fairness depends upon the switch drop policies and not on end-system policies.
In Satellite 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)  
  ⇒ 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.

<table>
<thead>
<tr>
<th>GR</th>
<th>GFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>per-class reservation</td>
<td>per-VC reservation</td>
</tr>
<tr>
<td>per-class scheduling</td>
<td>per-VC accounting/scheduling</td>
</tr>
<tr>
<td>No new signaling</td>
<td>Need new signaling</td>
</tr>
<tr>
<td>Can be done now</td>
<td>In TM4+</td>
</tr>
</tbody>
</table>
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.
- For Satellites, end-system policies seem more important.
Problem in TCP Implementations

- Linear Increase in Segments:
  \[ \text{CWND/MSS} = \text{CWND/MSS} + \frac{\text{MSS}}{\text{CWND}} \]

- In Bytes: \[ \text{CWND} = \text{CWND} + \text{MSS} \times \frac{\text{MSS}}{\text{CWND}} \]

- All computations are done in integer

- If CWND is large, \( \text{MSS} \times \frac{\text{MSS}}{\text{CWND}} \) is zero and CWND does not change. CWND stays at 512*512 or 256 kB.
Solutions

- **Solution 1**: Increment CWND after N acks (N > 1)
  \[ \text{CWND} = \text{CWND} + \frac{N \times \text{MSS} \times \text{MSS}}{\text{CWND}} \]

- **Solution 2**: Use larger MSS on Satellite links such that \( \text{MSS} \times \text{MSS} > \text{CWND}. \text{MSS} \geq \text{Path MTU} \).

- **Solution 3**: Use floating point

- **Recommendation**: Use solution 1. It works for all MSSs.
4 Ways to Improve UBR over Satellites

1. Implement “Selective Acknowledgement” in end-systems
2. Disable “Fast retransmit and recovery” in end-systems
3. Reserve a small fraction of bandwidth for UBR in the switches
4. Fix slow start implementations in end-systems to avoid errors due to integer arithmetic
Summary

- 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. UBR+ may be OK for LANs but not for long delay paths.
Summary (Cont)

- Implement VS/VD, BECN, RIF=1, TBE=Large to improve ABR over satellites
- Implement SACK, Disable FRR, reserve bandwidth for UBR, and correct TCP implementations to improve UBR over satellites.
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!