Measuring Provider Path Diversity from Traceroute Data: work in progress

[CAIDA-ISMA workshop 12/18/2001]

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Motivation: Multi-homing

• “Multi-homing” (connecting to multiple ISPs) is becoming increasingly popular

• Originally this redundancy was used to maintain connectivity to a large set of endpoints.

• Now being used to optimize performance over a large set of endpoints

“intelligent route control”
new companies
Multi-homed Network

Source

Provider A

Internet

Provider B

Destination
Path Diversity?
Path Diversity?
Questions

From a given customer {network viewpoint + destinations}:

- How much path diversity exists across providers?
- What combination of providers will give the most/least diversity?
Terminology

Viewpoint

A

B

Providers

Convergence Point

Endpoint

Shared Path
Measurement Sample

- **Viewpoint:** POP in San Jose, CA
- **Providers:** Exodus, UUNet, Sprint, AT&T
- **Endpoints:** 8,932 from unique /24 prefixes (randomly selected from 46,089 by netflow)
Measurement Setup/Tools

• UDP Traceroute: via BGP default path, and through all four providers
  ▪ Outbound TOS-filtering at border router
  ▪ Same source address

• Processing
  ▪ RTT (as a measure of forward latency) is made monotonically increasing
Single Host Convergence

- Convergence Points are located for each pair of providers

- The hop before the first shared IP address
  - Different interfaces to the same router will have different IP addresses
## Convergence Point

### Provider A (Sprint):  
<table>
<thead>
<tr>
<th>Hop</th>
<th>RTT</th>
<th>IP Address</th>
<th>IP Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.306</td>
<td>fe0-0.BR1.C11-0.SJC.ivmg.net</td>
<td>64.41.255.1</td>
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<td>12</td>
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<td>us-gw2.ja.net</td>
<td>193.62.157.17</td>
</tr>
<tr>
<td>18</td>
<td>151.053</td>
<td>wwwws-a.ucl.ac.uk</td>
<td>144.82.100.130</td>
</tr>
</tbody>
</table>

### Provider B (Exodus):  
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<thead>
<tr>
<th>Hop</th>
<th>RTT</th>
<th>IP Address</th>
<th>IP Address</th>
</tr>
</thead>
<tbody>
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<td>wwwws-a.ucl.ac.uk</td>
<td>144.82.100.130</td>
</tr>
</tbody>
</table>
Multiple Convergence Points

1: AT&T  
2: Sprint  
3: UUNET  
4: Exodus

2: 9/9ms  
3: 9/10ms  
4: 11/6ms

1: 8/11ms  
2: 10/10ms  
3: 10/10ms  
4: 14/14ms

SJC  
sade.stanford.edu
Summarizing Many Endpoints

- Difficult Problem

- Focus on two providers at a time
  - One convergence point per destination
  - One shared path per destination
Terminology

- Providers
- Viewpoint A
- Viewpoint B
- Convergence Point
- Endpoint
- Shared Path
## Verbose Reporting

<table>
<thead>
<tr>
<th>destination</th>
<th>sprint</th>
<th>CONV</th>
<th>exodus</th>
<th>CONV</th>
<th>%hop</th>
<th>%lat</th>
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</thead>
<tbody>
<tr>
<td>nytimes.com</td>
<td>--</td>
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<td>washingtonpost.com</td>
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<td>u-tokyo.ac.jp</td>
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<td>saab.com</td>
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Focus on Shared Path

• Possible to summarize

• Only destinations with full traceroutes
  3372 / 8932

• Histograms of Hop-Count
• Histograms of RTT
  ▪ Approximated as RTT to destination – RTT to convergence point.
Shared Path HOPs

- AT&T and Sprint
- AT&T and UUNet
- AT&T and Exodus
- Sprint and UUNet
- Sprint and Exodus
- UUNet and Exodus
Shared Path RTTs

- AT&T and Sprint
- AT&T and UUNet
- AT&T and Exodus
- Sprint and UUNet
- Sprint and Exodus
- UUNet and Exodus
Interpretation

• Least Diverse: AT&T and Exodus
  ▪ Often shared 10-15 hops with a wide range of shared path RTT.

• Most Diverse: Sprint and Exodus
  ▪ Lowest mean shared path RTT.

• Disclaimer: conclusions depend on the viewpoint and probed endpoints.
Minimum RTTs
### Minimum RTTs

<table>
<thead>
<tr>
<th>minimum RTT window</th>
<th>classification</th>
<th># hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>mRTT = 14ms</td>
<td>126</td>
</tr>
<tr>
<td>2</td>
<td>14ms &lt; mRTT = 43ms</td>
<td>466</td>
</tr>
<tr>
<td>3</td>
<td>43ms &lt; mRTT = 140ms</td>
<td>1440</td>
</tr>
<tr>
<td>4</td>
<td>140ms &lt; mRTT</td>
<td>1340</td>
</tr>
</tbody>
</table>
Future Work

• Repeat study from multiple viewpoints across the country.

• Correlate with other active TCP probe data.
  ▪ longitudinal SYN/ACK data: RTT, Loss, IPDV
Any Suggestions?

- How could the methodology be improved?
  - Are traceroutes informative?
  - Excluding partial traceroutes?
  - RTT information? Return path issues?
- What are interesting future directions?
  - AS# of Convergence Points? Core routers?
  - Is a longitudinal study necessary?