Understanding Broadband Traffic - Metrics, Measurements, and Policy

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CSAIL/MIT

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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"
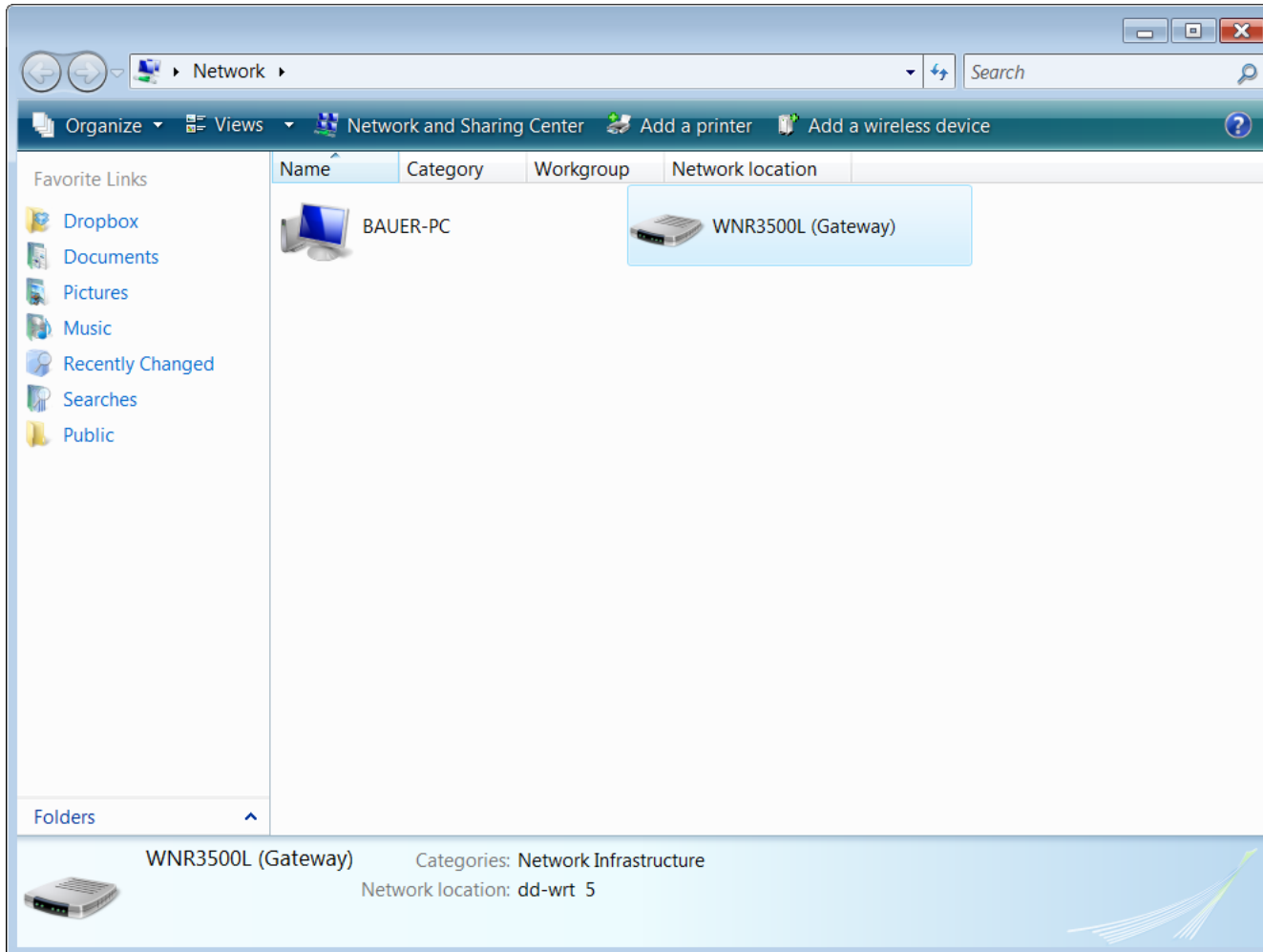
After double clicking on "Gateway"
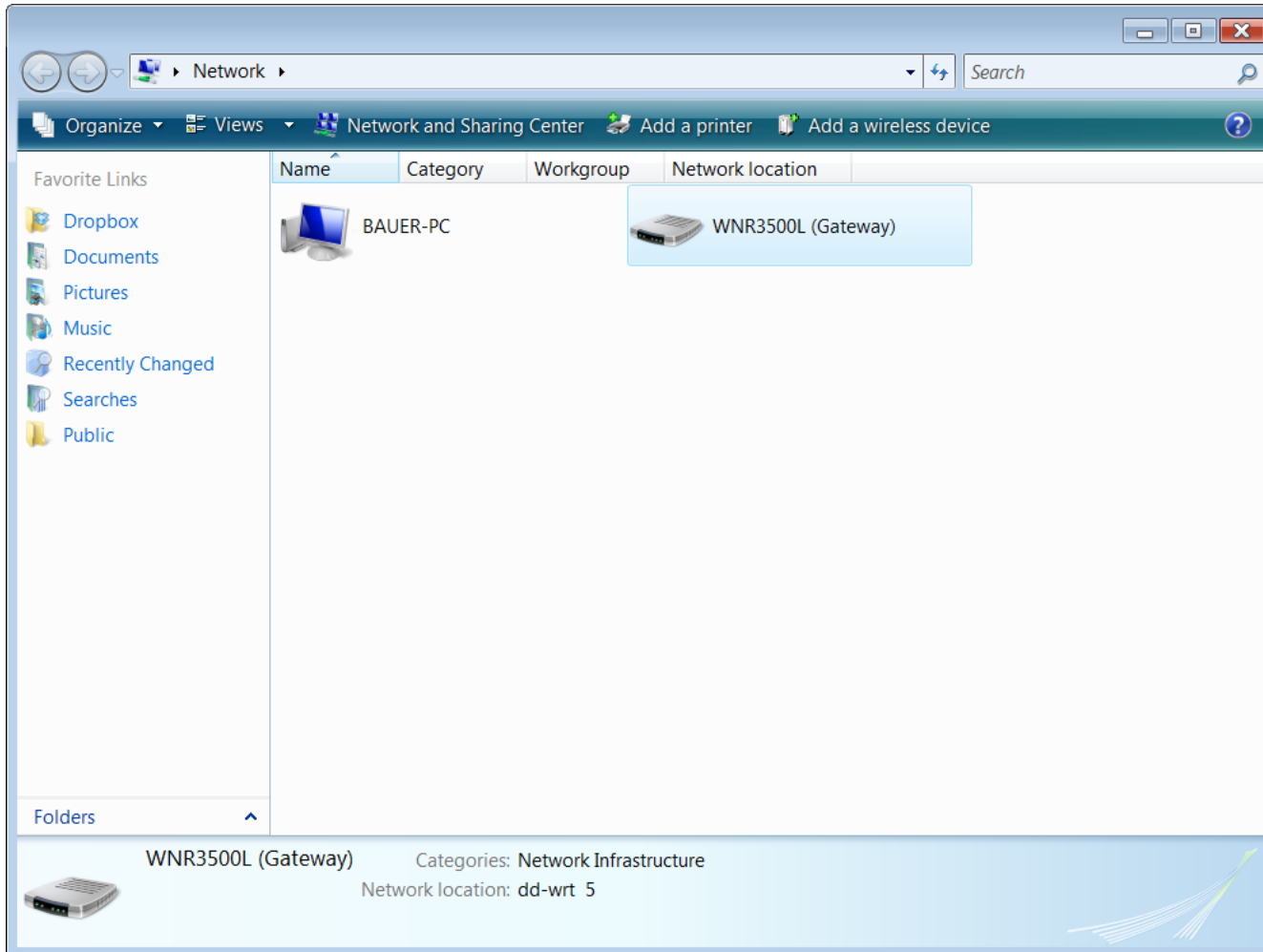
Hard at work
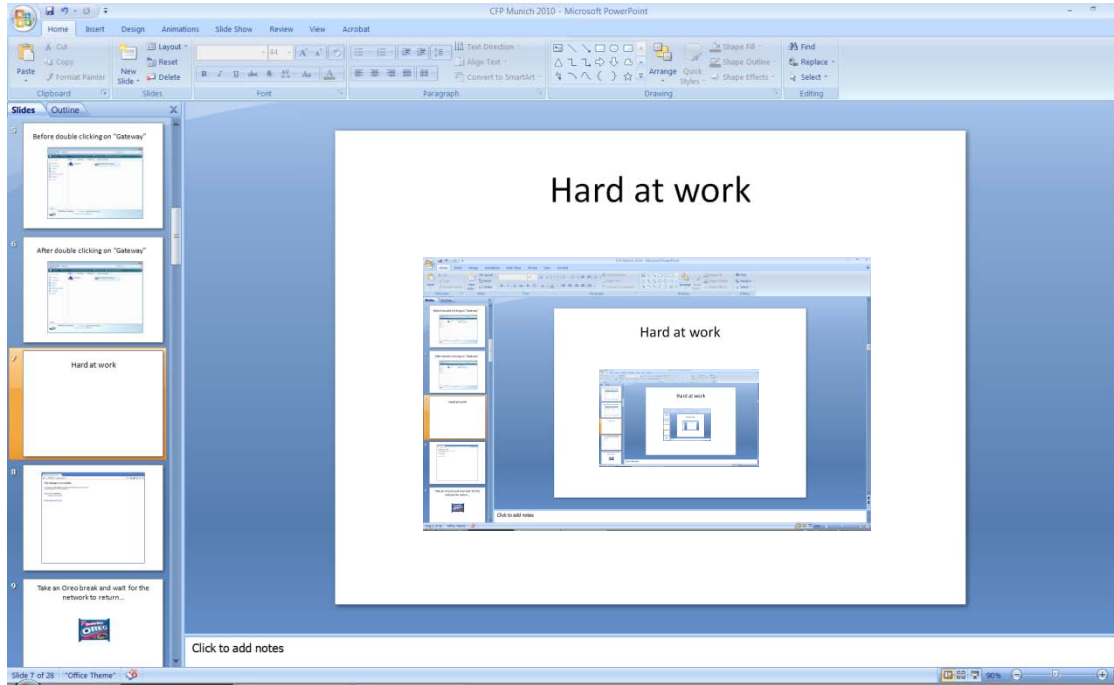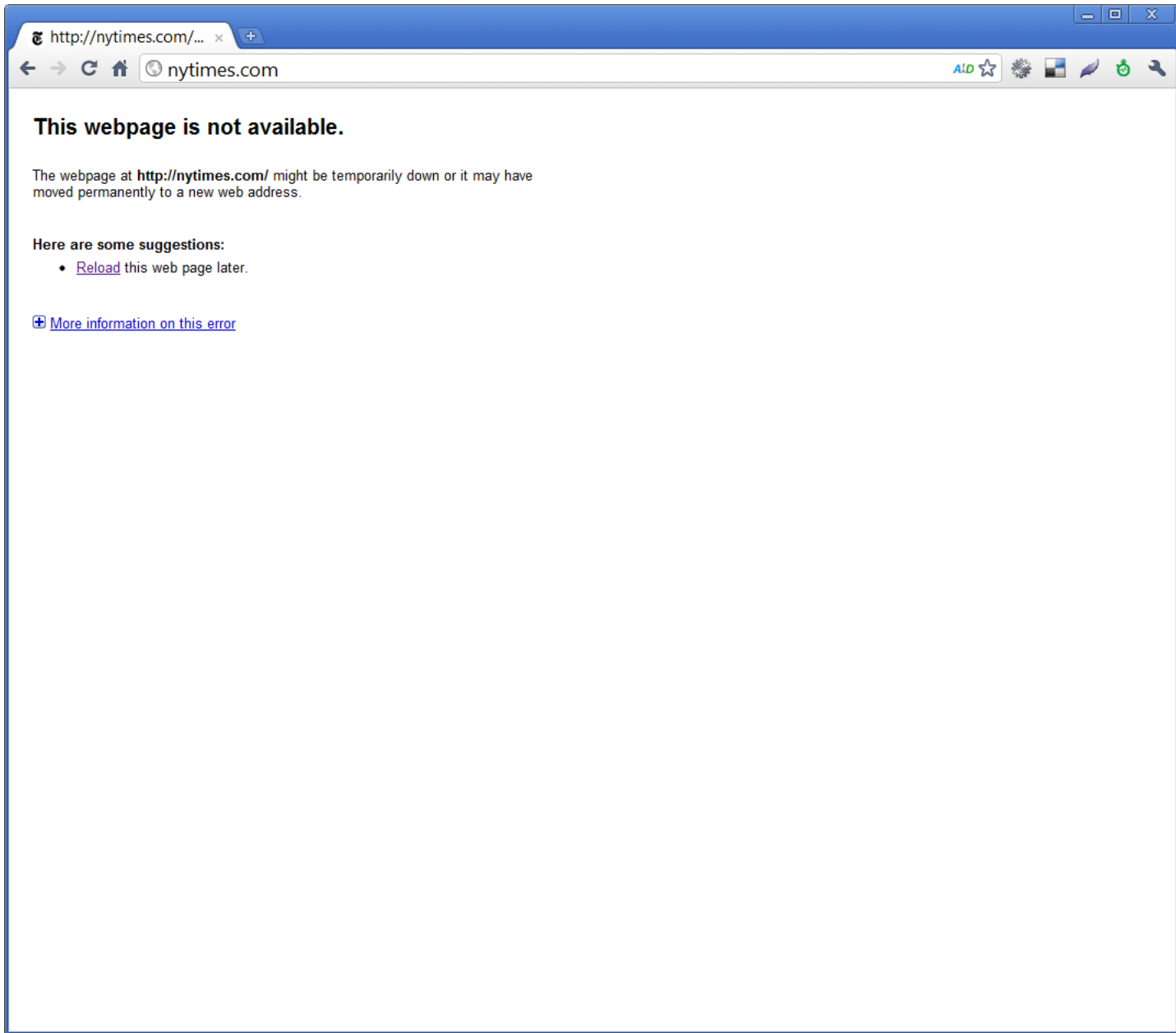
This webpage is not available.

