Traffic Management over Satellite ATM Networks: Recent Issues

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Overview

1. Buffer size for satellite links
2. Guaranteed Frame Rate (GFR) design issues
3. GFR with FIFO
4. Point-to-Multipoint connections
5. Multipoint-to-point connections
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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Our Recent Past Projects

- Performance of Internet Protocols on ATM over Satellite: ABR vs UBR
- Optimization of performance of TCP/IP over satellite ATM networks
- Multipoint to point ABR
- Guaranteed Rate Service

1. UBR Buffer Study:

Goals

- Assess buffer requirements for TCP over UBR for satellite latencies
- How does TCP throughput increase with increasing network buffers?
- How well can we do with less than 1 RTT buffers?

N identical infinite TCP sources, SACK TCP
Link Capacity = PCR = 155.52 Mbps
Per-VC buffer management in switches (sel. drop)
Simulation time = 100 s
Parameters

- Latency between earth stations via satellite (1 way)
  - Single hop LEO: 5ms
  - Multiple hop LEO: 50 ms
  - Single hop GEO: 275 ms

- Number of Sources
  - Single hop LEO: 15, 50, 100
  - Multiple hop LEO, single hop GEO: 5, 15, 50

- Buffer Size
  - $\text{RTT} \times 2^{-k}, k = -1, 0, 1 \ldots 6$
Single hop LEO

![Graph showing efficiency vs. buffer size for different numbers of sources]

- 15 sources
- 50 sources
- 100 sources

Efficiency vs. Buffer (cells)

0 10k 20k 30k

0.5RTT
Multiple hop LEO

Efficiency vs. Buffer (cells) for different number of sources (5, 15, 50) with RTT = 0.5RTT.
Single hop GEO

Efficiency

0 0.2 0.4 0.6 0.8 1

0 100k 200k 300k 400k 500k

Buffer (cells)

5 sources
15 sources
50 sources

0.5RTT
UBR Buffer: Results

- Very small buffer sizes result in low efficiency
- Moderate buffer sizes (less than 1 RTT)
  - Efficiency increases with increase in buffer size
  - Efficiency asymptotically approaches 100%
- Buffer size = 0.5*RTT results in very high efficiency (98% or higher) even for a large number of sources
- 0.5*RTT buffers provide sufficiently high efficiency for TCP over UBR even for a large number of TCP sources
2. Guaranteed Frame Rate (GFR)

- UBR with min 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 all cells have CLP=1
  - All frames below MCR are given CLP =0 service. All frames above MCR are given best effort (CLP=1) service.
GFR Study I: Goals

- Explore three options for providing GFR
  - Tagging (policing)
  - Buffer Management
  - Queuing

GFR Options

<table>
<thead>
<tr>
<th>Queuing</th>
<th>Per-VC</th>
<th>FIFO</th>
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</thead>
<tbody>
<tr>
<td>Buffer Management</td>
<td>Per-VC</td>
<td>Global</td>
</tr>
<tr>
<td></td>
<td>Thresholds</td>
<td>Threshold</td>
</tr>
<tr>
<td>Tag-sensitive Buffer Mgmt</td>
<td>2 Thresholds</td>
<td>1 Threshold</td>
</tr>
</tbody>
</table>
Equal Rate Allocations

- Used only per-VC buffer management (sel. drop) with FIFO queuing
- Bars = standard deviation. Large bars Þ Unfairness
- May allocate equal rates for symmetrical TCP sources with per-VC buffer management
Unequal Rate Allocations

- Used per-VC tag sensitive buffer management (WBA) with FIFO queuing
- Number of sources: 15.
- 5 Groups with rates = 2.6, 5.3, 8, 10.7, 13.5 Mbps
- Cannot allocate unequal rates with FIFO queuing
- Used only per-VC queuing/scheduling and a single global EPD threshold (not tag sensitive)
- Number of sources: 15.
- 5 Groups with MCR = 2.6, 5.3, 8, 10.7, 13.5 Mbps
- Can allocate unequal rates with per-VC queuing
GFR Study I: Results

- Per-VC queuing and scheduling is necessary for per-VC MCR. (FIFO + anything cannot do)
- FBA and proper scheduling is necessary for fair allocation of excess bandwidth
- One global threshold is sufficient for CLP0+1 guarantees. Two thresholds are necessary for CLP0 guarantees
3. GFR Study II: Goals

- Provide minimum rate guarantees with FIFO buffer for TCP/IP traffic.
- Guarantees in the form of TCP throughput.
- How much network capacity can be allocated before guarantees can no longer be met?
- Study rate allocations for VCs with aggregate TCP flows.

