August 13, 2010

Via Electronic Mail

Marlene H. Dortch
Office of the Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Review of Wireless Telecommunications Bureau Data Practices (WT Docket No. 10-131)

Dear Ms. Dortch:

The New America Foundation's Open Technology Initiative (NAF) submits these brief *ex parte* comments in response to the Federal Communication Commission Wireless Telecommunications Bureau's review of data practices. In previous comments to the Commission, NAF proposed a systematic data collection effort for mobile broadband communications including fundamental data on service capabilities, coverage and performance and traffic statistics. Here, we re-submit those comments (see Appendix) for review by the Wireless Telecommunication Bureau.

In the comments, NAF proposed data collection and the benefits of the measurement of mobile broadband performance and service coverage by utilizing a end-user measurement tests and systematic engineering approach. We encourage the Bureau to think broadly about data collection and ensure as much data as possible is publically available in raw form, to both empower consumers and create viable sources for unbiased data on mobile network performance and traffic for policymakers and network researchers.

Respectfully Submitted,
\s\
Benjamin Lennett
Senior Policy Analyst, Open Technology Initiative
New America Foundation
lennett@newamerica.net

\s\
Chiehyu Li
Program Associate, Open Technology Initiative
New America Foundation
li@newamerica.net

APPENDIX

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Consumer Information and Disclosure	)	CG Docket No. 09-158
Truth-in-Billing Format IP-Enabled Services	)	
	)	
Truth-in-Billing and Billing Format	)	CC Docket No. 98-170
	)	
IP-Enabled Services	)	WC Docket No. 04-36

COMMENTS OF
THE BENTON FOUNDATION, COLUMBIA TELECOMMUNICATIONS CORPORATION, CONSUMERS UNION, NATIVE PUBLIC MEDIA AND NEW AMERICA FOUNDATION

"Comments - Mobile Broadband Measurement"

Benjamin Lennett
Dan Meredith
Sascha Meinrath
Open Technology Initiative
NEW AMERICA FOUNDATION
1899 L Street NW, Suite 400
Washington, DC 20036
(202) 986 – 2700

Andrew Afflerbach, Ph.D.
Shivani Gandhi
COLUMBIA TELECOMMUNICATIONS CORPORATION
10613 Concord Street
Kensington, MD 20895
www.ctcnet.us

July 8, 2010

SUMMARY

The Benton Foundation, Columbia Telecommunications Corporation, Consumers Union, Native Public Media, and New America Foundation respectfully submit comments in response to the Commission's *Public Notice* seeking comment on the measurement of mobile broadband network performance. We commend the Commission for this *Notice* and commitment to promoting greater transparency in all broadband services. We believe both consumers and policymakers would benefit from a better understanding of the performance capabilities of mobile broadband networks. The comments provide an overview of several approaches to measuring mobile broadband including a systematic engineering approach and end-user or 'crowdsourcing' measurement tools. We encourage the Commission not to focus on a single approach but to utilize a wide variety of tools and tests. We further encourage the Commission to think broadly about measurement and data collection, both to empower consumers and policymakers with data-driven assessments of the capabilities of mobile broadband services and to provide viable sources of data on Internet traffic and network performance for the public and researchers. We believe that an open and transparent measurement process that ensures access to the underlying methodology of the utilized measurement tools and to the resulting raw data by the public, researchers and policymakers is essential to the success of this measurement effort and to promoting its extensibility for the future.

TABLE OF CONTENTS

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Consumer Information and Disclosure	)	CG Docket No. 09-158
Truth-in-Billing Format IP-Enabled Services	)	
	)	
Truth-in-Billing and Billing Format	)	CC Docket No. 98-170
	)	
IP-Enabled Services	)	WC Docket No. 04-36

COMMENTS OF
THE BENTON FOUNDATION, COLUMBIA TELECOMMUNICATIONS CORPORATION, CONSUMERS UNION, NATIVE PUBLIC MEDIA AND NEW AMERICA FOUNDATION

"Comments - Mobile Broadband Measurement"

The Benton Foundation, Columbia Telecommunications Corporation (CTC), Consumers Union, Native Public Media and New America Foundation (NAF) (together, "*Commenters")* respectfully submit these comments in response to the Commission's *Public Notice* seeking comment on the measurement of mobile broadband network performance in the above-captioned docket.[1] In the *Notice*, the Commission seeks comment on whether and how to pursue a measurement program for mobile broadband services given the growing significance of mobile Internet access and on how providers can improve voluntary self-reporting of network performance and coverage.

In previous comments to the Commission regarding broadband measurement and consumer transparency of fixed residential broadband services, NAF proposed a number of

[1] *See Comment Sought on Measurement of Mobile Broadband Performance and Measurement,* CG Docket No. 09-158, CC Docket No. 98-170, WC Docket No. 04-36, Public Notice, (rel. June 1, 2010) (*"Notice*").

measurement and data collection strategies.[2] Below we expand on and refine those comments in relation to a mobile broadband context. Here again, we urge the Commission to ensure the measurement process is as transparent and open as possible by allowing for public access to the underlying methodology of tools and the resulting raw data to support independent research and analysis.[3] We further encourage the Commission to think broadly about measurement and data collection to both empower consumers and create viable sources for unbiased data on Internet traffic and mobile network performance for policymakers, researchers and the public. The more data the Commission collects, the better, and it should not unnecessarily limit its focus to metrics just beneficial for consumer comparisons but rather utilize the measurement process to collect fundamental data on the inner workings of mobile networks, including traffic flows, traffic volume, and other performance data useful to network research and public policy. Last, we recommend the Commission utilize an extensible and open platform for measurement tools that will allow for the integration of new tools, support for additional measurements, upgrades as needed and ensure long-lasting positive impacts for consumers, researchers, and industry.

I. INTRODUCTION

The prominence of mobile broadband in the Commission's National Broadband Plan—both for bringing broadband to unserved areas and improving competition in the broader broadband marketplace[4]—underscores the need to improve transparency with respect to mobile broadband services, performance, and coverage. The existing information available to consumers purchasing mobile broadband service is insufficient and limited. Service providers routinely disclose little meaningful information regarding the performance capabilities of their service,

[2] *See* Comments of the New America Foundation, NBP Public Notice # 24, GN Docket No. 09-47 (filed Dec. 14, 2009) ("NBP Comments").
[3] *Id.*
[4] *See* Federal Communications Commission, *Connecting America: The National Broadband Plan*, 2010, at 41, 136.

often limiting such information to overly broad coverage maps, while failing to provide consumers with even a minimal understanding of the actual performance of the service. This creates substantial confusion for consumers when choosing among mobile service providers, assessing the value of the service, understanding whether their favorite mobile application will work as expected on a provider's network, or determining what it might cost them to use that application.

