Benchmarking Broadband Internet Performance

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What is the Performance of Network Access Links?

Your fears confirmed: "up to" broadband speeds are bogus

By Nate Anderson | Last updated 16 days ago

Broadband providers in the US have long hawked their wares in "up to" terms. You know—"up to" 10Mbps, where "up to" sits like a tiny pebble beside the huge font size of the raw number.

In reality, no one gets these speeds. That's not news to the techno-literate, of course, but a new Federal Communications Commission report (PDF) shines a

Ofcom: Broadband ISPs are pulling a fast one

- Average speed 46% below that promised by ISPs
- Mandatory code and clear penalties vital, experts say

Graeme Wearden
The Guardian, Tuesday 27 July 2010
Article history

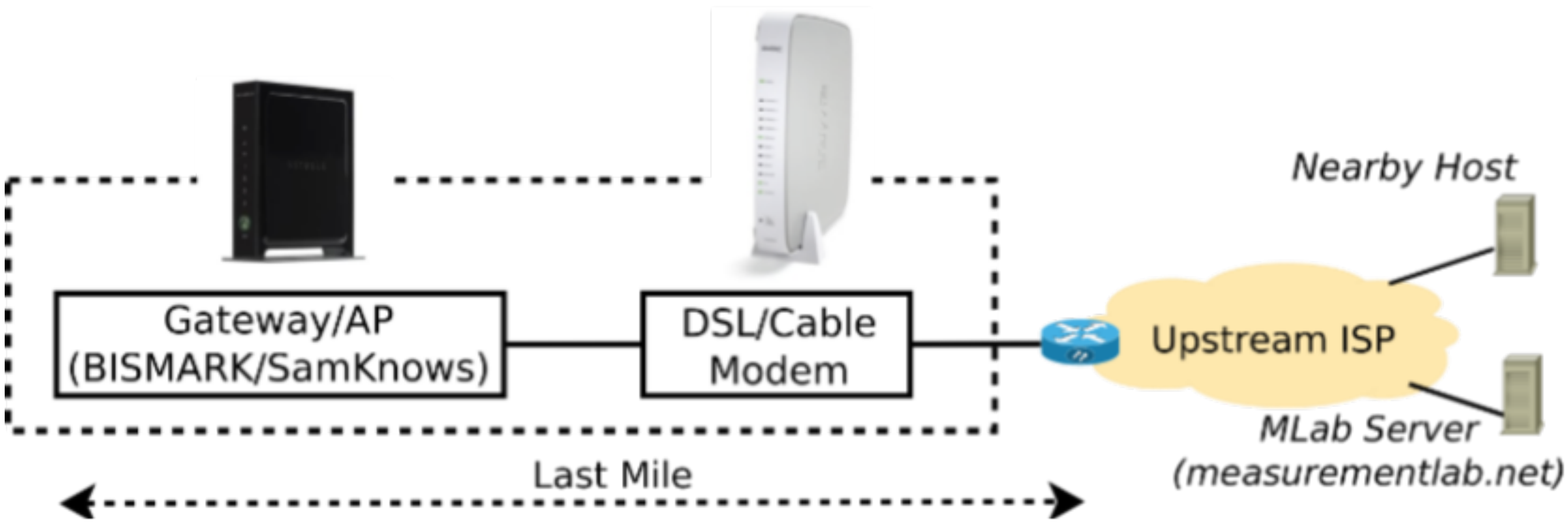
ACTUAL DOWNLOAD SPEEDS

As noted above, in 2009, average (mean) and median advertised download speeds were 7–8 Mbps, across technologies. However, FCC analysis shows that the median actual speed consumers experienced in the first half of 2009 was roughly 3 Mbps, while the average (mean) actual speed was approximately 4 Mbps. Therefore actual download speeds experienced by U.S. consumers appear to lag advertised speeds by roughly 50%.

Previous Performance Studies

- Study from **outside**
  - Dischinger et al. (IMC 2008), Netalyzr (IMC 2010)
  - Not continuous, not many per user, no view into home
- Study from **inside**
  - Grenouille project
  - Hard to account for device diversity
  - Hard to account for home network

The BISMark Project



- Periodic measurements to last mile and end-to-end
- Measure directly at the gateway device
- Adjust for confounding factors

BISMark

- Deploy programmable gateways in homes
- NoxBox deployment: about 35 around Atlanta
- SamKnows deployment: about 10000 around the US

NoxBox

Netgear

Gateway Vantage Point: Advantages

- Observes all traffic passing through network
- Isolate individual factors affecting network performance
  - Wireless
  - Cross traffic
  - Load on measurement host
  - End-to-end path
  - Configuration

Current Deployment

- 16 boxes deployed
- 10 in ATT, 4 in Comcast, 2 ClearWire
- Most of the deployments within Atlanta
- All measurements done to server at Georgia Tech

