# Broadband Internet Performance: A View from the Gateway

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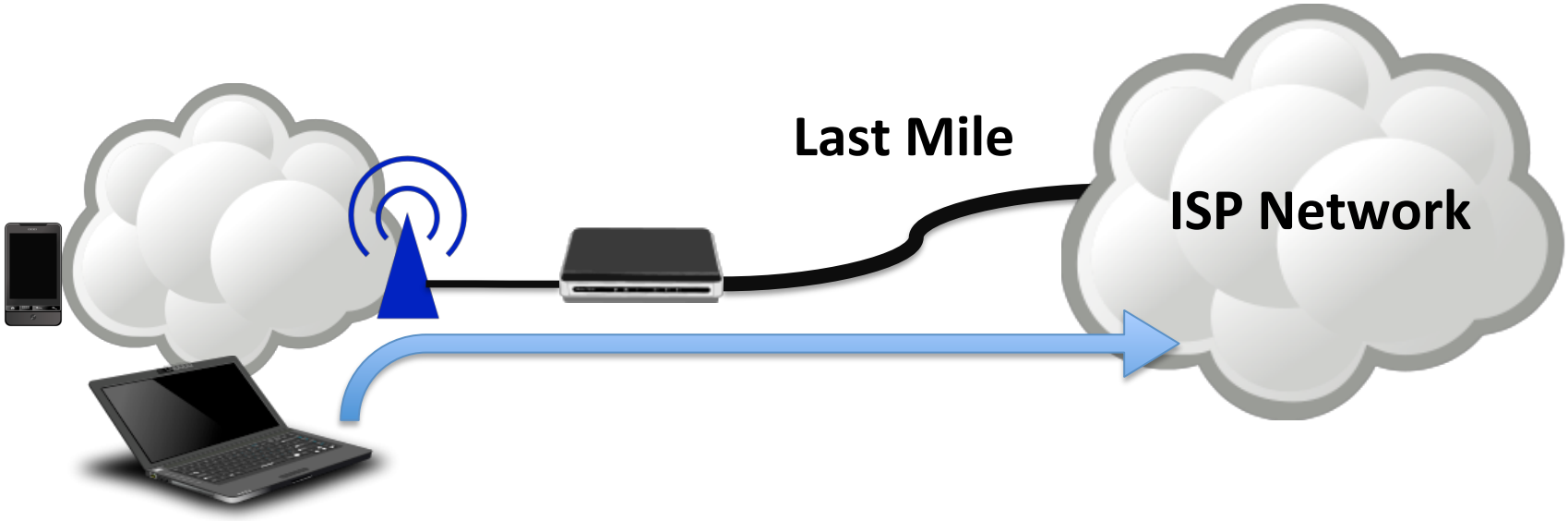
# What Affects Broadband Performance?



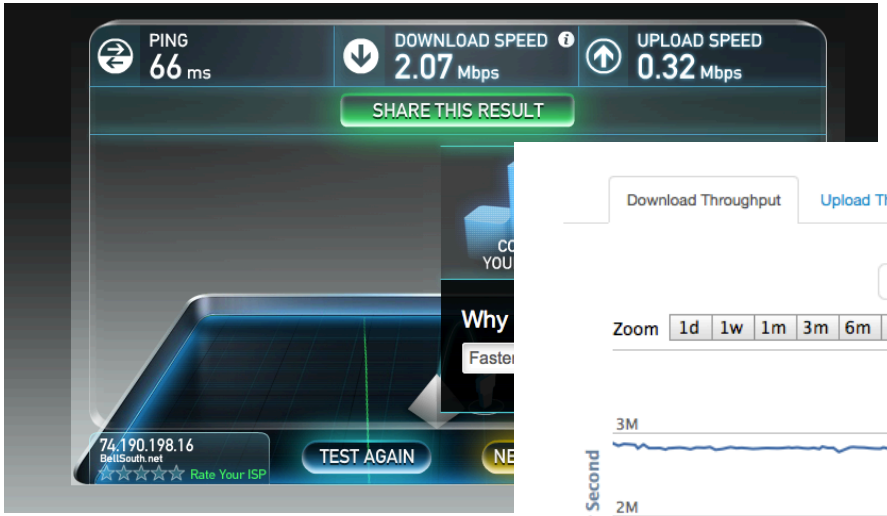
- Notion of performance is fuzzy
  - What metrics should we measure?
  - How to measure them?
- Important for regulators, consumers, ISPs, content providers
  - 500ms delay causes 20% decrease in Google search traffic

