

ENDNOTES

<sup>1</sup> John Horrigan and Ellen Satterwhite, *Americans' Perspectives on Online Connection Speeds for Home and Mobile Devices*, 1 (FCC 2010), at [http://hraunfoss.fcc.gov/edocs\\_public/attachmatch/DOC-298516A1.doc](http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-298516A1.doc) (finding that eighty percent of broadband consumers did not know what speed they had purchased).

<sup>2</sup> Aaron Smith, HOME BROADBAND 2010, Pew Research Center's Internet & American Life Project at 8, available at <http://www.pewinternet.org/~media/Files/Reports/2010/Home%20broadband%202010.pdf> (last accessed July 8, 2011).

<sup>3</sup> See CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN (2010), available at <http://www.broadband.gov/plan/> ("NBP").

<sup>4</sup> See [http://www.broadband.gov/qualitytest/?TB\\_iframe=true&height=500&width=470&qt=true](http://www.broadband.gov/qualitytest/?TB_iframe=true&height=500&width=470&qt=true) (last accessed July 8, 2011).

<sup>5</sup> The Consumer Broadband Test allows consumers to choose between testing performed by one of two entities: Ookla and M-Lab. However, these tests use different upload and download criteria, and so can return different results for the same broadband connection.

<sup>6</sup> *Consumer Information and Disclosure; Truth-in-Billing and Billing Format; IP-Enabled Services*, Notice of Inquiry, 24 FCC Rcd 11380 (2009).

<sup>7</sup> *Need for Speed Information for Consumers of Broadband Services*, CG Docket No. 09-158, Public Notice, 26 FCC Rcd 5847 (2011).

<sup>8</sup> NBP, Recommendation 4.4 at 45.

<sup>9</sup> The only fiber-to-the-home broadband service studied in this report is Verizon's FiOS. Other services use fiber optic technology and may be marketed as "fiber." See, e.g., note 36 *infra*.

<sup>10</sup> Participating ISPs were: AT&T (DSL); Cablevision (cable); CenturyLink (DSL); Charter (cable); Comcast (cable); Cox (cable); Frontier (DSL); Mediacom (cable); Insight (cable); Qwest (DSL); TimeWarner (cable); Verizon (DSL and fiber-to-the-home); and Windstream (DSL).

<sup>11</sup> As described more fully in the Appendix, this study allowed for a target deployment in up to 10,000 homes across the United States, and the final volunteer pool was created from over 75,000 initial volunteer broadband subscribers. Although test results were taken from 7,500 households over the course of the study, the results that are analyzed in this Report reflect broadband performance to 6,800 homes during the month of March 2011.

<sup>12</sup> In addition to the various data sets, the actual software code that was used for the testing will be made available for academic and other researchers for non-commercial purposes. *See infra* note 43.

<sup>13</sup> ISPs typically quote speeds or information rates in units of Megabits (millions of bits) per second, known as Mbps. A bit is the basic unit of information in computing.

<sup>14</sup> Sustained speeds are described in the Appendix and are averaged over five second intervals across the high and low rates that might dynamically occur in very short time interval measurements.

<sup>15</sup> Those earlier reports of broadband speeds in the United States and the United Kingdom had shown ISPs delivering a smaller percentage of advertised speeds. *See* FCC, BROADBAND PERFORMANCE, OBI Technical Paper No. 4, available at [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2010/db0813/DOC-300902A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2010/db0813/DOC-300902A1.pdf); Ofcom, UK BROADBAND SPEEDS (2009), available at <http://stakeholders.ofcom.org.uk/binaries/research/telecoms-research/broadbandspeeds.pdf>.

<sup>16</sup> The term “average” applied to results in this Report always means the arithmetic mean of the sample set under consideration. There is no weighting of samples in calculating averages.

<sup>17</sup> Although DSL-based services demonstrated overall performance that was somewhat slower and more subject to latency than cable and fiber-to-the-home, DSL is generally less expensive than either of other technologies discussed in this Report, which could be a considerable benefit to some consumers, and a significant factor in their choice of broadband provider.

<sup>18</sup> A 24-hour average was computed each day and then averaged over Monday through Sunday.

<sup>19</sup> In this context, the closest server is the measurement server providing minimum round-trip time.

<sup>20</sup> For example, downloading a large file while browsing the web would limit the effectiveness of PowerBoost.

<sup>21</sup> ISPs typically advertise a smaller number of speed tiers but must support legacy tiers – tiers promoted at one time but no longer offered for new subscription – until they are migrated to higher speeds. During deliberations with ISPs for this trial, some noted that they maintain a larger number of service tiers than they currently promote and advertise and that they may support as many as ten service tiers at a given time.

<sup>22</sup> This was a result of the limited number of white boxes – approximately 9,000 – that could be deployed over the course of the project. Region-specific data would have required an order of magnitude or greater deployment of equipment, at a corresponding increase in cost.

<sup>23</sup> See *Comment Sought on Measurement of Mobile Broadband Network Performance and Coverage*, Public Notice, 25 FCC Rcd 7069 (2010); *Request for Information: Measurement and Reporting of Mobile Broadband Performance and Coverage*, FEDBIZOPPS.GOV (Oct. 8, 2010), available at [https://www.fbo.gov/index?s=opportunity&mode=form&id=987657347a39a85e109ee4e057517340&tab=core&\\_cview=1](https://www.fbo.gov/index?s=opportunity&mode=form&id=987657347a39a85e109ee4e057517340&tab=core&_cview=1).

