

## *Chapter 1*

# **COMPETITION AMONG U.S. BROADBAND SERVICE PROVIDERS\***

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## **EXECUTIVE SUMMARY**

More than one quarter of American homes have not adopted Internet service, many citing cost as their primary reason. Since market competition can significantly affect consumer prices, we set out to ask: how many Internet service providers (ISPs) are available to consumers at different levels of download speeds?

Looking at Internet service options available to households in December 2013, using data from the Census Bureau and National Telecommunications and Information Administration, we find that more service providers offer lower-speed than higher-speed service. At download speeds of 3 megabits per second (Mbps), which is the Federal Communications Commission's current approximate standard for basic broadband service, 98 percent of the population had a choice of at least two mobile ISPs and 88 percent had two or more fixed ISPs available to them.

However, as multiple household members increasingly consume video streaming services music streaming, and online games, the adequate broadband speed bar has been raised. To understand just how slow 3 Mbps is,

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\* This is an edited, reformatted and augmented version of OCE Issue Brief # 01-14, issued by the Economics and Statistics Administration, U.S. Department of Commerce, December 2014.

it takes about 2.25 hours to download a 6 gigabyte movie. The same movie would only take 16 minutes to download at 25 Mbps.

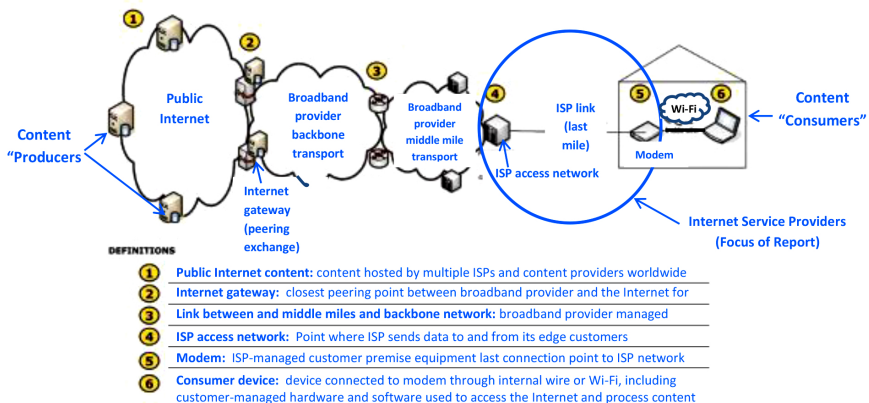
At somewhat higher speeds, such as 10 Mbps, the typical person still is able to choose among two fixed ISPs. The typical person also has the option of choosing among three mobile ISPs. At even higher speeds, however, the number of providers drops off dramatically. For example, only 37 percent of the population had a choice of two or more providers at speeds of 25 Mbps or greater; only 9 percent had three or more choices. Moreover, four out of ten Americans did not live where very-high-speed broadband service – 100 Mbps or greater – is available. Of those with access to broadband at this speed level, only 8 percent had access to two or more providers; 1 percent had access to three or more. Only 3 percent of the population had 1 Gbps or greater available; none had two or more ISPs at that speed.

The report examines both fixed and mobile ISPs. We separate our analysis of these two types of Internet access because some groups consider them to be imperfect substitutes, especially for higher-bandwidth applications. Mobile ISPs typically charge high fees if consumers exceed data usage limits. Furthermore, the service is less reliable, companies have not fully deployed newer generation technologies with higher download speeds and reduced latency, and mobile service is virtually non-existent at download speeds of 25 Mbps or greater.

In sum, the report finds that the number of ISPs from which consumers can choose varies by speed; there are multiple providers of lower speed broadband but this number dwindles at higher speeds. All else equal, having fewer competitors at a given speed is likely to drive up prices. As a result, some consumers will decide not to adopt Internet access at all, some will choose a slower speed than otherwise, and some will economize in other ways.

## INTRODUCTION

Over the past two decades, the Internet has had profound and rapidly growing effects on the economy, culture, and social interactions of Americans. Yet more than one in four households in the United States have not adopted broadband technology to access the Internet at home (on a computer, tablet, or mobile device). About 29 percent of households that have not adopted home Internet service cited cost as the primary reason.<sup>1</sup>



Adapted from Federal Communications Commission, “Exhibit 4-1: Simplified View of Internet Network Connections,” Connecting America: The National Broadband Plan, 2010, p. 45 (<http://www.fcc.gov/national-broadband-plan>).

Figure 1. Simplified View of Internet Network Connections.

Competitive market forces – the ability for a broadband service subscriber to switch ISPs – are powerful disincentives for ISPs to exercise market power. Increased market power by sellers often results in higher prices for consumers. In addition, increased market power may adversely affect customers in other ways, such as reductions in product quality or variety, service, or innovation.<sup>2</sup> Some observers have suggested that existing levels of broadband (including mobile) service competition are sufficient to limit the exercise of market power, thus keeping subscription rates consistent with the cost of service.<sup>3</sup>

This report uses Census block-level data<sup>4</sup> from two sources to understand the level of competition<sup>5</sup> in fixed and mobile residential broadband services (where “fixed” service includes wireline and terrestrial fixed wireless service<sup>6</sup>):

- The December 31, 2013 National Telecommunications and Information Administration’s State Broadband Initiative (SBI), which includes data on ISPs including their broadband technologies and advertised speeds they offered; and
- Population data from the Census Bureau’s 2010 Decennial Census Summary Files. We find that at download speeds of 3 Mbps, which is the approximate definition of basic “broadband” download speeds,<sup>7</sup> 98 percent of the population had a choice of at least two mobile ISPs, and 88 percent had two or more fixed ISPs available to them.

