Understanding Broadband Traffic - Metrics, Measurements, and Policy

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CSAIL/MIT
Oct 21, 2010
Outline

• The story of a $100,000 bug
• Why it (and hundreds of other details) matter to the FCC study of broadband
• Fascinating lessons learned from simply trying to calculate an average speed for one connection
• Important policy implications
• Other ongoing MITAS projects that are shedding more light on broadband
The story of a $100,000 bug

• Why $100,000? Derivation of a guesstimate
  – Assume 10 million broadband customers
  – 1 out of 1000 will trip over this bug a year causing them to call their broadband provider’s customer support number
  – 12 minutes per support call
  – 2000 hours of support
  – Necessitating one customer support representative at a fully loaded cost of $100,000
Before double clicking on “Gateway”
After double clicking on “Gateway”
Hard at work
This webpage is not available.

The webpage at http://nytimes.com/ might be temporarily down or it may have moved permanently to a new web address.

Here are some suggestions:
- Reload this web page later.

More information on this error
Take an Oreo break ... 

... and wait for connectivity to hopefully return
This webpage is not available.

The webpage at http://news.ycombinator.com/ might be temporarily down or it may have moved permanently to a new web address.

Here are some suggestions:
- Reload this web page later.

More information on this error
Grumble...

1. Try to debug this myself?
2. Call customer support?
C: \>
C: \>
C: \>
C: \>
C: \>
C: \>
C: \>
C: \>
C: \>
C: \>
C: \>
C: \>
C: \>
C: \>
Pinging 18.26.0.106 with 32 bytes of data:
Reply from 192.168.1.1: Destination net unreachable.
Reply from 192.168.1.1: Destination net unreachable.
Reply from 192.168.1.1: Destination net unreachable.
Reply from 192.168.1.1: Destination net unreachable.
Ping statistics for 18.26.0.106:
   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
C: \

C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>tracert 18.26.0.106

Tracing route to 18.26.0.106 over a maximum of 30 hops

    1 192.168.1.1 reports: Destination net unreachable.

Trace complete.
1. Try to debug this further myself?
2. Call customer support?
## Router Status

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardware Version</strong></td>
<td>WNR3500L</td>
</tr>
<tr>
<td><strong>Firmware Version</strong></td>
<td>V1.2.2.28_33.0.289K</td>
</tr>
<tr>
<td><strong>GUI Language Version</strong></td>
<td>V1.2.28_2.17.1</td>
</tr>
</tbody>
</table>

### Internet Port
- **MAC Address**: 00:1E:8C:2A:92:53
- **IP Address**: 192.168.1.1
- **IP Subnet Mask**: 255.255.255.0

### LAN Port
- **MAC Address**: 00:1E:8C:2A:92:53
- **IP Address**: 192.168.1.1
- **IP Subnet Mask**: 255.255.255.0

### Wireless Port
- **Name (SSID)**: netgear
- **Region**: North America
- **Channel**: Auto (9)
- **Mode**: Up to 144 Mbps
- **Wireless AP**: On
- **Broadcast Name**: On

### Router Status Help

**Hardware Version**: The router model.

**Firmware Version**: This is the current software the router is using. This will change if you upgrade your router.

**GUI Language Version**: The localized language version of the GUI.

**Internet Port**: These are the current settings that you set in the Setup Wizard or Basic Settings screens.

- **MAC Address**: The physical address of the router, as seen from the Internet.
- **IP Address**: The current Internet IP address. If assigned dynamically, and no Internet connection exists, this will be blank or 0.0.0.0.
- **IP Subnet Mask**: The subnet mask associated with the Internet IP address.
- **Default Gateway**: The current Internet gateway. If assigned dynamically, and no Internet connection exists, this will be blank or 0.0.0.0.
- **Domain Name Server**: Displays the address of the current DNS.
- **DHCP**: Indicates either Client (IP address is obtained dynamically) or None.