<sup>24</sup> In addition to the 13 ISPs who took part in this study, contributors included M-Lab, ADTRAN, Corning, Fiber to the Home Council, Georgia Tech, Intel, MIT, Motorola, National Cable Television Association, the New America Foundation, and the US Telecom Association.

<sup>25</sup> An initial goal for the project included measurements for satellite and fixed terrestrial wireless technologies as well. While consumer volunteers were obtained for these technologies, these test results were not included in this Report due to the low number of samples. Such results were included in the raw bulk data set. This data also includes test results for speed tiers for DSL, cable, and fiber-to-the-home technologies for which an insufficient number of panelists was recruited to create a statistically significant sample.

<sup>26</sup> These speed ranges were chosen to provide alignment with broadband tiers as categorized in the “Form 477” reports that the Commission uses as its primary tool for collecting data about broadband networks and services. See *Modernizing the FCC Form 477 Data Program*, Notice of Proposed Rulemaking, 26 FCC Rcd 1508, 1512 n.27 (2011), citing *Development of Nationwide Broadband Data to Evaluate Reasonable and Timely Deployment of Advanced Services to All Americans, Improvement of Wireless Broadband Subscribership Data, and Development of Data on Interconnected Voice over Internet Protocol (VoIP) Subscribership*, Report and Order and Further Notice of Proposed Rulemaking, 23 FCC Rcd 9691, 9700-01 (2008).

<sup>27</sup> M-Lab is a non-profit corporation supporting research on broadband networks that maintains an open, distributed server platform for researchers to deploy Internet measurement tools. More information on M-Lab can be found on its website, <http://www.measurementlab.net/>.

<sup>28</sup> “Middle mile” transport refers generally to the transport and transmission of data communications from the central office, cable headend, or wireless switching station to an Internet point of presence. In contrast, “last mile” refers to the connection between a consumer’s home and that consumer’s broadband service provider’s first aggregation point.

<sup>29</sup> A simple view of an ISP’s network from the consumer perspective is that it consists of a path connecting the consumer’s modem to a major aggregation point and that such aggregation points are connected with high bandwidth facilities

forming a core or backbone network. Connecting paths joining one or more subscribers to these aggregation points typically have significantly less bandwidth or capacity than the connecting links between aggregation points and other major locations within this core network.

<sup>30</sup> A byte is a standard unit of measure in computing indicating 8 bits. A megabyte represents 8 million bits.

<sup>31</sup> This latency is often colloquially called the “ping time,” named after a network tool used to measure the latency. The measurement methodology used in this Report differs slightly from that tool, but the results should be essentially the same.

<sup>32</sup> See International Telecommunication Union (ITU), *Series G: Transmission Systems and Media, Digital Systems and Networks; International Telephone Connections and Circuits – General Recommendations on the Transmission Quality for an Entire International Telephone Connection*, G.114 (May 2003).

<sup>33</sup> The March 2011 data set was validated to remove anomalies which would have produced errors in the Report. This data validation process is described in the Appendix.

<sup>34</sup> For a discussion of how averages were calculated for the purposes of this Report, see *supra* note 16.

<sup>35</sup> Throughout this Report, results are recorded separately for CenturyLink and Qwest. These two entities completed a merger on April 1, 2011; however, during the testing in March 2011, they were separate companies.

<sup>36</sup> U-Verse is a service mark offering of AT&T supporting a bundled service package of voice, video, and Internet services. U-Verse incorporates multiple technologies. The most common arrangement is a fiber-to-the-node architecture with DSL technology terminating to the home. All U-Verse panelists tested during this survey utilized DSL technology.

<sup>37</sup> As noted elsewhere, see *supra* note 16, all averages used in this Report are unweighted arithmetic averages of the relevant data sets. However, the sample plan was based on market share data for all ISPs. Comparison of unweighted averages with averages weighted by market share showed close agreement.

<sup>38</sup> Only 10 out of 53 service tiers tested in this study returned less than 80 percent of advertised performance during peak periods.

<sup>39</sup> A 50 Mbps service tier can be seen in this chart, but not in other charts that provide results for individual ISPs. This is a result of filtering for low sample counts. While a 50 Mbps service tier is offered by some of the ISPs included in the study, our survey did not obtain enough samples to include this service tier in results for individual ISPs. However, when aggregated by technology, the number of independent samples for 50 Mbps exceeded our threshold criteria for the study.

<sup>40</sup> We provide latency figures for peak periods. As noted earlier, latency during peak periods was seen to increase by about 7.6% across all technologies. Latencies

---

measured for other periods can be found in  
<http://www.data.fcc.gov/download/measuring-broadband-america/statistical-averages.xls>.

<sup>41</sup> See <http://www.data.fcc.gov/download/measuring-broadband-america/statistical-averages.xls>.

<sup>42</sup> For a definition of web loading time, see Appendix at 24-25.

<sup>43</sup> To apply for non-commercial review of the code, interested parties may contact SamKnows directly at [team@samknows.com](mailto:team@samknows.com), with the subject heading “Academic Code Review.”