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
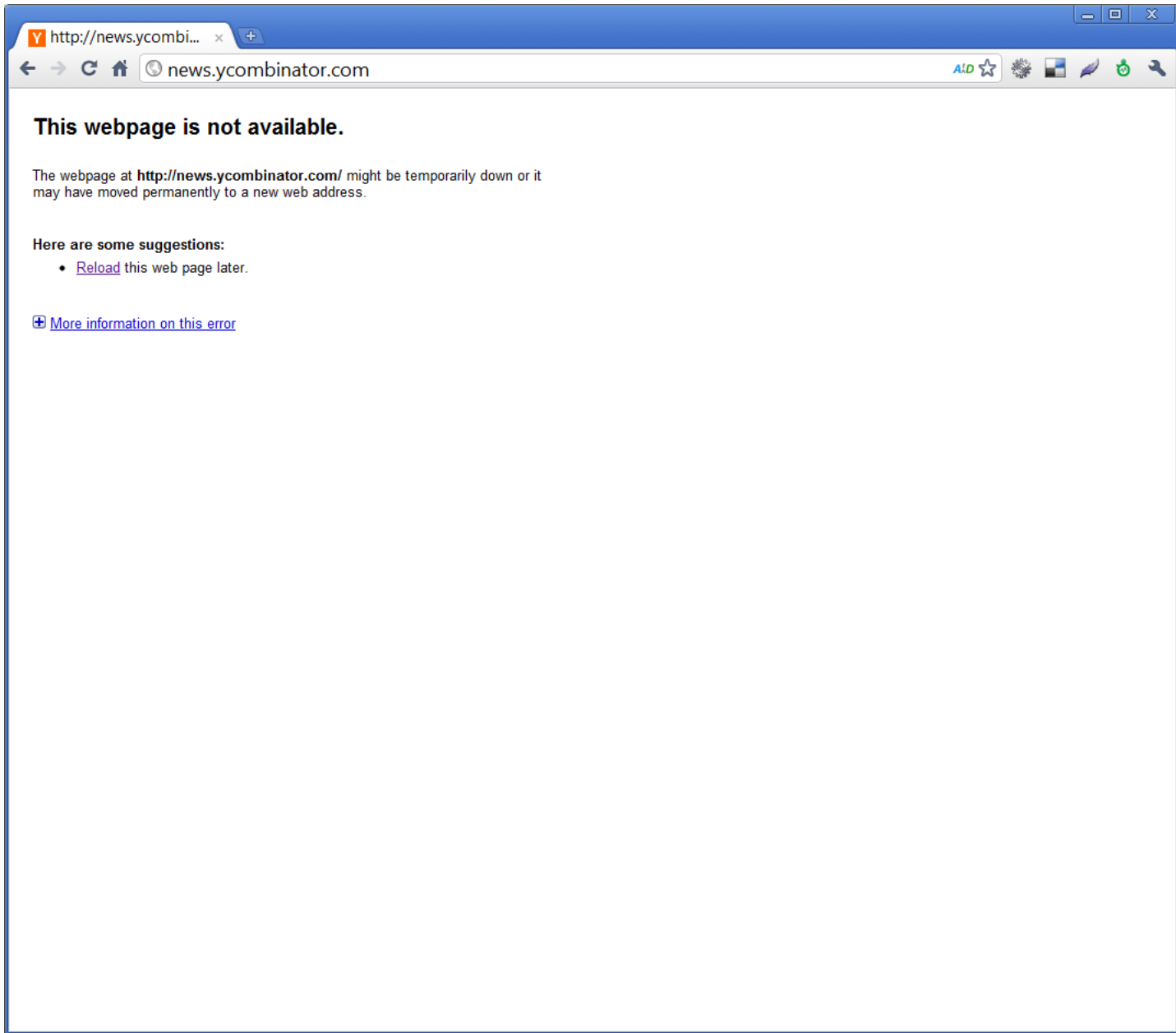
This webpage is not available.