# Accurate Measurements are Difficult



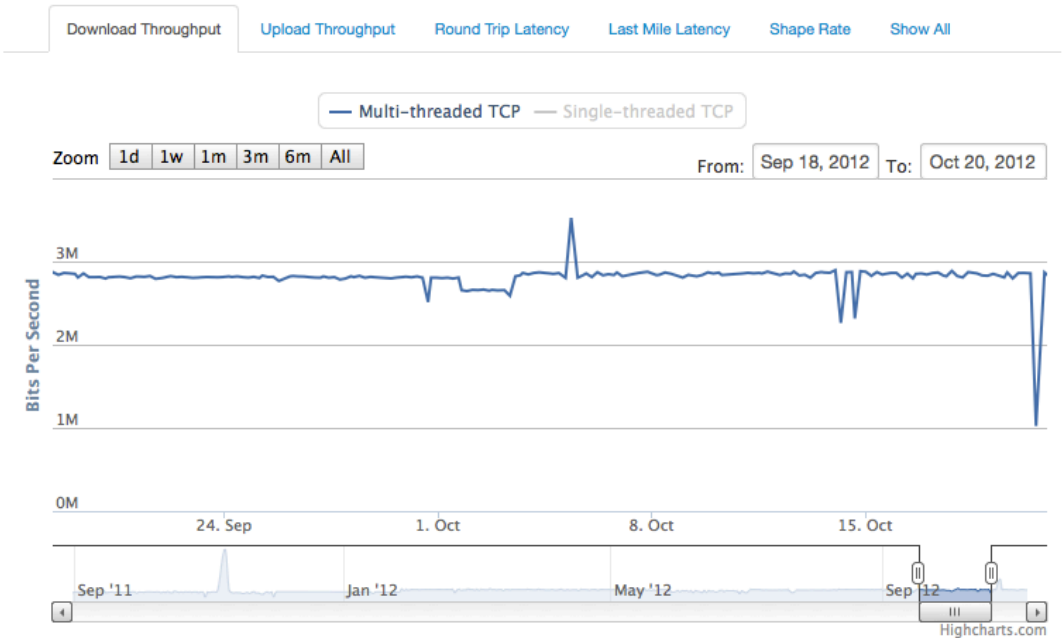

**End host measurements are not continuous, and affected by *confounding factors***

# The Case For the Gateway



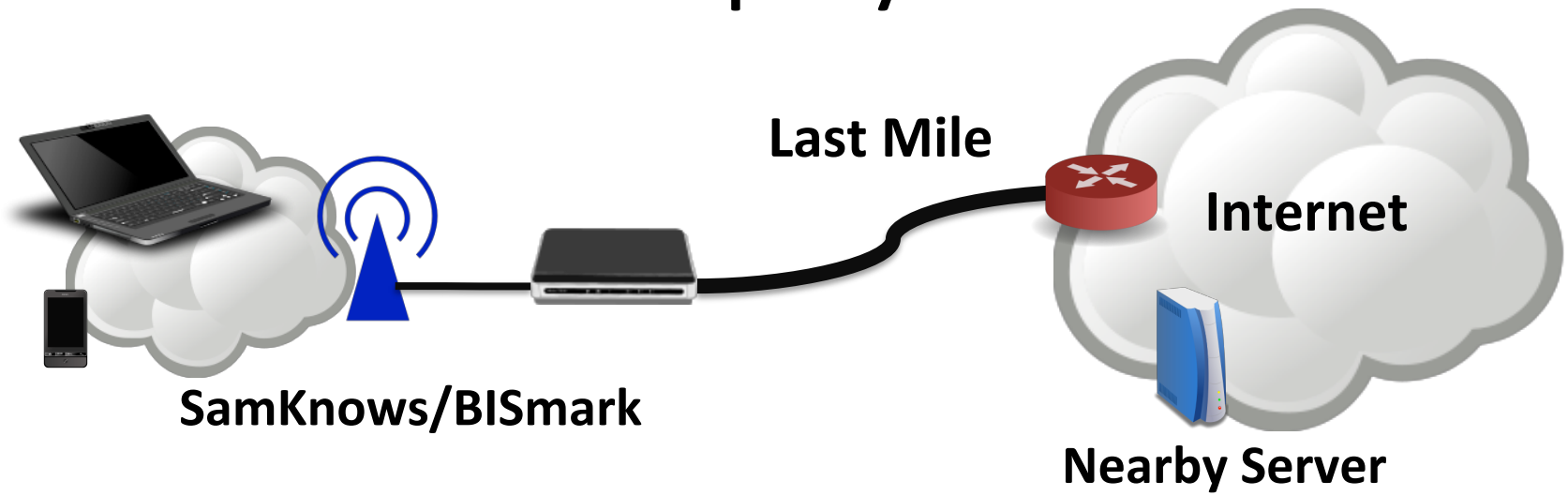

**Actual Service plan: AT&T DSL 3 Mbps Down, 384 Kbps Up**

**Measured average: 2.85 Mbps Down, 338 Kbps Up**




**Gateway enables periodic measurements, and can account for confounding factors**

# The Deployments




- Breadth: The FCC/SamKnows study
  - 7,800 gateways, 18 ISPs, multiple service plans
- Depth: The BISmark study
  - 120+ gateways in 28 countries worldwide, periodic and on-demand measurements

# Results: Overview

- Throughput:
  - Depending on technique, results can vary up to 25%
  - Traffic shaping varies across users, affects results
- Latency:
  - Access link characteristics introduce loss/latency/ throughput trade-offs
  - Modem buffers can induce latencies up to 10 seconds
- Application Performance – Web:
  - Latency becomes bottleneck beyond 16 Mbits/s