Active Measurements

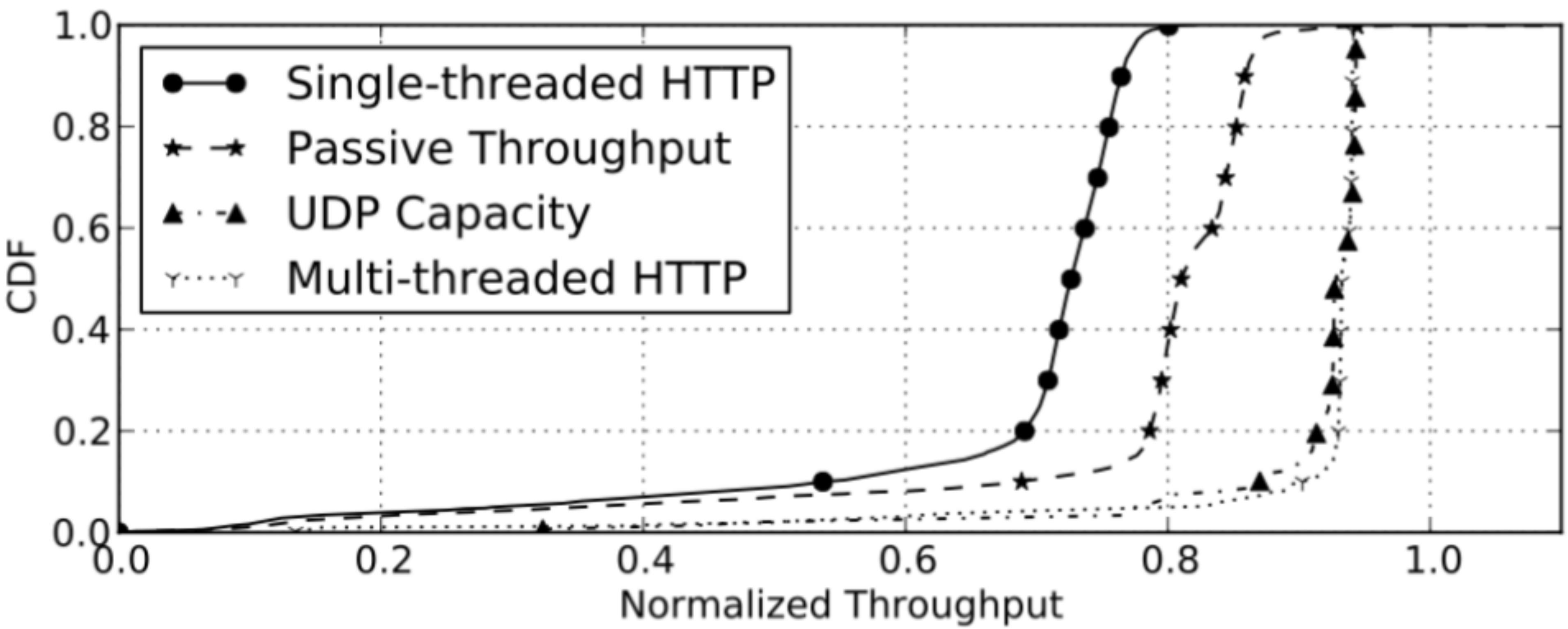
Parameter	Type	Prot.	Freq.	Comments
BISMark: 17 devices, 3 ISPs				
Latency	End-to-end	ICMP	5 min	Host
	Last-mile	ICMP	5 min	First IP hop
	Upstream load	ICMP	30 min	During upload
	Downstream load	ICMP	30 min	During download
Packet loss	End-to-end	UDP	15 min	D-ITG
Jitter	End-to-end	UDP	15 min	D-ITG
Downstream Throughput	Single-thread HTTP	TCP	30 min	curlget to Host
	Passive throughput	N/A	30 min	/proc/net/dev
	Capacity	UDP	12 hrs	ShaperProbe
Upstream Throughput	Single-thread HTTP	TCP	30 min	curlput to Host
	Passive throughput	N/A	30 min	/proc/net/dev
	Capacity	UDP	12 hrs	ShaperProbe

Results

- Throughput
  - Different throughput techniques capture different aspects of throughput
  - There is high variation across users with same technique
- Latency
  - Latencies vary within the same ISP
  - Last-mile latencies are significant
  - Modem buffers are too large
  - Modifying data transfer using using traffic shaping might mitigate the problem in the short term