**LAN Port**: These are the current settings, as set in the LAN IP Setup screen.

- **MAC Address**: The physical address of the router, as seen from the LAN.
- **IP Address**: The LAN IP address of the router.
- **IP Subnet Mask**: The subnet mask associated with the LAN IP address.
- **DHCP**: Indicates if the router is acting as a DHCP server for devices on your LAN.

**Wireless Port**: These are the current settings, as set in the Wireless Settings screen.

- **Name (SSID)**: SSID of the router.
- **Region**: The location (country).
- **Channel**: The current channel in use.
### System Up Time

<table>
<thead>
<tr>
<th>Port</th>
<th>Status</th>
<th>TxPkts</th>
<th>RxPkts</th>
<th>Collisions</th>
<th>Tx B/s</th>
<th>Rx B/s</th>
<th>Up Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAN</td>
<td>100M/Full</td>
<td>35120</td>
<td>81150</td>
<td>0</td>
<td>2564</td>
<td>11029</td>
<td>00:54:05</td>
</tr>
<tr>
<td>LAN1</td>
<td>Link Down</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAN2</td>
<td>Link Down</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAN3</td>
<td>1000M/Full</td>
<td>37758</td>
<td>31003</td>
<td>0</td>
<td>8755</td>
<td>2055</td>
<td>00:54:06</td>
</tr>
<tr>
<td>LAN4</td>
<td>1000M/Full</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>00:54:06</td>
</tr>
<tr>
<td>WLAN</td>
<td>145M</td>
<td>11486</td>
<td>10608</td>
<td>0</td>
<td>1852</td>
<td>674</td>
<td>00:54:11</td>
</tr>
</tbody>
</table>

Poll Interval: 5 (secs)
<table>
<thead>
<tr>
<th>Port</th>
<th>Status</th>
<th>TxPkts</th>
<th>RxPkts</th>
<th>Collisions</th>
<th>Tx B/s</th>
<th>Rx B/s</th>
<th>Up Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAN</td>
<td>100M/Full</td>
<td>35132</td>
<td>81962</td>
<td>0</td>
<td>2515</td>
<td>10829</td>
<td>00:55:10</td>
</tr>
<tr>
<td>LAN1</td>
<td>Link Down</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAN2</td>
<td>Link Down</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAN3</td>
<td>1000M/Full</td>
<td>37791</td>
<td>31055</td>
<td>0</td>
<td>8584</td>
<td>2016</td>
<td>00:55:11</td>
</tr>
<tr>
<td>LAN4</td>
<td>1000M/Full</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>00:55:11</td>
</tr>
<tr>
<td>WLAN</td>
<td>145M</td>
<td>11846</td>
<td>10932</td>
<td>0</td>
<td>1854</td>
<td>674</td>
<td>00:55:16</td>
</tr>
</tbody>
</table>

Poll Interval: 5 (secs)
Grumble...

1. Try to debug this **even further** myself?
2. Call customer support?
**Router Status**

<table>
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</tr>
</tbody>
</table>

**Internet Port**

<table>
<thead>
<tr>
<th>MAC Address</th>
<th>CD:3F:DE:A9:2A:93</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP Address</td>
<td>0.0.0.0</td>
</tr>
<tr>
<td>DHCP</td>
<td>DHCPClient</td>
</tr>
<tr>
<td>IP Subnet Mask</td>
<td>0.0.0.0</td>
</tr>
<tr>
<td>Domain Name Server</td>
<td>0.0.0.0</td>
</tr>
</tbody>
</table>

**LAN Port**

<table>
<thead>
<tr>
<th>MAC Address</th>
<th>CD:3F:DE:A9:2A:92</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP Address</td>
<td>192.168.1.1</td>
</tr>
<tr>
<td>DHCP</td>
<td>On</td>
</tr>
<tr>
<td>IP Subnet Mask</td>
<td>255.255.255.0</td>
</tr>
</tbody>
</table>