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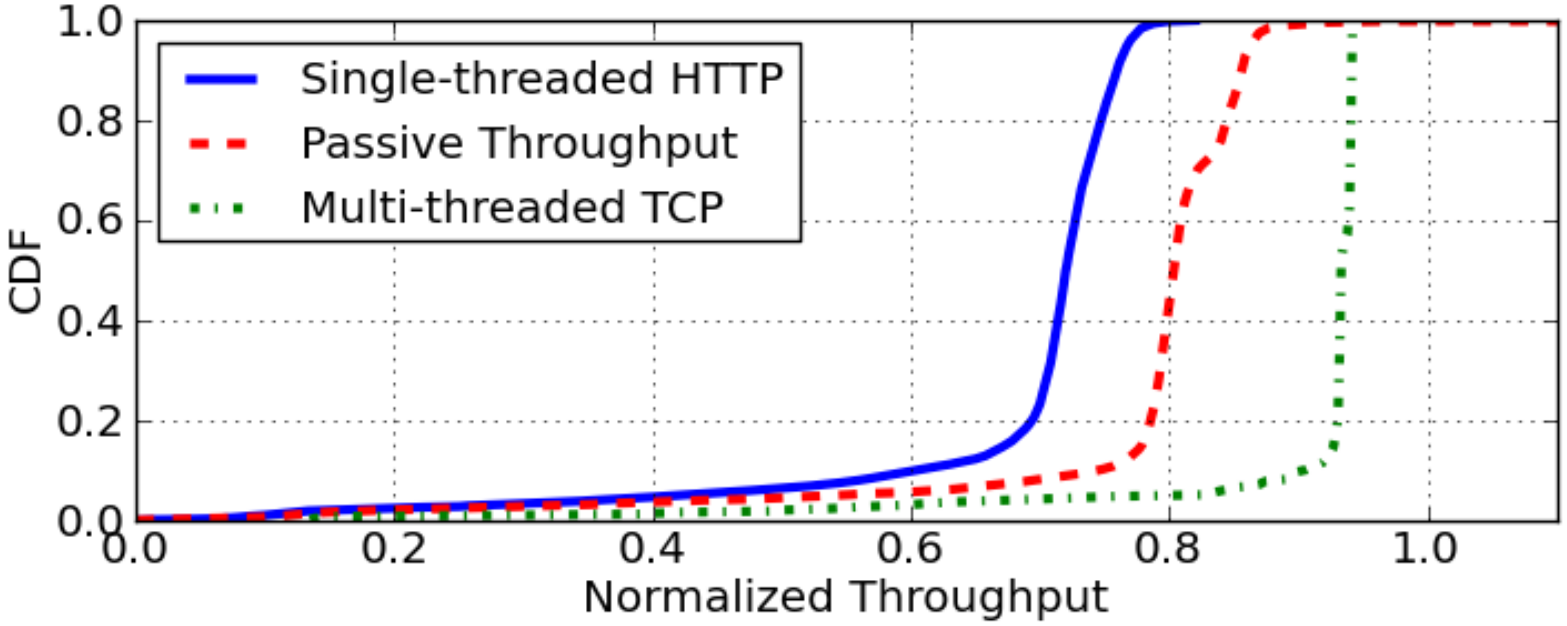
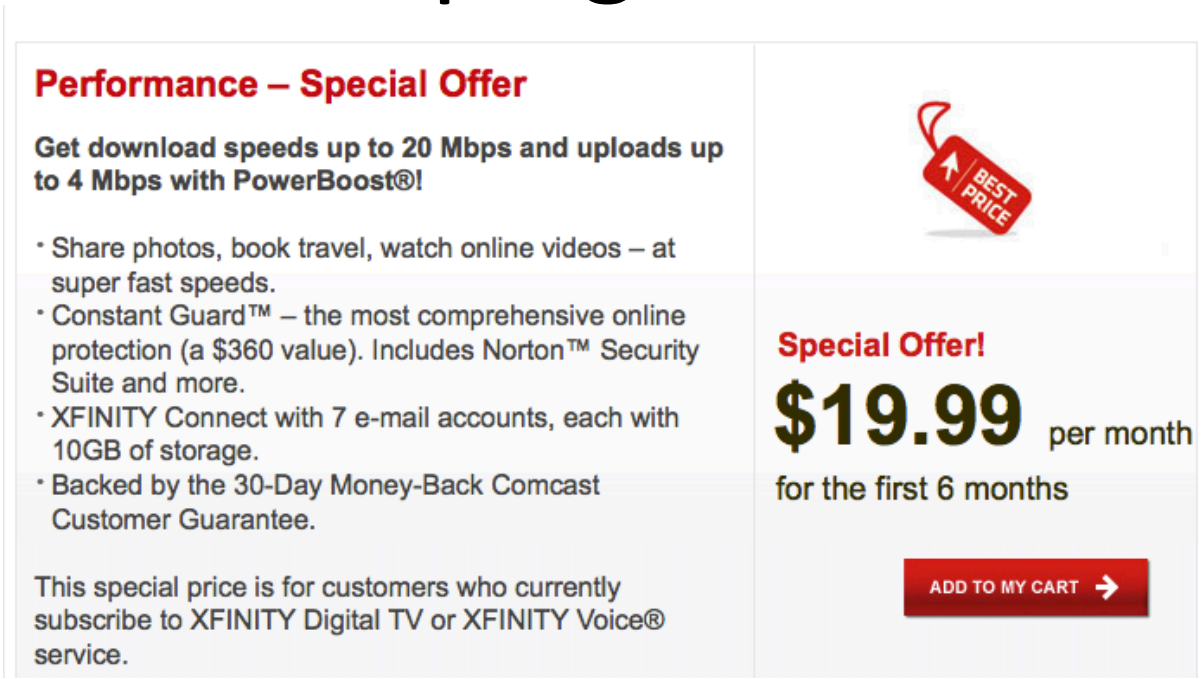
# Interpreting Throughput Results