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?

```
smartctl (CMD)                                                    _ □ ✕

C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>ping 18.26.0.106

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:\>
```

```
smartctl (CMD)                                            _ □ ✕

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.

C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
```

Grumble…

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

192.168.1.1/start.htm

NETGEAR
SMARTWIZARD

router manager
RangeMax™ Wireless-N Gigabit Router   model WNR3500L

Select Language:

English

Apply

- **Add WPS Client**

Setup
- **Basic Settings**
- **Wireless Settings**
- **Guest Network**

USB Storage
- **Basic Settings**
- **Advanced Settings**

Content Filtering
- **Logs**
- **Block Sites**
- **Block Services**
- **Schedule**
- **E-mail**

Maintenance
- **Router Status**
- **Attached Devices**
- **Backup Settings**
- **Set Password**
- **Router Upgrade**

Advanced
- **Wireless Settings**
- **Wireless Repeating Function**
- **Port Forwarding / Port Triggering**
- **WAN Setup**
- **LAN Setup**
- **QoS Setup**
- **Dynamic DNS**
- **Static Routes**
- **Remote Management**
- **UPnP**

Router Status

Hardware Version	WNR3500L
Firmware Version	V1.2.2.26_33.0.28SK
GUI Language Version	V1.2.2.26_2.1.7.1

Internet Port
MAC Address	C0:3F:0E:A9:A2:93
IP Address	0.0.0.0
DHCP	DHCPClient
IP Subnet Mask	0.0.0.0
Domain Name Server	0.0.0.0

LAN Port
MAC Address	C0:3F:0E:A9:A2:92
IP Address	192.168.1.1
DHCP	On
IP Subnet Mask	255.255.255.0

Wireless Port
Name (SSID)	dd-wrt
Region	North America
Channel	Auto (6)
Mode	Up to 145 Mbps
Wireless AP	On
Broadcast Name	On

Show Statistics   Connection Status

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.

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.

NETGEAR Router - Google Chrome

192.168.1.1/RST_statistics.htm

System Up Time 00:54:24

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

Poll Interval : 5 (secs)   Set Interval   Stop

NETGEAR Router - Google Chrome

192.168.1.1/RST_statistics.htm

System Up Time 00:55:29

Port	Status	TxPkts	RxPkts	Collisions	Tx B/s	Rx B/s	Up Time
WAN	100M/Full	35132	81962	0	2515	10829	00:55:10
LAN1	Link Down						--
LAN2	Link Down	37791	31055	0	8584	2016	--
LAN3	1000M/Full						00:55:11
LAN4	1000M/Full						00:55:11
WLAN	145M	11846	10932	0	1854	674	00:55:16

Poll Interval : 5 (secs)   Set Interval   Stop

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192.168.1.1/start.htm

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router manager
RangeMax™ Wireless-N Gigabit Router model WNR3500L

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Wireless Port

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Wireless AP	On
Broadcast Name	On

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- Region. The location (country).
- Channel. The current channel in use.

Connection Status

IP Address	0.0.0.0
Subnet Mask	0.0.0.0
Default Gateway	0.0.0.0
DHCP Server	0.0.0.0
DNS Server	0.0.0.0
Lease Obtained	0 Seconds
Lease Expires	0 Seconds

Release   Renew

Close Window

Gmail   Calendar   Web   Documents   Reader   more ▼   steven.bauer@gmail.com | 🧪 | Settings | Help | Si

Gmail
by Google

in:spam   Search Mail   Search the Web   Show search options
                                                                    Create a filter

Mail
Contacts
Tasks

Compose mail

Inbox
Priority Inbox
Buzz 💬
Starred ⭐
Sent Mail
Drafts (2)
All Mail

Spam

business
e2e
linux-net (5)
needs response
nnsquad (3)
R (1852)
re-ECN
5 more▼

Quick Links   ⊟

☐▼   **Delete forever**   Not spam   Mark as read   ⊕ ⊖   Move to ▼   Labels ▼

More actions ▼   Refresh

(messages that have been in Spam more than 30 days will be automatically deleted)

Hooray, no spam here!

☐▼   **Delete forever**   Not spam   Mark as read   ⊕ ⊖   Move to ▼   Labels ▼

More actions ▼   Refresh

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.

This account is open in 1 other location (18.26.0.106). Last account activity: 1 hour ago on this computer. Det

Conclusion…

It's my providers fault:

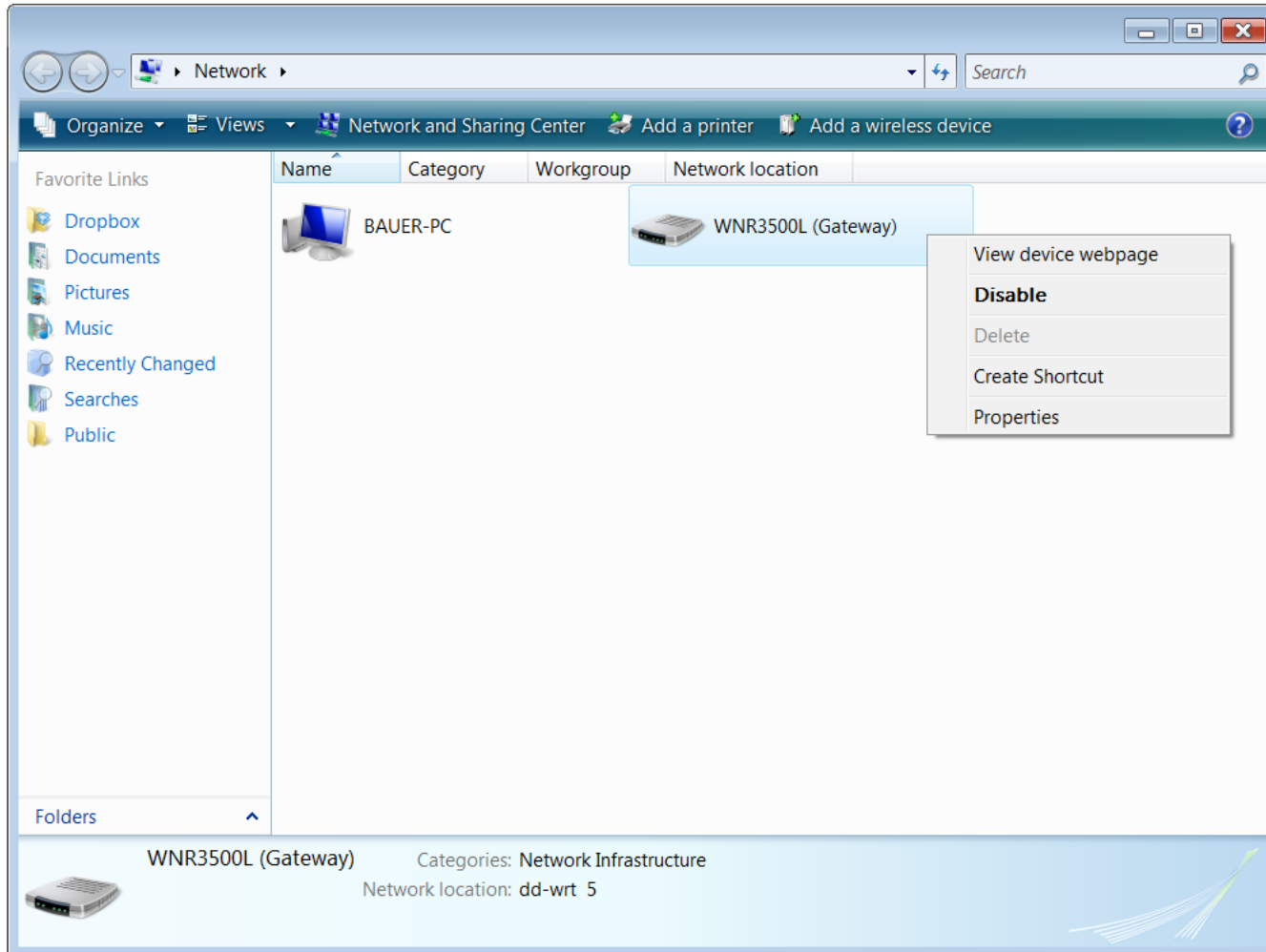- DHCP failed to renew?

- Cable modem problem?

