

Methodology

The study detailed in this Report, which took place from February through June of 2011, represents the first comprehensive analysis of wireline broadband performance in the United States. The techniques used in the study, which are described in more detail below and in the Appendix, were developed through a collaborative process involving 13 major ISPs, academics and other researchers, consultants, and consumer organizations.

It is important to note some limitations in this effort. Only the most popular service tiers within an ISP's offerings were tested, even though some service providers may offer additional tiers.²¹ In addition, the data collected is only analyzed at the national level, and does not permit meaningful conclusions about broadband performance at the local level.²² The results only include measurement of the data path from content source to the consumer, and any bandwidth limitations or delays incurred in the consumer's home or in segments of the Internet outside an ISP's network are not reflected in the results.

For practical reasons, certain consumer broadband technologies are not analyzed in this Report. Mobile broadband services, which are increasingly important to consumers, were not included in this study due to the special challenges inherent in measuring the actual performance of mobile networks. The FCC has issued a Request for Information on measurement approaches for mobile broadband, as well as a Public Notice on this topic,²³ and is undertaking additional efforts to collect performance data on mobile data services. Due to the small number of consumer volunteers for satellite and fixed wireless services in the current study, limited data was collected on these technologies, and consequently these results are not included in this study. However, the data captured for both of these technologies is included in the raw bulk data set.

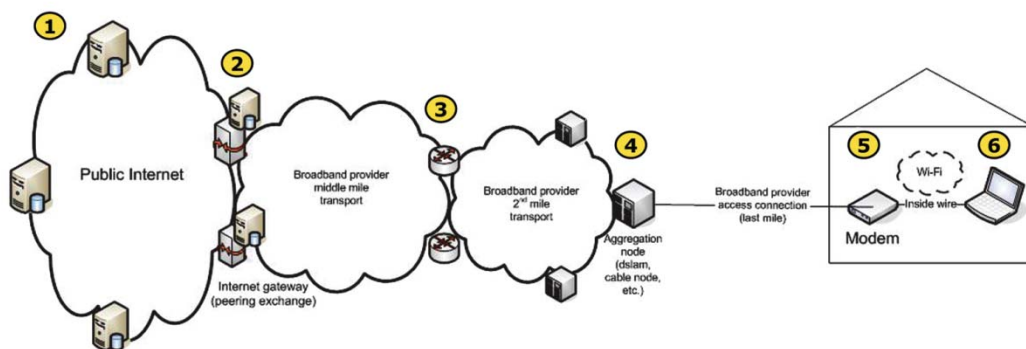
At the outset of this study, the Commission launched an open competition for entities that could assist with the design and management of a study of broadband performance. The FCC ultimately selected SamKnows to administer the FCC's broadband performance testing initiative. SamKnows is an analytics company that had recently completed a similar study of broadband performance for Ofcom, the United Kingdom's telecommunications regulatory agency. In July 2010 Commission staff held an open meeting to announce the start of the project and to seek input from interested parties. At the inaugural and subsequent meetings, industry, consumer groups, and academic attendees expressed an interest in participating in the study.

Overall, 22 stakeholders contributed to this project, including 13 wireline ISPs; academic researchers from MIT and Georgia Tech; technology vendors and consumer groups; and other industry representatives.²⁴ Most stakeholders, including all participating ISPs, signed a Code of Conduct, included in the Appendix to this Report, which helped ensure the integrity of the study and its results. Participants contributed significantly to this project by, among other things: creating and agreeing on a standard methodology for testing broadband performance; collaborating on the parameters for these tests; providing proposals for how to analyze the

data; validating the panelist information to ensure that the test results were properly correlated to the correct service tier; and developing strategies to maintain the privacy of the panelists and the integrity of the testing. Commission staff also held a number of open meetings where the public was able to express views on the study.

The basic objective of the study was to measure broadband service performance as delivered by an ISP to the home of a consumer. As illustrated below, many factors contribute to end-to-end consumer broadband performance.

