Characterizing Residential Broadband Networks

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Goals & Motivation

- Goal
  - Rigourously measure residential broadband use on a large scale
- Why?
  - Most studies just aren't done on residential broadband
  - Previous studies had small samples ($< 1{,}000$ samples)
  - Previous studies had inherent bias from accessibility

What are we measuring?

- Cable
  - Master headend connects regional headends with fiber
  - Regional headends (CMTS) connect to homes with coax to cable modems (CM)
  - Highly asymmetric. Upload is TDM'd. Can be heavily queue'd.
- DSL
  - Uses existing phone lines. Also asymmetric
  - Access to central is not shared. Everyone connects to DSLAM.
  - Distance from DSLAM effects performance

How are we measuring?

- Goal: require as little cooperation from end users as possible to provide a larger and more representative sample
- Solution: send only ICMP and TCP ACK packets
- What do we want?
  - Bandwidth, upstream and downstream, latency, jitter, packet loss
  - Things we *should* want but can't get: TCP window size, scaling, etc.
- Do home routers matter?

The borderline evil stuff

To determine downstream bandwidth we're gonna DoS their connection for 10 s without telling them

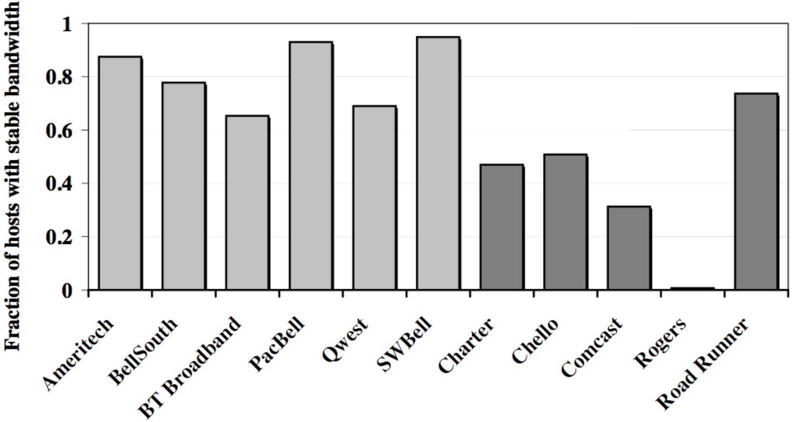
Assumptions

- We can reach the end user: cooperate with end users to verify packets are reaching them.
- Last mile link is the weakest: have end users modify modems to respond instead of hosts; check to see if there's a difference
- Hosts are responding to requests: same as trying to reach end user
- Are our bandwidth measurements accurate? Compare to advertised bandwidth

Assumption Assumptions

- Confirm bandwidth measurement accuracy by comparing to posted bandwidth; Compare posted bandwidth by comparing to measured
- Artificially limited sample – drop hosts whose responses aren't quick enough (ack'd)
- TCP packet bandwidth vs TCP "download" bandwidth