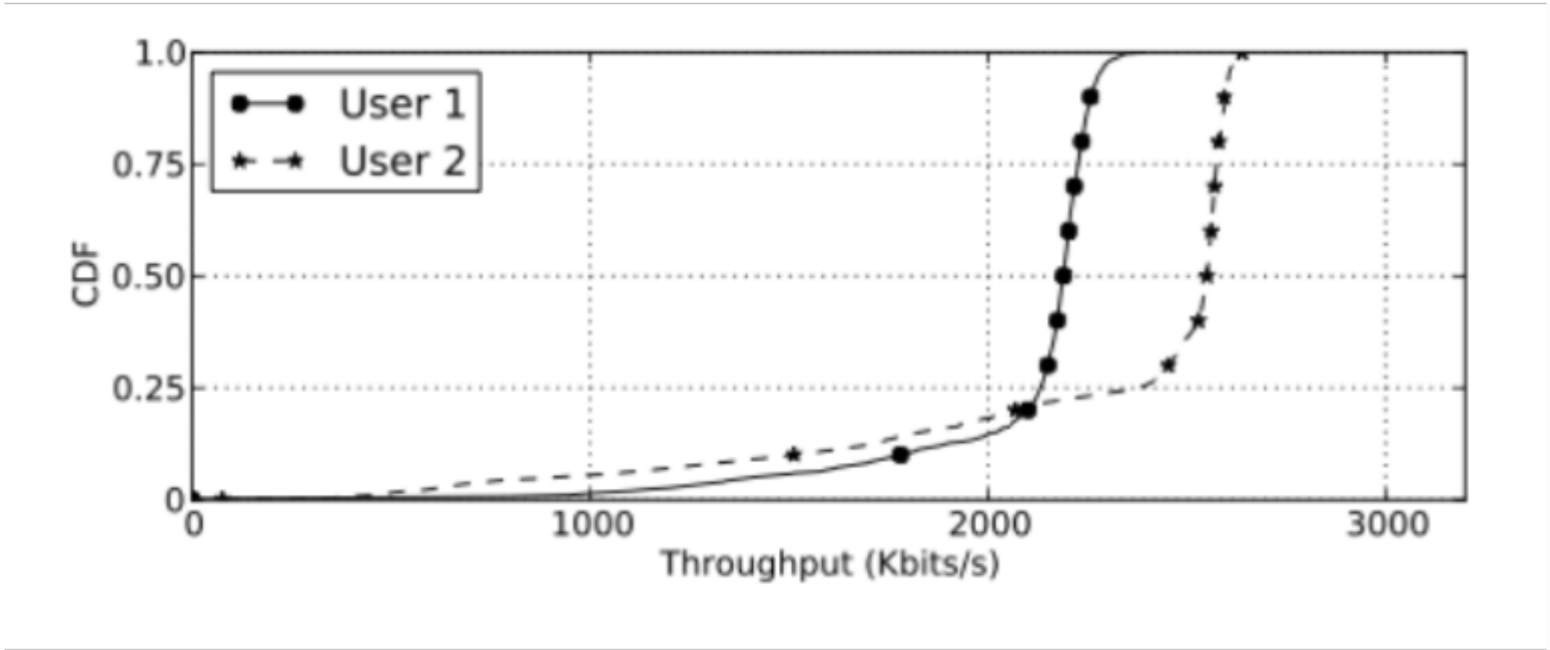
Different Techniques, Different Aspects of Throughput

- Single threaded is what users see on a single download
- Web browsing is mostly multi-threaded



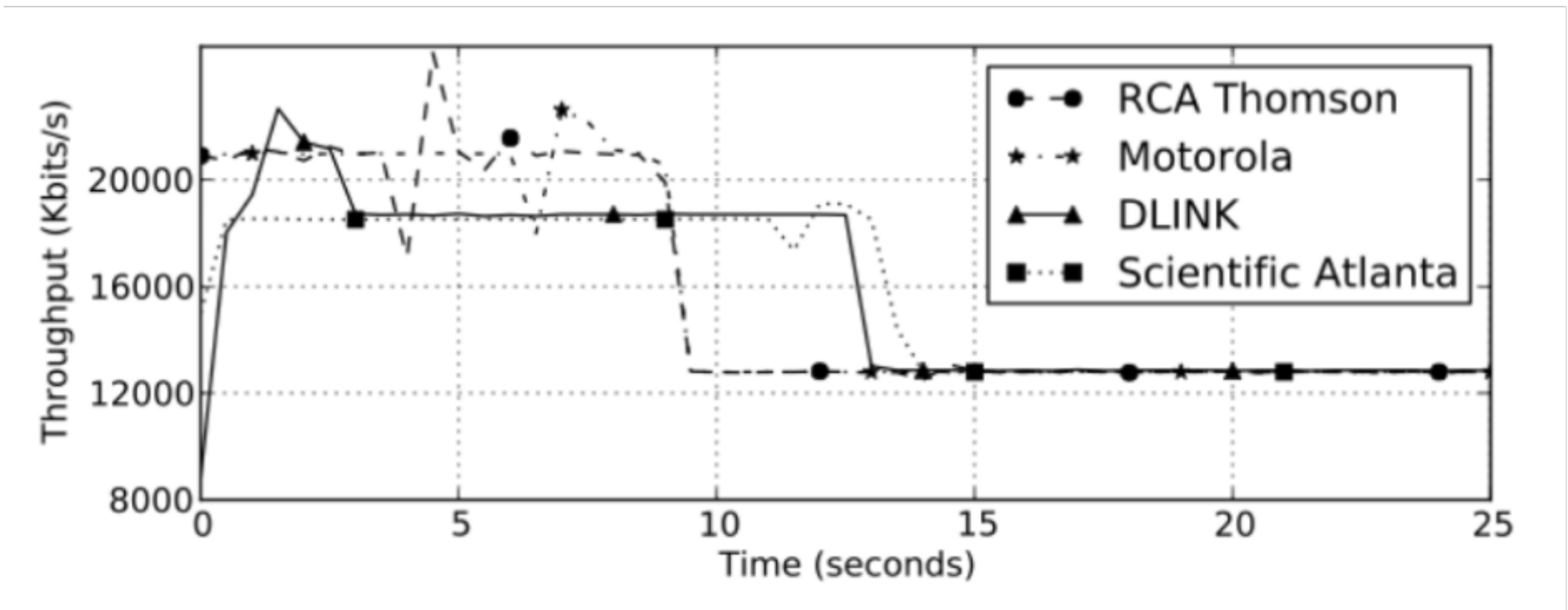
Different Users, Different Performance

- Same service plan & ISP, different loss profile
- User 1 sees much more loss, but also much lower latency
- User 2 has interleaving turned on