However, as multiple household members increasingly consume video streaming services<sup>8</sup> (often “cutting the cord” and abandoning traditional cable television<sup>9</sup>), music streaming, and online games, the bar for what constitutes adequate broadband speed has been raised.<sup>10</sup> For example, at 3 Mbps it takes about 2.25 hours to download a 6 gigabyte movie (and downloading such a movie may exhaust many monthly data caps on mobile service). In contrast, at download speeds of 25 Mbps it takes only 16 minutes to download the same size movie.<sup>11</sup> The Federal Communications Commission (FCC) currently suggests for single usage a range of 0.7 Mbps for “standard steaming videos” to 4 Mbps for “HD-quality streaming movie or university lecture.”<sup>12</sup> The FCC says 1-2 Mbps is adequate for up to three users performing “basic functions” (“email, web surfing, basic streaming video”), but if more persons are using basic functions plus one or more “high-demand applications” (i.e., “streaming HD, video conferencing, OR online gaming”) then as much as 15 Mbps or more may be needed.<sup>13</sup> Netflix recommends between 0.5 and 25 Mbps depending on the level of video picture definition.<sup>14</sup>

The following section provides a brief overview of the ISP industry (Box 1) as well as additional detail of the degree of competition in the ISP industry. The Appendix describes the data and methodology used in this report, includes a table with a more complete set of estimates of competition, and provides definitions of the ISP technologies discussed in the report. The Appendix also discusses and reconciles recent FCC estimates of the degree of choice in ISPs that are lower than ours.

At 10 Mbps, the typical person still is able to choose among two fixed ISPs. The typical person also has the option of choosing among three mobile ISPs. At even higher speeds, however, the number of providers drops off dramatically. For example, only 37 percent of the population had a choice of two or more providers at speeds of 25 Mbps or greater; only 9 percent had three or more choices. Moreover, four out of ten Americans did not live where very-high-speed broadband service – 100 Mbps or greater – is available. Of those with access to broadband at this speed level, only 8 percent had access to two or more providers; 1 percent had access to three or more. Only 3 percent of the population had 1 Gbps or greater available; none had two or more ISPs at that speed.

**Box 1. The Internet Service Provider Industry**

The Internet service provider (ISP) industry is part of a larger ecosystem that produces, transmits, and consumes information via the Internet. Figure 1 is a schematic diagram of the interconnected networks that comprise the Internet. Content producers and consumers constitute “edge users” (depicted on the left and right sides of Figure 1).<sup>i</sup> Consumers obtain access to the Internet by subscribing to ISPs that connect consumers’ computers via “last mile” connections owned by ISPs. Edge users’ data are transmitted to and from their ISPs’ last mile connection points (point 4 in Figure 1) to “middle mile” networks (see point 3 in Figure 1) and then on to very high-capacity and high speed backbone networks owned by some larger ISPs and other companies (see point 2 in Figure 1), which together comprise the “core” of the Internet. Within this core, end users’ data are handed off from one network to another and ultimately to destination end users under interconnection arrangements. Such arrangements might be zero-price “peering” agreements if data flows are symmetric, or they might entail fees if data flows are asymmetric or a content provider pays for more direct (hence faster) interconnection. The focus of this report is depicted in the blue oval of Figure 1, which includes ISPs’ first mile connections between their subscribers and the middle mile of the Internet. The main categories of ISPs include:<sup>ii</sup> Landline telephone companies, which provide broadband service primarily using two different technologies. The most widely available of the technologies is digital subscriber line (DSL), which was available to about 89 percent of the population in 2013 but subscribed to by only 21 percent of households. The other technology, optical fiber, is much faster than DSL but very costly to install. It is available to 24 percent of the population but only 8 percent of households had subscriptions in 2013. Cable television companies provided Internet access to 43 percent of households, although it was available to 88 percent of the population. Cable ISPs use several different technologies, including copper co-axial lines (increasingly using software to increase speeds) and optical fiber. Mobile wireless companies have increased the speed of the data services they provide. However, their ability to substitute for wireline ISPs is limited by congestion, transmission sensitivity to obstacles between the user and the cell tower, and constraints on the availability of the electromagnetic spectrum. These companies are sometimes owned by telephone companies that also offer wireline ISP services.

Wireless broadband service (including fixed terrestrial service) was available to 99 percent of the population, while 56 percent of adults own a smartphone.<sup>iii</sup> In sum, while many different broadband service technologies exist, differences in congestion, reliability, and capacity constraints limit their substitutability— and these variations should be kept in mind when considering competition among ISPs in this report.

<sup>i</sup> The distinction between “consumers” and “providers” is not clear. Consumers often produce content such as photographs, videos, and blogs and upload them to content producer websites and applications, such as Facebook or Tumblr, which utilize uploaded content.