The lack of transparency in mobile broadband goes beyond just the challenges faced by consumers; policymakers, researchers, and innovators are also faced with a dearth of information on the workings of mobile broadband and the Internet. Access to raw data on mobile broadband speeds, traffic, and coverage is currently very limited, only available through the carriers themselves or from a few high-cost commercial analysts. As the Commission looks to improve its data about the state of broadband deployment and capabilities, a coordinated and comprehensive measurement effort is critical to determining where mobile broadband is actually available and at what speeds and capabilities. Consistent with the Commission's obligation under Section 706(b) of the Telecommunications Act of 1996, data collected regarding mobile broadband offerings will help the Commission to more accurately evaluate the state of mobile advanced services offered to the American public.[5] Further, measurements could also inform the Commission's assessment of complex broadband issues such as network congestion and management, where it is in the unfortunate position of depending entirely on analysis of traffic and usage data from service providers.

---

[5] Section 706(b) of the Telecommunications Act of 1996 requires the Commission to regularly examine and report on the "availability of advanced telecommunications capabilities to all Americans …." 47 U.S.C. § 1302(b).

II. MEASUREMENT METRICS

The minimum acceptable range of parameters or metrics for broadband performance, wired or wireless, are end-to-end downstream and upstream transmission speed (throughput) and latency. The additional parameters for wireless must include the client's signal strength, accessibility of the service, the frequency band and protocols in use, and the geographic location of the client. It is possible that, with some wireless technologies, the radio frequency (RF) signal strength corresponds closely to the primary broadband wireless performance parameters, such as transmission speed, under certain conditions of usage. However, other parameters, such as usage of the network, backhaul capacity, and behavior of the components of the data network (IP network, authentication system) independent of the RF network may be dominant in determining broadband performance. Therefore, Commenters do not recommend simply using RF signal strength as a direct proxy for other broadband network characteristics. Below is a list of metrics that we believe are important for the Commission to include in its measurement effort:

- Speed (Throughput)
- Latency
- Jitter
- TCP Performance variables[6]
- Trace Route (IP packet path from client to server)
- Client RF Signal Strength
- Client RF Signal to Noise Ratio (SNR)
- Service Type (WCDMA, CDMA, GSM, EvDo)

---

[6] *See* e.g. RFC4898 describing available performance statistics for TCP http://www.ietf.org/rfc/rfc4898.txt and Web100's working implementation of 152 TCP performance variables http://web100.org/download/kernel/2.5.28/tcp-kis.txt.

- Cell Tower ID Number
- Location Area Code
- Client Geolocation Information
- Provider

a. Geographic Sampling

Sufficient geographic granularity is critical to effectively measuring performance of a wireless broadband service. Performance can change radically over the course of a fraction of a mile due to a range of factors, including terrain, foliage, obstructions, and interference. The objective in selecting an interval is to make the best effort to find the actual performance that a given user will experience. For example, in a rural area one-quarter-mile granularity on each public road can effectively sample the range of actual available mobile broadband service, even in the presence of terrain or trees; in a suburban or urban area, an interval as small as a city block may be more appropriate. CTC has performed and repeated tests of broadband performance and found significant variations over less than one-quarter mile in fairly standard light-suburban development. Built-up areas will have more obstructions and more variables affecting capacity and therefore will require smaller sampling intervals. Measurement sampling can be performed in a similar manner to that of Google Earth drive-by photography and measurement or in the manner in which carriers currently perform drive tests.

It is critical to both capture and quantify the users who are in poor service areas. Using too large a sampling interval can overestimate the available capacity, because a large sampling interval (such as a half-mile in a rural area with terrain and foliage) may miss many problem areas altogether. Practicality requires tradeoffs in any measurement effort—even an optimal set of measurements on public roads will underestimate actual coverage for all users, since it will not include users who are indoors or set back from the roads. Therefore, the measurements from the public roads will be an important and greatly improved measurement baseline with known, controlled measurement characteristics but will still likely represent an upper end. *The public road measurements will need to be augmented with other tools that sample a wider range of users, such as active and passive crowdsourced measurements.*

b. Temporal Sampling

Ideally, measurements should take place as close as possible to peak time, similar to carrier telephone metrics. Service provider networks should be able to determine the range of peak usage times from monitoring their internal network traffic at the physical granularity of particular base stations or sectors. One approach would be for measurements to take place within the peak six hours of usage of a day or within the peak forty hours of a week.

Technological innovations and new devices may radically change usage patterns—the increased use of app-phones or smart phones, followed by changes in pricing policies by carriers, may significantly impact broadband performance. Network upgrades may also change performance. Test intervals should reflect these changes. Six months may be an appropriate interval for repeating testing. Even so, this approach may still overestimate performance, since the most critical events (large-scale traffic problems, special events) may stress the network considerably harder than typical peak periods. Again, the approach provides a thorough and well-controlled baseline, but should be augmented by 'crowdsourcing' approaches to sample performance in the most critical periods.

III. PARTS OF THE NETWORK

The figure below depicts the various network segments providing connectivity from a mobile end-user to the content hosted on the public Internet, represented by the numbers in yellow circles.

Public Internet: The Public Internet or "network of networks" represents the interconnections between private and public networks, Internet Service Providers, Internet Exchange Points, content providers, and other entities in a geographically diverse (worldwide) manner.