What actually had happened?
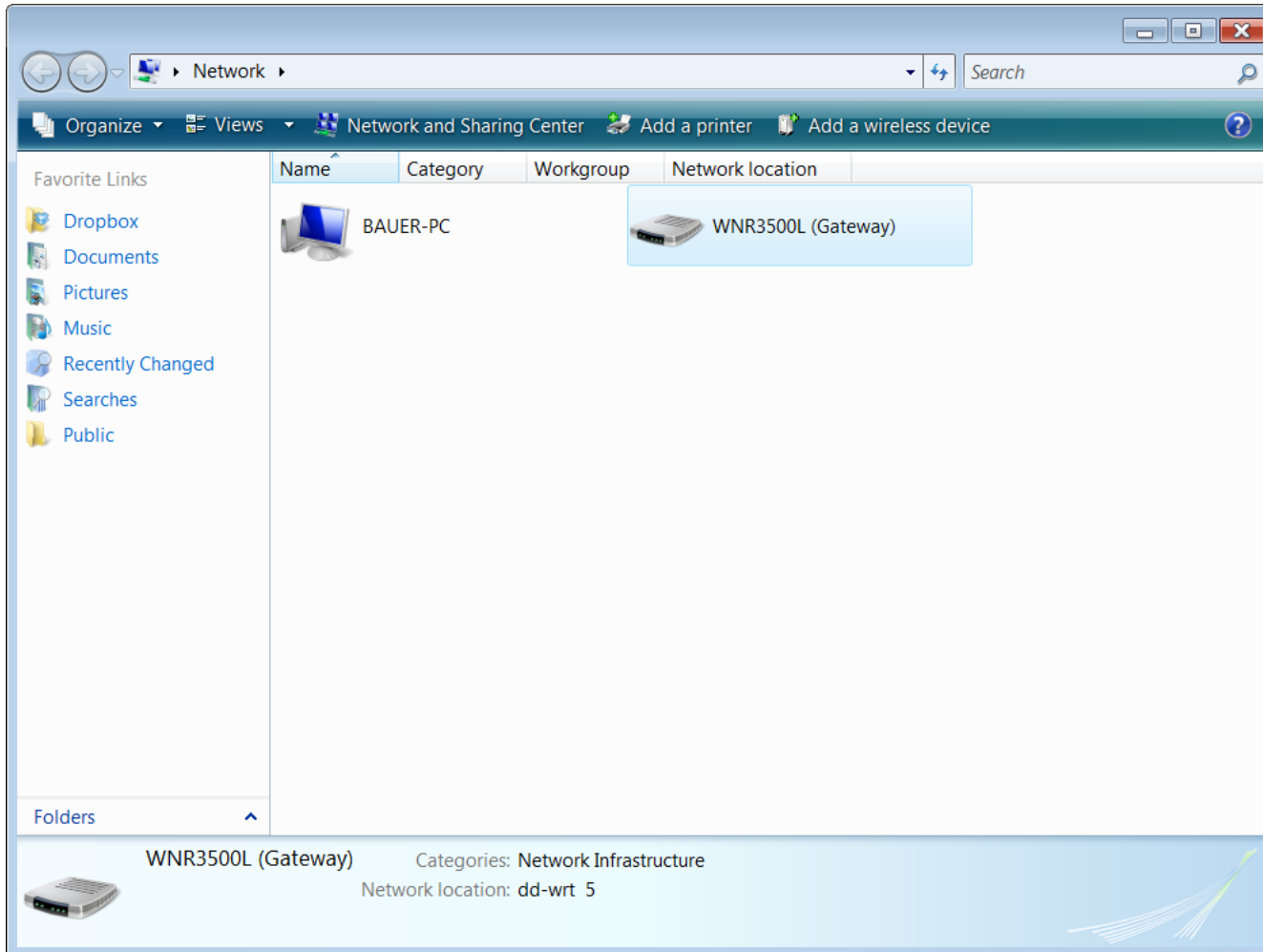
Double clicking invokes the default action
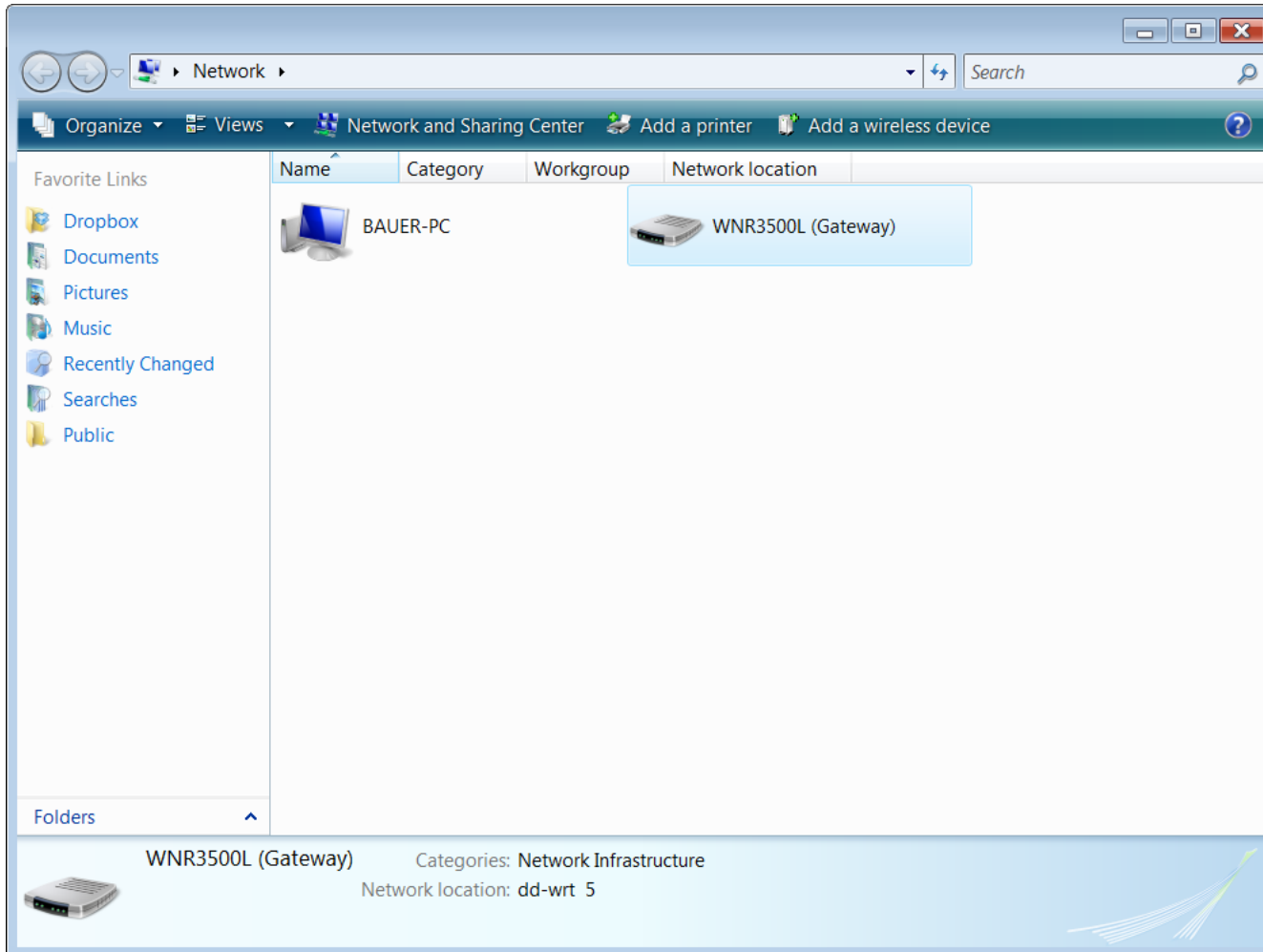
Disable!

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 1st, 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**
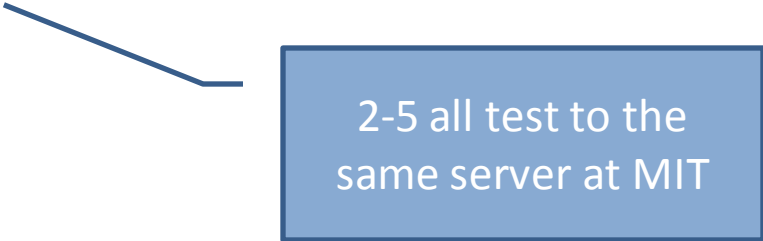- Expect eventual access to full data set

