A brief investigation into two common causes of TCP throughput degradation in a broadband access environment

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Brief summary

Investigated TCPs reactions to packet loss

Investigated TCPs interactions with competing streams

Caused intolerable amounts of packet loss on a DSL link
Packet loss

Why did we study this topic?

Can we predict the effects of the packet loss?

How severe is the impact to common home situations?

Experimental method

PC-PT Client  PC-PT Bridge  PC-PT Server
Measuring effects of packet loss

Sampling a wider range of data
Working out an equation

\[ y(x) = a + b \cdot e^{c\cdot x} \]

Applying the prediction
Testing the model

Accuracy of data

Figures for 500kB file, as depicted in previous slide.

Values are a percentage error

<table>
<thead>
<tr>
<th>Filesize</th>
<th>Bandwidth</th>
<th>0%</th>
<th>2%</th>
<th>5%</th>
<th>8%</th>
<th>10%</th>
<th>15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>500000</td>
<td>1500</td>
<td>7.25</td>
<td>1.94</td>
<td>0.85</td>
<td>10.89</td>
<td>17.44</td>
<td>36.50</td>
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<tr>
<td>500000</td>
<td>6000</td>
<td>7.37</td>
<td>-9.08</td>
<td>-8.46</td>
<td>5.48</td>
<td>20.00</td>
<td>22.80</td>
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<tr>
<td>500000</td>
<td>25000</td>
<td>6.88</td>
<td>-24.68</td>
<td>-23.70</td>
<td>5.79</td>
<td>23.96</td>
<td>7.22</td>
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</tbody>
</table>

Standard deviation of experimental results, as a percentage of mean

<table>
<thead>
<tr>
<th>Filesize</th>
<th>Bandwidth</th>
<th>0%</th>
<th>2%</th>
<th>5%</th>
<th>8%</th>
<th>10%</th>
<th>15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>500000</td>
<td>1500</td>
<td>1.69</td>
<td>9.26</td>
<td>24.28</td>
<td>21.77</td>
<td>38.99</td>
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</tr>
<tr>
<td>500000</td>
<td>6000</td>
<td>9.32</td>
<td>25.58</td>
<td>39.68</td>
<td>41.86</td>
<td>37.73</td>
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<tr>
<td>500000</td>
<td>15000</td>
<td>21.07</td>
<td>47.71</td>
<td>56.05</td>
<td>41.71</td>
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<tr>
<td>500000</td>
<td>25000</td>
<td>40.79</td>
<td>52.03</td>
<td>48.08</td>
<td>52.16</td>
<td>44.68</td>
<td></td>
</tr>
</tbody>
</table>
Adding delays in

In the context of home

Packet loss hits HTTP browsing in multiple times
Interactive connections suffer even more
Streaming media could be subject to pauses while it buffers
Very noticeable in games
Alleviating packet loss

Identify and fix source of loss
Send less data (compression)
Use a different protocol
   eg, SPDY
Send data multiple times, preempting that n% of the packets will get lost

Diminishing returns
Competing TCP streams

Experimental setup
Dummynet configuration

- incoming packets: 
  - host
- Which port is it destined for?
  - 5018
  - 5019
- Delay for 50ms
- Delay for 50ms
- 24Mb/s down
- 3Mb/s up
- Queue and bandwidth restriction: 3ms
- Allow packet through

Experimental considerations

- Congestion control algorithm/OS specific nuances
- Plausible situations
Control data

Control, staggered start
Disparate RTT values

Disparate RTT values, staggered start
Long running with disparate RTTs

Short bursts of far traffic against near
Short bursts of near against far

![Graph showing Near and Far stream]

Window size variation

![Graph showing Queue size vs Window size]
Alleviating these effects

Use a delay based congestion control

Some kind of QoS or put a cap on bandwidth available to individual streams

Other activities undertaken at CAIA
Real world packet loss

Used the BART equipment to test

Rather impractical to get packet loss to occur on ADSL

Noise margin

Tx/rx gain

Modulation (g.lite – but it drops speed from 8Mb/s to 2Mb/s)

1.2km of cat5 in a box

ADSL line statistics

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
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<tbody>
<tr>
<td>Noise Margin</td>
<td>2.5 dB</td>
<td>7.0 dB</td>
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<tr>
<td>Output Power</td>
<td>17.0 dBm</td>
<td>12.0 dBm</td>
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<tr>
<td>Attenuation</td>
<td>12.5 dB</td>
<td>15.5 dB</td>
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<tr>
<td>Interleave</td>
<td>Fast</td>
<td>Interleave</td>
</tr>
<tr>
<td>Speed (kbps)</td>
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<td>0</td>
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<tr>
<td>Reed-Solomon EC</td>
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<td>0</td>
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<tr>
<td>CRC Errors</td>
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<tr>
<td>Header Errors</td>
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<td>0</td>
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<tr>
<td>Bit Errors</td>
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<td>BER Valid sec</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BER Invalid sec</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
ADSL testing conditions

(508 byte packet)
--- 10.2.0.55 ping statistics ---
1000 packets transmitted, 760 packets received, 24.0% packet loss
round-trip min/avg/max/stddev = 19.786/23.432/41.670/1.910 ms

(1008 byte packet)
--- 10.2.0.55 ping statistics ---
5000 packets transmitted, 4894 packets received, 2.1% packet loss
round-trip min/avg/max/stddev = 28.703/32.649/57.068/2.129 ms

Conclusion

Created a basic model for the impact of packet loss on file transfers

Found that in concurrent near and far TCP stream situations, the far stream always loses, sometimes badly.

Caused some significant packet loss on an ADSL line and ran some tests, but did not get to analyse in depth
Thank you!