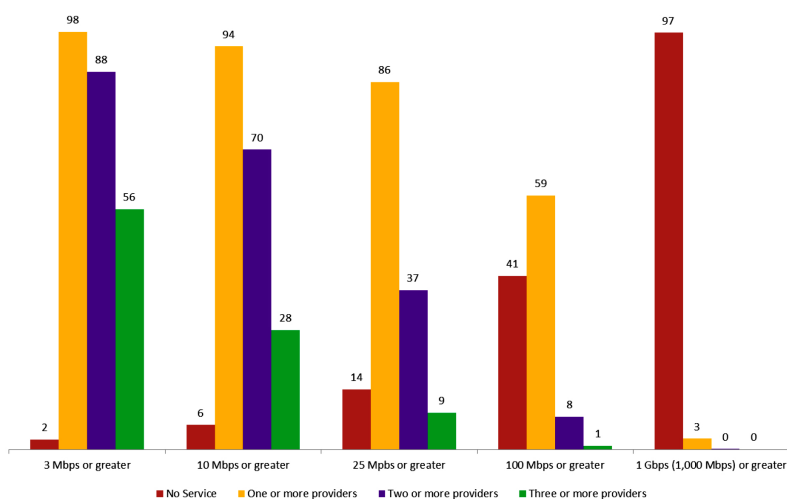
<sup>ii</sup> See the Appendix for more detailed definitions of broadband technologies other than dial-up and satellite. In this box, except where otherwise indicated, all estimates of the share of households that subscribed to an ISP using a particular technology are from File, Thom and Camille Ryan, “Computer and Internet Use in the United States: 2013,” American Community Survey Reports, ACS-28, U.S. Census Bureau, Washington, DC, 2014 (<http://www.census.gov/content/dam/Census/library/publications/2014/acs/acs-28.pdf>, accessed November 14, 2014). (Note that households may subscribe to more than one technology.) All estimates of the share of population for which the technology was available are from <http://www.broadbandmap.gov/summarize/nationwide> (accessed September 24, 2014). Two other fixed broadband service technologies each were used by 2 percent or less of households in 2011 and may be weak substitutes for wireline broadband service (National Telecommunications and Information Administration and Economics and Statistics Administration. Exploring the Digital Nation: America’s Emerging Online Experience. U.S. Department of Commerce. June 2013. Available at <http://esa.doc.gov/sites/default/files/reports/documents/digitalnation-americasemergingonlineexperience.pdf>). Terrestrial fixed wireless service (classified under “other broadband services”) is often offered in rural areas where the average fixed cost per household of deploying wireline service is much higher than in more densely populated areas. Speeds are lower than for wireline services, costs per megabyte are generally higher (see Federal Communications Commission’s (FCC) 2010 report Connecting America: The National Broadband Plan <http://www.fcc.gov/national-broadband-plan>, p. 37), and it requires a clear line-of-sight to obtain acceptable service. For these reasons, until recently, it has not been a close substitute for wireline Internet service, but some argue that may change (Eric Geier, “Meet WISP, the wireless future of Internet service” PC World <http://www.pcworld.com/article/2067283/meet-wisp-the-wireless-future-of-internet-service.html> accessed September 29, 2014). Satellite broadband service has generally offered slower speeds with lower data caps and greater latency problems at higher prices than wireline broadband service; satellite ISP availability is not collected in the data used in this report.

<sup>iii</sup> Kathryn Zickuhr and Aaron Smith, “Home Broadband 2013.” Pew Research Center. August 26, 2013. (<http://www.pewinternet.org/2013/08/26/home-broadband-2013/> accessed September 25, 2014).

## THE CURRENT STATE OF COMPETITION AMONG BROADBAND SERVICE PROVIDERS

### Overall

Both the fixed and mobile ISP sectors are highly concentrated. The five largest fixed ISP companies (excluding fixed terrestrial fixed wireless ISPs) serve over three-quarters of the 84.3 million cable and telephone company fixed ISP customers.<sup>15</sup> The four largest mobile ISPs (Verizon Wireless, AT&T, Sprint Nextel, and T-Mobile together accounted for 92 percent of total industry revenues of \$175 billion in 2011<sup>16</sup>). ISPs that provide fixed service are generally cable television and telephone companies, some of which also provide mobile Internet service (for example two of the largest wireline ISPs – Verizon and AT&T – are also two of the largest mobile ISPs).



Source: December 2013 National Telecommunications and Information Administration State Broadband Initiative dataset; Census Bureau’s 2010 Decennial Census; and author’s calculations.

Figure 2. December 2013 Population Shares by Numbers of Available Fixed Broadband Providers by Maximum Available Advertised Download Speed in Mbps.

These aggregate subscribership numbers, however, do not tell us the extent of competition among ISPs in any given location or any given speed; this is done in the following subsection of the report.

## **At Home**

Figures 2 and 3 show respectively the percent of U.S. population with various numbers of residential fixed and mobile ISPs available at different download speeds as of December 2013. The estimates are shown for a wide range of download speeds due to the absence of a clear consensus about what speeds are adequate for various purposes and for multiple household members sharing an Internet connection. We show separate estimates of the number of fixed and mobile provider choices available to residents because there is some debate over how substitutable mobile broadband service is for fixed service (see endnote 3).