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
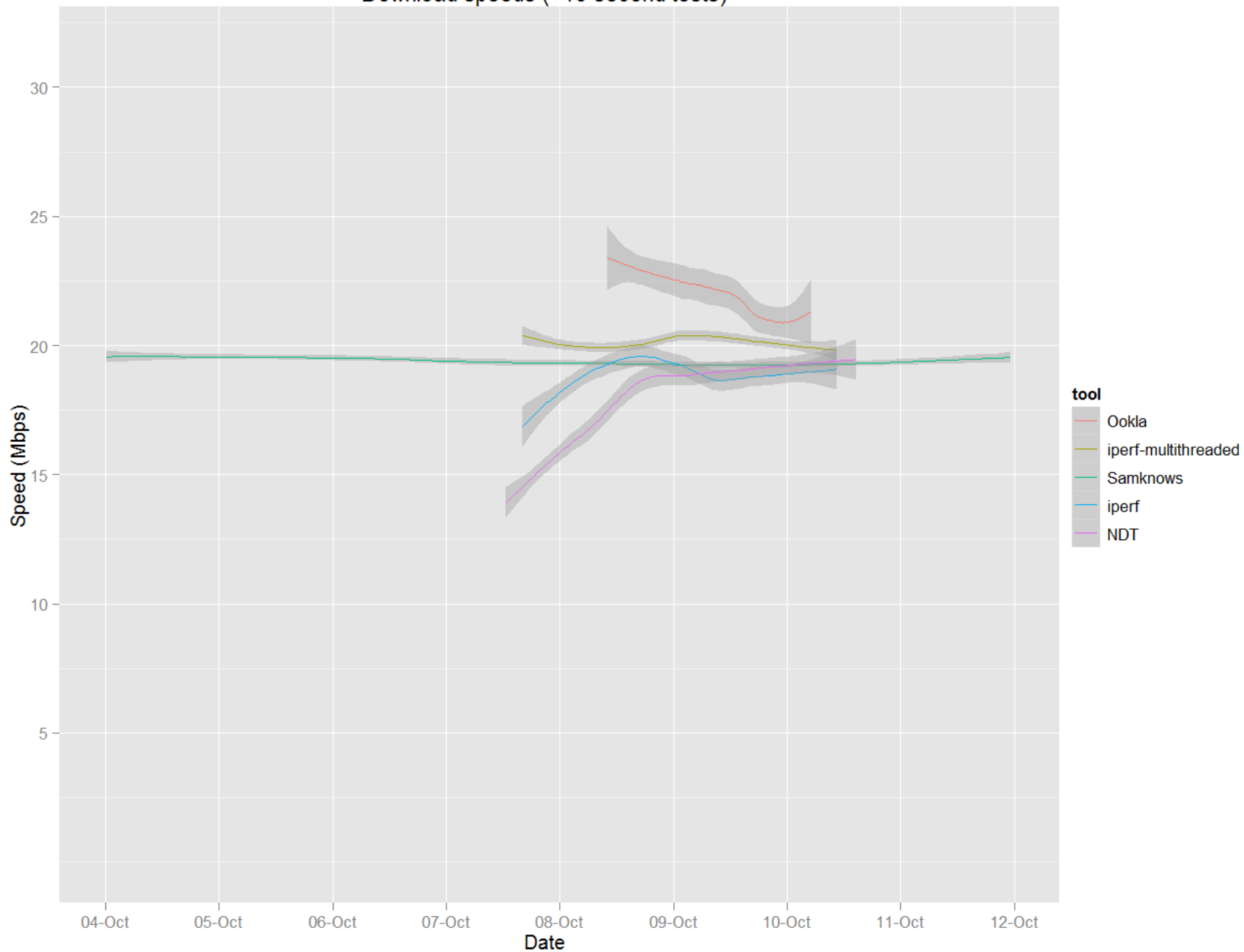- Test finishes after a fixed time duration
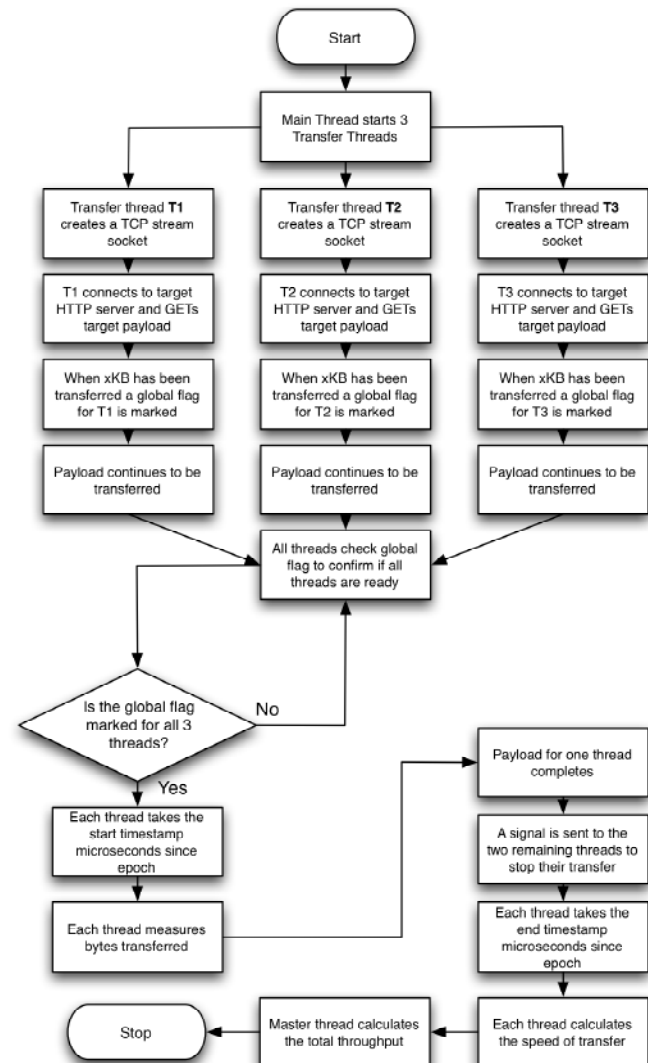
Preliminary speed comparison test

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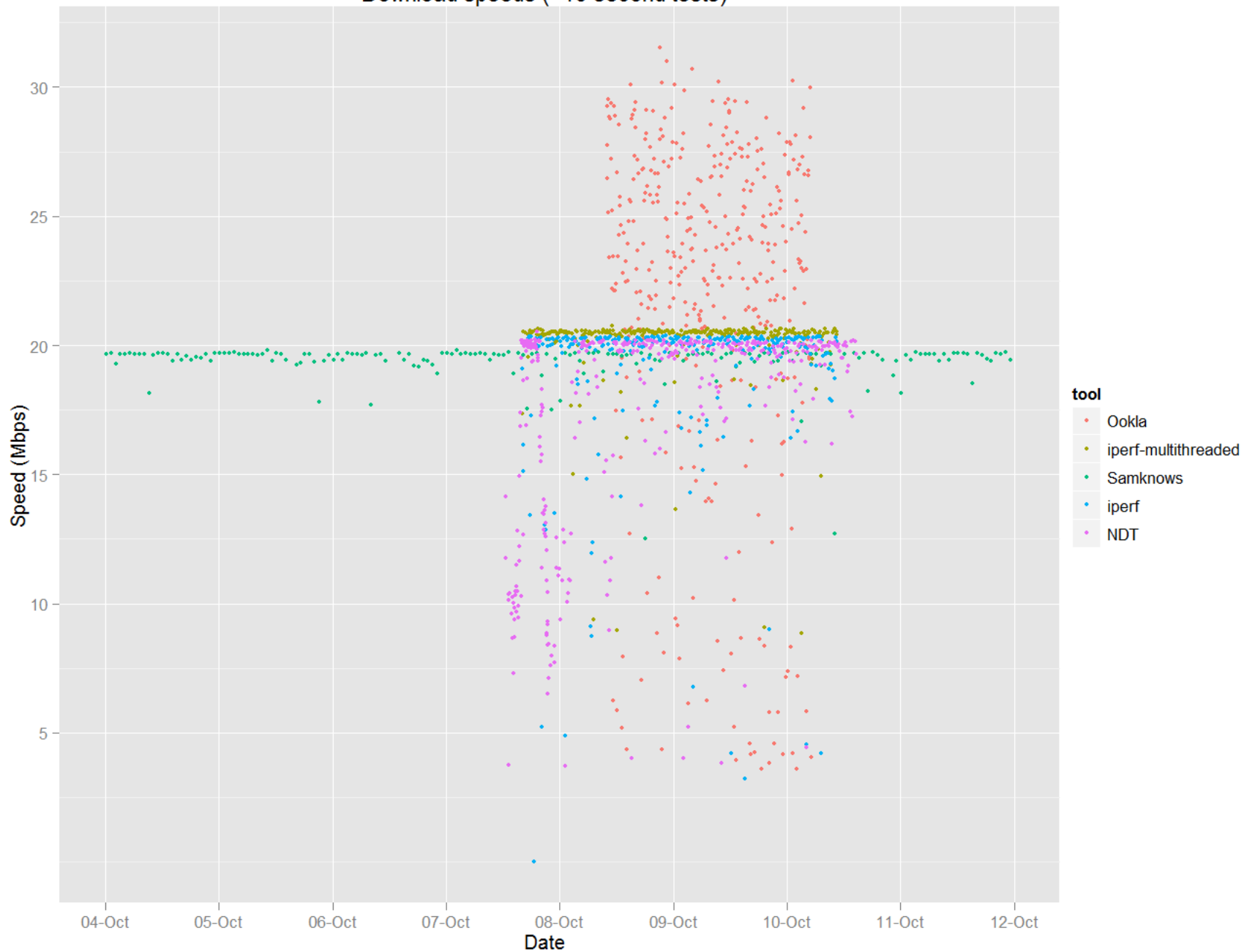3. Measurement Lab/NDT
4. Iperf
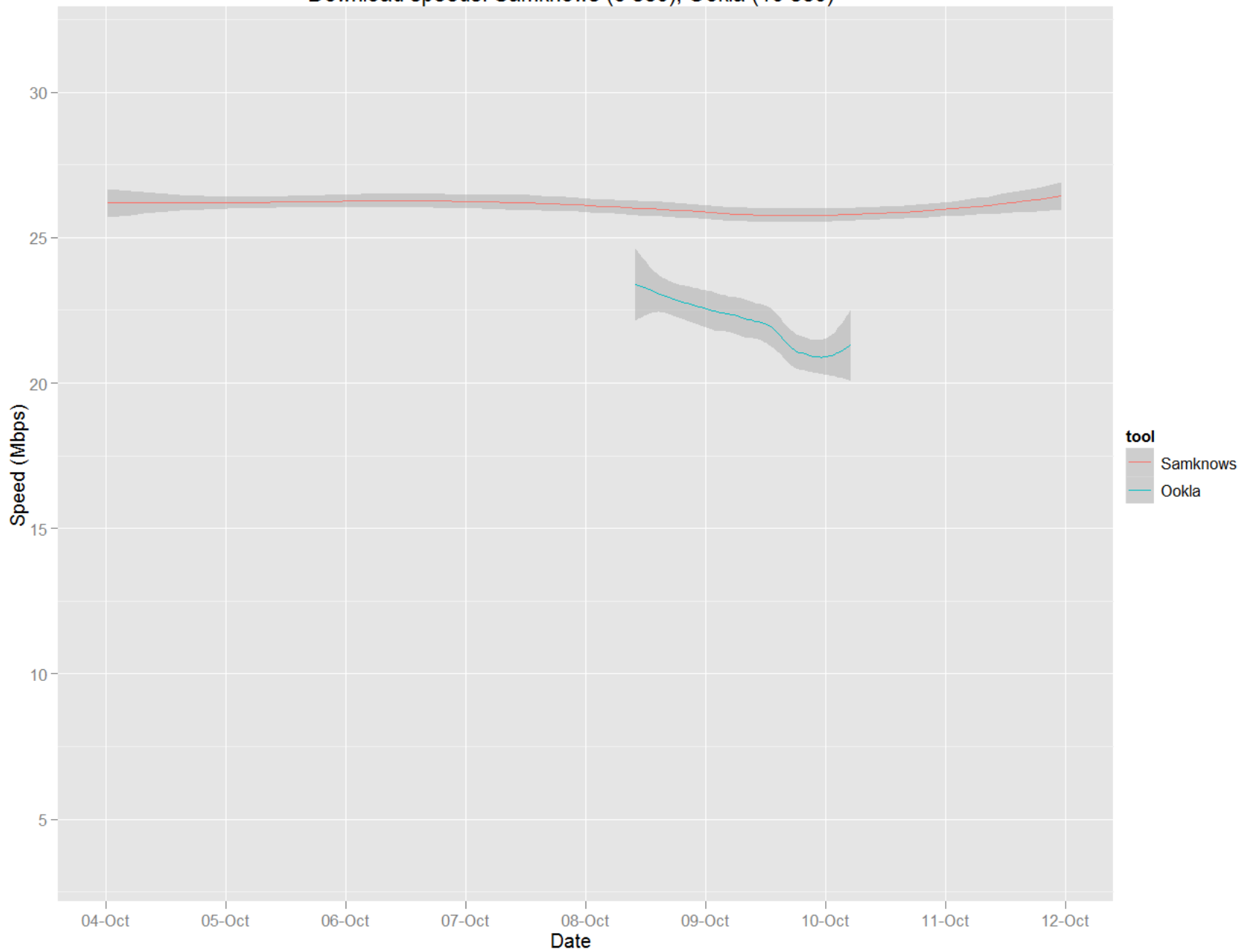5. Iperf-multithreaded