**Wireless Port**

<table>
<thead>
<tr>
<th>Name (SSID)</th>
<th>nd-wrt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td>North America</td>
</tr>
<tr>
<td>Channel</td>
<td>Auto (9)</td>
</tr>
<tr>
<td>Mode</td>
<td>Up to 145 Mbps</td>
</tr>
<tr>
<td>Wireless AP</td>
<td>On</td>
</tr>
<tr>
<td>Broadcast Name</td>
<td>On</td>
</tr>
</tbody>
</table>

**Router Status Help**

You can use the Router Status screen to check the current settings and statistics for your router. This screen shows you the current settings. If something needs to be changed, you will have to change it on the relevant screen.

**Hardware Version:** The router model.

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- Name (SSID): SSID of the router.
- Region: The location (country).
- Channel: The current channel in use.
<table>
<thead>
<tr>
<th>Connection Status</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IP Address</strong></td>
<td>0.0.0.0</td>
</tr>
<tr>
<td><strong>Subnet Mask</strong></td>
<td>0.0.0.0</td>
</tr>
<tr>
<td><strong>Default Gateway</strong></td>
<td>0.0.0.0</td>
</tr>
<tr>
<td><strong>DHCP Server</strong></td>
<td>0.0.0.0</td>
</tr>
<tr>
<td><strong>DNS Server</strong></td>
<td>0.0.0.0</td>
</tr>
<tr>
<td><strong>Lease Obtained</strong></td>
<td>0 Seconds</td>
</tr>
<tr>
<td><strong>Lease Expires</strong></td>
<td>0 Seconds</td>
</tr>
</tbody>
</table>

[Buttons: Release, Renew, Close Window]
Hooray, no spam here!

Compose a message in a new window by pressing "Shift" while clicking Compose Mail or Reply.

You are currently using 1740 MB (23%) of your 7507 MB.
Conclusion...

It’s my providers fault:

• DHCP failed to renew?
• Cable modem problem?
What actually had happened?
Double clicking invokes the default action
Disable!
Beyond $100,000 of customer support costs, why does this story matter?

• Could have impacted the reliability measurements being gathered by an important larger scale study of broadband networks
  – On its own, a very small potential effect
  – But the total of hundreds of such little details matter a great deal to our ability to have confidence in the measurements
FCC broadband measurement project run by Samknows

- Samknows will deploy 10,000 boxes in United States
- Real tests are scheduled to start on January 1\textsuperscript{st}, 2011
- Performance tests currently planned
  - Web browsing
  - Video streaming
  - Voice over IP
  - Availability Test
  - UDP Latency and Packet Loss
  - Data Usage Test
  - Speed Tests
  - Jitter Test
  - ICMP Latency and Packet Loss
  - DNS resolution
Why does the Samknows study matter beyond the US and UK markets?

• Similar EU study upcoming
  – Quality of Broadband services in the EU
    “provide information on the difference between advertised and effective speed and comparison between Member States... [and] assess the effective quality ”

• Samknows is an increasingly important player in the broadband measurement area
  – Trials with a telecom regulator in Asia
  – Trials with EU ISPs
  – Has a deal with Thomson/Technicolor for embedding measurement software in DSL gateways
Why are we involved?

“Understanding broadband speed measurements”

1. Presented at TPRC (Oct 2010)
2. Passed around the FCC
3. Submitted to the FTC
4. ISPs
5. Samknows
6. Circulated among academics
7. Cited in a proposal to the NSF
8. MIT news release
9. Reporters
Detailing MIT’s involvement in the FCC/Samknows broadband study

Disclaimers
• Not conducting an audit
• No authority or responsibilities
• No access to the full source code (currently)

Contributions
• Probing test methodology
• Finding and eliminating potential sources of problems
• Offering constructive criticism
• Beginning to analyze small sets of raw data
• Expect eventual access to full data set
Samknows speed measurement methodology

