WTF? Locating Problems in Home Networks

Srikanth Sundaresan
Nick Feamster
Georgia Tech
Renata Teixeira, INRIA

Ongoing work with Federal Communications Commission.
BISmark: A platform to study home networks
BISmark: A platform to study home networks

- Custom OpenWrt firmware
  - Netgear gateways – 650 MHz processor, 128 MB RAM
BISmark: A platform to study home networks

- Custom OpenWrt firmware
  - Netgear gateways – 650 MHz processor, 128 MB RAM
- Active and passive measurements in and out of home network
Deployment

200+ gateways in 20+ countries (Jan 2014)
Are homes bottlenecked by the wireless network or the access link?
Are homes bottlenecked by the wireless network or the access link?

- Clients or servers don’t have sufficient visibility
  - Can identify presence of bottlenecks, but not location
Are homes bottlenecked by the wireless network or the access link?

• Clients or servers don’t have sufficient visibility
  – Can identify presence of bottlenecks, but not location

• The gateway sits at the junction of the two networks
  – It sees traffic on both sides
Are homes bottlenecked by the wireless network or the access link?

• Clients or servers don’t have sufficient visibility
  – Can identify presence of bottlenecks, but not location

• The gateway sits at the junction of the two networks
  – It sees traffic on both sides

How can we exploit the gateway’s vantage point to locate performance bottlenecks?
Router Sees Bottlenecks in the Last Mile

Intuition: packets are buffered at bottleneck link.
Router Sees Bottlenecks in the Last Mile

Intuition: packets are buffered at bottleneck link.
Router Sees Bottlenecks in the Last Mile

**Intuition:** packets are buffered at bottleneck link.

- Smoothed departures on bottleneck leads to steady packet inter-arrival times at the destination
Router Sees Bottlenecks in the Last Mile

Intuition: packets are 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
Router Sees Bottlenecks in the Last Mile

Intuition: packets are 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
Bottleneck Smoothes Interarrival

Packets after bottleneck have low coefficient of variation of interarrival time ($cv_t$)
LAN RTT Detects Wireless Bottlenecks

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

- Random variable takes different values depending on conditions
- Pick a threshold that minimizes false positives and false negatives

Distribution given: “Access Link Bottleneck”

Detection Threshold

Distribution given: “Access Link Not Bottleneck”

False Positives

False Negatives
Putting It Together

Collect packet trace

- $c v_t < T_c$
  - Yes: Access bottleneck
  - No: Wireless bottleneck
- $\tau > T_t$
  - Yes: Wireless bottleneck
  - No: Not enough demand

$T_c = 0.8$
$T_t = 15$ ms

Where’s The Fault (WTF): A lightweight threshold-based system that runs on the gateway
Wireless Bottlenecks are Common

Wireless bottlenecks are common, especially as throughput increases.

Access link bottlenecks are rare, only happens at low throughput.

Homes with throughput greater than 35 Mbits/s almost never see access link bottleneck.
Bottlenecked wireless latencies affect end-to-end latencies

Median LAN/WAN RTT latency is 10%

In-home latency is a significant contributor to end-to-end latency
FCC Deployment: Challenges

- **Advantages**: Much bigger deployment
- **Challenges**: Weaker hardware, closed chipset

<table>
<thead>
<tr>
<th></th>
<th>WNDR 3800 (BISmark)</th>
<th>WNR3500L (SamKnows)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM</td>
<td>512 MB</td>
<td>128 MB</td>
</tr>
<tr>
<td>Processor</td>
<td>650 MHz Geode</td>
<td>480 MHz MIPS 74k</td>
</tr>
<tr>
<td>Flash Storage</td>
<td>16 MB</td>
<td>8 MB</td>
</tr>
<tr>
<td>Chipset</td>
<td>Atheros 9k (Open)</td>
<td>Broadcom (Closed)</td>
</tr>
</tbody>
</table>

- **Additional challenge**: Newer whitebox deployments are “off the critical path”
Implications

• Continuous packet capture is not an option
  – Even sampling is tricky

• Cannot collect wireless statistics, so full algorithm cannot be deployed
Broader Project: Fixed and Mobile Measurements

Home Gateway (BISmark)

- Fixed-line measurements
- Dongle-based measurements
- [http://projectbismark.github.com/](http://projectbismark.github.com/)

Mobile Handset (MySpeedTest)

- Periodic latency measurements
- Upload and download throughput tests on demand