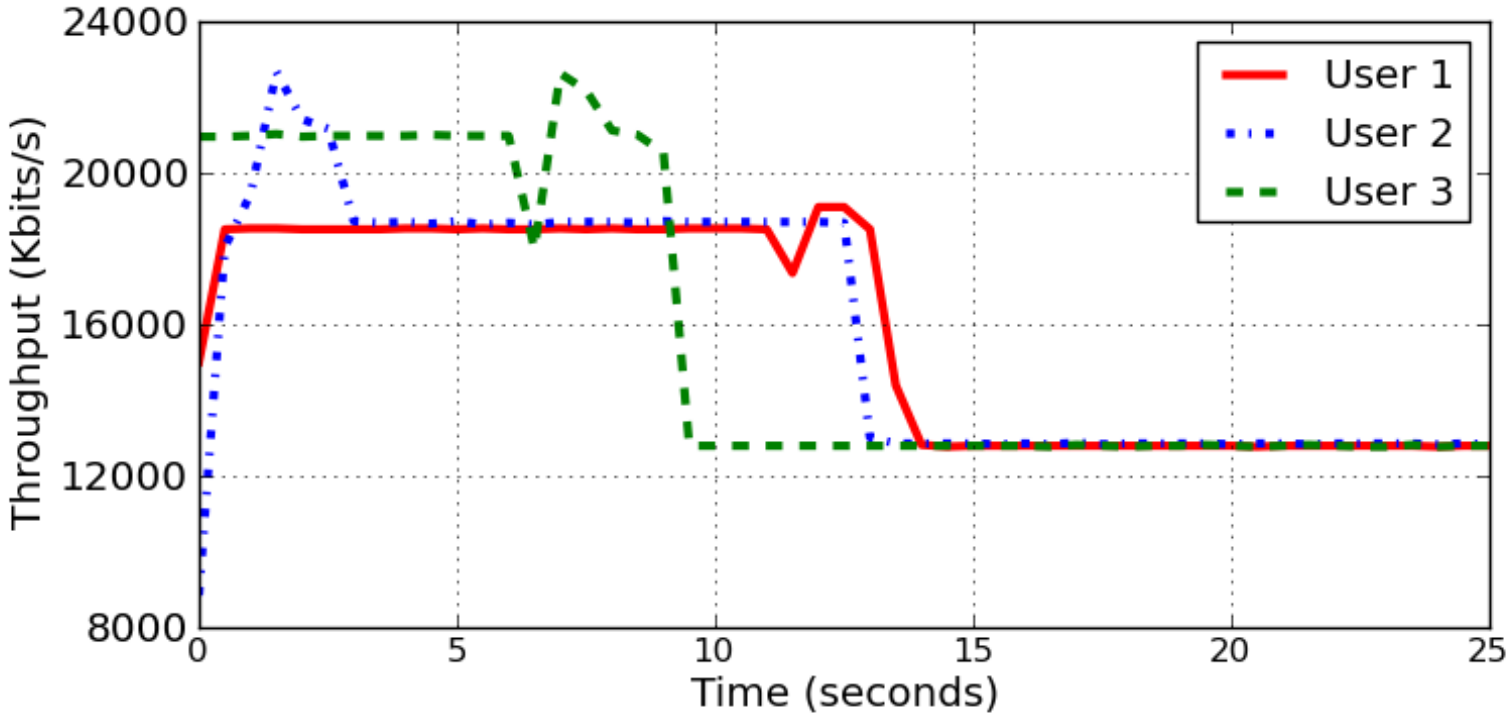

**Different techniques measure different aspects of throughput**

# 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**

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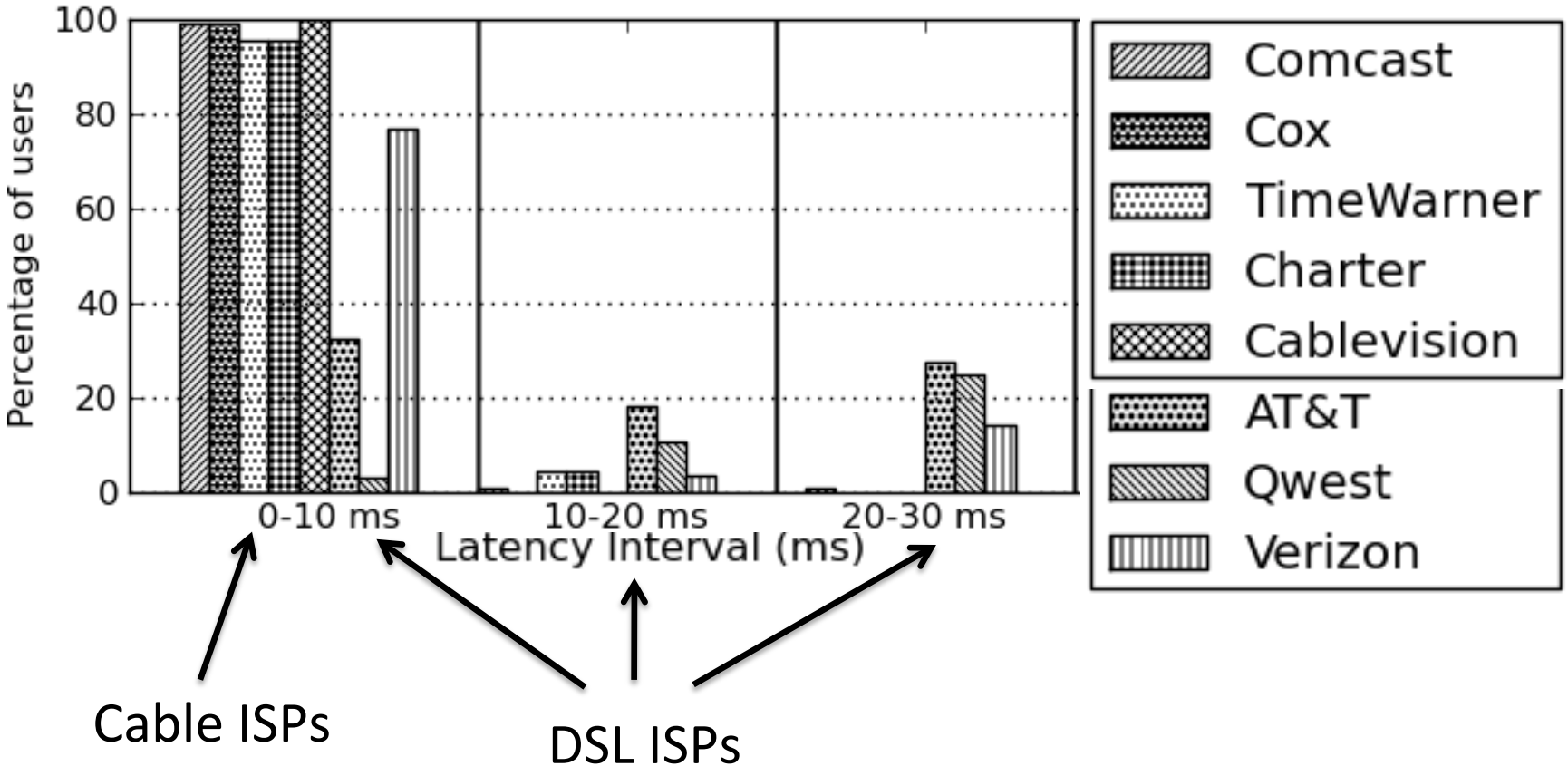
# Latency Measurements

| Parameter | What it captures |
| --- | --- |
| End-to-end | Latency to nearby server |
| Last-mile | Latency to edge of ISP network |
| Under Load | Buffer delays due to cross traffic |

