Home Network or Access Link?

Locating Last-mile Downstream Throughput Bottlenecks

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It is Difficult to Locate Problems in the Last Mile

Many sources of problems

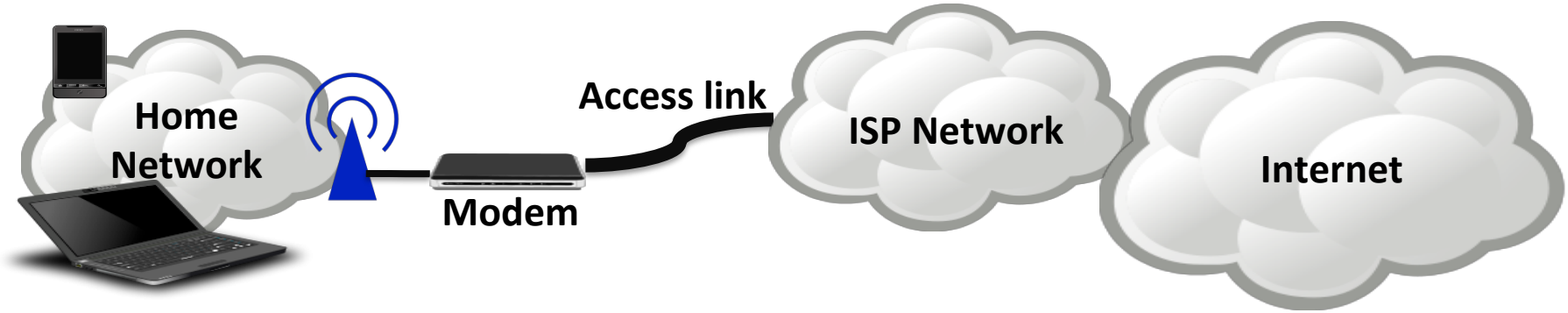
- ISP congestion
- Wireless / End-Clients

Or beyond

- Peering
- Server-side

How can we determine whether the problem is the home wireless network or access link?

Exploiting the Gateway's Vantage Point to Locate Bottlenecks



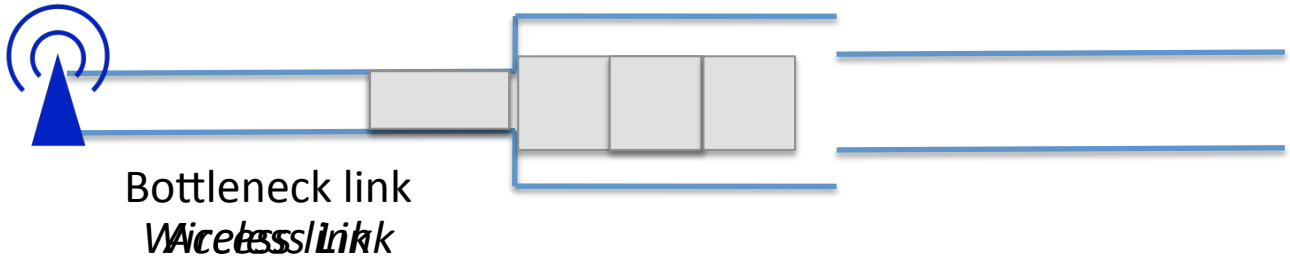
- End hosts do not have sufficient visibility
  - No global view: can identify *presence* of bottlenecks, but not location
- The gateway has visibility into access link and wireless network

Locating Last-mile Bottlenecks from the Gateway

- Active measurements are not representative
  - Throughput/latency don't mean much *per se*
  - May not represent actual performance users see
  - Wireless conditions vary too much
- We need to measure *passively*
  - Represents actual user traffic (and end-to-end)

What metrics can we use from the gateway?