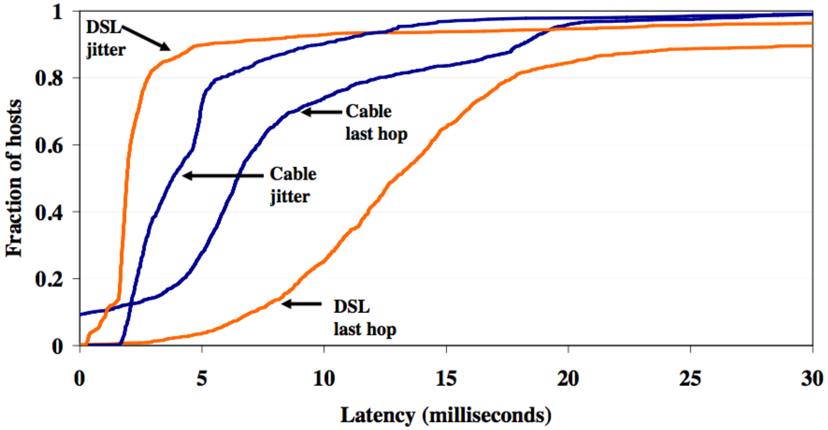
Results – Bandwidth



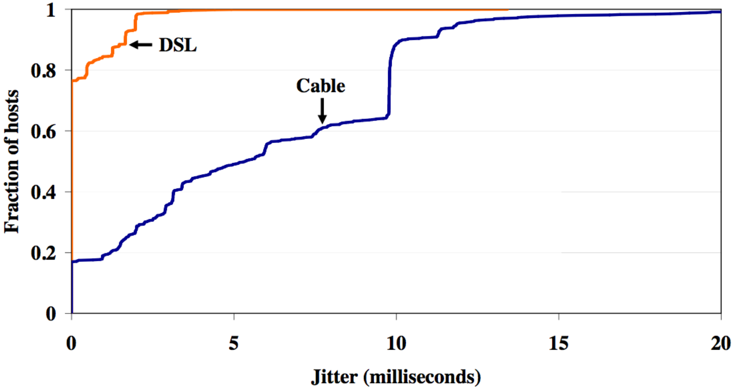
Traffic Shaping

- 11% of Ameritech, 26% of Comcast, and 67% of Chello links provide an initial burst
- Burst rates $\approx$1 Mbps higher than stable
- Results unreliable because of time limit

Last Hop Delay and Jitter

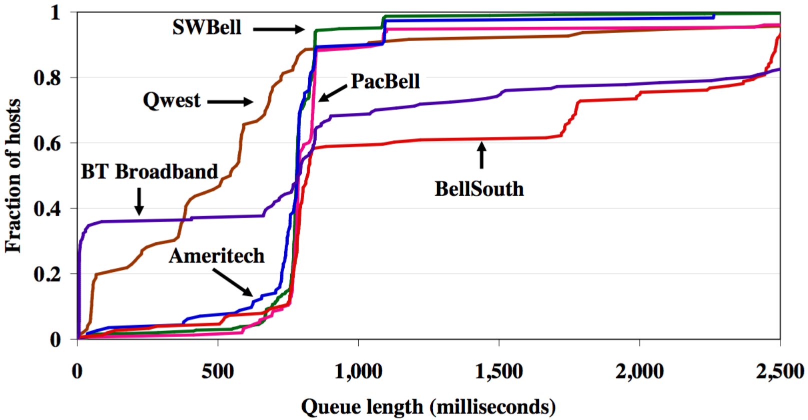


Vs. Jitter in Saturated Link



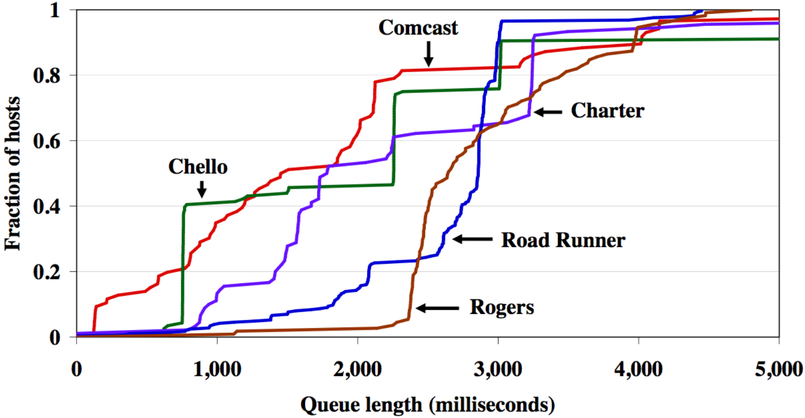
(b) Lower bound estimate of concatenation jitter

Queue Length – DSL



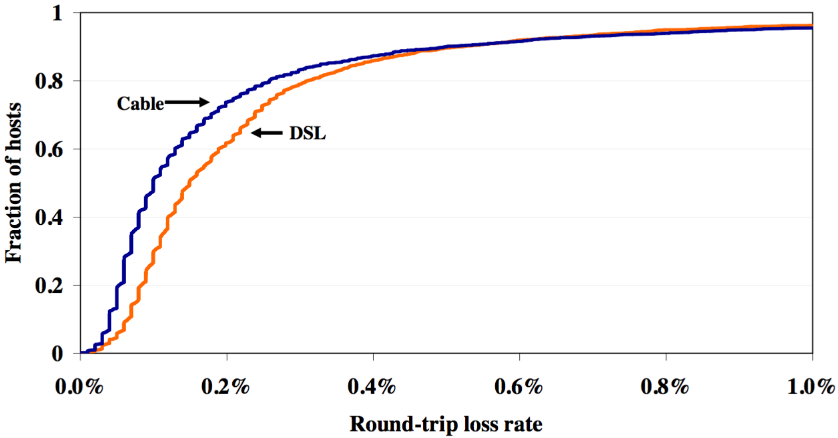
(c) DSL (upstream)

Queue Length – Cable



(d) Cable (upstream)

Packet Loss


1
0.8
0.6
0.4
0.2
0
Fraction of hosts
Cable
DSL
0.0%
0.2%
0.4%
0.6%
0.8%
1.0%
Round-trip loss rate

Questions?