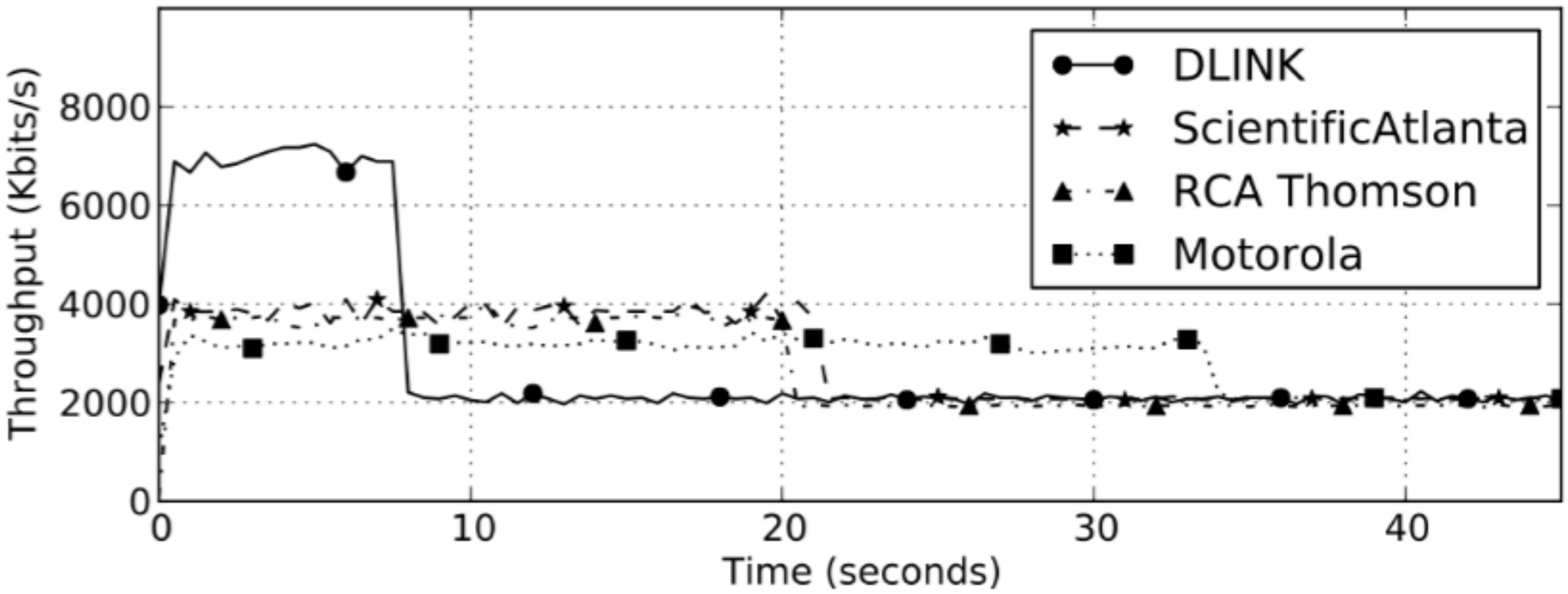
Traffic Shaping Differs Across Users

- Different burst magnitudes
- Different lengths of time



Download shaping

Traffic Shaping under Upload



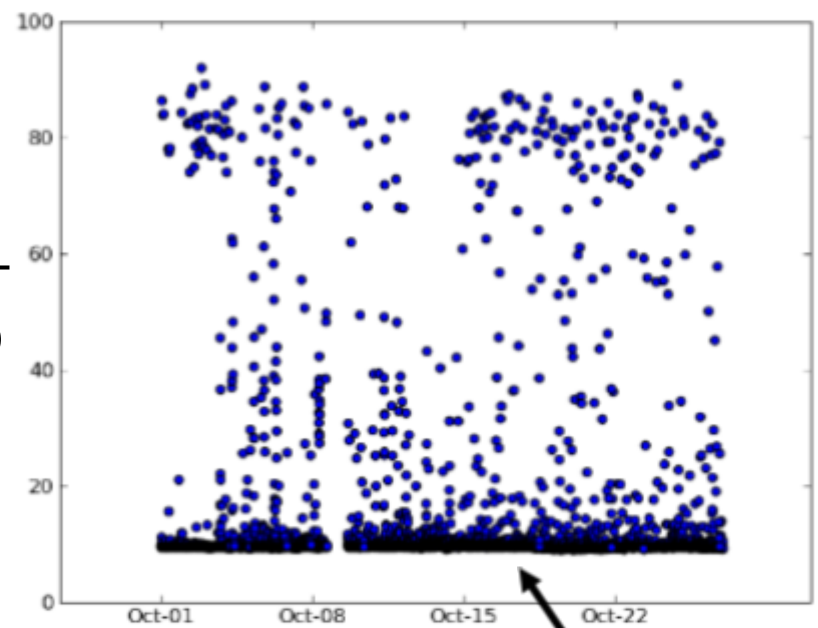
- How do we account for such variance?
- Implications for speed test results?