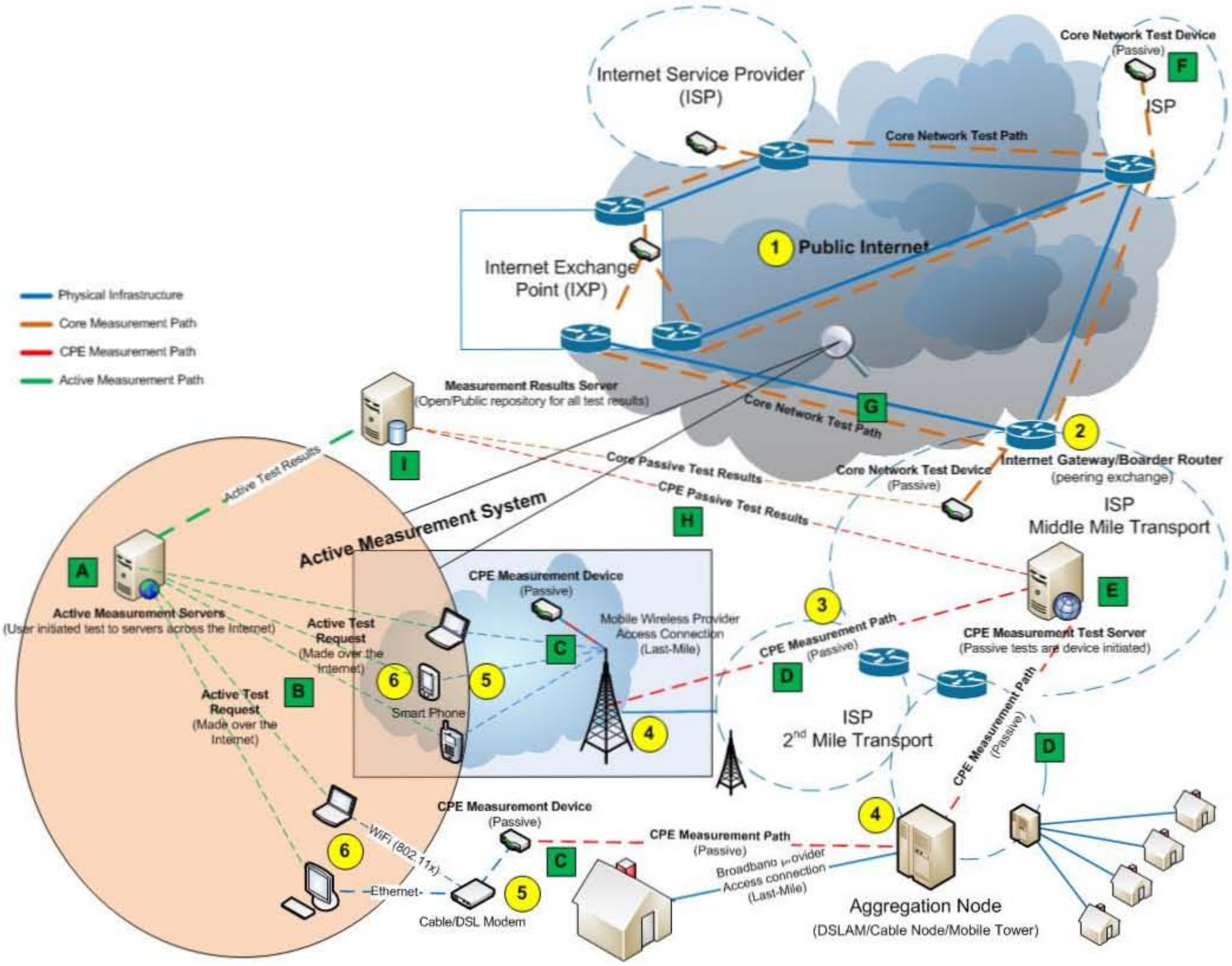
Internet Gateway/Border Router: The Internet Gateway or Border Router is the closest peering point between the Internet backbone and the internal middle mile network of an Internet Service Provider (ISP) and/or Internet Exchange Points (IXP).

Link between Middle Mile and 2nd Mile network: The connection between the middle mile network and a 2nd mile network is often provider managed.

Aggregation Node (Link between 2nd Mile and Last Mile network): The 2nd mile network terminates at an aggregation node, such as a cellular tower, etc., the first aggregation point from the provider's 2nd mile network to the start of the last mile network.

Consumer Devices: Consumer devices, such as desktop/laptop computers or cellular phones, connect to the network through an internal wired or wireless connection to a modem. In some cases the Customer device and modem can be the same piece of hardware, though in the case of laptops or netbooks the modem may come in the form of a USB dongle offered by the provider or an internal mobile radio expansion card. Hardware and software used to access and process content are usually managed by the consumer.

Figure 1: Measuring Mobile Broadband Services and the Internet



The above figure depicts our proposed system for measuring network segments and use from mobile end-users and points within the public Internet indicated by the letters in green squares. The numbered and lettered items below correlate with those items in the figure above.

A. Active Measurement Servers: Active Measurement Servers process user-initiated tests and are located within provider's Middle Mile network and at Internet Exchange Points to provide the best possible connection to Internet Gateway/Border Routers (circle 2).

B. Active Measurement Test Request: Users can, on mobile computers and other mobile devices (circle 6), request a test of their network by Active Measurement Servers located within their provider's Middle Mile networks or within other provider's Middle Mile networks over the Internet.

C. CPE Measurement Device: Managed devices connected to the Last Mile Network, just like Customer Premise Equipment (CPE) that request passive (not initiated by a user) network measurements of the providers network from the CPE Measurement Server (E).

D. CPE Measurement Path: A CPE Measurement Test connects to a CPE Measurement Server (E) after flowing from the user's device (circle 5), through the Aggregation Node (circle 4), and the 2nd Mile network into the Middle Mile (circle 3).

E. CPE Measurement Server: The CPE Measurement Server is the end point of the CPE Measurement Path and where testing tools and results are initially stored. The CPE Measurement server determines which tests, and at what frequency, the CPE Measurement Device initiates requests.

F. Core Network Test Device: Core Network Test Devices are located within provider's Middle Mile networks and Internet Exchange Points with best available connections to Internet Gateway/Border Routers (circle 2). They perform passive (not initiated by a user) measurements of Middle Mile to Middle Mile network states. The testing tools on Core Network Test Devices will be able to both initiate a test and respond to a request from another Core Network Test Device. Results are then relayed directly to the Measurement Results Server (I).

G. Core Network Measurement Path: The test path taken by Core Network Test Devices will be across primary peering points between ISP's and IXP's networks.

H. Passive Test Results: Results from the CPE Measurement Devices (C) and Core Network Test Devices (F) are sent to a central Measurement Results Server (I).

I . Measurement Results Server: All measurements from both passive [(CPE (C) and Core devices (F)] and active test (A) are stored on a Measurement Results Server, providing a central repository. All results are stored in a standard open format and available to the public for review analysis, and to researchers for independent verification of the data.

a. Measuring the end-to-end user experience

The objective of the tests should be to quantify the end-to-end and user experience, taking into account the full service provider network (radio access plus internal backhaul) but minimizing contributions from factors that may be due to causes unrelated to the broadband wireless network. Examples of suitable test server locations may be data centers in proximity to central Internet peering points. Multiple server measurement locations should be used in order to cancel problems related to the Internet and the data center but not the wireless network. This test methodology will also minimize intrusion into proprietary carrier facilities, reducing the cost and logistical impact of the testing, and also enabling testing to be performed without prior notice to the wireless service provider. Tests performed in this manner will measure the optimal experience for a user. Performance may be worse when trying to reach resources or sites with poor Internet access.

b. Core network testing - examining traffic and network management

A separate set of measurements should be performed under optimal RF and capacity conditions to sample the behavior of the broadband wireless core network and examine how the network operator is implementing quality-of-service and other traffic management techniques. This set of tests does not need to be conducted geographically throughout a network, simply near a peak time at a sample location served by a network core. Tests should include a range of applications, including media streaming, voice-over-IP, file downloads, VPN, and sampling of a range of source locations and traffic types (eg. peer-to-peer and client-server) in order to determine if traffic management practices or other configurations are affecting or limiting users on the network.