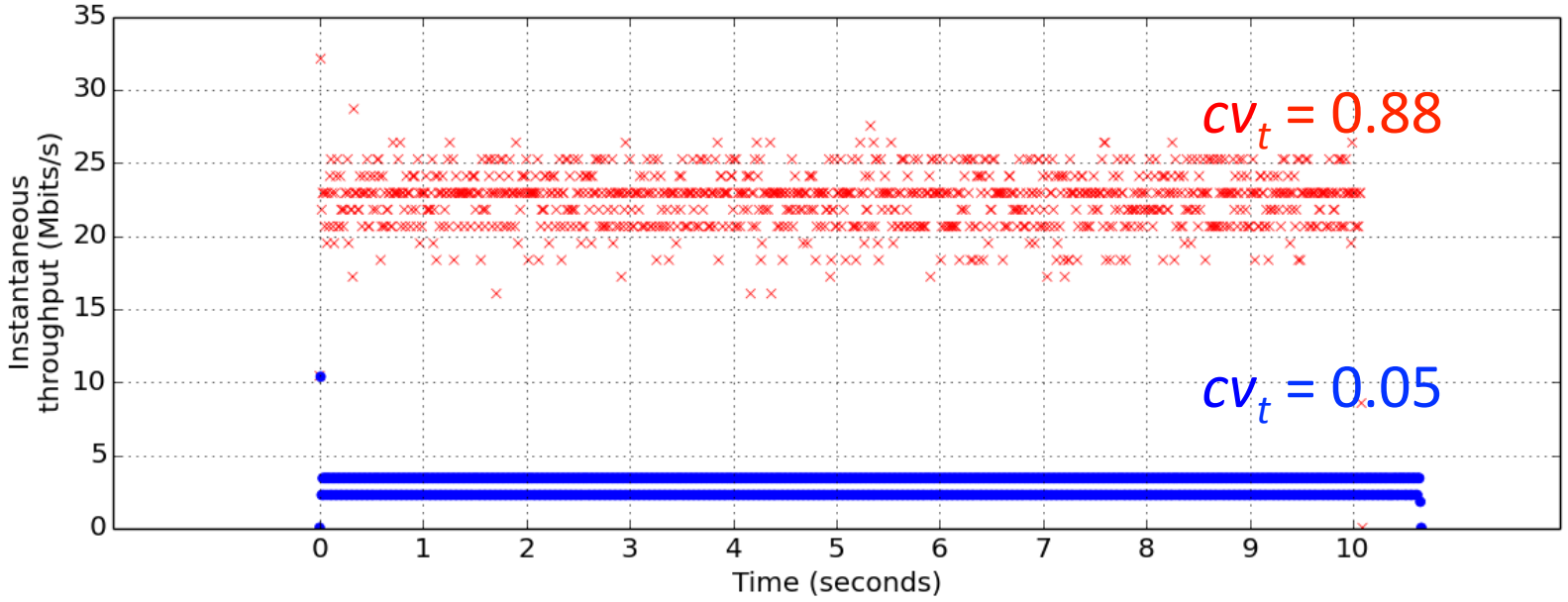
Locating Last-mile Bottlenecks Using Buffering Information



Packets get buffered at bottleneck link

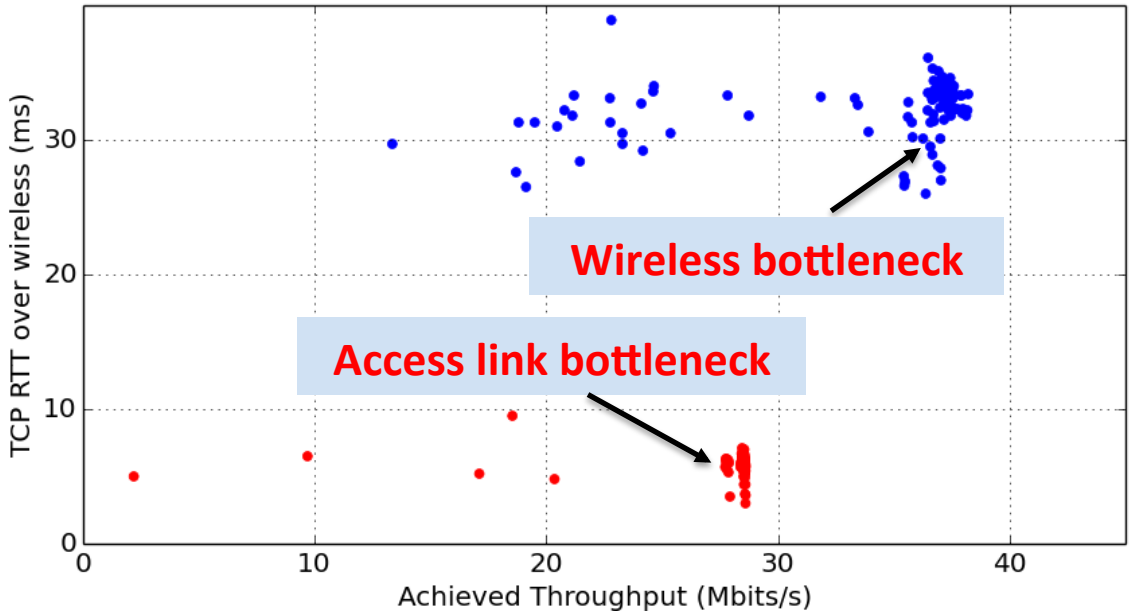
- Smoothed departures on bottleneck leads to steady packet inter-arrival times at the destination
- Buffering delays at queue leads to increased RTT