Results

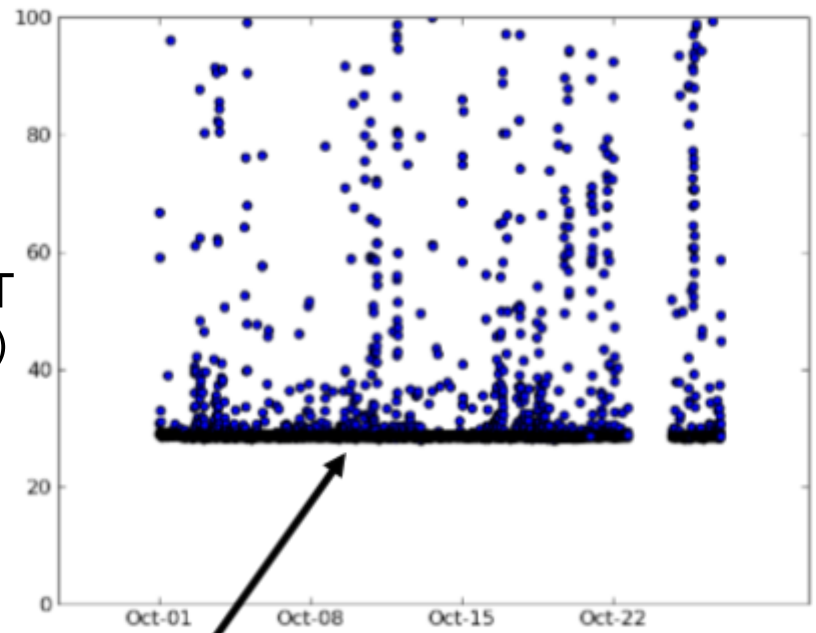
- Throughput
  - Different throughput techniques capture different aspects of throughput
  - Depending on how throughput measurements are conducted, they may vary considerably across users
- Latency
  - Latencies vary within the same ISP
  - Last-mile latencies are significant
  - Modem buffers are too large
  - Modifying data transfer using using traffic shaping might mitigate the problem in the short term

Last mile latency varies across users

RTT
(ms)



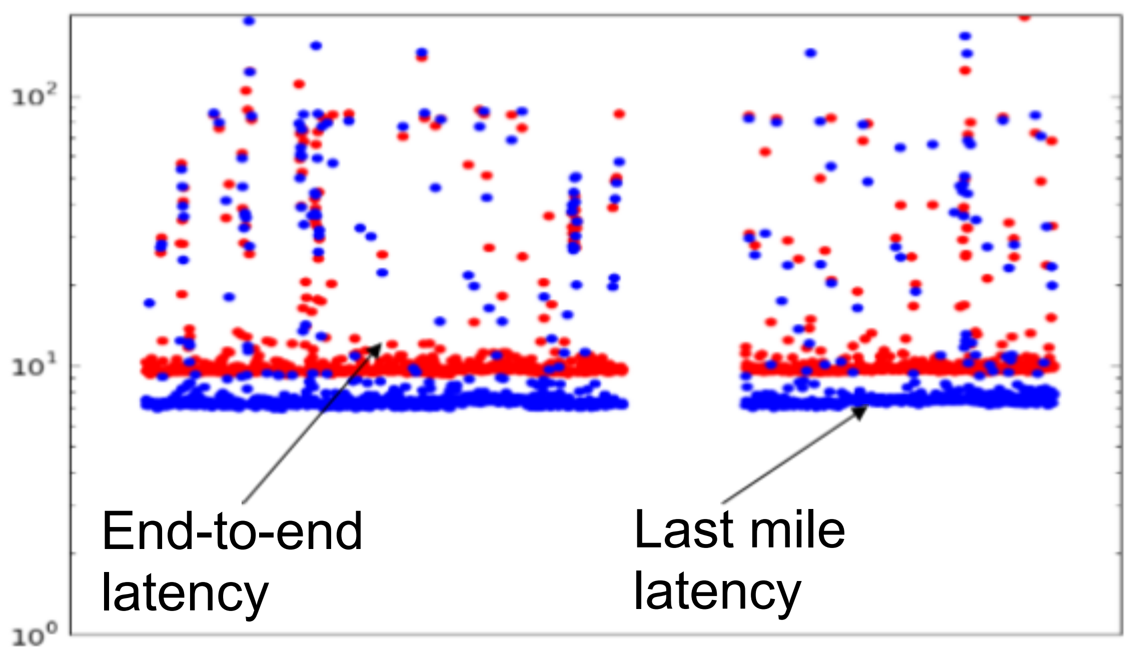
RTT
(ms)



Baselines Different for 2 ATT customers.
Same service plan, within a few blocks of each other.
Interleaving modes are different.