GFR Study II: Results

- SACK TCP throughput may be controlled with FIFO queuing under certain circumstances:
  - TCP, SACK (?)
  - $\Sigma$ MCRs < Uncommitted bandwidth
  - Same RTT (?), Same frame size (?)
  - No other non-TCP or higher priority traffic (?)
GFR: Future Work

- Other TCP versions.
- Effect to non-adaptive (UDP) traffic
- Effect of RTT
- Effect of tagging
- Effect of frame sizes
- Parameter study
- Buffer threshold setting formula?
- How much buffer can be utilized?
4. Multipoint Consolidation Operation

- Necessary to prevent feedback implosion: too many BRMs per FRM at the root
## Performance Comparison

- Studied 4 existing and 3 new algorithms.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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</thead>
<tbody>
<tr>
<td>Complexity</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Med</td>
<td>&gt;Med</td>
<td>&gt;Med</td>
<td>&gt;&gt;Med</td>
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<tr>
<td>Transient Response</td>
<td>Fast</td>
<td>Med</td>
<td>Med</td>
<td>Slow</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Response</td>
<td>Fast for overload</td>
<td>Very fast for overload</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Noise</td>
<td>High</td>
<td>Med</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>BRM:FRM</td>
<td>1</td>
<td>&lt; 1</td>
<td>&lt;= 1</td>
<td>&lt;= 1</td>
<td>may &gt; 1</td>
<td>lim = 1</td>
<td>lim = 1</td>
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<tr>
<td>Sensitivity to branch points and levels</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Med</td>
<td>&gt;Med</td>
<td>Med</td>
<td>Med</td>
</tr>
</tbody>
</table>
Multipoint Consolidation: Results

- Consolidation algorithms offer tradeoffs between complexity, transient response, noise, overhead and scalability.
- The new algorithms 6 and 7 speed up the transient response, while eliminating consolidation noise and controlling overhead.
5. Multipoint-to-Point VCs

- How can bandwidth be allocated fairly?

Cell Interleaving Solutions

- VP merge: VCI = sender ID
  VPs are used for other purposes.

- VC merge: Buffer at merge point till EOM bit = 1.
  Requires memory and adds to traffic burstiness and latency.
Sw₂ has to deal with

- Two VCs: Red and Blue
- Four sources: Three red sources and one blue source
- Three flows: Two red flows and one blue source
Fairness Definitions

- Source-based: N-to-one connection
  - N one-to-one connections
  - Use max-min fairness among sources
- VC/Source-based:
  1. Allocate bandwidth fairly among VCs
  2. For each VC, allocate fairly among its sources
- Flow-based: Flow = VC coming on an input link. Switch can easily distinguish flows.
- VC/Flow-based: Allocate bandwidth fairly among VCs
  2. For each VC, allocate fairly among its flows
Example

- How is the bandwidth of LINK3 allocated?
- Source: \{S1, S2, S3, SA\} ← \{37.5, 37.5, 37.5, 37.5\}
- VC/Source: \{S1, S2, S3, SA\} ← \{25, 25, 25, 75\}
- Flow: \{S1, S2, S3, SA\} ← \{25, 25, 50, 50\}
- VC/Flow: \{S1, S2, S3, SA\} ← \{18.75, 18.75, 37.5, 75\}
Summary

- One-half of RTT buffers are OK with SACK
- GFR guarantees, in general, require per-VC queueing
- GFR guarantees may be possible w SACK TCP
- Point-to-mpt extensions to ABR switch algorithms
- Sources, VCs, and flows are different in Mpt-to-pt VCs
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.