# Impact of Last-mile on Latency



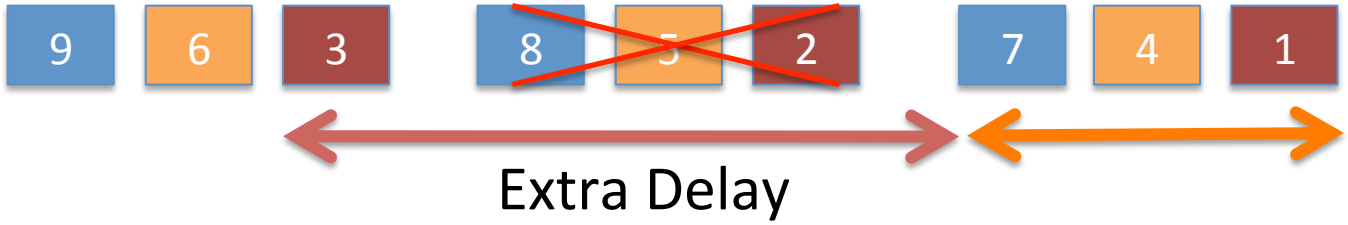

**DSL last-mile latencies can be very high – 20% of users > 40ms for some ISPs**

# DSL Interleaving Affects Latency

## Fastpath vs. Interleaved last-mile data path

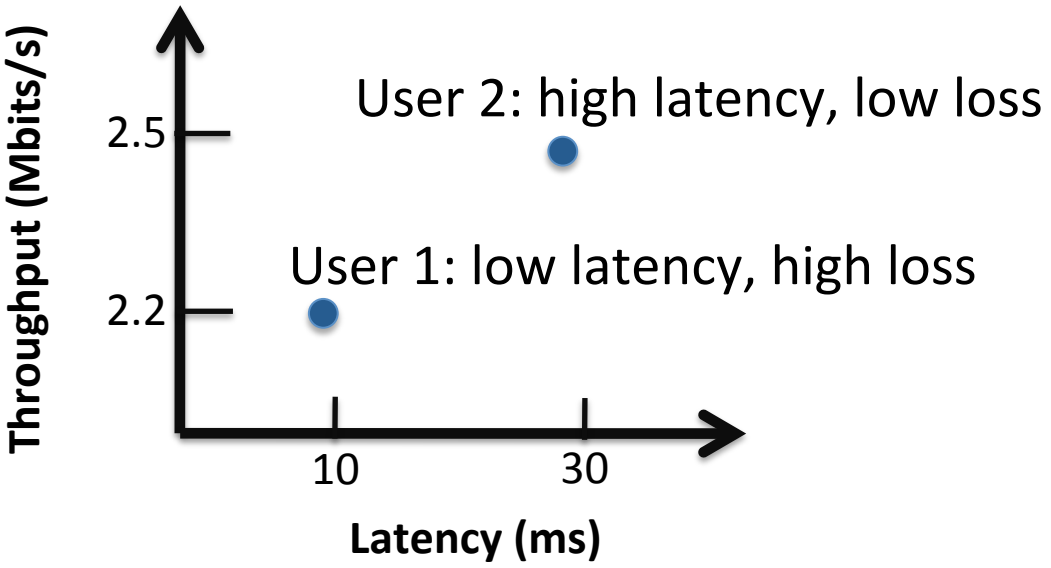

Fastpath sends data in order, can recover from single losses