Last-Mile Latencies are Significant

- All but 2ms comes from last mile

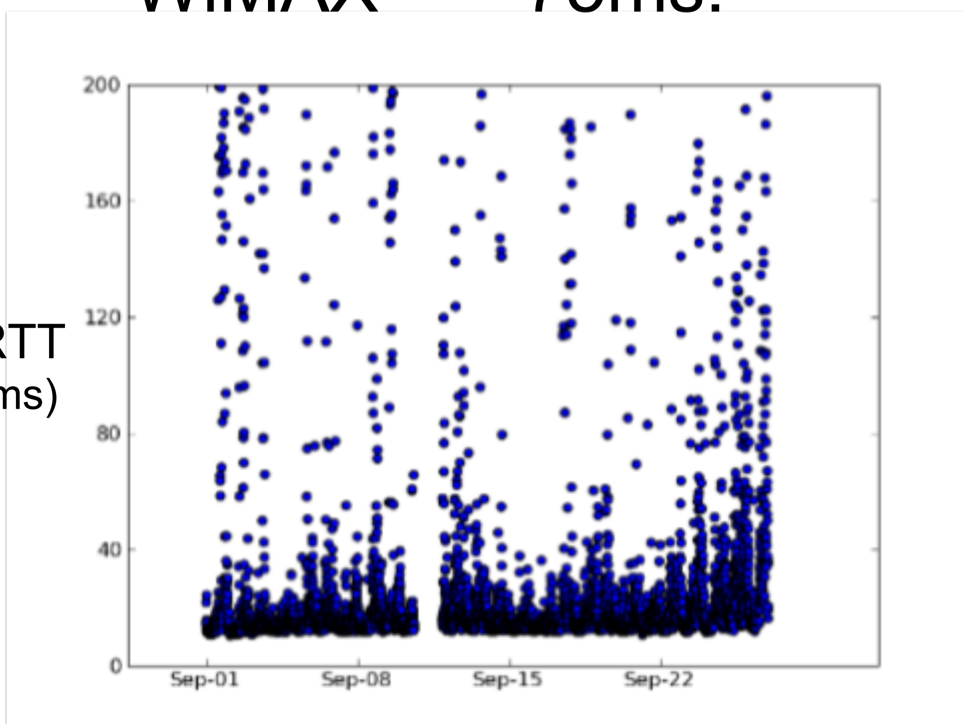


High correlation (0.95) with end-to-end latency

Effect of Access Link Technology

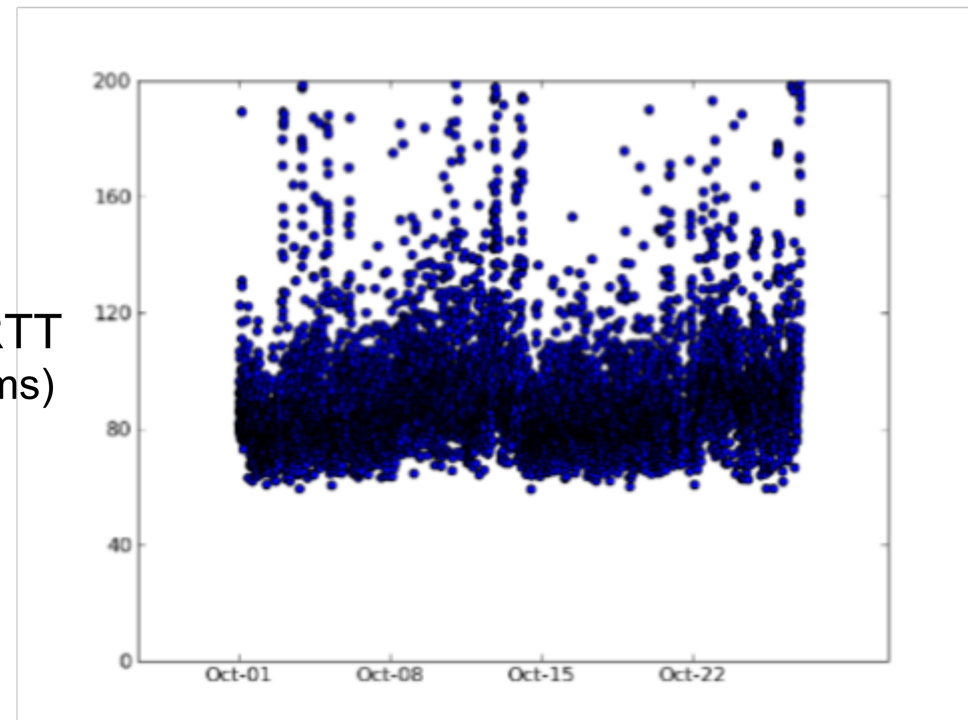
- Baseline latency dependent on access technology
- ADSL last mile – 8 to 25ms, Comcast ~10ms WiMAX – ~ 75ms!

RTT (ms)



Comcast

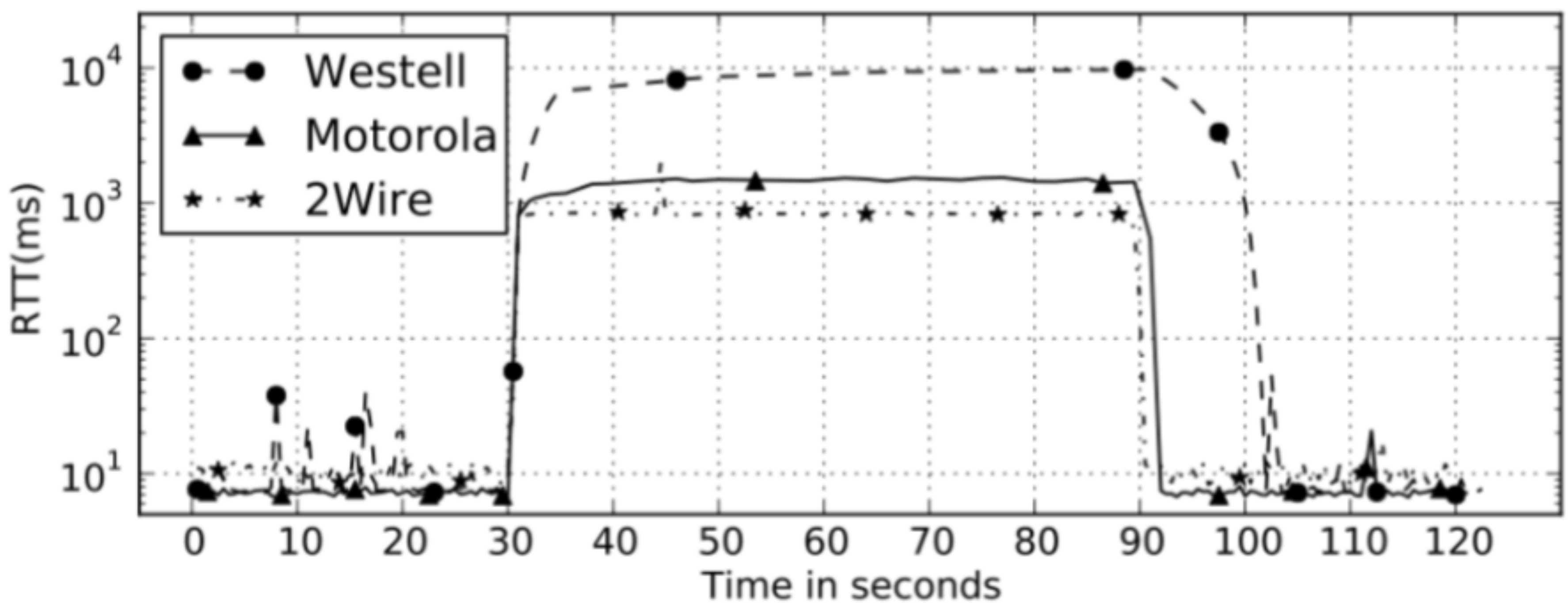
RTT (ms)