2-5 all test to the same server at MIT

Download speeds (~10 second tests)

Speed (Mbps)

Date

tool
— Ookla
— iperf-multithreaded
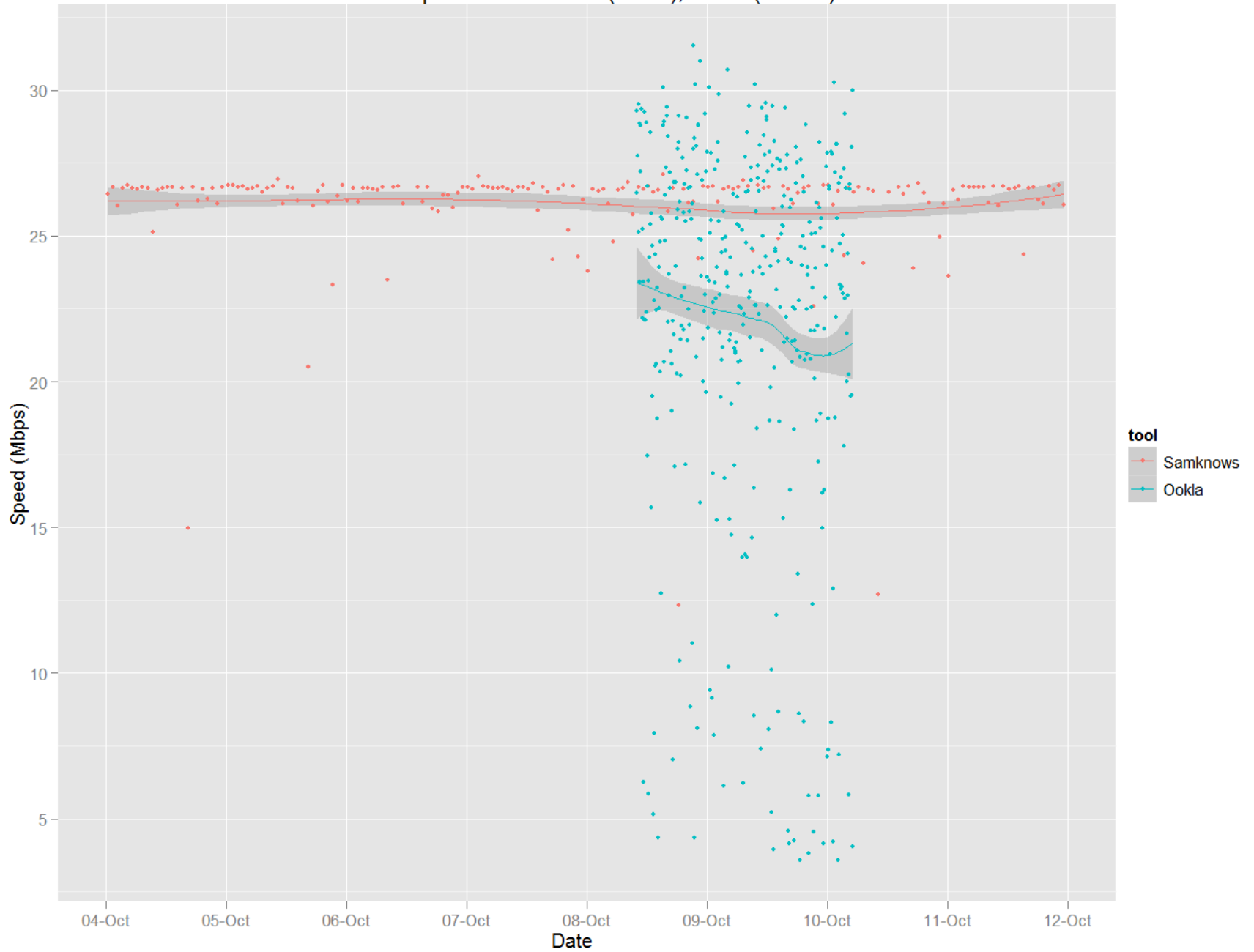— Samknows
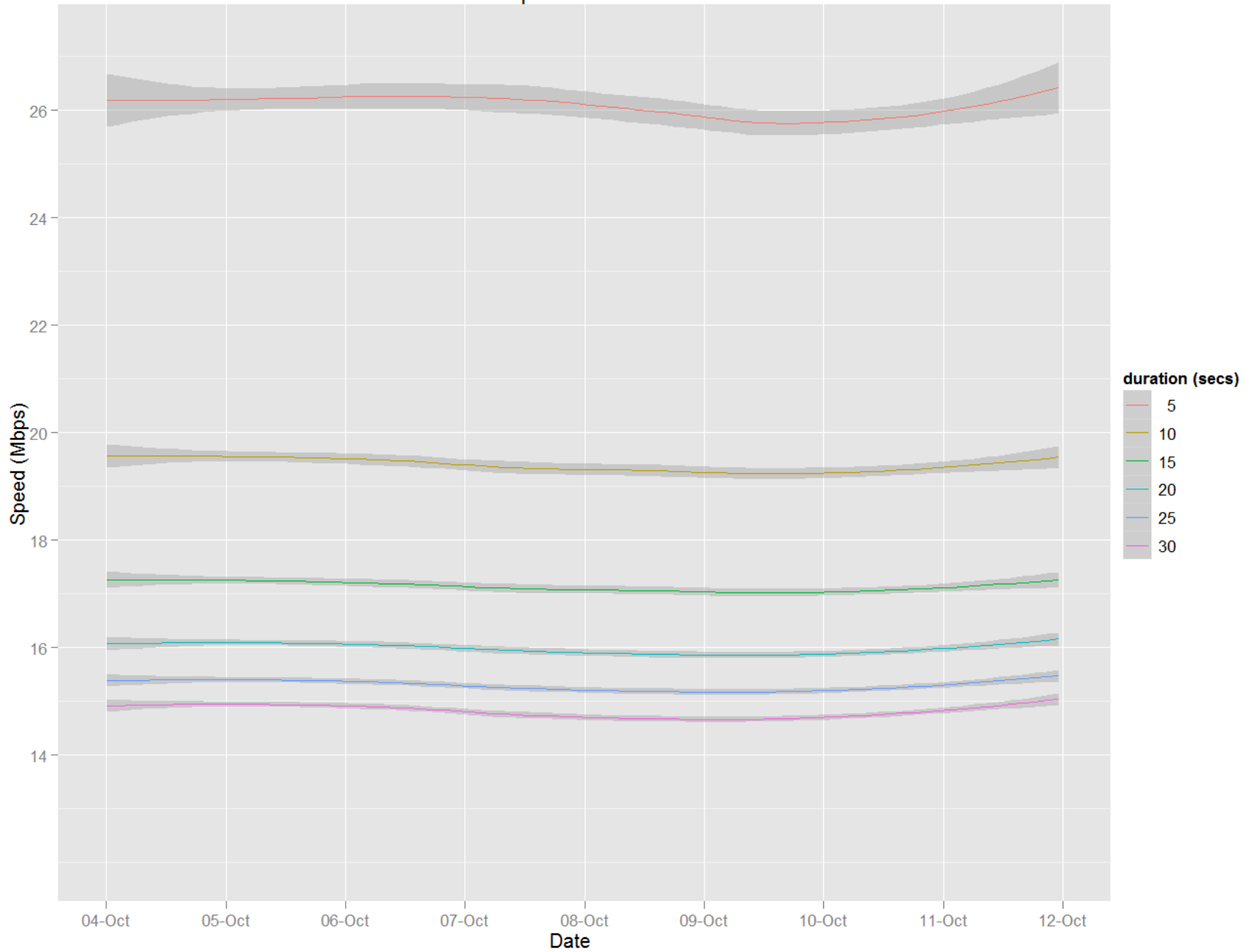— iperf
— NDT