Bottlenecked Packets Have Steady Inter-arrival Times



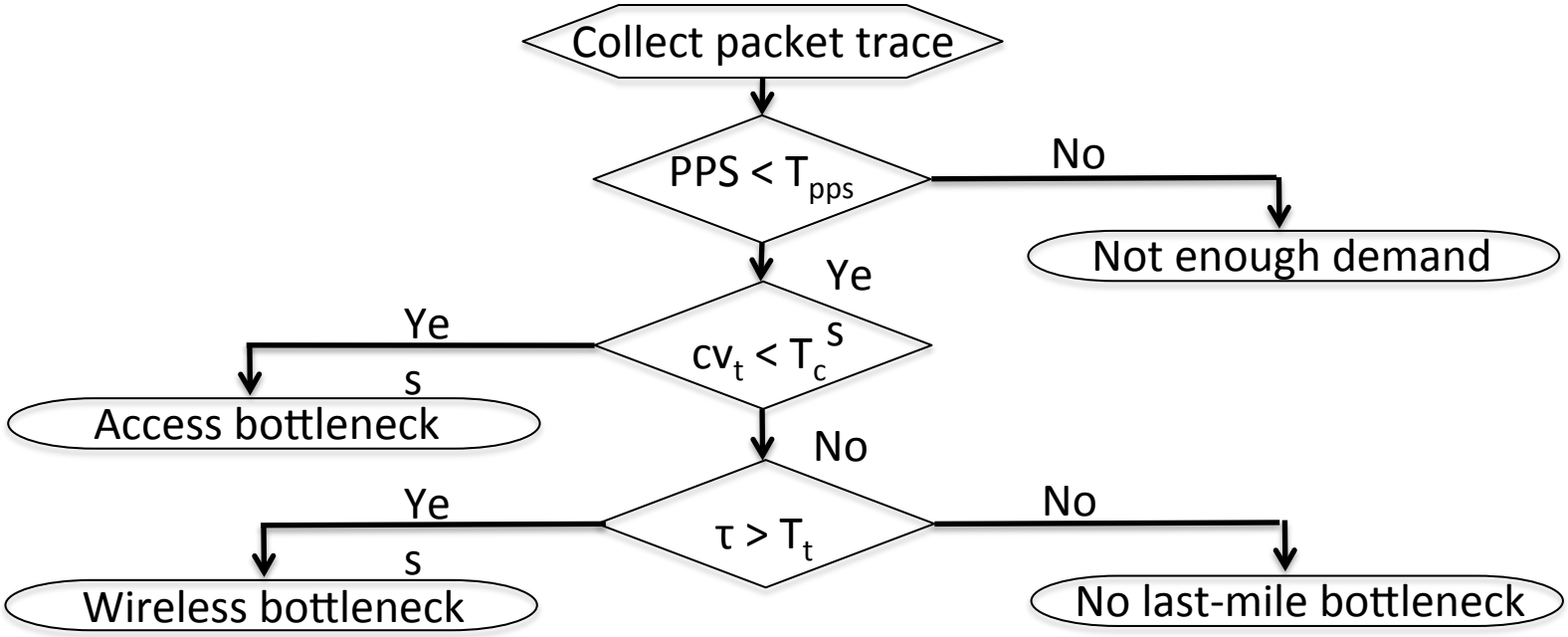
Packets *after* bottleneck have low coefficient of variation of inter-arrival time (cv_t)

Using LAN RTT to Detect Wireless Bottlenecks



LAN RTT (τ) between gateway and client increases significantly if the wireless is the bottleneck

Home or Access?: A Light-weight Bottleneck Locator for the Gateway



Experimental Evaluation

- Testbed with configurable "access link"
  - Varying wireless, access link, loss/latency
  - Emulate wireless, access link, and miscellaneous bottlenecks
  - Wide area pathologies - loss, high latency
- High detection accuracy for simple thresholds
  - $[cv_t < 0.8, \tau > 15$ ms] leads to TPR > 95%, FPR < 5%