Clear

Buffers are Too Large

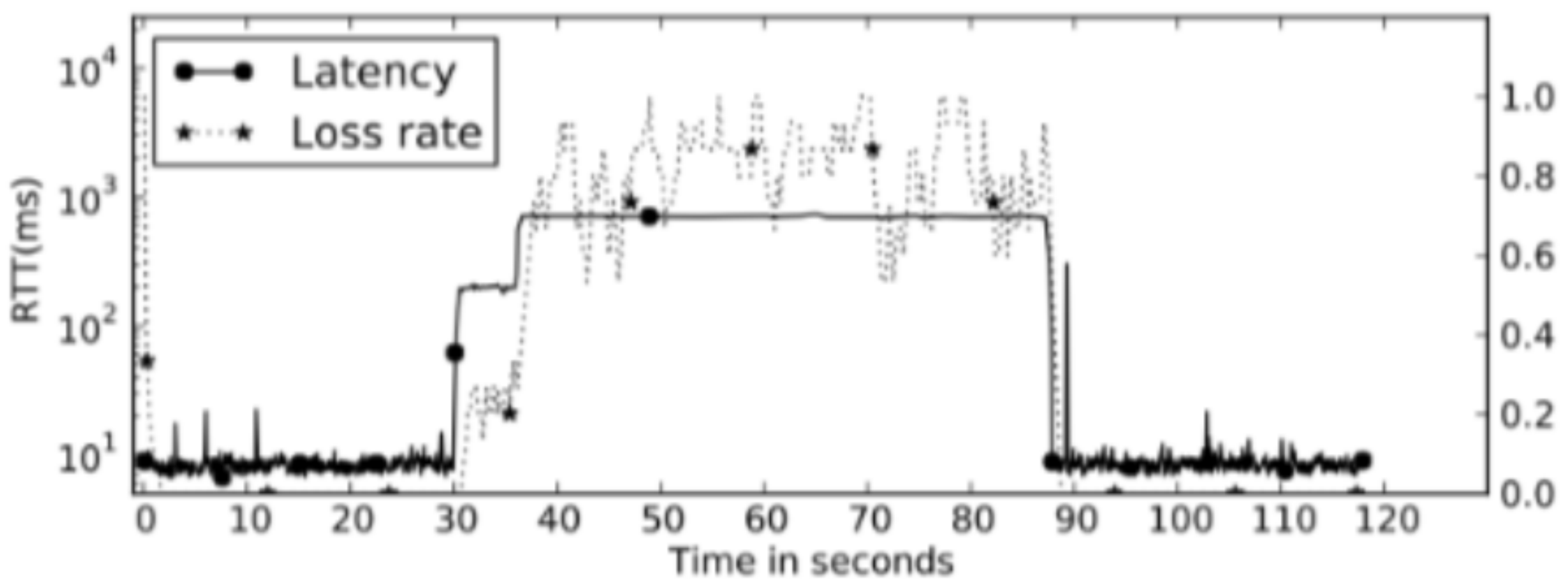
- Buffering in modems can be as high as ten seconds!
- Can be empirically modeled with token-bucket filter
- Also exist elsewhere in the stack