IV. TOOLS AND METHODS FOR MEASURING PERFORMANCE AND SERVICE COVERAGE

Measuring mobile broadband services requires a number of the procedures and tools used to measure wireline broadband network performance, plus the radio frequency (RF) and mobility tracking that has been part of planning, designing, deploying and testing radio and cellular services. As such, measurement tools and tests will need to include the standard set of wireless RF test tools used by wireless carriers and others, plus user devices with installed measurement software. This will require the Commission to expand its measurement processes compared with its efforts in measuring fixed broadband services. It may still use managed approaches such as SamKnows' sandbox.[7] Although, the SamKnows' approach may be useful in this context, in particular for assessing the availability of 3G or 4G broadband for home or business access, it will only provide a limited snapshot of the performance capabilities in any given area and will not account for the substantial variation in mobile broadband coverage and capabilities. This

[7] *See* https://www.testmyisp.com/faq.html.

will require the Commission to look at more systematic engineering approaches (described below) as well as utilizing 'crowdsourcing' methods both through active measurement test initiated by the end-user as well as more systematic, managed tests similar to SamKnows' approach but through software or applications installed directly on the mobile device.

One solution the Commission cannot rely on in the mobile context is the use of similar web-based, active measurement tools such as those currently provided on broadband.gov.[8] Limitations built into the operating system of smart phones often prevent users from running certain software including in browser Java that is utilized by a large number of web-based applications, meaning that web-based tests cannot be guaranteed to work properly through a smart phone user's browser.

With the diversity that exists in network architectures and the evolving nature of the Internet, an extensible and open measurement platform will ensure long-lasting positive impacts for consumers, researchers, and industry. An open platform will allow integration of new tools, support for more measurements, and upgrades as needed. Below *Commenters* propose several strategies for appropriately measuring mobile performance, a systematic engineering approach, end-user initiated measurement tests, and end-user passive tests.

a. Systematic engineering approach

A systematic engineering approach is important to characterize the network performance with high geographic precision using standardized test apparatus. The intent is to determine how standard consumer technology will function throughout the measurement area with adequate sampling, and to augment or replace less informative coverage maps currently posted by service providers. The tests should be performed with an inexpensive field test apparatus, and will not require entry to private property or proprietary wireless network facilities to establish useful

[8] *See e.g.* http://www.broadband.gov/qualitytest/about/.

baselines of performance data for a given coverage area. This approach should allow for the reasonable extrapolation of network performance for indoor connectivity from varying user devices, but should also be augmented by "crowdsourcing" methods (discussed below) to further quantify how users with a wide range of devices, software configurations, and indoor and outdoor locations experience wireless broadband.

Testing should include a sufficiently large number of packets to simulate a real flow of traffic and be reflective of actual use. Tests can be accomplished with user equipment flexible enough to interface with all the available wireless networks and with an external GPS source. Specially designed drive testing tools like Agilent E647A or TEMS are preferred examples. One standardized software and hardware configuration should be chosen and used for an entire set of observations. The measurement devices should record the frequency band, channel width, wireless protocols in use (1xRTT, HSPA, LTE), pilot sets thresholds, RX Power, TX Power, TX Gain Adjustment, FER, RPC Index, and RX /TX Vocoder Rates (though this information is expected to be more for analytical purposes than for display as primary data, i.e. for cross-check and analysis of other recorded data). Tests should be performed for all the broadband wireless services available at a location.

The measurement technique should not blindly use geographic information from the wireless device taking part in the test. Frequently, the precision is not adequate. The measurement technique should record the position from a device such as a vehicle GPS that the tester can verify matches with the road location. Since key national broadband parameters used by the FCC and the Department of Commerce include a residence served by wireless broadband as being "served" by broadband, it is important that testing be valid enough to find if supposedly "served" households are in fact underserved or entirely unserved.

b. End-user approach

As the Commission considers methods for measuring mobile broadband services through end-user devices, it is important to make a distinction between user-initiated "active" and client-side managed "passive" measurements. Active measurements are initiated by an end-user and measure the network for a specific time. Examples include basic speedtest tools to more sophisticated tools such as those found on the Measurement Lab platform.[9] Client-side managed passive measurement infrastructures involve hardware and software integrated into the networking technology to collect and track traffic and performance data over a network over time.[10]

i. Active measurement (end-user initiated tests)

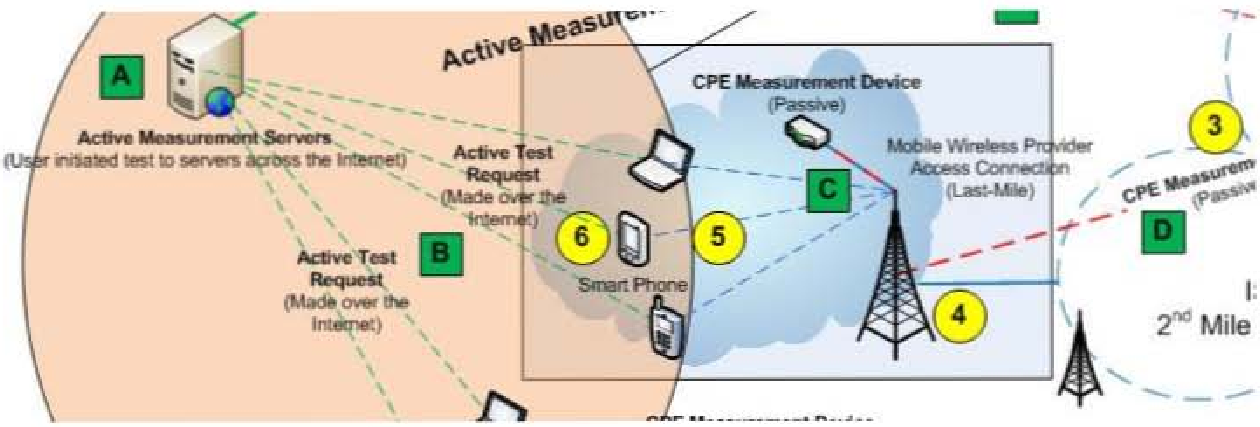


Figure 2: Active Measurement on End-User Devices

[9] *See e.g.* Steve Bauer, David Clark, and William Lehr, "Understanding Broadband Speed Measurements," Massachusetts Institute of Technology, available at http://mitas.csail.mit.edu/papers/Bauer_Clark_Lehr_Broadband_Speed_Measurements.pdf.

[10] *See e.g.* https://www.testmyisp.com/faq.html. Also note our use of the term Active vs. Passive in this paper is particular to the way that the test is initiated, e.g. "is the user actively or passively involved in initiating the test?" The research community recognizes a passive test as a test that observes the behavior of test object during normal operation. Under this definition, passive testing does not initiate the activity or use its own data as inputs where an active test introduces data and analyzes the result. While the definition of active and passive test used in this document is not identical to that often used in the research, there are many instances where tests can fit under both definitions.