Download speeds (~10 second tests)

Download speeds: Samknows (5 sec), Ookla (10 sec)

Download speeds: Samknows (5 sec), Ookla (10 sec)

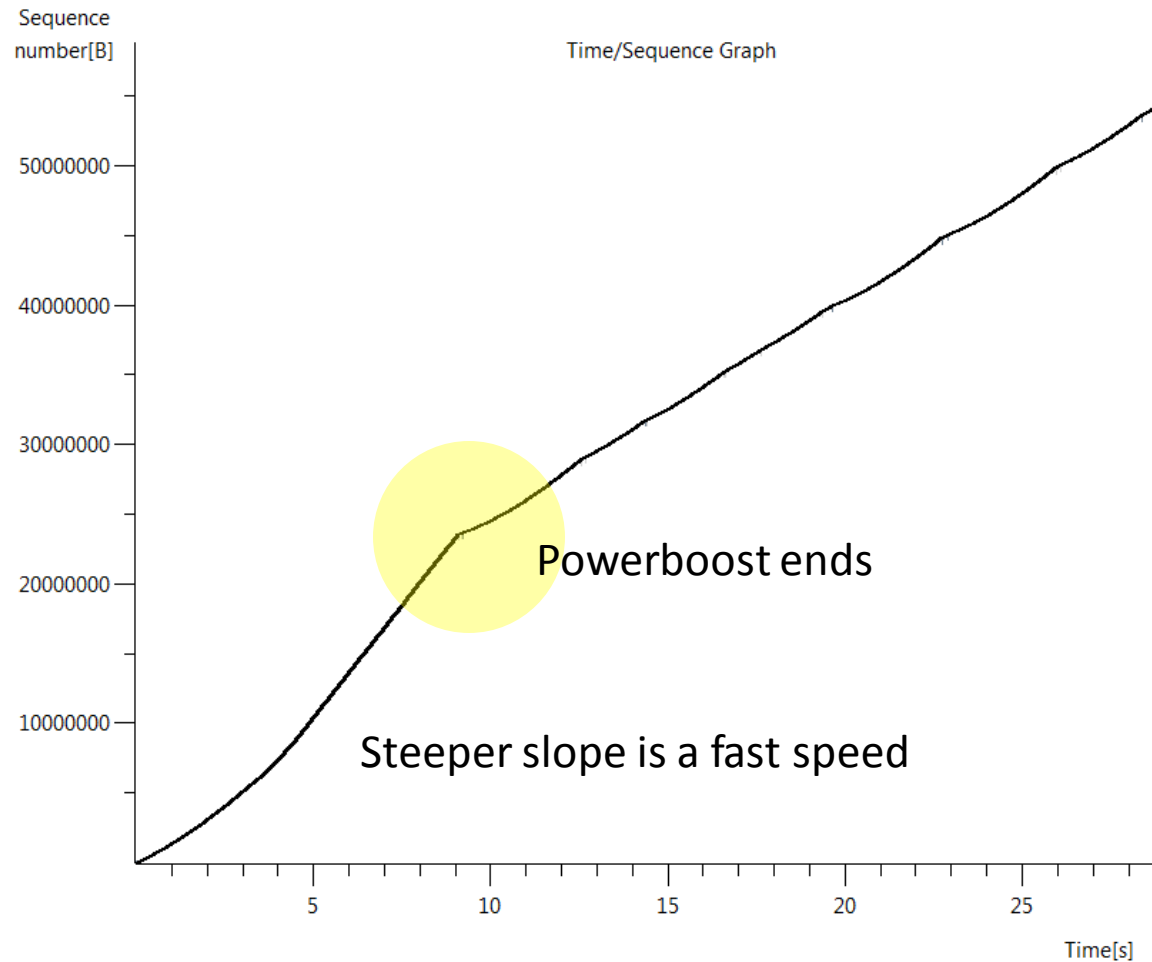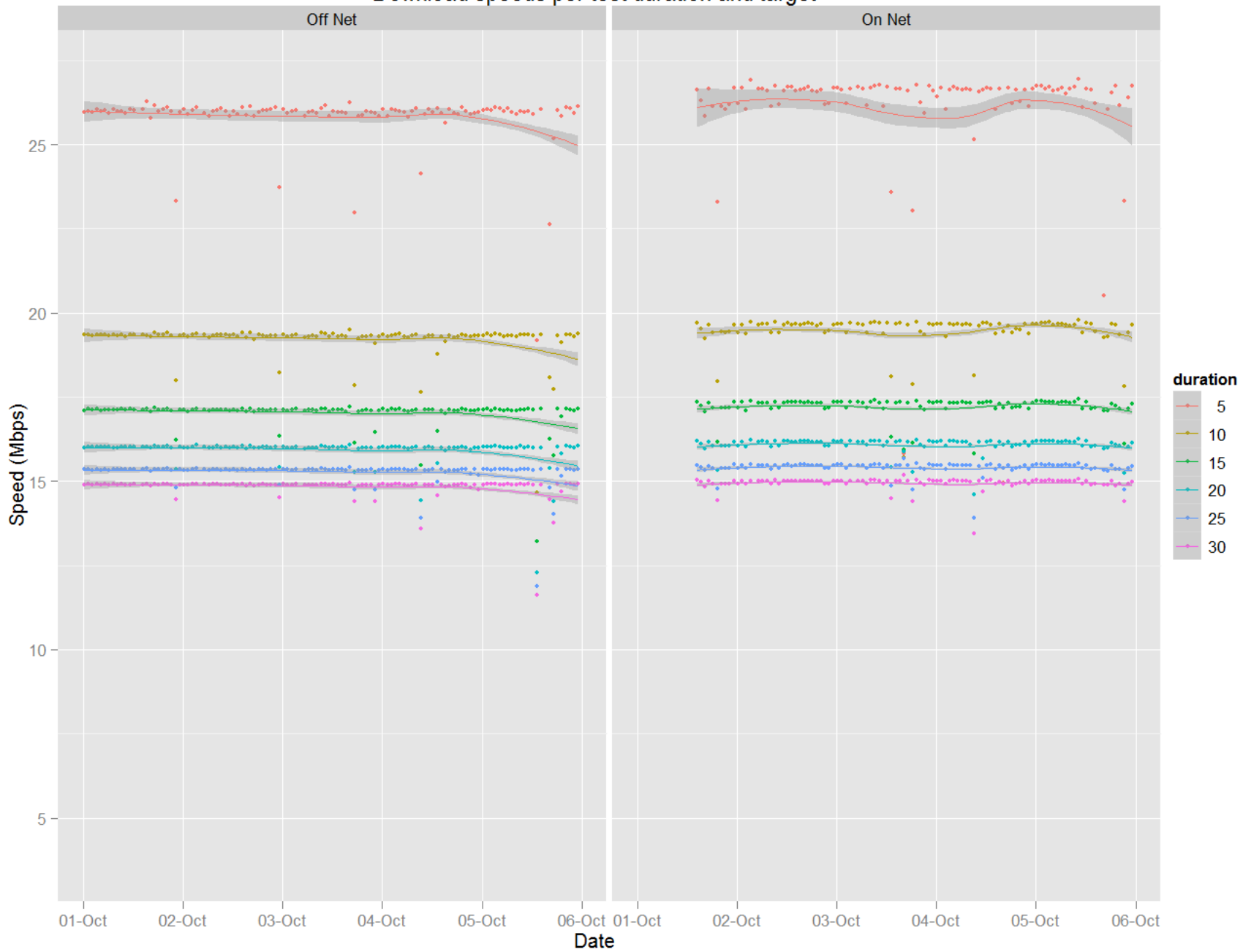Samknows download speeds for different test durations
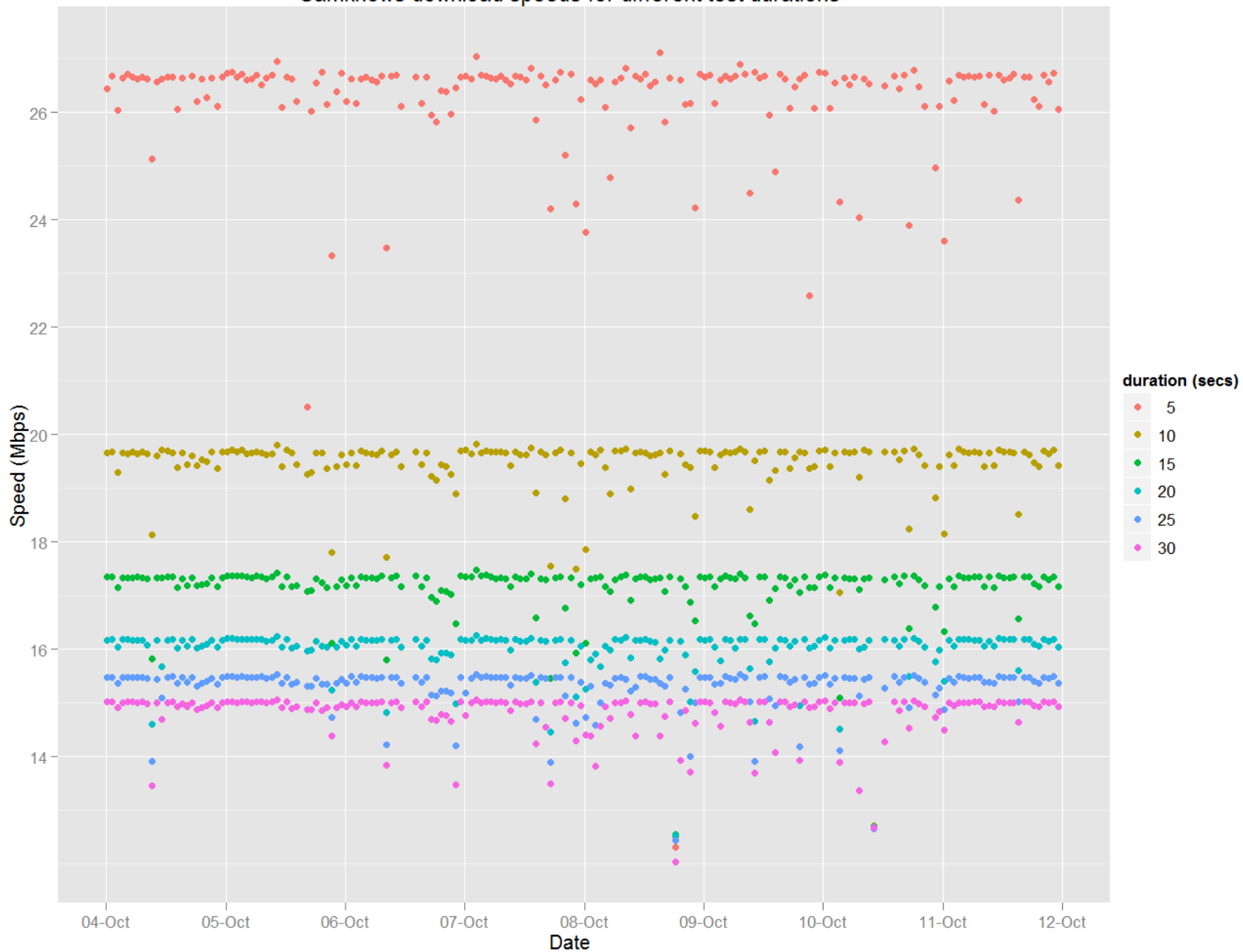
Effects of Powerboost

