Which Service for TCP/IP
Traffic on ATM: ABR or UBR?

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Overview

- Service classes in ATM
- Seven Facts about TCP
- Performance on ABR
- Performance on UBR
- ABR or UBR?
Service Classes

- **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...
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.

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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
- UBR+:
  - Early packet discard (EPD)
  - EPD + Selective discard (Fair buffer allocation)
Observations about TCP

- TCP successfully avoids congestion collapse.
- TCP can automatically fill any available capacity.
- TCP performs best when there is NO packet loss. Even a single loss can reduce throughput considerably.
- Slow start limits the packet loss but loses time. You may not lose too many packets but you loose time.
- Fast retransmit/recovery helps in isolated losses but not in bursty losses.
- Bursty losses cause more degradation
- Timer granularity is the key in determining time lost.
$n$ Source + VBR Configuration

- All links 155 Mbps
- If VBR background, 100 ms on (80%), 100 ms off, start at $t = 2$ ms
- All traffic unidirectional, Large file transfer.
Simulation Results: Summary

<table>
<thead>
<tr>
<th># srcs</th>
<th>TBE</th>
<th>Buffer Size</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>Throughput</th>
<th>% of Max</th>
<th>CLR.</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>128</td>
<td>256</td>
<td>3.1</td>
<td>3.1</td>
<td>6.2</td>
<td>10.6</td>
<td>1.2</td>
<td>6.2</td>
<td>10.6</td>
<td>1.2</td>
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<td>128</td>
<td>1024</td>
<td>10.5</td>
<td>4.1</td>
<td>14.6</td>
<td>24.9</td>
<td>2.0</td>
<td>14.6</td>
<td>24.9</td>
<td>2.0</td>
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<td>2</td>
<td>512</td>
<td>1024</td>
<td>5.7</td>
<td>5.9</td>
<td>11.6</td>
<td>19.8</td>
<td>2.7</td>
<td>11.6</td>
<td>19.8</td>
<td>2.7</td>
</tr>
<tr>
<td>2</td>
<td>512</td>
<td>2048</td>
<td>8.0</td>
<td>8.0</td>
<td>16.0</td>
<td>27.4</td>
<td>1.0</td>
<td>16.0</td>
<td>27.4</td>
<td>1.0</td>
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<td>5</td>
<td>128</td>
<td>640</td>
<td>1.5</td>
<td>1.4</td>
<td>3.0</td>
<td>1.6</td>
<td>1.6</td>
<td>9.1</td>
<td>15.6</td>
<td>4.8</td>
</tr>
<tr>
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<td>128</td>
<td>1280</td>
<td>2.7</td>
<td>2.4</td>
<td>2.6</td>
<td>2.5</td>
<td>2.6</td>
<td>12.8</td>
<td>21.8</td>
<td>1.0</td>
</tr>
<tr>
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<td>512</td>
<td>2560</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>3.9</td>
<td>4.1</td>
<td>19.9</td>
<td>34.1</td>
<td>0.3</td>
</tr>
<tr>
<td>5</td>
<td>512</td>
<td>5720</td>
<td>11.7</td>
<td>11.8</td>
<td>11.6</td>
<td>11.8</td>
<td>11.6</td>
<td>58.4</td>
<td>100.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

- CLR has high variance
- CLR does not reflect performance. Higher CLR does not necessarily mean lower throughput
- CLR and throughput are one order of magnitude apart

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Observations About ABR

- ABR performance depends upon the switch algorithm. Following statements are based on our *ERICA* algorithm. (For ERICA, see http://www.cis.ohio-state.edu/~jain/)

- No cell loss for *TCP* if switch has Buffers = 4 × RTT.

- No loss for any number of TCP sources w 4 × RTT buffers.

- No loss even with *VBR*. W/o VBR, 3×RTT buffers will do.

- Under many circumstances, 1× RTT buffers may do.

- Required buffers depend upon RTT, feedback delay, switch parameters, and characteristics of VBR.
### UBR Results

<table>
<thead>
<tr>
<th>Buffer Size</th>
<th>Receiver Window</th>
<th>EPD</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>Efficiency</th>
<th>Fairness</th>
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<tbody>
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<td>12000</td>
<td>600000</td>
<td>N</td>
<td>16.9</td>
<td>17.9</td>
<td>17.9</td>
<td>19.2</td>
<td>17.4</td>
<td>71%</td>
<td>1.00</td>
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<tr>
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<td>1800000</td>
<td>N</td>
<td>16.9</td>
<td>17.9</td>
<td>17.9</td>
<td>19.2</td>
<td>17.4</td>
<td>74%</td>
<td>1.00</td>
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<td>36000</td>
<td>600000</td>
<td>N</td>
<td>21.3</td>
<td>21.3</td>
<td>21.3</td>
<td>21.3</td>
<td>21.2</td>
<td>85%</td>
<td>1.00</td>
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<tr>
<td>36000</td>
<td>1800000</td>
<td>N</td>
<td>27.2</td>
<td>28.1</td>
<td>11.0</td>
<td>12.1</td>
<td>27.9</td>
<td>85%</td>
<td>0.88</td>
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<tr>
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<td>600000</td>
<td>Y</td>
<td>31.8</td>
<td>15.9</td>
<td>15.3</td>
<td>15.8</td>
<td>15.4</td>
<td>75%</td>
<td>0.89</td>
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<td>1800000</td>
<td>Y</td>
<td>31.8</td>
<td>15.9</td>
<td>15.3</td>
<td>15.8</td>
<td>15.4</td>
<td>75%</td>
<td>0.89</td>
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<tr>
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<td>600000</td>
<td>Y</td>
<td>21.1</td>
<td>21.1</td>
<td>21.7</td>
<td>21.2</td>
<td>20.8</td>
<td>85%</td>
<td>1.00</td>
</tr>
<tr>
<td>36000</td>
<td>1800000</td>
<td>Y</td>
<td>13.3</td>
<td>31.9</td>
<td>14.5</td>
<td>14.5</td>
<td>31.7</td>
<td>85%</td>
<td>0.86</td>
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<td>12000</td>
<td>1200000</td>
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<td>24.0</td>
<td>24.1</td>
<td>24.0</td>
<td>24.1</td>
<td>24.0</td>
<td>96%</td>
<td>1.00</td>
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<tr>
<td>36000</td>
<td>3600000</td>
<td>N/A</td>
<td>23.9</td>
<td>24.2</td>
<td>23.9</td>
<td>24.2</td>
<td>23.9</td>
<td>96%</td>
<td>1.00</td>
</tr>
</tbody>
</table>

- For full throughput: Need buffers = $\Sigma$ receive windows
- EPD improves throughput but not fairness.

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Observations about UBR

- No loss for TCP if Buffers = $\Sigma$ TCP receiver window
- Required buffering depends upon number of sources.
- Receiver window $\geq$ RTT for full throughput
- Unfairness in many cases.
- Fairness can be improved by proper buffer allocation, selective drop policies, and scheduling.
- No starvation $\Rightarrow$ 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
**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
Packet loss results in a significant degradation in TCP throughput. For best throughput, TCP needs no loss.

With enough buffers, ABR may guarantee zero loss for any number of TCP sources.

Performance of ABR depends on the switch algorithm.

For zero loss, UBR need buffers = $\Sigma$ receiver windows.
Our Papers/Contributions

All our past ATM forum contributions, papers and presentations can be obtained on-line at http://www.cis.ohio-state.edu/~jain/


TCP over ATM: References


B.J. Ewy, et al, "TCP/ATM Experiences in the MAGIC Testbed,"