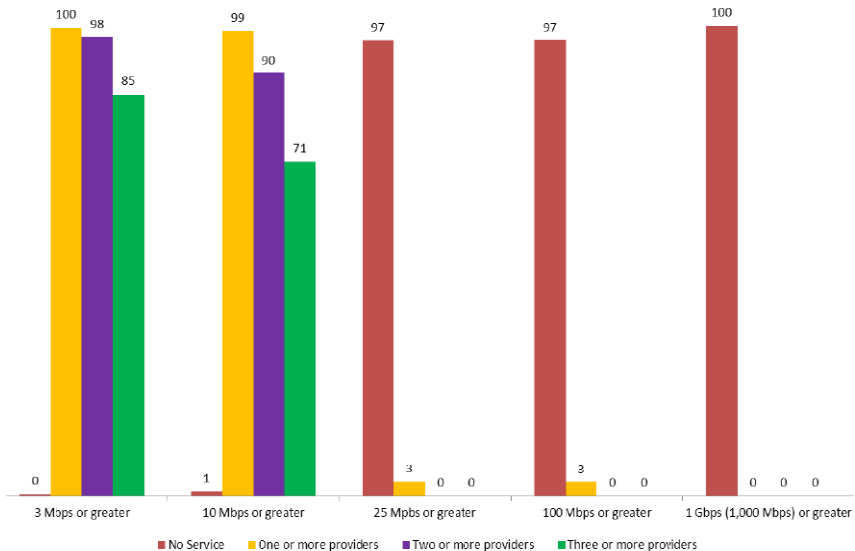
For example, Figure 2 shows that at download speeds of 3 Mbps or greater, 98 percent of the population had at least one fixed ISP available (in other words, 2 percent had no ISP available); 88 percent had two or more ISPs available; and 56 percent had three or more ISPs from which to choose.<sup>17</sup>

Figures 2 and 3 show that nearly all residents had fixed and mobile broadband service available at basic download speeds of 3 Mbps or greater, with nearly all having a choice of at least two ISPs (88 percent for fixed service and 98 percent for mobile) and a majority of residents having three ISPs to choose from (56 percent for fixed service and 85 percent for mobile service). A large majority of the population had at least two providers at speeds up to 10 Mbps or greater (70 percent for fixed and 90 percent for mobile), but far fewer had a choice of three or more providers (28 percent for fixed and 71 percent for mobile).

However, at speeds of 25 Mbps or greater, mobile service was nearly nonexistent (only 3 percent of the population had service at that speed). For fixed service, 86 percent had access to 25 Mbps or greater speeds, but only 37 percent of persons had a choice of two or more fixed ISPs, and only 9 percent had a choice of three or more. While about 6 out of 10 persons had a fixed ISP available offering speeds of 100 Mbps or greater, only 8 percent had two or more providers at those speeds, and 1 percent had three or more. Finally, only 3 percent of the population had fixed ISP service at speeds of 1 Gbps or greater available, and none had two or more providers at that speed. Broadband service with speeds of 1 Gbps or greater is available in only a



handful of communities, in many cases provided by municipal utilities or Google.<sup>18</sup>



Source: December 2013 National Telecommunications and Information Administration State Broadband Initiative dataset; Census Bureau's 2010 Decennial Census; and author's calculations.

Figure 2. December 2013 Population Shares by Numbers of Available Mobile Broadband Providers by Maximum Available Advertised Download Speed in Mbps.

At speeds of 10 Mbps or greater, the typical (i.e., median) person had a choice of three mobile providers. At those speeds, the typical person also could choose from two fixed service providers (see Appendix Table 1), although in some cases mobile and fixed ISPs may be owned by the same company.

## CONCLUSION

Broadband download speeds up to 10 Mbps may be less than optimal for increasingly popular higher-bandwidth applications such as streaming video and audio and multi-player online games, especially in households with multiple simultaneous Internet users. This report shows that in December 2013, the typical person could choose between two fixed broadband providers

at download speeds of 10 Mbps. The typical person also has the option of choosing between three mobile broadband service providers at 10 Mbps. At even higher speeds, however, the number of providers drops off dramatically. For example, only 37 percent of the population had a choice of two or more providers at speeds of 25 Mbps or greater; only 9 percent had three or more choices. Moreover, four out of ten Americans did not live where very-high-speed broadband service – 100 Mbps or greater – is available. Of those with access to broadband at this speed level, only 8 percent had access to two or more providers; 1 percent had access to three or more. Only 3 percent of the population had 1 Gbps or greater available; none had two or more ISPs at that speed.

In sum, our report finds that broadband competition across the U.S. varies by speed, with lower speeds seeing multiple providers but a dwindling in available ISPs with higher speeds.

## **TECHNICAL APPENDIX**

### **Data and Methodology**

This report uses data from the December, 2013 National Telecommunications and Information Administration's (NTIA) State Broadband Initiative (SBI) dataset and the Census Bureau's 2010 Decennial Census Summary Files, which are described in David Beede and Anne Neville, "Broadband Availability in the Workplace" National Telecommunications and Information Administration and Economics and Statistics Administration, Broadband Brief No. 3 (November 2013). A new feature of the December 31, 2013 SBI dataset is that it has nearly complete (covering 90.5 percent of the population) information about the class of end-user served by wireline ISPs: residences only, businesses only, or both. (Mobile service is assumed to be offered to both residences and businesses.)

These two datasets were merged by Census block to obtain the following data for each block:

- 2010 population
- ISP identification numbers
- Maximum advertised download speed level offered by each ISP in that block

- Technology used by each ISP in that block
- The class of end-user served by the ISP in that block

To understand how the estimates in Figures 2 and 3 (and the more complete set of estimates in Appendix Table 1) were developed, the steps for calculating a particular number are outlined below. For example, in order to obtain the percent of population with two or more fixed technology ISP providers offering speeds of 10 Mbps or greater (37.3 percent), the following was done:

- For each Census block, the number of fixed technology providers offering speeds of 10 Mbps or greater to residences was counted.
- The population for the subset of Census blocks with two or more such ISPs was summed.
- The total subpopulation in the preceding step was divided by total US population and the result multiplied by 100 to arrive at the share of the population with two or more fixed technology ISP providers offering speeds of 10 Mbps or greater.