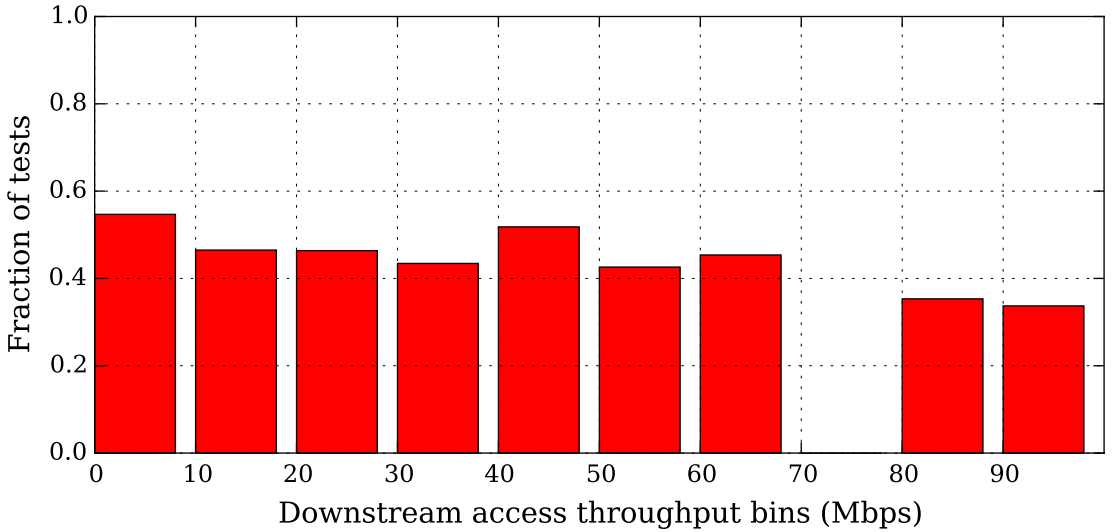
System Prototype Design

- Collect pcaps on device
  - No payload: only TCP/IP headers
  - Headers completely anonymized on device
  - 10 seconds or 10,000 pkts, whichever comes first
  - Number of devices using network (anonymized)
  - Wireless configuration
- Data collected 3 times an hour
- Offline analysis of anonymized data

Deployments

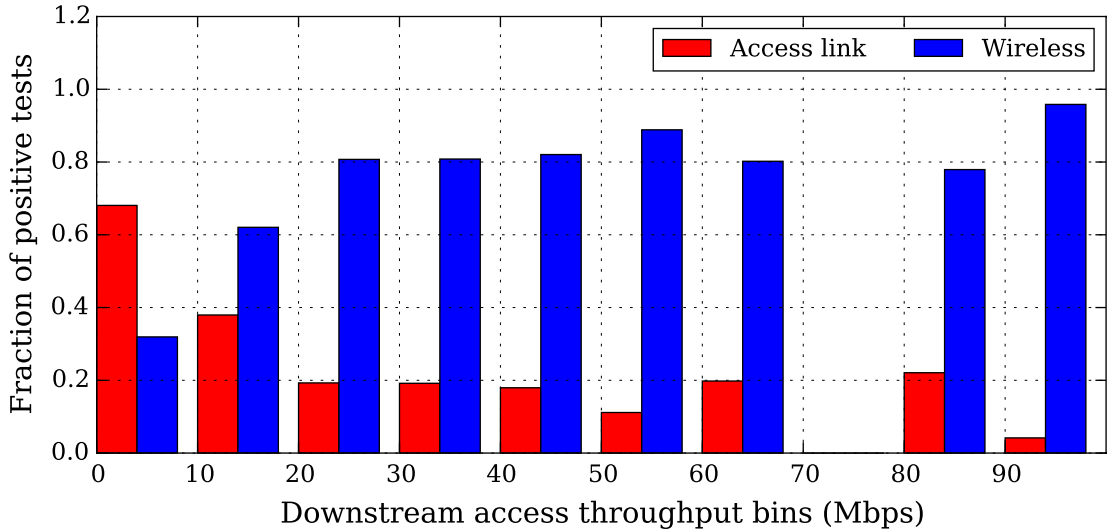
- Pilot: on Project BISmark deployment
  - Netgear WNDR 3700v2, 3800 (802.11 agn)
  - 650MHz processor, 128 (64 for 3700v2) MB RAM
  - 64 homes worldwide, 1 month
- FCC/SamKnows deployment
  - Netgear WNR 3500L (802.11 bgn)
  - 480 MHz processor, 32 MB RAM
  - 2652 homes in US, 2 days

How Frequent are Throughput Bottlenecks?