Latency profile while saturating upstream link

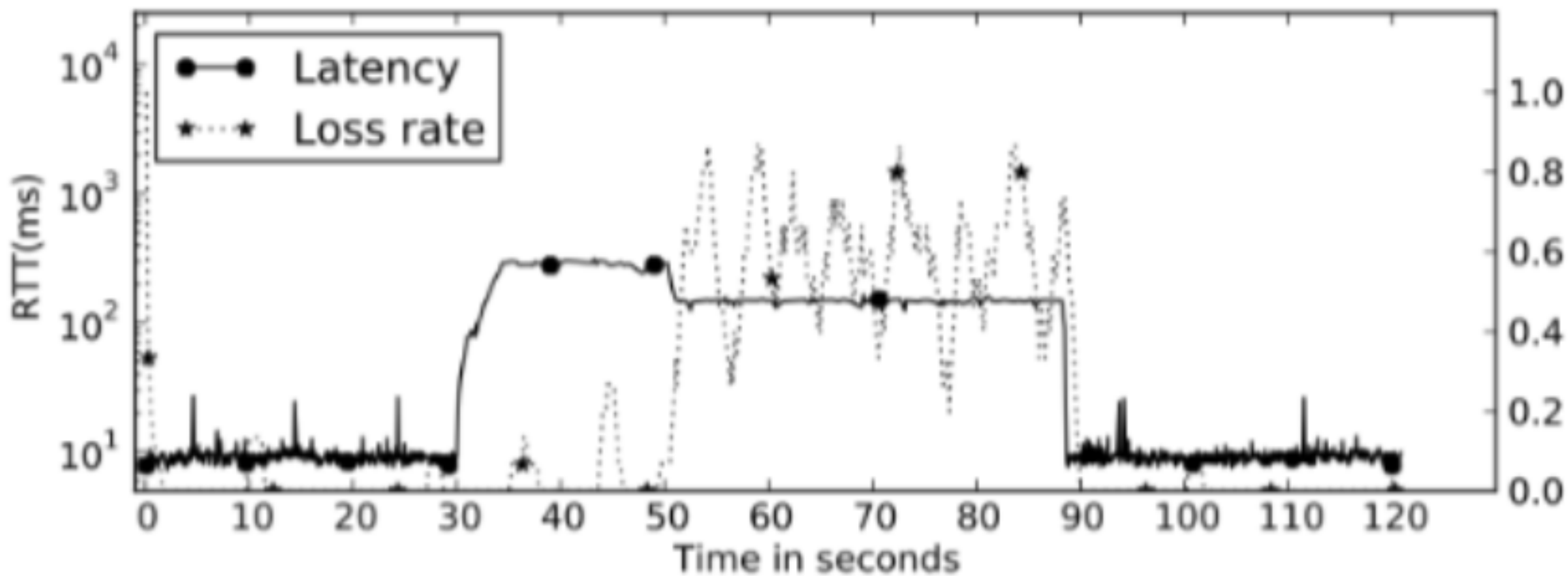
Traffic Shaping Affects Latency, Too

- After different periods of time, latency and loss profiles change dramatically



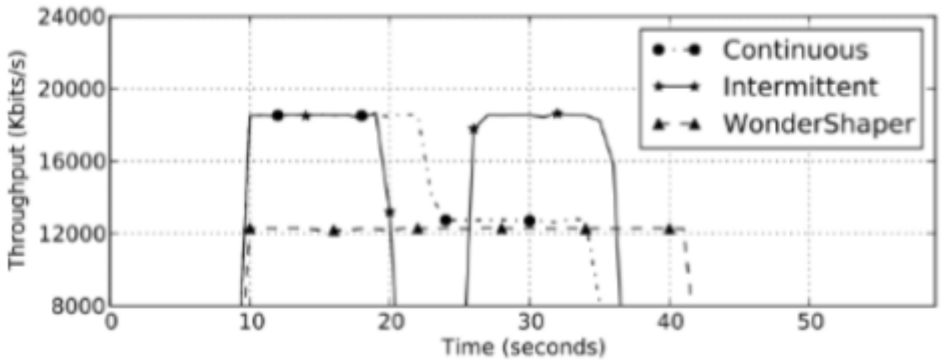
… and in different ways

- **Possible cause:** dynamic buffer sizing

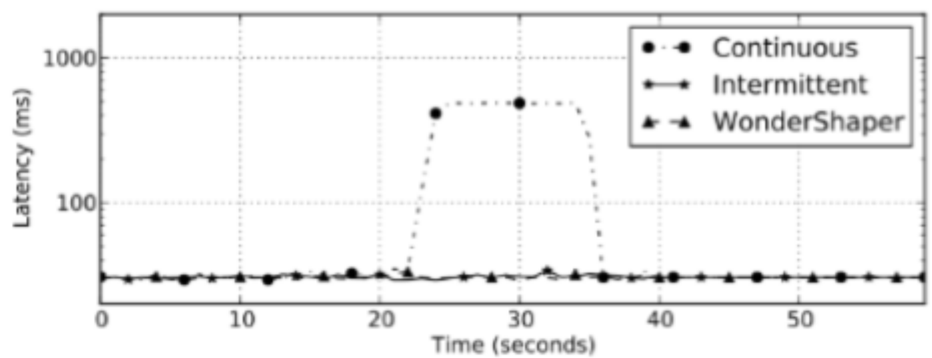


Keeping Latency Under Control

- Intermittent or shaped traffic can achieve same levels of throughput, without incurring high latency



(a) Throughput.



(b) Latency.

Other fixes for Latency Under load

- Shaping traffic comes at the cost of sacrificing throughput
  - Is it possible to fix latency without affecting throughput?
  - Smaller buffers might affect long flows
- Some sort of Active Queue Management?
  - RED, Fair queueing

Takeaway Lessons

- One measurement does not fit all
  - Different measurements yield different results
  - Different ISPs have different shaping behaviors
- One ISP does not fit all
  - There is no “best” ISP for all users
  - Different users may prefer different ISPs
  - There is a need for a “nutrition label”
- Home network equipment can significantly affect performance

Thanks!

Comments?

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