The preceding list of steps was repeated for each combination of

- Maximum speed level (there were 9 different speed levels ranging from 0.768 megabit per second to 1,000 megabits – i.e., 1 gigabit – per second)
- Technology class (fixed or mobile)
- End-user class (residence or business)
- Number of ISPs offering service (zero providers, one or more providers, two or more providers, or three or more or more providers)

To reach the estimates in Figures 2 and 3, it was assumed that mobile and terrestrial fixed wireless ISP service is available to all consumers and businesses, and that all wireline (i.e., fixed excluding terrestrial fixed wireless) ISPs with missing end-user class information served residences. In contrast, treating all the fixed ISPs with unknown end-user class as not serving residences reduces the population shares with various levels of competition by roughly five percentage points (both sets of estimates are shown for mobile and fixed technologies in Appendix Table 1). We also show estimates for wireless (i.e., mobile plus terrestrial fixed wireless) and wireline technologies

in Appendix Table 2. Note that the results reported in the main body of this report combined wireline broadband service ISPs with terrestrial fixed wireless ISPs to examine competition among fixed ISPs because NTIA suggested that fixed terrestrial wireless service was more of a substitute for wireline than for mobile service. In a recent speech (“The Facts and Future of Broadband Competition” 1776 Headquarters, Washington, DC, September 4, 2014 available at [https:// apps.fcc.gov/edocspublic/attachmatch/DOC-329161A1.pdf](https://apps.fcc.gov/edocspublic/attachmatch/DOC-329161A1.pdf)), FCC Chairman Tom Wheeler reported estimates on wireline (i.e., not including fixed terrestrial wireless) broadband service competition at download speeds of 25 Mbps or greater, based on similar data used in this (ESA’s) report. The FCC estimates show less competition than the results we report in Figure 2 and the middle panel of Appendix Table 1 for fixed ISPs (in which we assume ISPs with missing end-user class information served residences). The main reason for the different estimates is the inclusion or exclusion of fixed terrestrial wireless. However, the FCC estimates are within one percentage point of ESA’s estimates of wireline competition shown in the bottom panel of Appendix Table 2 (assuming ISPs with missing end-user class information do not serve residences). These remaining differences are due to the fact that ESA looked at population shares and did not take upload speeds into account, while the FCC looked at housing unit shares and did take upload speeds into account. All this is summarized in the following table:

**Competition Estimates at Download Speeds of 25 Mbps or Greater  
(in percents of population or housing units)**

	ESA (Figure 2 and Middle Panel of Appendix Table 1)	ESA (Bottom Panel of Appendix Table 2)	FCC
No ISPs	14.1	20.0	19.4
One or more ISP	85.6	80.0	80.6
Two or more ISPs	37.3	26.3	25.3
Three or more ISPs	8.7	2.5	2.4
Main Difference in Methodology	Fixed ISP technologies (includes fixed terrestrial wireless service)	Wireline ISP technologies (does not include fixed terrestrial wireless service)	Wireline ISP technologies (does not include fixed terrestrial wireless service)
Minor Differences in Methodology	<ul style="list-style-type: none"><li>• Looks at percent of population</li><li>• Does not take upload speeds into account</li></ul>		<ul style="list-style-type: none"><li>• Looks at percent of housing units.</li><li>• Takes upload speeds into account (3 Mbps or greater)</li></ul>

**Appendix Table 1. December 2013 Population Shares by Numbers of Available Mobile and Fixed Broadband Providers By Maximum Available Advertised Download Speeds in Mbps\* (in percents)**

Number of Residential Service Providers	Greater than or equal to 0.768 Mbps	Greater than or equal to 1.5 Mbps	Greater than or equal to 3 Mbps	Greater than or equal to 6 Mbps	Greater than or equal to 10 Mbps	Greater than or equal to 25 Mbps	Greater than or equal to 50 Mbps	Greater than or equal to 100 Mbps	Greater than or equal to 1,000 Mbps
<u>Mobile Service</u>									
None	0.2	0.2	0.4	0.9	1.0	96.9	97.0	97.0	100.0
>=1	99.8	99.8	99.6	99.1	99.0	3.1	3.0	3.0	0
>=2	99.2	98.5	97.6	92.0	89.9	0	0	0	0
>=3	94.6	87.8	85.4	80.6	71.2	0	0	0	0
Median	5	4	4	4	3	0	0	0	0
<u>Fixed Service: Residential Service Providers</u> (including providers with unspecified end user categories)									
None	1.5	1.8	2.4	3.7	5.8	14.1	17.3	40.6	97.4
>=1	98.5	98.2	97.6	96.3	94.2	85.9	82.7	59.4	2.6
>=2	92.5	91.4	88.3	80.5	70.1	37.3	23.8	7.7	0.2
>=3	62.8	60.8	56.2	44.0	28.0	8.7	4.3	0.9	0.1
Median	3	3	2	2	2	1	1	1	0
<u>Fixed Service: Residential Service Providers</u> (excluding providers with unspecified end user categories)									
None	4.6	5.0	5.7	7.2	9.3	18.3	21.5	44.0	97.8
>=1	95.4	95.0	94.3	92.8	90.7	81.7	78.5	56.0	2.2
>=2	87.4	86.4	83.5	76.2	66.2	35.0	21.8	7.2	<0.05
>=3	57.1	55.2	51.2	40.9	25.8	8.0	3.8	0.7	0
Median	3	3	3	2	2	1	1	1	0

\*Megabits per second.