- If Powerboost is present, shorter tests will be reporting more of the "Powerboost speeds"
- Long durations will be slower

Sequence number[B]

Time/Sequence Graph

Powerboost ends

Steeper slope is a fast speed

Time[s]

Download speeds per test duration and target

On-net versus off-net speed differential for download speed test

Test duration (secs)	Difference in average speeds (Kbps)
5	383
10	308
15	225
20	185
25	155
30	132

- 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?

| Test	Average Download Speed
Samknows on-net 5 second test	26.2
Samknows off-net 5 second test	25.8
Ookla/Speedtest	22.0
Iperf-multithreaded	20.1
Samknows on-net 10 second test	19.5
Samknows off-net 10 second test	19.2
Iperf	18.9
Measurement Lab's NDT	17.4
Samknows on-net 15 second test	17.2
Samknows off-net 15 second test	17.0
Samknows on-net 20 second test	16.1
Samknows off-net 20 second test	15.9
Samknows on-net 25 second test	15.4
Samknows off-net 25 second test	15.3
Samknows on-net 30 second test	15.4
Samknows off-net 30 second test	14.8

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

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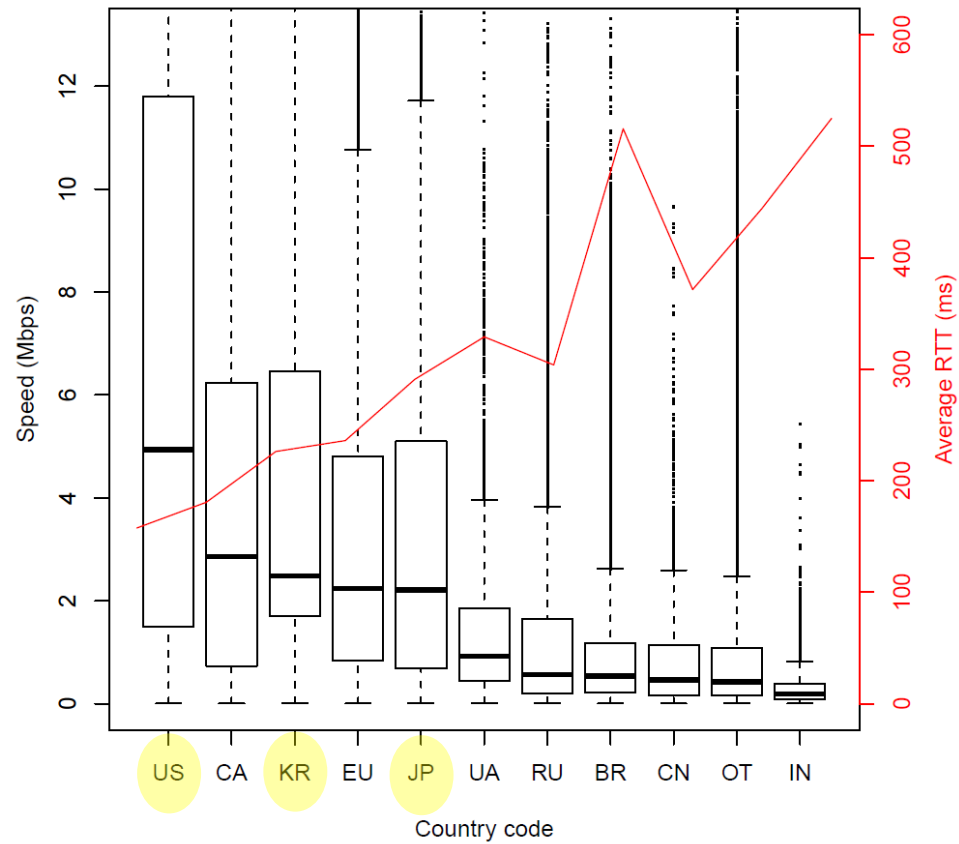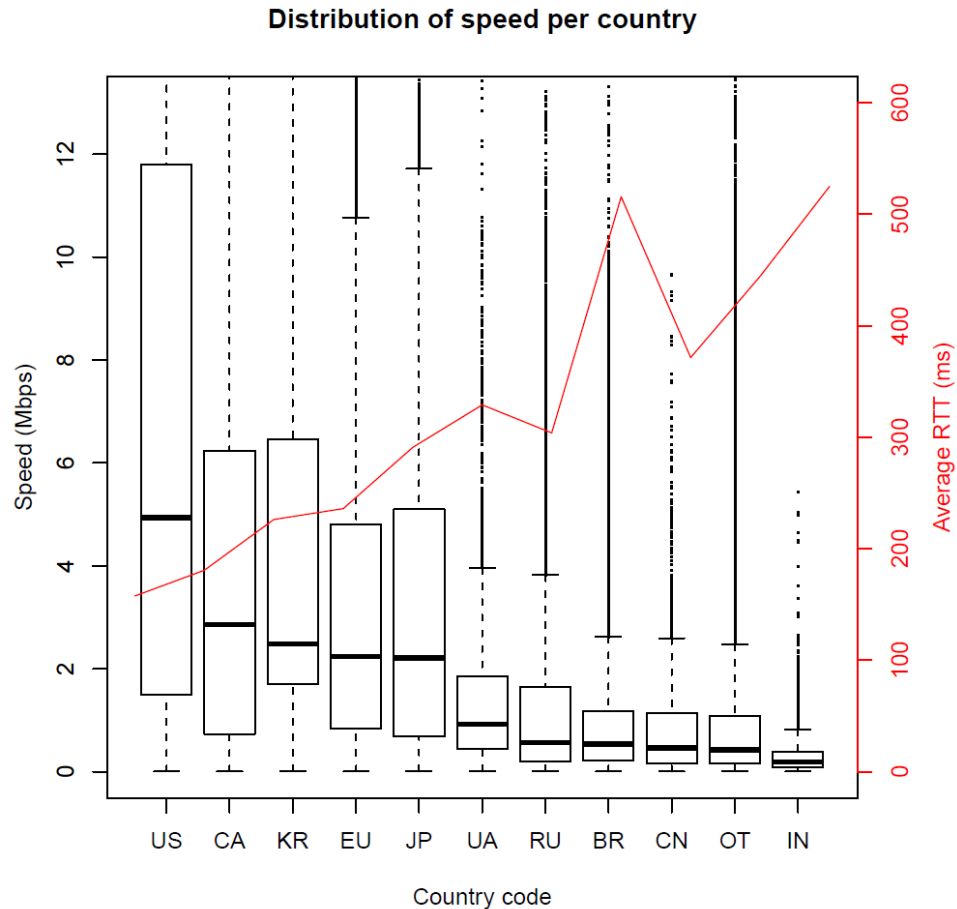
Real lesson is **not** the ranking but the importance of round trip time (RTT) and other factors that inhibit speed

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