Figure 1: Network diagram



DEFINITIONS

- 1 **Public Internet content:** public Internet content that is hosted by multiple service providers, content providers and other entities in a geographically diverse (worldwide) manner
- 2 **Internet gateway:** closest peering point between broadband provider and public Internet for a given consumer connection
- 3 **Link between 2nd mile and middle mile:** broadband provider managed interconnection between middle and last mile
- 4 **Aggregation node:** First aggregation point for broadband provider (e.g. DSLAM, cable node, satellite, etc.)
- 5 **Modem:** Customer premise equipment (CPE) typically managed by a broadband provider as the last connection point to the managed network (e.g. DSL modem, cable modem, satellite modem, optical networking terminal (ONT), etc.)
- 6 **Consumer device:** consumer device connected to modem through internal wire or Wi-Fi (home networking), including hardware and software used to access the Internet and process content (customer-managed)

Not all elements of broadband performance are under the control of the consumer's ISP, and there are factors that affect a consumer's broadband experience that were not measured in this study. For example, broadband performance experienced by the consumer may be affected by the capabilities or limitations of the consumer's own computer or local area network (LAN) devices such as home WiFi routers, or by the performance of the content and application providers the consumer is accessing, such as a search engine or video streaming site. In these instances, the broadband provider is controlling only a portion of the chain that determines the overall performance experienced by the consumer. There are other aspects of broadband performance that are technically outside the ISP's network, but that can be affected by the ISP's behavior, such as peering arrangements, which are the policies by which an ISP exchanges traffic with another ISP. In future performance measurements, it will be important to keep in mind that these arrangements by ISPs—which were not measured in the present study—can

affect broadband performance. The ultimate goal is to know how well consumer broadband is working in actual use conditions.

This study focused on those elements of the Internet pathway under the direct or indirect control of a consumer's ISP on that ISP's own network: from the consumer gateway—the modem used by the consumer to access the Internet—to a nearby major Internet gateway point (from the modem to the Internet gateway in Figure 1, above). This focus aligns with the broadband service advertised to consumers and allows a direct comparison across broadband providers of actual performance delivered to the household.

More than 78,000 consumers volunteered to participate in this study and a total of approximately 9,000 consumers were selected as potential participants and were supplied with specially configured routers. The data in this Report is based on a statistically selected subset of those consumers—approximately 6,800 individuals—and the measurements taken in their homes during March 2011. The participants in the volunteer consumer panel were recruited with the goal of covering ISPs within the U.S. across all broadband technologies, although only results from three major technologies—DSL, cable, and fiber-to-the-home—are reflected in this Report.²⁵ To account for network variances across the United States, volunteers were recruited from the four Census Regions: Northeast, Midwest, South, and West. Within each Census Region, consumers were selected to represent broadband performance in three typical speed ranges: less than 3 Mbps, between 3 and 10 Mbps, greater than 10 Mbps.²⁶

The testing methodology itself required innovation on both the consumer, or “client,” side and on the ISP, or “server,” side. The server-side infrastructure, which comprised reference measurement points that were distributed geographically across nine different U.S. locations, was made available to SamKnows for the project by M-Lab, a non-profit organization that supports Internet research activities.²⁷ Each consumer participant's broadband performance was measured from a hardware gateway in his or her household to the off-net test node that had the lowest latency to the consumer's address.

On the “client” side of the test, consumers self-installed a measurement gateway that was provided by SamKnows. These gateways, or “Whiteboxes,” were installed between the consumer's computer and Internet gateway and came pre-loaded with custom testing software. The “Whitebox” software was programmed to automatically perform a periodic suite of broadband measurements while excluding the effects of consumer equipment and household broadband activity. This approach permitted a direct measure of the broadband service an ISP delivered to a consumer's household.

The participating ISPs also volunteered to establish two kinds of additional reference measurement points within their own networks. Some ISPs installed a measurement reference point within their networks at a major peering facility, which represented the mirror image of the SamKnows peering reference points. These reference points served as a validity check and verified that the SamKnows measurements were not significantly affected by peering relationships or other network degradations. Some ISPs also installed measurement points at various ISP interior network points that did not correspond to the M-Lab peering locations. These reference points were principally intended to test for performance degradations caused

by bandwidth limitations in “middle mile” segments,²⁸ or for effects caused by the specific design of the network. Test results demonstrated that measurements from all ISP-installed reference points, regardless of location, agreed closely with the results from the M-Lab peering reference measurements, which strengthens confidence in the results. The general correspondence between results taken from the M-Lab and the independent ISP reference points also suggests that among the ISPs tested, broadband performance that falls short of expectations is caused primarily by the segment of an ISP’s network from the consumer gateway to the ISP’s core network.²⁹ The results contained in this Report are based on the measurements obtained from the M-Lab peering reference points only, while the raw bulk data set contains all results, including those from the ISP-only reference points.