Sources: December 2013 National Telecommunications and Information Administration's State Broadband Initiative dataset, the Census Bureau's 2010 Decennial Census Summary Files, and ESA calculations.

**Appendix Table 2. December 2013 Population Shares by Numbers of Available Wireless and Wireline Broadband Providers By Maximum Available Advertised Download Speeds in Mbps\* (in percents)**

Number of Residential Service Providers	Greater than or equal to 0.768 Mbps	Greater than or equal to 1.5 Mbps	Greater than or equal to 3 Mbps	Greater than or equal to 6 Mbps	Greater than or equal to 10 Mbps	Greater than or equal to 25 Mbps	Greater than or equal to 50 Mbps	Greater than or equal to 100 Mbps	Greater than or equal to 1,000 Mbps
<u>Wireless Technologies*</u>									
None	0.1	0.2	0.3	0.7	0.9	82.0	89.5	92.1	99.9
>=1	99.9	99.8	99.7	99.3	99.1	18.0	10.5	7.9	0.1
>=2	99.5	99.1	98.5	94.2	90.8	2.8	1.1	0.3	0
>=3	96.8	93.0	90.6	84.5	74.6	0.7	0	0	0
Median	5	5	4	4	3	0	0	0	0
<u>Wireline Technologies: Residential Service Providers (including unknown end users)</u>									
None	3.5	3.9	4.7	5.9	7.5	15.8	17.9	41.1	97.5
>=1	96.5	96.2	95.3	94.1	92.5	84.2	82.1	58.9	2.5
>=2	86.0	84.6	79.8	71.5	63.0	28.7	18.8	3.7	0.2
>=3	27.6	27.0	24.6	17.7	12.4	3.2	1.7	0.3	0.1
Median	2	2	2	2	2	1	1	1	0
<u>Wireline Technologies: Residential Service Providers (omitting unknown end users)</u>									
None	8.2	8.5	9.3	10.5	12.0	20.0	22.0	44.5	97.8
>=1	91.8	91.5	90.7	89.5	88.0	80.0	78.0	55.5	2.2
>=2	80.3	78.9	74.6	67.0	59.2	26.3	16.8	3.2	<0.1
>=3	21.8	21.3	19.5	14.8	10.6	2.5	1.3	0.1	<0.0001
Median	2	2	2	2	2	1	1	1	0

\*Megabits per second.

Sources: December 2013 National Telecommunications and Information Administration's State Broadband Initiative dataset, the Census Bureau's 2010 Decennial Census Summary Files, and ESA calculations.

**Appendix Table 3. Broadband Service Technologies Covered in this Report<sup>19</sup>**

Technology	Fixed <sup>20</sup> or Mobile	Wireline or Wireless	Definition
Asymmetric xDSL	Fixed	Wireline	Digital Subscriber Line (DSL) is a fixed wireline transmission technology that transmits data over traditional copper telephone lines to homes and businesses (using separate lines to carry voice traffic). Users are able to connect to the high-speed Internet via a modem without disrupting their telephone service. DSL is the technology most commonly used by local telephone companies to provide high-speed data services. Asymmetric DSL, used primarily by residential consumers, typically provides faster download speed for receiving data than upstream speed for sending data. This means that it may be faster to download webpages, data or media than it would be to upload this information. Transmission capacity declines with length of wire, so it requires signal boosting, which is costly. But new DSL technologies (e.g., hybrid copper-fiber loops and VDSL) may close the gap between wireline telephone company and cable company speed offerings
Symmetric xDSL	Fixed	Wireline	Symmetric DSL is intended to provide equal speed for uploading and downloading data. This arrangement is standard for businesses that move large files among various users and between multiple sources.
Other Copper Wireline	Fixed	Wireline	These are other technologies that use phone lines to transmit data. Examples include T-1 and ISDN lines.
Optical Carrier -Fiber to the End User	Fixed	Wireline	This refers to a fiber-optic-based broadband network. Fiber optic technology converts electrical signals carrying data to light and then sends the light through transparent glass fibers about the diameter of a human hair. Fiber has the capacity to transmit data at speeds surpassing any other broadband technology.
Cable Modem -DOCSIS 3.0	Fixed	Wireline	Cable modem service enables high-speed Internet access using the same cable television infrastructure, including coaxial cables, which

**Appendix Table 3. (Continued)**

Technology	Fixed <sup>20</sup> or Mobile	Wireline or Wireless	Definition
			deliver cable TV programming and Internet service on separate lines. Users can access the Internet without disrupting cable TV service. "DOCSIS 3.0" refers to Data Over Cable Service Interface Specifications. It is the current technological standard for cable modems and offers faster broadband service than older standards.
Cable Modem – Other	Fixed	Wireline	Cable modem service which utilizes versions of DOCSIS (Data Over Cable Service Interface Specifications) other than the current standard, DOCSIS 3.0.
Terrestrial Fixed Wireless – Unlicensed	Fixed	Wireless	This technology enables wireless broadband service to a specific geographic location using spectrum that is shared among Internet service providers. This wireless service includes WiFi and other similar technologies such as WiMAX (Worldwide Interoperability for Microwave Access). This technology requires unimpeded line of sight for transmission of data.
Terrestrial Fixed Wireless – Licensed	Fixed	Wireless	This technology is similar to unlicensed Terrestrial Fixed Wireless except that it uses spectrum licensed to the Internet service provider.
Terrestrial Mobile Wireless – Licensed	Mobile	Wireless	This technology enables wireless broadband services in a specific geographic location using spectrum that is dedicated to an Internet service provider and targeted for mobile use by consumers within the area. This wireless service is generally offered by cellular phone providers, and includes technologies such as LTE, mobile WiMAX, CDMA2000 (EVDO), and UMTS (HSPA). It is constrained in providing high-speed broadband service by limited spectrum availability and congestion.