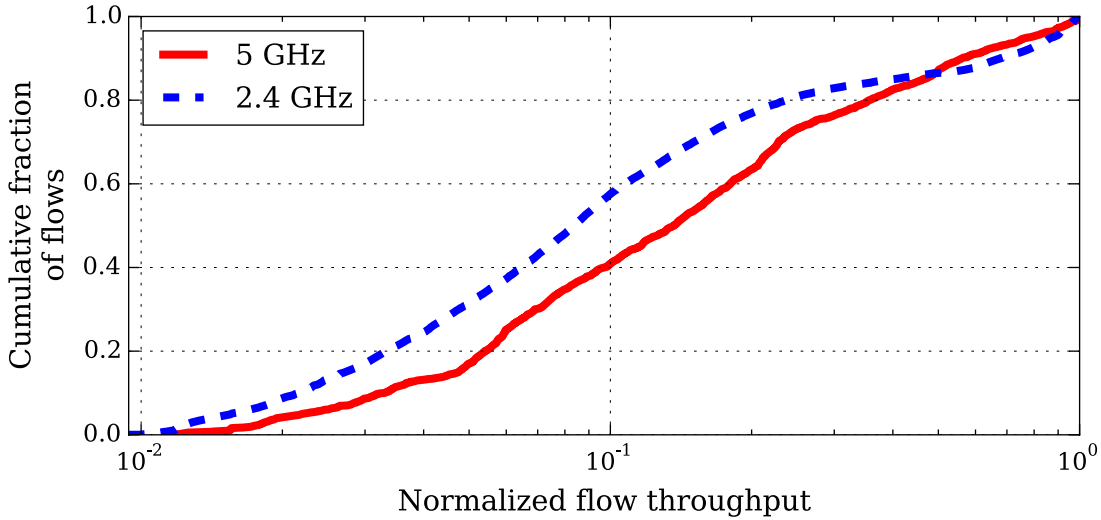
40-55% of tests with significant traffic see throughput bottlenecks

Access-link *vs* Wireless bottlenecks



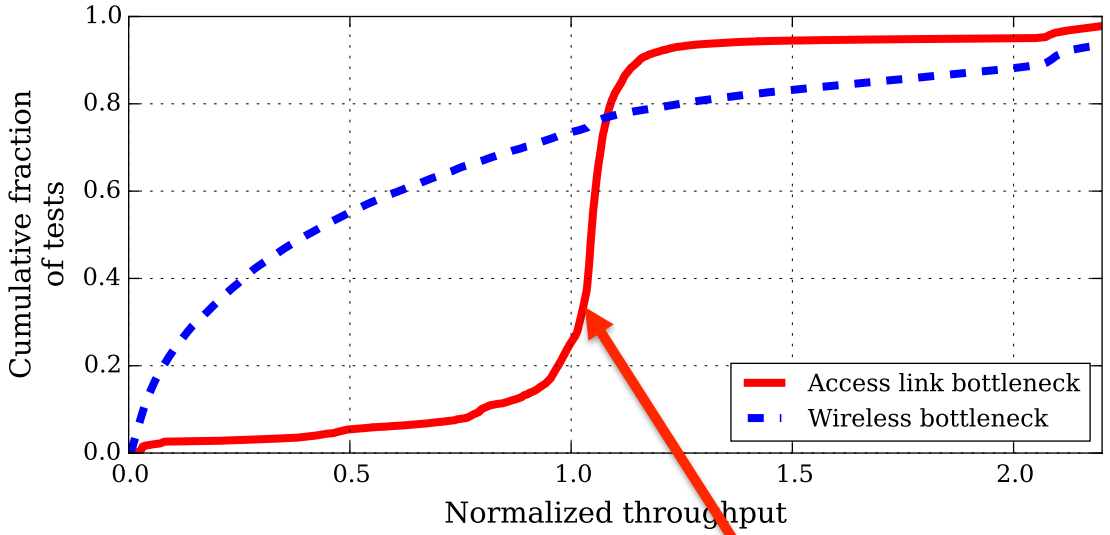
Access link bottlenecks are only significant < 20 Mbps.
Wireless bottlenecks dominate beyond 20 Mbps.

Potential Wireless Problem: 2.4GHz



The 5 GHz channel has higher bitrates, lower retransmission rates

What Throughputs do Users Get When They are Access Bottlenecked?



Throughput matches user's access link throughput (measured independently)

Project Status

- Proof-of-concept system works on OpenWRT
  - FCC deployment had some resource constraints issues
  - Actively developed for improved robustness
  - Online version demo'd at ACM SIGCOMM 2014
- Caveats: Does not work for upstream traffic or with wireless upstream (WiMax/4G)
- Looking for deployments in home routers!

Conclusion

- **HoA**: A light-weight and accurate system to locate last-mile downstream throughput bottlenecks
  - Deployed by the FCC MBA program in resource-constrained gateways
  - Looking for further deployments!
- Access link bottlenecks are common < 20~Mbps
  - Wireless bottlenecks dominate > 20~Mbps

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