Active measurements are initiated by an end user and measure the network during a specific task (square B). Examples include basic speedtest tests, but they can also include measuring more sophisticated performance and diagnostic tests to determining if an ISP is throttling or blocking specific applications.[11] The possible uses of active measurement systems for include: 1) consumers testing the performance capabilities of their broadband connection, 2) diagnostic tools to determine problems with a broadband connection or why an application is not working, 3) tools for consumers and regulators to compare actual broadband performance versus advertised, and, 4) experimentation and data collection for Internet researchers and regulators.

A sample architecture of an active measurement system is provided above in the cut-out from Figure 2. Measurement servers that process the user-initiated tests and are located within provider's Middle Mile network and Internet Exchange points (square A). Ideally, for most situations, servers are located as close as possible to a provider's Gateway/Border Router to accurately measure performance metrics and networking characteristics on the last-mile connection. (However, active measurement tools may also seek to examine the entire path of a transmission along multiple networks.) Broadband users on devices such as smart phones, laptops, or netbooks can run a test from the measurement server, which then processes the test, collects the data, and provides the user with results.

An example of a measurement system for consumers and researchers is Measurement Lab (M-Lab).[12] NAF is a founding member of M-Lab, which provides an open platform to assist scientific research by provisioning widely-distributed servers and ample connectivity for researchers' use; server-side tools that are open-sourced to allow third-parties to develop their own client-side measurement software; and open and publicly accessible data about Internet

---

[11] *See e.g.* http://www.measurementlab.net/measurement-lab-tools#tool5.
[12] *See* http://measurementlab.org/.

measurements for the research community, policymakers, and the public. M-Lab currently has two tools specifically designed for mobile broadband users: an Android smartphone application for its Network Diagnostic Tool (NDT) and WindRider tool for the Windows mobile platform.[13] Another example is Ookla's mobile broadband speedtest through native applications on the iPhone and Android smartphones.[14] The main challenge for active and passive measurement (discussed below) tools is developing an application for each smart phone platform as competing platforms have different standards and development processes. On other, non-smart phones, the process for designing application is even more cumbersome and closed. Although end-users may also utilize web-based measurement tools on M-Lab or Ookla via their netbook or laptop's browser, as noted earlier this is not feasible on smart phones.

Although M-Lab provides the public with access to raw data from a number of the active measurement tools available on its platform[15], for many other measurement tools or services, data collected from other measurement tests is unavailable to the public, researchers, or policymakers or, if access is available, come encumbered with problems such as fees, irreproducibility, or uncertainties regarding the test methods. This substantially limits the usefulness of the data. It is critical that any data collected through a Commission-led effort be open and publicly available to encourage robust and independent analysis.

---

[13] *See e.g.* http://www.measurementlab.net/measurement-lab-tools#tool6.
[14] *See* http://www.ookla.com/otherprojects.php.
[15] *See e.g.* http://measurementlab.org/news/2010/jun/18/more-good-thing-analyze-and-access-m-lab-data-using-google-bigquery-and-google-stor and http://measurementlab.org/data.

ii. Passive measurement (software or application initiated tests on the end-user device)

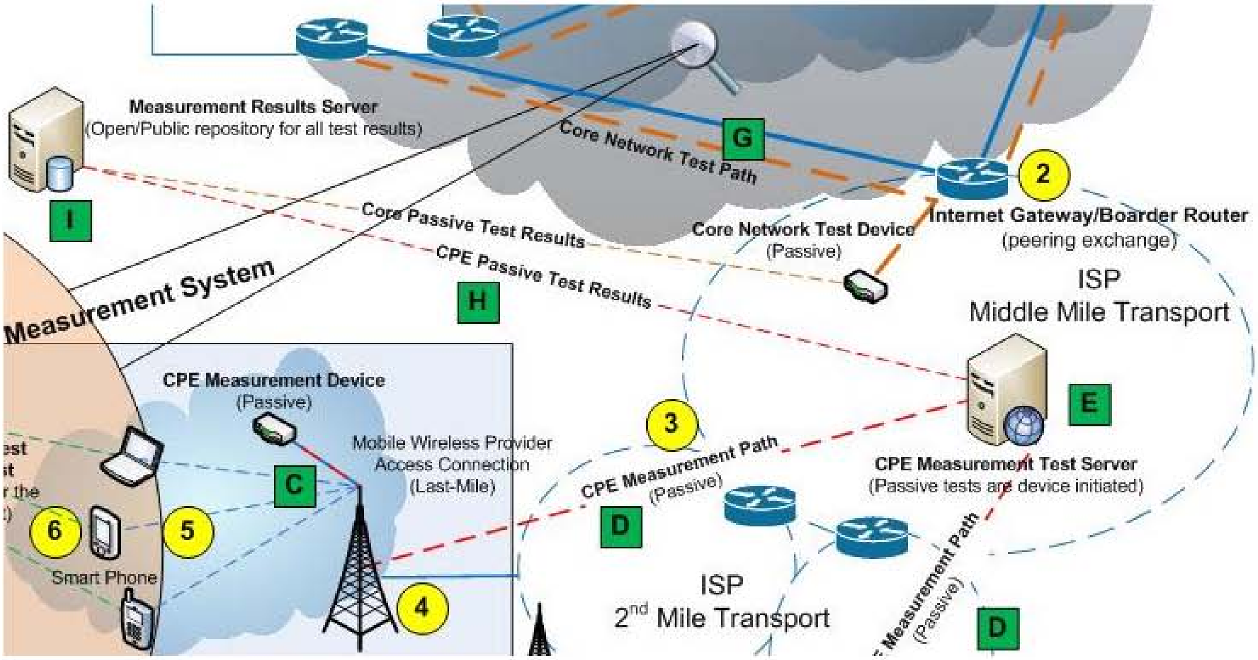


Figure 3: Passive Measurement on End-User Devices

Similar to user-initiated active measurements, passive measurements could be utilized to test mobile broadband connections without initiation from an end-user. In this model, a panel of selected users voluntarily could install software or application on their smart phone, laptop, or netbook that passively runs tests under controlled conditions and report them back to measurement server (square E). The benefits of this approach are that measurements can be collected in a consistent manner over time and representative panels can be designed. As with user-initiated active measurement tools, the main challenge for passive measurement tools is developing an application for each smart phone platform, each of which have different standards and development processes.

c. 'Crowdsourcing' device level performance measurements

As previously noted, M-Lab provides an open platform to assist Internet researchers and consumers in understanding their broadband connection. Currently, six tools are available, including two tests for mobile platforms, running on 16 nodes with 49 servers in regions around the globe. Among those are two tests that run as applications on smart phones: the NDT Android application and the WindRider test for Window mobile platform.