## End Notes

<sup>1</sup> Another 48 percent profess a lack of need or interest in the Internet, while another 11 percent cite having “no computer or computer inadequate” which straddles the unaffordability/lack



of interest reasons. National Telecommunications and Information Administration (NTIA). Exploring the Digital Nation: Embracing the Mobile Internet. U.S. Department of Commerce. October 2014. (Hereafter referred to as Digital Nation.) Available at [http://www.ntia.doc.gov/files/ntia/publications/exploring\\_the\\_digital\\_nation\\_embracing\\_the\\_mobile\\_internet10162014.pdf](http://www.ntia.doc.gov/files/ntia/publications/exploring_the_digital_nation_embracing_the_mobile_internet10162014.pdf).

<sup>2</sup> See, for example, U.S. Department of Justice and Federal Trade Commission. Horizontal Merger Guidelines. August 19, 2010. <http://www.justice.gov/atr/public/guidelines/hmg-2010.pdf>, accessed October 28, 2014.

<sup>3</sup> For example, see Robert E. Litan and Hal J. Singer. *The Need for Speed: A New Framework for Telecommunications Policy for the 21st Century*. Brookings Institution Press. 2013). Others suggest that mobile ISPs (some of which are owned by fixed ISPs) provide insufficient competition to check the market power of fixed ISPs offering high-speed service. For example, see Susan Crawford. *Captive Audience: The Telecom Industry and Monopoly Power in the New Gilded Age*. Yale University Press. 2013). Some observers, such as Crawford, argue that mobile and fixed broadband services are “complements” in the sense that generally different tasks are used for each. As noted in a recent report by the Pew Research Center, “There is no widespread consensus as to whether 3G or 4G smartphones qualify as “broadband” speed, and many would question whether they offer the same utility to users as a dedicated home internet connection (activities such as updating a resume, filing taxes, or viewing educational content are certainly more challenging on a smartphone operating over a cell phone network, than on a broadband-connected home computer).” Furthermore, only 10 percent of adults have a smartphone without a home broadband connection, compared to 46 percent with both a smartphone and a home broadband connection and 24 percent with only a home broadband connection, which suggests that using a smartphone as one’s sole Internet connection is relatively rare (Zickuhr and Smith, 2013). Another observer suggests that mobile broadband is not yet ready as a substitute for wireline mobile because new generation technologies that have greater capacity to provide broadband service have not been fully deployed and constraints on the supply of spectrum limits mobile providers’ ability to meet advertised speeds and reliability (Hal Singer, “Promoting Broadband Competition: Will Consumers Opt for Mobile-Only Broadband?” February 25, 2014. <http://www.forbes.com/sites/halsinger/2014/02/25/promoting-broadband-competition-will-consumersopt-for-mobile-only-broadband/> accessed October 6, 2014). Finally, mobile service can be very expensive for downloading video, given the data charges and caps typical under many mobile plans.

<sup>4</sup> Census blocks are the smallest areas for which the Census Bureau tabulates statistics in the Decennial Census. They are generally bounded by physical features or administrative borders. Census blocks are typically small in area, such as a single city block, but can be much larger in less densely populated areas, and can also have no residences (e.g., may only have workplaces). In the 2010 Decennial Census there were 11,078,297 Census blocks covering 308,745,538 persons in the United States (consisting of the 50 states and the District of Columbia for the purpose of this report). Sources: “2010 Census Tallies of Census Tracts, Block Groups & Blocks” [https://www.census.gov/geo/reference/gtc/gtc\\_block.html](https://www.census.gov/geo/reference/gtc/gtc_block.html); “United States Census 2010: Interactive Population Map” (<https://www.census.gov/geo/mapsdata/data/tallies/tractblock.html>); and “Geographic Terms and Concepts-Block” (<http://www.census.gov/2010census/popmap/>). All sources were accessed on October 30, 2014.

<sup>5</sup> A different type of ISP market power may exist at the national level, in which ISPs may become large enough to compel large content providers to pay to connect to the ISP’s customers.

Such agreements may lead ISPs to forge deals with content providers to offer exclusive packages of content to ISP customers. Because home users cannot practically be expected to subscribe to more than one ISP at a time, a user might be constrained by whatever special deals her current ISP has struck with the ISP's preferred content providers. (See, for example, Crawford 2013.)