Fastpath is susceptible to bursty loss




Interleaving sends data out-of-order, can recover from bursty loss

# Example: Latency-Throughput Tradeoff

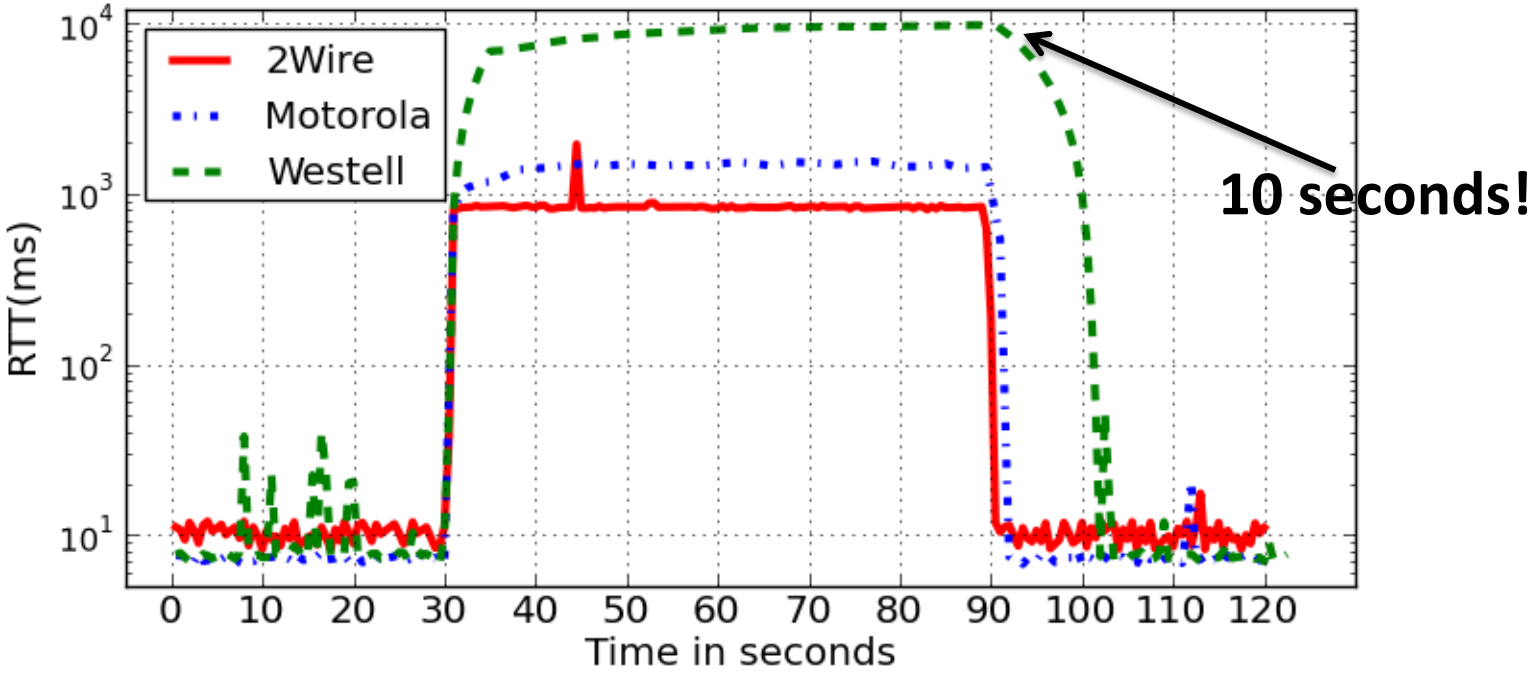



**Both users have same service plan**

**Interleaving decreases loss, increases latency, improves throughput**