- Tests run to on-net and nearby off-net servers
- 3 simultaneous TCP connections
- Measurements starts after a “warm up” period
- Test finishes after a fixed time duration
Preliminary speed comparison test

1. FCC/Samknows (on-net, 10 second test)
2. Ookla/Speedtest
3. Measurement Lab/NDT
4. Iperf
5. Iperf-multithreaded

2-5 all test to the same server at MIT
Download speeds (~10 second tests)
Samknows download speeds for different test durations

![Graph showing download speeds over time for different test durations.](image-url)
Effects of Powerboost

• If Powerboost is present, shorter tests will be reporting more of the “Powerboost speeds”
• Long durations will be slower
On-net versus off-net speed differential for download speed test

<table>
<thead>
<tr>
<th>Test duration (secs)</th>
<th>Difference in average speeds (Kbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>383</td>
</tr>
<tr>
<td>10</td>
<td>308</td>
</tr>
<tr>
<td>15</td>
<td>225</td>
</tr>
<tr>
<td>20</td>
<td>185</td>
</tr>
<tr>
<td>25</td>
<td>155</td>
</tr>
<tr>
<td>30</td>
<td>132</td>
</tr>
</tbody>
</table>

- Belmont MA -> Needham MA versus Belmont MA -> NYC
- 7 versus 15 traceroute hops
- 8 ms versus 16 ms ping times
What is the average speed of this one cable network connection?

<table>
<thead>
<tr>
<th>Test</th>
<th>Average Download Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samknows on-net 5 second test</td>
<td>26.2</td>
</tr>
<tr>
<td>Samknows off-net 5 second test</td>
<td>25.8</td>
</tr>
<tr>
<td>Ookla/Speedtest</td>
<td>22.0</td>
</tr>
<tr>
<td>Iperf-multithreaded</td>
<td>20.1</td>
</tr>
<tr>
<td>Samknows on-net 10 second test</td>
<td>19.5</td>
</tr>
<tr>
<td>Samknows off-net 10 second test</td>
<td>19.2</td>
</tr>
<tr>
<td>Iperf</td>
<td>18.9</td>
</tr>
<tr>
<td>Measurement Lab’s NDT</td>
<td>17.4</td>
</tr>
<tr>
<td>Samknows on-net 15 second test</td>
<td>17.2</td>
</tr>
<tr>
<td>Samknows off-net 15 second test</td>
<td>17.0</td>
</tr>
<tr>
<td>Samknows on-net 20 second test</td>
<td>16.1</td>
</tr>
<tr>
<td>Samknows off-net 20 second test</td>
<td>15.9</td>
</tr>
<tr>
<td>Samknows on-net 25 second test</td>
<td>15.4</td>
</tr>
<tr>
<td>Samknows off-net 25 second test</td>
<td>15.3</td>
</tr>
<tr>
<td>Samknows on-net 30 second test</td>
<td>15.4</td>
</tr>
<tr>
<td>Samknows off-net 30 second test</td>
<td>14.8</td>
</tr>
</tbody>
</table>
Other ongoing MITAS data analysis

• Lots more analysis work on existing data sets
  – MITAS provider data
  – Measurement Lab’s NDT data
  – Ookla/Speedtest data
  – FCC/Samknows data

• Comparative analysis across studies
2009 NDT data

Distribution of speed per country
2009 NDT data

Real lesson is **not** the ranking but the importance of round trip time (RTT) and other factors that inhibit speed.
Conclusion

- Lots more broadband measurement data is becoming available
  - First 3 months of FCC data will be released
  - Richer other data sets coming as well – a new broadband measurement era
- Questions selected to ask of the data matter a great deal
- Input into a very important discussion of broadband performance
- What we measure now is going to shape the future of broadband connectivity
  - Regulatory policy
  - Consumer marketplace
  - Application/Service providers