NDT provides a sophisticated speed and diagnostic test. An NDT test reports more than just the upload and download speeds. It also attempts to determine what, if any, problems limited these speeds, differentiating between computer configuration and network infrastructure problems. Recently, computer scientists at MIT completed a study of several broadband speed tests, including NDT and noted:

"[NDT] is an excellent testing tool and infrastructure. The insights to draw from this data, however, are not simple averages of the upload and download speeds from different user populations…. Rather the value of the NDT data is in understanding the sources of the performance bottlenecks for today's network users.[16]

NDT is an active test for a variety of performance metrics including: Download and Upload Speed, Latency, Jitter, Traceroute, Packet queuing, Existence of firewalls, Client system details, Round Trip Time.[17] The NDT application (app) available for the Android platform is a

[16] *See* Steve Bauer, David Clark, and William Lehr, "Understanding Broadband Speed Measurements," Massachusetts Institute of Technology, available at http://mitas.csail.mit.edu/papers/Bauer_Clark_Lehr_Broadband_Speed_Measurements.pdf.
[17] A full list of documented variables for the Web100 TCP Kernel Instrumentation used by NDT is available at http://www.web100.org/download/kernel/2.5.28/tcp-kis.txt.

variation of the NDT test utilized by the Commission in its consumer broadband test.[18] In addition to the above listed metrics, the NDT Android app collects mobile specific metrics including latitude and longitude.

The WindRider tool attempts to detect whether a consumer's mobile broadband provider is performing application- or service-specific differentiation, i.e. prioritizing or slowing traffic to certain websites, applications, or content.[19] It initiates a series of downstream and upstream transfers with the Measurement Lab Server and records statistics regarding the observed performance. The different transfers are initiated on different ports in order to see if the provider is differentiating traffic based on application; for example, web transfers experience faster speeds than applications on other ports. Active measurement results are stored on the Measurement Lab servers. Passive measurements are also performed on the mobile device with the user's opt-in agreement. The application measures the delays experienced by different web pages and records explicit user feedback about different applications. The passive tests collect statistics regarding the delays experienced by same pages on different providers and locations and attempt to determine if certain web pages experience higher delays on certain providers or do not load at all. The statistics are uploaded to the WindRider developer's servers and not to the Measurement Lab servers.[20]

As the Commission considers utilizing various 'crowdsourcing' tools, Commenters urge the Commission to focus on two key aspects to maximize the usefulness and public benefit:

- **Measurement transparency:** The lack of transparency in both methodology and source code is an important criticism often mentioned in critiques of broadband speed tests.

---

[18] *See* http://www.broadband.gov/qualitytest/about/.
[19] *See* http://www.measurementlab.net/measurement-lab-tools#tool6.
[20] *See* http://www.cs.northwestern.edu/~ict992/mobile.htm.

Therefore, it is important for the Commission to ensure that any measurement tools should be open source, with an open API, to allow for independent verification of test methodologies and maximum extensibility. Transparency is a cornerstone to the M-Lab project. M-Lab requires all its tools to be open source, providing anyone with an opportunity to examine their contents and offer suggestions for improvement. For example, anyone who wants to find out how NDT tests are conducted can view its test methodology on the FCC's NDT help page, in more detail on the NDT Google Code Project Page, or on the NDT Internet2 page. [21] For even greater detail, anyone can download the complete test application source code for further investigation and analysis.

- **Publicly accessible data:** Openness and publicly available "raw" data are also key to maximizing the benefits of measurements for consumers, researchers, policymakers, innovators, and service providers alike. M-Lab provides the public with access to the data from a number of the measurement tools running on its platform. Currently, M-Lab datasets (currently featuring tens of terabytes, and counting, from the NDT, NPAD, and Glasnost tools) are available on Amazon Web Services and Google Storage for Developers.[22] The usefulness of measurements of broadband connections and the Internet to improve research, innovation, and public policy is substantially tied to the data being made open and accessible. It is critical that any data collected through this Commission effort be open and publicly available to encourage robust research, analysis and independent verification, while also protecting user privacy. The Commission

[21] *See* http://www.measurementlab.net/news/2010/apr/01/good-data-better-no-data-m-lab-built-continually-improve-data-collection-efforts.
[22] *See e.g.* http://www.measurementlab.net/news/2010/jun/18/more-good-thing-analyze-and-access-m-lab-data-using-google-bigquery-and-google-stor.

should also provide easy to comprehend summary reports in the form of info-graphics and interactive visualizations to ensure an important feedback loop from all broadband consumers in the data verification process.

i. Measurement variations based on device and/or location

It is unclear to what extent measurements tools, particularly end-user measurement tools installed on devices can account for variations in device capabilities and/or location. It will in large part depend on the specific measurement tool. For example, M-Lab's NDT application for the Android platform collects data on a device's operating system and software environment. Such data points could allow the Commission to control for those device specific factors in a regression analysis of the data.

The issue of variations due to locations within a building is a bit more of a challenge. End-user measurement tools can often utilize the GPS capabilities within a smart phone to provide the location of a user within a few feet, but they do not know if said user is indoors or at a specific elevation, etc. Therefore, it is not possible to account for those factors through the initial data collection from the measurement tool on a mobile phone other device. However, the Commission could overlay Google mapping or similar data to determine if there is a building there or if there are other geographical factors that may account for some variation in the performance.

The systematic engineering approach discussed earlier may allow the Commission to better account for indoor v. outdoor variation and other variations in performance due to location. For example during network design, the carriers typically use simulation tools in order to provide for indoor coverage. The RF simulation tools can account for additional losses. Thus, for example, if a carrier needs a target signal level of -75dBm for reliable indoor coverage, then they will simulate the same using RF tools such as RFCAD. At times, a site survey is performed in order to check the level of building penetration and material used for construction. The same is true for coverage within trains. Typically for indoor coverage, the carriers rely to a large extent on customer complaints[23] about dropped calls and connection failures and will make upgrades to the network accordingly. In some instances, the upgrades call for use of a Distributed Antenna System (DAS) where the main purpose is to provide indoor coverage.