- <sup>6</sup> The Appendix provides a list and definitions of fixed and mobile broadband service technologies covered in this report as well as the data sets and methodology used in this report. It also contains tables showing the full set of results for this study. The broadband availability data used in this report does not include satellite service, nor does it include data on the availability of dial-up Internet service.
- <sup>7</sup> This report cites speed tiers adopted by NTIA when it undertook to develop the State Broadband Initiative data in 2009. The following year, the FCC's Connecting America report defined basic broadband service as 4 Mbps download and 1 Mbps upload, an increase from its previous download threshold of 768 Mbps (<http://www.fcc.gov/national-broadbandplan>).
- <sup>8</sup> See, for example, Molly Wood, "TV Apps Are Soaring in Popularity, Report Says," *The New York Times*, June 4, 2014 (<http://bits.blogs.nytimes.com/2014/06/04/reporttv-apps-are-soaring-in-popularity/> accessed September 28, 2014). Also Netflix "said in its earnings report it added 2.25 million customers to its U.S. streaming business during the quarter that ended in March ... for a total of 35.7 million. In international markets, its customer base reached 12.7 million, a gain of 1.8 million during the quarter." ("Netflix to Raise Prices as Streaming Business Grows." *The New York Times* April 21, 2014 <http://www.nytimes.com/reuters/2014/04/21/business/21reuters-netflix-results.html> accessed September 28, 2014).
- <sup>9</sup> Cable companies such as Comcast have growing broadband and declining cable television subscribership: "High-Speed Internet Customers Increased by 203,000; The Best Second Quarter Net Additions in Six Years...Video Customer Net Losses Declined to 144,000; The Best Second Quarter Result in Six Years" ("Comcast Reports 2nd Quarter 2014 Results" July 22, 2014. <http://cmcsk.com/releasedetail.cfm?ReleaseID=861091> accessed September 28, 2014).
- <sup>10</sup> Federal Communications Commission Chairman Tom Wheeler recently noted in a speech that "a 25 Mbps connection is fast becoming 'table stakes' in 21st century communications." ("The Facts and Future of Broadband Competition" 1776 Headquarters, Washington, DC, September 4, 2014 available at <https://apps.fcc.gov/edocspublic/attachmatch/DO-C-329161A1.pdf>). The FCC is considering an increase in its threshold for defining broadband speeds from the current 4 Mbps download to 10 Mbps or more to reflect today's bandwidth requirements. The FCC's Tenth Broadband Progress Notice of Inquiry solicits public comment on a modern definition of broadband, including both download and upload speeds and methods of measurement (e.g., maximum advertised vs. actual). See <https://apps.fcc.gov/edocspublic/attachmatch/FCC-14-113A1.pdf> (accessed October 20, 2014).
- <sup>11</sup> See <http://www.broadbandmap.gov/classroom/speed> (accessed October 3, 2014). These download times are reported solely to illustrate what different download speeds imply for quality of service; although many customers with high-speed broadband service stream videos, many customers download videos to their computers and tablets and view them later (see, for example, Ben Fritz, "Sales of Digital Movies Surge: Delaying Availability of DVDs, Rentals Nudged Consumers", *Wall Street Journal*, January 7, 2014 (<http://online.wsj.com/articles/SB10001424052702304887104579306440621142958> accessed November 13, 2014).

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- <sup>12</sup> See Federal Communications Commission “Broadband Speed Guide” <http://www.fcc.gov/guides/broadband-speed-guide> (accessed October 28, 2014).
- <sup>13</sup> See Federal Communications Commission “Household Broadband Guide” (<http://www.fcc.gov/guides/household-broadbandguide> accessed October 28, 2014).
- <sup>14</sup> See Netflix “Internet Connection Speed Recommendations” (<https://help.netflix.com/en/node/306> accessed October 28, 2014).
- <sup>15</sup> Source: Leichtman Research Group (<http://www.leichtmanresearch.com/research.html>) This estimate does not reflect the results of any announced but not yet approved mergers.
- <sup>16</sup> Federal Communications Commission. 16th Mobile Competition Report, p. 54 ([https://apps.fcc.gov/edocs/public/attachmatch/FC\\_C-13-34A1.pdf](https://apps.fcc.gov/edocs/public/attachmatch/FC_C-13-34A1.pdf) accessed September 28, 2014).
- <sup>17</sup> While the data on broadband speed availability is actually based on maximum advertised download speeds, in fact advertised and actual fixed broadband download speeds are often quite close. Federal Communications Commission. Measuring Broadband America – 2014: A Report on Consumer Wireline Broadband Performance in the U.S. <http://www.fcc.gov/reports/measuring-broadbandamerica-2014#Findings>, accessed September 23, 2014. In contrast, evidence is sometimes mixed on how close are advertised and actual mobile broadband speeds. For example, one observer asserts that “Verizon claims peak speeds of around 25 Mbps [for post-third generation service], and average speeds of around half that” (see Crawford 2013) while some tests indicate that Verizon offers median actual download speeds that are about 99 percent of advertised speeds. See <http://www.speedtest.net/isp/verizon-wireless> (accessed October 14, 2014). Ookla ([www.ookla.com](http://www.ookla.com)) describes itself as “the global leader in broadband testing.”
- <sup>18</sup> For example, see Dominic Rushe, “Chattanooga’s Gig: How One City’s Super-Fast Internet is Driving a Tech Boom,” *The Guardian* (<http://www.theguardian.com/world/2014/aug/30/chattanooga-gig-high-speed-internet-tech-boom> accessed November 13, 2014).
- <sup>19</sup> This table quotes extensively from National Broadband Map. “Broadband Classroom: Technology” and also uses information from Jonathan E. Neuchterlein and Philip J. Weiser (2013) *Digital Crossroads: Telecommunications Law and Policy in the Internet Age*, 2nd ed. MIT Press.
- <sup>20</sup> Note that dial-up and satellite are fixed Internet services that are not included in data used in this report.