**Interleaving creates a trade-off between latency and throughput**

# Modem Buffers are Too Large




**Service plans can interact badly with modem buffers**

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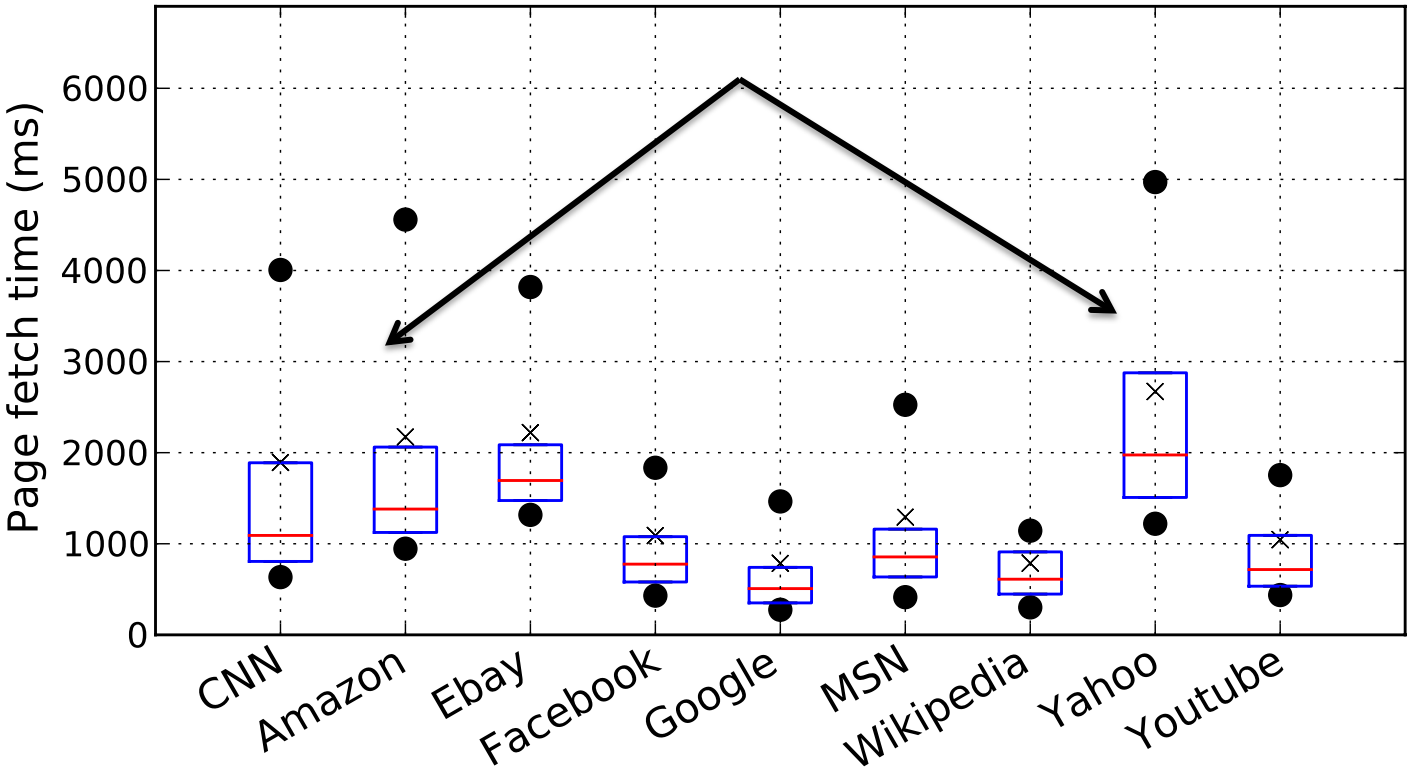
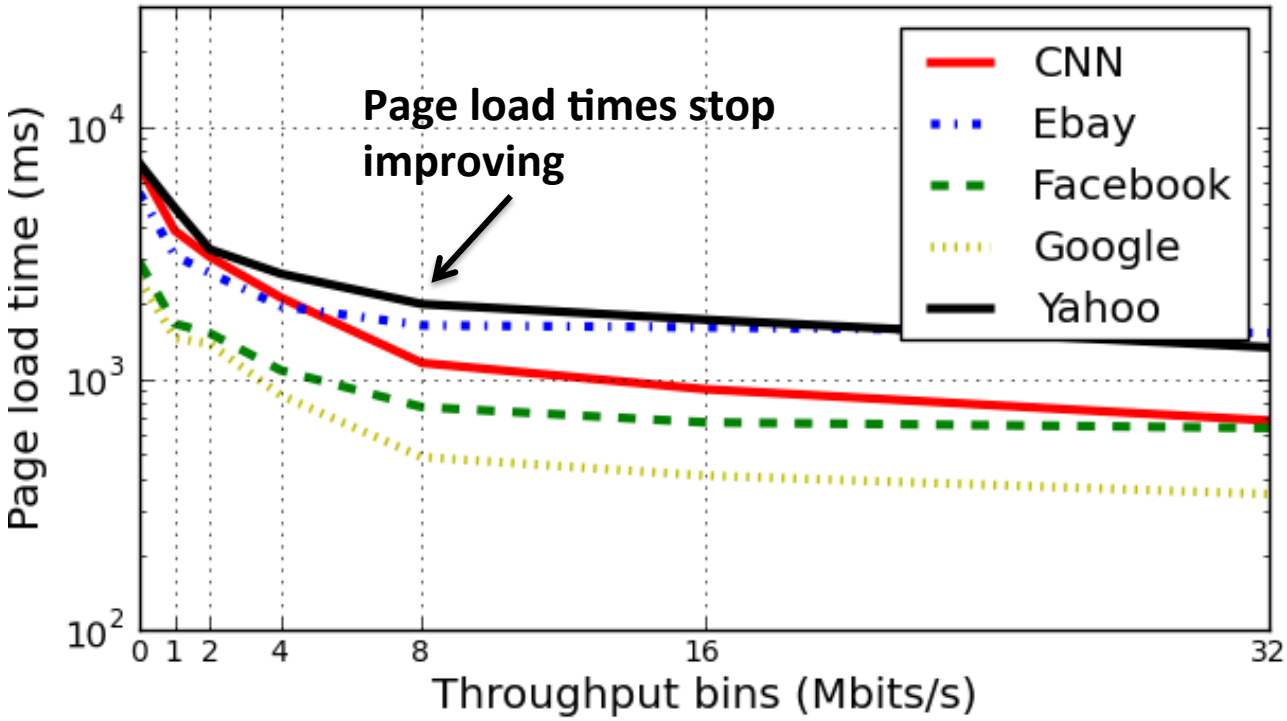
# Implications: Web Performance