The Commission could also model all of the various factors (building construction type, basement, etc.) through controlled experimentation to determine the typical range of signal impairment due to controlled factors. From this, the Commission could generate a range of coverage maps that illustrate effective coverage with these factors in place for typical scenarios. These maps would be mathematically extrapolated from reference drive test measurements we presented earlier. For example, the Commission could have an online map that shows basic driving coverage/data speeds, with checkboxes the user can enable for typical impairment factors, like “typical home indoors, basement, stucco, high-rise building, etc.” This way, if a consumer wants to know if their 4G modem will work if installed in the basement next to a structured wiring panel, they can get this information from a map by zooming in on their house with the box checked for “basement.”

ii. Impact on the network and/or device

It is possible that tests running on the overloaded devices or networks might create a misleading test result. The capabilities of different mobile phones for example are likely to impact the type of measurement tool that can be installed, impacting what type of measurements the application could make and how much the measurement tool could affect the performance of the device. The problem is less pronounced on smart phones, where the processing power

[23] *See e.g.* http://www.deadcellzones.com/indoor_factors.html.

should be sufficient to handle most measurement applications, but could be an issue on less advanced phones. This is a risk that can only be minimized, but not easily removed. For example M-Lab's most widely used test, NDT, addresses this issue by generating data streams from program memory, thus minimizing issues with hard drive activity and memory swaps. Within a single connection, it performs tests with multiple TCP streams in 5 millisecond increments and analyzes and error checks to see if anything appears to have impacted the test. These advanced diagnostic features enables both client and server machines to collect more detailed information than most other broadband tests. These results include all of the TCP diagnostic data needed to identify end-to-end problems affecting throughput.[24]

IX. BENEFITS AND COSTS OF MEASUREMENT

a. Benefits to consumers, researchers, service providers and policymakers

Empowering Consumers and Promoting Competition

As the Commission correctly concluded, "the proper functioning of competitive markets is predicated on consumers having access to accurate, meaningful information in a format that they can understand."[25] This is currently not the case in advertising for mobile broadband services provide little information on any performance metrics for the service. Ideally, an FCC-led measurement effort would provide consumers with access to performance information on a very granular level, i.e. where they live, work, or travel for metrics such as average speed, latency, jitter, and RF signal strength on each provider. This could come in the form of an FCC-led effort or preferably through an open and publicly accessible raw data set that would allow

[24] *See* http://www.measurementlab.net/news/2010/apr/01/good-data-better-no-data-m-lab-built-continually-improve-data-collection-efforts.
[25] *Second Truth-in-Billing Order* at para. 3.

any number of organizations or businesses to take the data and develop a myriad of customer comparisons and guides.

Improving Public Policy

Measuring mobile broadband would also be useful for a number of policy issues. First it will help the Commission better ascertain the availability of 3G and 4G mobile broadband coverage in areas across the country, serving as a useful comparison for both provider self-reported coverage and state level broadband mapping. Second, an in-depth analysis of mobile broadband performance will also help the Commission better ascertain the potential substitutability of the service as compared to fixed broadband service. Third, as the Commission examines complex issues of network congestion and network management, a broad-based measurement effort to look at end-user performance but also core network functionality, traffic flows and usage analysis is critical. The Commission is currently in the unfortunate position of depending entirely on the network information shared by the provider that would be affected by a policy and regulatory change. Data that are publicly accessible and independently verifiable would support public analysis of actual Internet traffic on mobile broadband networks to inform salient debates on technical, economic, policy, privacy, and social issues relating to the Internet – many of which have been shrouded in secrecy.[26]

Spurring Research and Innovation

Obstacles to the collection and analysis of Internet traffic and performance data since the transition to the commercial Internet pose not only formidable technical and engineering challenges, but more daunting legal, logistical, and proprietary considerations. In combination, these issues have left the Internet research community continually struggling to validate research

[26] *Id.*

that foster new network innovations. An FCC effort to collect measurements of mobile broadband networks offers an unprecedented opportunity to provide rigorous empirical data against which to validate theory, modeling, and support for scientific research, development of new measurement technology and evaluation of proposed future Internet architectures. Key to this benefit is public access to the underlying raw measurement data, in easily readable and standard formats to spur robust analysis.

Helping Service Providers

The measurement effort along with consumer access to measurement tools on their devices would also benefit mobile broadband service providers. First, through measurement 'crowdsourcing' service providers could better understand where the gaps for their service exist, particularly as they relate to data speeds and latency that may not be evident from their standard RF measurements or modeling. Second, advanced end-user measurement tools such as NDT that measure both performance as well as attempts to determine if there are any problems as a result of device configuration would be extremely useful to providers to better assist consumers when they are having an issue with the service and allow for them to distinguish between network infrastructure problems and those associated with their consumer device.

b. Costs of measurement

Though we cannot comment on the cost associated for providers to measure their network performance or assist with a measurement effort, we can provide some estimated costs for the M-Lab server platform. As of June 2010, the M-Lab has a total of 16 nodes with 49 servers are operational across geographically distributed regions in the United States, Europe and Australia. M-Lab nodes are provided by various corporate, academic, and governmental entities. An M-Lab node is composed of multiple "server-class" computers for redundancy with dual eight- core Intel Xeon processors running at 2 or more gigahertz and three or more gigabytes of main memory in each computer. Further, each node is connected to one or more Internet service providers (ISPs) with dedicated 1 gigabit per second upstream capacity. Each node is standardized and well provisioned for conducting accurate high-bandwidth measurements. Although it is difficult to quantify the actual cost of M-Lab infrastructure and operations due to its open platform and crowd sourced nature, it is estimated the total investment to date exceeds $2.5 million since the projects creation 2 years ago.

c. Legal, security, privacy or data sensitivity issues

Measurement tools that only look at communication “flows” will for the most part limit privacy concerns for end-users. At M-Lab each tool generates and sends data back and forth between an end-user device and an M-Lab server. The tools collect data related to the particular communication "flows" generated by the client-server test and do not collect information about the user’s other Internet traffic such as emails and Web searches, unless they affirmatively provide it in response to a specific request (such as a form that asks the user to provide an email address).[27] Some researchers may offer client-server tests that use the M-Lab server platform, combined with separate components that measure other Internet traffic and do not rely on M-Lab. These tools will only report the client-server test data back to M-lab and will not report any data about your other Internet traffic back to the M-Lab servers. That data will go directly to the researcher responsible for the tool.

All M-lab tools do collect the full IP address of the user. Unfortunately, a partial IP address would not be useful to researchers for future analysis. For example, if a researcher wanted to analyze the variance in performance among tests conducted by different hosts within the same ISP edge prefix, it would be important to be able to distinguish data from tests

[27] *See e.g.* http://www.measurementlab.org/faq#b.

conducted by different endpoints from those of multiple tests conducted by the same endpoint. In addition, if a researcher wanted to join data from two different experiments in their analysis, having only partial IP address information would make it impossible to do 1:1 matching of test data generated by the same host using a different tool. In short, storing complete IP address data maximizes the research value of the data for various dimensions of analysis and enables future innovation by the research community in the analysis of broadband network data.

X. CONSUMER INFORMATION ON MOBILE BROADBAND PERFORMANCE

For a consumer to (1) choose a provider, (2) choose a service plan, (3) manage the use of the service plan, and (4) decide whether and when to switch to an existing provider of the plan, they need to have information that is easily available and comparable between providers, services, and plan. However, service providers routinely disclose little meaningful information regarding the performance capabilities of their service, often limiting such information to overly broad coverage maps, while failing to provide consumers with even a minimal understanding of the actual performance of the service. This creates substantial confusion for consumers when choosing among mobile service providers, assessing the value of the service, understanding whether their favorite mobile application will work as expected on a provider's network, or what it might cost them to use that application.

