Receiver-side Real-Time Congestion Control (RRTCC)

Google Congestion Control Algorithm
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Outline

• Related Drafts:
  – draft-alvestrand-rmcat-congestion
  – draft-alvestrand-rmcat-remb-02

• Single Flow
  – Different losses, latency, queue length

• 3 RMCAT flows
  – Start together
  – Start at 30s apart

• RMCAT vs long TCP flows
Evaluation Setup

Foreman CIF, 30FPS 5-10 minutes

Chrome Browser v27.01453.12

StatsAPI (every 1s)

Video, FEC, RETX →

Network

← RTCP Feedback (every 1s)

Chrome Browser v27.01453.12

tcpdump
https://github.com/vr000m/ConMon

http://media.xiph.org/video/derf/
Single flow

• Fixed capacity with different
  1. path latencies
  2. path losses
  3. router queue size
Different Latencies

<table>
<thead>
<tr>
<th>Latency (ms)</th>
<th>Rate (Kbps)</th>
<th>RTT (ms)</th>
<th>Residual Loss (%)</th>
<th>Packet Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ms</td>
<td>1949.7±233.62</td>
<td>9.57±2.41</td>
<td>0.011</td>
<td>0.011</td>
</tr>
<tr>
<td>50 ms</td>
<td>1913.56±254.86</td>
<td>102.51±1.44</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>100 ms</td>
<td>1485±268.11</td>
<td>202.57±3</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>200 ms</td>
<td>560.82±129.57</td>
<td>401.91±3.33</td>
<td>0.33</td>
<td>0.4</td>
</tr>
<tr>
<td>500 ms</td>
<td>255.67±45.85</td>
<td>1001.36±3.99</td>
<td>0.35</td>
<td>0.37</td>
</tr>
</tbody>
</table>
**Different Loss**

**Graph:**
- Observed rate [kbps] vs. Time [s]
- Different loss percentages (1%, 5%, 10%, 20%)

**Table:**
<table>
<thead>
<tr>
<th>Loss (%)</th>
<th>Rate (Kbps)</th>
<th>RTT (ms)</th>
<th>Residual Loss (%)</th>
<th>Packet Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>1949.7±233.62</td>
<td>9.57±2.41</td>
<td>0.011</td>
<td>0.011</td>
</tr>
<tr>
<td>1%</td>
<td>1986.91±256.78</td>
<td>8.12±1.86</td>
<td>0.09</td>
<td>2</td>
</tr>
<tr>
<td>5%</td>
<td>1568.74±178.52</td>
<td>6.98±1.79</td>
<td>0.23</td>
<td>9.77</td>
</tr>
<tr>
<td>10%</td>
<td>1140.82±161.92</td>
<td>6.28±3.24</td>
<td>0.49</td>
<td>19.02</td>
</tr>
<tr>
<td>20%</td>
<td>314.4±61.98</td>
<td>5.42±4.03</td>
<td>2.43</td>
<td>36.01</td>
</tr>
</tbody>
</table>
### Different Queue Size

#### Link Capacity = 1 Mbps

<table>
<thead>
<tr>
<th></th>
<th>Rate (Kbps)</th>
<th>RTT (ms)</th>
<th>Residual Loss (%)</th>
<th>Packet Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 ms</td>
<td>362.87±68.18</td>
<td>31.42±11.9</td>
<td>0.79</td>
<td>1.42</td>
</tr>
<tr>
<td>1 s</td>
<td>374.64±58.64</td>
<td>27.48±8.81</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>10 s</td>
<td>438.32±31.58</td>
<td>27.16±7.32</td>
<td>0.04</td>
<td>0.04</td>
</tr>
</tbody>
</table>

#### Link Capacity = 5 Mbps

<table>
<thead>
<tr>
<th></th>
<th>Rate (Kbps)</th>
<th>RTT (ms)</th>
<th>Residual Loss (%)</th>
<th>Packet Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 ms</td>
<td>1965.95±224.02</td>
<td>20.13±4.16</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>1 s</td>
<td>1920.67±234.38</td>
<td>18.45±5.57</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>10 s</td>
<td>1722.08±261.42</td>
<td>17.05±4.52</td>
<td>0.03</td>
<td>0.03</td>
</tr>
</tbody>
</table>
3 RMCAT streams

Call 1
Call 2
Call 3
3 RMCAT flows (time-shifted arrival)

In all the cases, the first call reduced its rate. In 20% of the cases it recovered after ~50s.
TCP and RMCAT

- **Observed rate [kbps]**
- **Delay Variation [s]**

**Stream A->B**
- **Stream B->A**

**Time [s]**
Observations

• Up to 20% the average send rate can be FEC

• Retransmissions (retx)
  – Used extensively in low latency scenarios.

• Observed starvation when competing with TCP traffic

• In self-fairness, first flow starves sometimes.
Additional Reading

• **Performance Analysis of Receive-Side Real-Time Congestion Control for WebRTC**, Singh et al.  


• **Performance analysis of topologies for Web-based Real-Time Communication (WebRTC)**, A. Lozano  
  [https://aaltodoc.aalto.fi/bitstream/handle/123456789/11093/master_Abell%C3%B3 Lozano Albert 2013.pdf?sequence=1](https://aaltodoc.aalto.fi/bitstream/handle/123456789/11093/master_Abell%C3%B3 Lozano Albert 2013.pdf?sequence=1)

• **Understanding the Dynamic Behaviour of the Google Congestion Control**, Cicco et al.