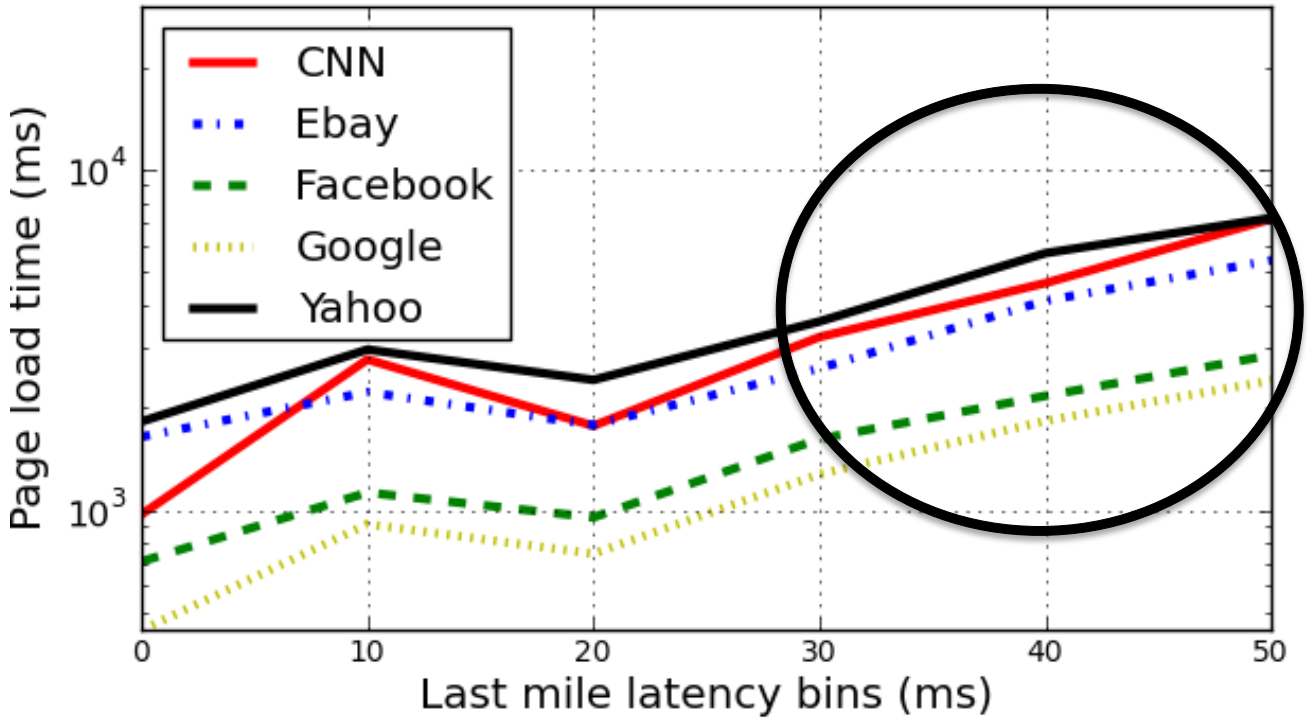

**Page load times can exceed 3 seconds – even for popular sites**

# More Throughput Isn't Everything




**Page load times stop improving above about 8-16 Mbit/s**

# Last-Mile Latency Matters




**Page load times increase with last mile latency**

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# Future Work

- Performance monitoring from the edge
  - Effect of peering on performance
  - Effect of CDN location, traffic engineering on application performance
  - Effect of home wireless networks on performance
- Improve end-host performance
  - How can we minimize the effect of last mile bottlenecks?

# http://projectbismark.net
# http://www.samknows.com


## Interested in a BISmark router? Interested in contributing?

**srikanth@gatech.edu**

# Previous Studies

- Measurement from outside
  - Dischinger et al [1] initiated measurements from wide area server
  - Indirect measurements, not continuous
- Measurements from inside
  - Endhost based measurements
    - Grenouille [2], Netalyzr [3]
  - Can't account for confounding factors

[1] Characterizing Residential Broadband Networks IMC 2007
[2] http://www.grenouille.com
[3] http://netalyzr.icsi.berkeley.edu Netalyzr: Illuminating the Network Edge IMC 2010