Announcements

• SVN account/password should be fixed
• HW3 out tomorrow
• P2 discussions on 10/31
• Need volunteers
  – Standardize HTTP header extensions (p2)
  – Coordinate HW2 measurements
HW3

• Build a map of wireless network access performance
  – Different areas of campus
  – Different times
• Need a volunteer to coordinate this effort
• The class will together write a final report on this effort
Internet Measurement

• Complex system
  – Can use models to understand
  – How do we build the model?

• Need measurements
  – Performance
    • Latency
    • Data rates
    • Traffic mix
  – Prevalence of problems
    • BGP route oscillations, convergence
Internet Traffic Volume

[Labovitz 2010]
## Traffic Mix

<table>
<thead>
<tr>
<th>Rank</th>
<th>Application</th>
<th>2007</th>
<th>2009</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Web</td>
<td>41.68%</td>
<td>52.00%</td>
<td>24.76%</td>
</tr>
<tr>
<td>2</td>
<td>Video</td>
<td>1.58%</td>
<td>2.64%</td>
<td>67.09%</td>
</tr>
<tr>
<td>3</td>
<td>VPN</td>
<td>1.04%</td>
<td>1.41%</td>
<td>35.58%</td>
</tr>
<tr>
<td>4</td>
<td>Email</td>
<td>1.41%</td>
<td>1.38%</td>
<td>-2.13%</td>
</tr>
<tr>
<td>5</td>
<td>News</td>
<td>1.75%</td>
<td>0.97%</td>
<td>-44.57%</td>
</tr>
<tr>
<td>6</td>
<td>P2P (*)</td>
<td>2.96%</td>
<td>0.85%</td>
<td>-71.28%</td>
</tr>
<tr>
<td>7</td>
<td>Games</td>
<td>0.38%</td>
<td>0.49%</td>
<td>28.95%</td>
</tr>
<tr>
<td>8</td>
<td>SSH</td>
<td>0.19%</td>
<td>0.28%</td>
<td>47.37%</td>
</tr>
<tr>
<td>9</td>
<td>DNS</td>
<td>0.20%</td>
<td>0.17%</td>
<td>-15.00%</td>
</tr>
<tr>
<td>10</td>
<td>FTP</td>
<td>0.21%</td>
<td>0.14%</td>
<td>-33.33%</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>2.56%</td>
<td>2.67%</td>
<td>4.30%</td>
</tr>
<tr>
<td></td>
<td>Unclassified</td>
<td>46.03%</td>
<td>37.00%</td>
<td>-19.62%</td>
</tr>
</tbody>
</table>

[Labovitz 2010]
How Fast is Our Internet Access

- Marketing brochure from ISP
- Can download a large file
- Run some tests
Next: slides from Srikanth Sundaresan’s talk
Accurate Measurements are Difficult

Home Network: AT&T DSL
6 Mbps Down, 512 Kbps Up

Last Mile

ISP Network

speedtest.net: 4.4 Mbps, 140 Kbps
Netalyzr: 4.8 Mbps, 430 Kbps

End host measurements are not continuous, and affected by *confounding factors*
The Case For the Gateway

Home Network: AT&T DSL
6 Mbps Down, 512 Kbps Up

Last Mile

speedtest.net: 4.4 Mbps, 140 Kbps
Netalyzr: 4.8 Mbps, 430 Kbps
Gateway: 5.6 Mbps, 460 Kbps

Gateway enables periodic measurements, and can account for confounding factors
The Deployments

• Breadth: The FCC/SamKnows study
  – 4,000 gateways, 16 ISPs, multiple service plans
• Depth: The BISmark study
  – 16 gateways in Atlanta, on-demand measurements
• Duration: Dec 2010 – Jan 2011
Results: Overview

• Throughput measurement technique depends on usage scenario
• Traffic shaping is highly variable across users
• Access link characteristics affect performance
• Modem buffers induce high latency
Results: Overview

• Throughput measurement technique depends on usage scenario
• Traffic shaping is highly variable across users
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Interpreting Throughput Results

Different techniques measure different aspects of throughput
Results: Overview

- Throughput measurement technique depends on usage scenario
- Traffic shaping is highly variable across users
- Access link characteristics affect performance
- Modem buffers induce high latency
Traffic Shaping: PowerBoost

- Cable companies advertise “PowerBoost”
  - Short bursts of high bandwidth
- Non-existent in DSL
Traffic Shaping Varies Across Users

Short-term throughput significantly different from sustainable throughput
Results: Overview

• Throughput measurement technique depends on usage scenario
• Traffic shaping is highly variable across users
• Access link characteristics affect performance
• Modem buffers induce high latency
## Latency Measurements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>What it captures</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-to-end</td>
<td>Latency to nearby server</td>
</tr>
<tr>
<td>Last-mile</td>
<td>Latency to edge of ISP network</td>
</tr>
<tr>
<td>Under Load</td>
<td>Buffer delays due to cross traffic</td>
</tr>
</tbody>
</table>
Impact of Last-mile on Latency

DSL last-mile latencies can be very high
DSL Interleaving Affects Latency

Fastpath vs. Interleaved last-mile data path

Fastpath sends data in order, can recover from single losses

Fastpath is susceptible to bursty loss

Interleaving sends data out-of-order, can recover from bursty loss
Example: Latency-Throughput Tradeoff

Both users have same service plan:
Interleaving decreases loss, increases latency, improves throughput.

Interleaving creates a trade-off between latency and throughput.
Results: Overview

• Throughput measurement technique depends on usage scenario
• Traffic shaping is highly variable across users
• Access link characteristics affect performance
• Modem buffers induce high latency
Modem Buffers are Too Large

Service plans can interact badly with modem buffers

10 seconds!
Conclusion

- The gateway provides unique insight into home network
- Throughput measurements are affected by measurement technique, shaping
- Latency is affected by last-mile, buffering
- ISPs generally deliver consistent throughput, with some time-of-day effects
- How to mitigate buffering effects
Throughput Across Time

![Graph showing throughput across time for different providers]