As discussed below, the providers coverage maps present service quality only in a few contour levels, described with qualitative terms such as Good, Fair, and Poor, rather than quantifying a data rate for the service in that area. Such an absence of data is particularly problematic, given the Commission's reliance on mobile broadband to improve competition in the broader broadband marketplace as provided in the National Broadband Plan. Without any means to understand the actual performance of the service, consumers currently lack the necessary information to assess the value of a mobile broadband service versus a fixed broadband service and whether it will meet all of their broadband needs.

Providing clear, meaningful, comparable disclosures ultimately spurs competition between providers and encourages the future development of new broadband technologies. In particular, consumers would substantially benefit from standardized disclosures of performance capabilities. For example, NAF developed a sample truth in broadband label, based on a nutrition label and on the "Schumer box" required for lenders.[28] The label could be adapted to wireless services and made available in advertisements, at the point of sale and in monthly bills to more clearly inform consumers of not just actual performance but other essential information about their service.[29] Moreover, the providers could also improve their service coverage maps to reflect some measure of the actual performance capabilities of their service at an address level. Although the variation in demand per cell phone tower would make defining a universally accurate metric for something like speed difficult, it seems plausible that providers could utilize their own RF measurements along with data on the utilization of the tower on a daily basis to develop a more useful metric such as average speed or a minimum speed based upon a carrier defined uptime percentage.[30]

[28] *See* Comments of the New America Foundation, CG Docket No. 09-158, (Sept. 25, 2009), available at http://fjallfoss.fcc.gov/ecfs/document/view?id=7020385891.
[29] *See* Comments of the New America Foundation *et al.*, CG Docket No. 09-158, (July 6, 2010).
[30] NAF's sample truth in broadband label proposed that broadband providers should offer a minimum guaranteed speed based upon an uptime of 95%. *See* Comments of the New America Foundation, *supra note* 30.

XI. CURRENT INDUSTRY PRACTICES AND COVERAGE MAPS

a. Coverage and service maps

The four major carriers in the U.S. (AT&T, Verizon Wireless, Sprint, and T-Mobile) currently have coverage maps on their websites.[31] Unfortunately, many of the maps present service quality only in a few contour levels, described with qualitative terms such as Good, Fair, and Poor, rather than quantifying a data rate. Also, the coverage maps describe coverage available from the network base stations under optimal conditions and typically do not take into account congestion or small-scale variations in coverage or available data capacity. In our experience, carrier maps are sometimes not based on actual coverage but on projected coverage, with the carrier assuming a particular distribution of base stations and a particular RF model. For example, CTC has observed in locations where a carrier is known to be planning to add a new base station that the carrier indicates on the website that coverage already exists, but in reality there is only poor coverage or no coverage.

b. Technologies used to collect

The carriers use RF simulation tools such as RFCAD[32] in order to decide the need for additional sites in a particular geographic region based on coverage and capacity needs. These tools allow the carrier to model around different parameters such as the frequency bands, antenna height, antenna gain, and transmit power. The tools also account for factors such as terrain, foliage, and atmosphere. The receive signal levels are set based on the carrier defined thresholds for different coverage levels such as urban vehicular, indoor residential or on-street.

---

[31] *See e.g.* http://www.wireless.att.com/coverageviewer/#?type=data, http://www.verizonwireless.com/b2c/CoverageLocatorController?requesttype=NEWREQUEST&coveragetype=broadband, http://coverage.sprint.com/IMPACT.jsp?ECID=vanity:coverage, and http://www.t-mobile.com/coverage/pcc.aspx.

[32] *See* http://www.rfcad.com/.

As part of their operations, carriers perform a field test as part of activating or upgrading their system. Some of the parameters tested are:

- Call-send and packet-send origination: This test checks if the radio link connection (RLC) has been established for the initial call set up. RLC failure occurs due to poor RF conditions or low transmit power levels
- Handover (HO) success/failure: In order to ensure seamless communication, the carriers check for handoff between sectors of the same site or between neighboring sites. This test shows command such as HO Fail/ HO Success
- Ec/No
- Receive signal levels: This test is to check the coverage level (indoor, vehicular, on street) at different signal levels
- Active neighbor set update to scan for strong neighbors for hand off purposes
- Inter-radio access technology testing- while moving between one base station to another
- Sustained download rate for the duration of the connection

Carriers perform drive tests to verify that the network supports voice calls and specified data throughputs. Mapping tools such as MapInfo create a driving route for each area under test. The test is conducted using specially designed drive testing tools such as Agilent E647A[33] or TEMS.[34] Drive testing is normally conducted using minivans or SUVs in order to give enough room to set up the test equipment. The team typically consists of two people. The set up takes approximately 30 to 45 minutes. The testing equipment consists of a laptop for logging data, two

---

[33] *See e.g.* http://www.home.agilent.com/agilent/product.jspx?nid=-536900143.536880705.00&cc=US&lc=eng.
[34] *See e.g.* http://archive.ericsson.net/service/internet/picov/get?DocNo=28701-FAP9010495.

mobile stations, a GPS receiver and a scanner. Once the set up is complete and a call connect is established, the team drives a pre-defined path. The team is instructed to drive at 25 to 30 mph. The data is continuously collected, logged and stored. If at any point during the drive the call disconnects or the system freezes, the team stops the vehicle and reboots the equipment so as to not have gaps in the collected data.

Once the route is completed, the log file is closed, and the data are transferred to an external disk drive. The team transports the data to the data processing and analyzing team who then analyses the data using tools such as the Lucent Data Analysis Tool (LDAT). LDAT allows the carrier network engineer review each individual command, analyze the recorded data and make changes to the operational network parameters. If a particular section of the drive is a trouble area, then the drive testing team repeats the measurements after the engineer makes changes to the site.

XII. CONCLUSION

The comments provide an overview of a number of approaches to measuring mobile broadband including a systematic engineering approach and end-user measurement tools that could be utilized by the Commission. We encourage the Commission to think broadly about measurements for mobile broadband; focusing not just on metrics useful to consumers, but also creating viable sources for data on mobile Internet traffic and network performance for network researchers and policymakers. We believe that the key to this effort will be utilizing a number of testing methods and measurement, maximizing the openness and transparency of the measurements, and ensuring that data is publicly available to allow for independent and robust analysis. Taken together, these efforts will bring much-needed transparency to the broadband marketplace, empower consumers, spur research and innovation, and improve public policy.

Respectfully submitted,
/s/

Benjamin Lennett
Dan Meredith
Sascha Meinrath
Open Technology Initiative
NEW AMERICA FOUNDATION
1899 L Street NW, Suite 400
Washington, DC 20036
(202) 986 - 2700

Andrew Afflerbach, Ph.D.
Shivani Gandhi
COLUMBIA TELECOMMUNICATIONS CORPORATION
10613 Concord Street
Kensington, MD 20895
www.ctcnet.us

July 8, 2010