The Effect of Layer-2 Switches on Pathchar-like Tools

Ravi S. Prasad,*
Constantinos Dovrolis,*
and
Bruce A. Mah†

*Networking and Telecommunications Group,
College of Computing, Georgia Tech.
†Packet Design Inc.
Overview of pathchar-like tools

- **pathchar, pchar, clink** - Objective: estimate link capacities
- They all use the Variable Packet Size (VPS) probing methodology
- Estimate Round Trip Time (RTT) up to hop $I$

- Propagation delays $\tau$
- Queuing delays $d$
- Serialization delays $L/C$

Ravi S. Prasad - ravi@cc.gatech.edu, IMW, Nov 2002
VPS methodology

- Assume that minimum RTT for each packet size does **not** include queuing delays

- Minimum RTT for packet size $L$ up to hop $I$:

  \[
  T_I(L) = \alpha_I + L \sum_{i=1}^{I} \frac{1}{C_i} = \alpha_I + L\beta_I
  \]

- Estimated capacity of hop $I$:

  \[
  C_I = \frac{1}{\beta_I - \beta_{I-1}}
  \]
A single-hop path

- A and B have Fast Ethernet network interfaces
- Correct capacity \( \simeq 97 \text{Mbps (IP layer)} \)
- All these tools consistently underestimate the link capacity
- What went wrong?
  - The tool, or the estimation methodology?
Effect of L2 store-and-forward switches

\[ \beta_1 = \frac{1}{C_{1,1}^{L2}} + \frac{1}{C_{1,2}^{L2}} \]

Estimated capacity \[= \frac{1}{\frac{1}{C_{1,1}^{L2}} + \frac{1}{C_{1,2}^{L2}}} < \text{Correct capacity} = \min \{ C_{1,1}^{L2}, C_{1,2}^{L2} \} \]
Experimental results at a UDel campus network path

□ :Fast Ethernet Switch;  ● :Ethernet Switch

<table>
<thead>
<tr>
<th>L3 hop</th>
<th>Capacity</th>
<th>L2 segments</th>
<th>pathchar</th>
<th>clink</th>
<th>pchar</th>
</tr>
</thead>
<tbody>
<tr>
<td>A to B</td>
<td>100Mbps</td>
<td>5 Fast-Ethernet</td>
<td>17.0±0.0</td>
<td>17.0±0.0</td>
<td>17.0±0.4</td>
</tr>
<tr>
<td>B to C</td>
<td>100Mbps</td>
<td>2 Fast-Ethernet</td>
<td>62.2±7.2</td>
<td>64.7±9.3</td>
<td>62.3±9.1</td>
</tr>
<tr>
<td>C to D</td>
<td>100Mbps</td>
<td>1 Fast-Ethernet</td>
<td>100.5±15.0</td>
<td>100.3±22.0</td>
<td>101.9±26.0</td>
</tr>
<tr>
<td>D to E</td>
<td>10Mbps</td>
<td>2 Ethernet</td>
<td>5.75±0.15</td>
<td>5.6±0.1</td>
<td>5.7±0.1</td>
</tr>
<tr>
<td>E to F</td>
<td>10Mbps</td>
<td>??</td>
<td>4.5±0.1</td>
<td>3.7±0.1</td>
<td>6.5±0.6</td>
</tr>
</tbody>
</table>
Other sources of error in VPS tools

- Non-zero queuing delays
- Limited clock resolution
- Error propagation/amplification from the previous hop
- ICMP generation latency

  - For a detailed analysis, see Infocom 2003, San Francisco.
Thank you!