Realtime Burstiness Measurement

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PSPacer

Achieves precise pacing only by software
PSPacer can be downloaded from:
http://www.gridmpi.org/gridtcp.jsp
Outline

- Background
- Definition of Burstiness
- Burstiness Measurement Method
- Experiment
- Conclusion
Bursty traffic (1)

- **Burst** is a sequence of packets transmitted back-to-back
  
  8 packets are transmitted back-to-back

- **Bursty traffic** is traffic in which the short-term bandwidth exceeds the average bandwidth
Bursty traffic (2)

• Causes
  – TCP’s slow start, ACK compression, etc

• Problems
  – Bursty traffic may cause excessive queuing delay and packet loss
  – Such packet loss may markedly degrade TCP communication performance over high bandwidth-delay product networks
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• Background
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Basic idea

- Burstiness is the degree of bursty traffic
- Quantitative definition of burstiness is not well established.
- The definition should be directly related to performance factors (i.e. packet loss, queuing delay)
- At bottleneck router, the excessive packets are stored on the buffer. The queue size indicates burstiness
Virtual Bottleneck (VB)

To measure burstiness of traffic, we introduce a Virtual Bottleneck (VB)

- The bandwidth of VB is $BW_{vb}$
- Excessive packets are stored on the buffer just before VB (VB buffer)
- The queue size ($Q$) indicates burstiness

\[
\text{incoming rate} \quad \overbrace{\quad Q \quad}^{\text{VB buffer}} \quad \text{outgoing rate} \quad (\leq BW_{vb})
\]
Two definitions of burstiness

- **A static burstiness**
  - $BW_{vb}$ is set to a given value
    - $Q$: a static burstiness
  - Useful for traffic with fixed and known bandwidth
    - e.g. CBR transmission

- **A dynamic burstiness**
  - $BW_{vb}$ is set to the average bandwidth ($ABW_T$)
    - $Q$: a dynamic burstiness
  - Useful for long-term variable traffic
Outline

• Background
• Definition of Burstiness
• Burstiness Measurement Method
  – Implementation on GtrcNET-1
• Experiment
• Conclusion
Dynamic burstiness measurement logic

- 2 stages: $ABW_T$ measurement, VB
- Incoming traffic is processed by pipeline manner

$ABW_T$ is measured by the amount of incoming packet during a period of $T$.

$ABW_T$ is forwarded to VB, and used as $BW_{VB}$.

Packets are dequeued at the rate of $BW_{VB}$, and burstiness is measured.
GtrcNET-1: Programmable Gigabit Network Testbed

1 Gbps read and write simultaneously 144Mbits/port

Xilinx XC2V6000 (76K logic cells)

4 GbE ports
Outline

• Background
• Definition of Burstiness
• Burstiness Measurement Method
• Experiment
  – Relationship between burstiness and packet loss
  – Behavior of Flow aggregation (on proceeding)
• Conclusion
Experimental setting

B Flet's (FTTH subscriber line)
Bandwidth 100 Mbps
RTT 6.0 ms

We measure a static burstiness ($BW_{vb}$ is 40 Mbps) on both side

40 Mbps CBR UDP flow

Distance: 60km

Sender@Tsukuba
GbE

Receiver@Akihabara
GbE

GbE

B Flet’s (FTTH subscriber line)
Bandwidth 100 Mbps
RTT 6.0 ms
## Specifications of hosts

<table>
<thead>
<tr>
<th></th>
<th>Sender@Tsukuba</th>
<th>Receiver@Akihabara</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CPU</strong></td>
<td>AMD Opteron/2.8GHz dual</td>
<td>Intel Xeon/2.4GHz dual</td>
</tr>
<tr>
<td><strong>M/B</strong></td>
<td>IBM eServer 325</td>
<td>SuperMicro X5DAE</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td>6GB (PC2700)</td>
<td>2GB (PC2100)</td>
</tr>
<tr>
<td><strong>NIC</strong></td>
<td>Broadcom BCM5704 (GbE)</td>
<td>Intel 82545EM (GbE)</td>
</tr>
<tr>
<td><strong>I/O bus</strong></td>
<td>PCI-X 133MHz/64bit</td>
<td>PCI-X 133MHz/64bit</td>
</tr>
<tr>
<td><strong>OS</strong></td>
<td>SUSE SLES 8.1</td>
<td>FedoraCore 3</td>
</tr>
<tr>
<td></td>
<td>Kernel 2.4.21-251</td>
<td>Kernel 2.6.13.3</td>
</tr>
</tbody>
</table>
CBR transmission methods

- **Target rate**: 40Mbps on GbE
- **Token Bucket Filter (TBF)**
  - TBF is a timer-interrupt driven method, and its burst size is as large as “rate / a timer frequency”
  - Example: 33 packets (40 Mbps / 100 = 50KB)
  - Interval: 9.6 ms

- **PSPacer**
  - PSPacer inserts a gap packet between packets to adjust the interval. Traffic is precisely paced
  - Example: 288 us
TBF

Sender-side (TBF/TX)

Receiver-side (TBF/RX)

Packet loss rate 34.8%

Ave. of $ABW_{100ms}$: 39.4 Mbps

Ave. of burstiness: 46.9 KB

Ave. of burstiness: 25.7 Mbps

Ave. of burstiness: 4.43 KB

moderated by intermediate bottleneck (FastEther)
PSPacer

Sender-side (PSP/TX)

Receiver-side (PSP/RX)

Packet loss rate 5.0%

Ave. of. $ABW_{100ms}$: 39.9 Mbps
Ave. of. Burstiness: 0 KB

Ave. of. $ABW_{100ms}$: 37.9 Mbps
Ave. of. Burstiness: 3.27 KB

effect of packet clustering
### Relationship between burstiness and packet loss rate

<table>
<thead>
<tr>
<th></th>
<th>ABW&lt;sub&gt;100ms&lt;/sub&gt; (Mbps)</th>
<th>max(Q)&lt;sub&gt;100ms&lt;/sub&gt; (KB)</th>
<th>Packet loss rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ave</td>
<td>max</td>
<td>ave</td>
</tr>
<tr>
<td>TBF/TX</td>
<td>39.4</td>
<td>39.5</td>
<td>46.9</td>
</tr>
<tr>
<td>TBF/RX</td>
<td>25.7</td>
<td>39.4</td>
<td>4.43</td>
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<tr>
<td>PSP/TX</td>
<td>39.9</td>
<td>39.9</td>
<td>0</td>
</tr>
<tr>
<td>PSP/RX</td>
<td>37.9</td>
<td>48.0</td>
<td>3.27</td>
</tr>
</tbody>
</table>

(measured over a period of 1 minute)

- Larger burstiness increases the probability of packet loss
  - Pacing can improve the bandwidth utilization
- Burstiness is affected for moderation by intermediate bottleneck and packet clustering
Conclusion

• We proposed a quantitative definition of burstiness
• We implemented a realtime burstiness measurement method on GtrcNET-1
• The preliminary experimental results show relationship between burstiness and packet loss
• There are many works to do…
  – Effectiveness and usage of the quantitative definition of burstiness is not clear
For More Information

- GtrcNET-1: http://gtrc.aist.go.jp/gnet/
- PSPacer: http://www.gridmpi.org/gridtcp.jsp
  - PSPacer has released under the GNU GPL.
- NAREGI: http://www.naregi.org/

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