The University of Texas at Austin
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Broadband, the Backbone of Communication

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TECHNOLOGY & INFORMATION
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Broadband – What is it?

The term 'broadband' refers to an advanced telecommunication service that developed from a need for greater amounts of information to be transmitted across the Internet. The Federal Communications Commission (FCC) defines broadband in terms of speed. The current standard specifies at least 25 megabits per second (Mbps) downloading and 3 Mbps uploading. In essence broadband is a service that enables reliable, high-speed transfer of data, voice and video over the Internet. In the 1990s, the only option to use the Internet was through a dial-up connection using your home phone line and a modem, but the technologies have changed and evolved. As interest and as Internet applications grew, solutions were needed to meet the demands for greater data transmission.

Broadband connectivity is a foundation for economic growth, job creation, global competitiveness and a better way of life. It enables entirely new industries and unlocks vast new possibilities for existing industries. Broadband is changing how we educate children, deliver health care, ensure public safety, engage government, and access, organize and disseminate knowledge in communities.

Types of Broadband Connections

The most common types of broadband carriers include: (1) cable using coaxial cable line originally used for television signals; (2) DSL (Digital Subscriber Line) which is carried along phone lines; (3) fiber-optic cable; (4) mobile broadband through 3G and 4G mobile reception; and (5) satellite transmission. As of 2016, 59% of U.S. customers had wired Internet connections via cable, followed by DSL (29%) and fiber options (9%).

This list of broadband services includes a variety of wired and wireless technologies, each of which offers unique advantages in speed and capacity, reliability and affordability. All providers of such broadband connections are called Internet Service Providers (ISPs). Wired, or fixed, broadband services (DSL, cable, fiber, etc.) tend to be faster than wireless alternatives, but often are not deployed to geographically remote areas. Wireless broadband networks, which can be accessed via cell phones, satellite, and Wi-Fi signals, provide advantages in mobility, convenience, and sometimes cost. *Table 1* presents some comparisons.

Fixed Broadband Networks

- *Cable Broadband* – Cable broadband uses coaxial cable that connects to your computer through a modem to transmit data. Coaxial cable was originally designed for transmitting television signals, and it has far less signal deterioration and much faster broadband speeds compared to telephone lines. Another advantage of cable is its capacity to handle a greater volume of audio and visual signals. This capability allows you to get your phone and digital TV as well as Internet connection services from your cable broadband provider. Cable is either buried underground or uses same utility poles already in place for your telephone and electricity.
- *DSL Broadband* – DSL is a wireline transmission technology which allows faster data transmission through existing copper telephone lines already available to homes and businesses. DSL broadband comes from your local telephone company (i.e., ISP). Since the signal deterioration is relatively greater through telephone lines than other technologies, the distance of one's home to the local ISP hub could influence DSL broadband speed.
- *Fiber Optic Broadband* – Fiber optic technology uses glass polymer fibers for data transmission. This technology converts electrical signals to light, which is sent through transparent glass fibers. It enables significantly faster data transmission over greater distances compared to other broadband technologies. Due to the fact that the transmission material is glass, which cannot generate electricity, fiber optic broadband is immune to interference, and this minimizes data deterioration. Other wireline services such as cable broadband often incorporate fiber into some portion of their infrastructure.

Wireless Broadband Networks

- *Mobile Broadband* – Mobile broadband is transmitted over mobile phone networks and requires no physical cable connection for end users. Users are able to get online wherever there is a mobile phone signal. 3G and 4G mobile broadband (refers to the 3rd and 4th generation of mobile phone standards) enables devices such as mobile phones to deliver high speed Internet.
- *Satellite Broadband* – Satellite broadband uses satellites in orbit to transmit data using radio waves. Satellite data transmission depends on the location of a particular satellite picking up the signal, so it may be slow and is often expensive. However, it can be useful for remote areas that do not have an appropriate infrastructure in place to support other types of broadband.
- *Fixed Wireless* – Fixed wireless requires consumers' receivers to be within the line of sight for a service tower, which can range from a silo to a cell phone tower. Service towers disseminate wireless Internet signals in the form of radio waves to substantially large coverage areas. This makes fixed wireless a flexible option for rural areas that have only few wired Internet connection options and that can support line-of-sight services. The speeds for fixed wireless vary greatly but seem to average around 10 Mbps.

TV White Spaces Internet – TV White Space Internet involves radio wave frequency ranges that are newly available due to the recent conversion from analog TV to digital TV. Internet signals are transmitted through frequencies that used to bring us terrestrial TV broadcasts. This particular set of frequencies can travel several miles and is affected less by blockages such as buildings. White Space Internet services are still in an exploratory stage, existing in a few test sites and experiments.

TABLE 1. MAJOR ISPS & SPEED BY BROADBAND TECHNOLOGY

Type	Major ISPs*	Median Download/Upload (Sep 2015)**	Note
DSL	• AT&T Internet • CenturyLink • Verizon • Frontier Communications	11.4/1.3 Mbps	• Works on traditional telephone line
Cable	• XFINITY from Comcast • Charter Spectrum • Cox Communications • Optimum by Cablevision	52.3/7.1 Mbps	• Works on buried or aerial coaxial cable • Most popular broadband type in U.S.
Fiber	• Verizon Fios • AT&T Fiber • Frontier Communications • CenturyLink • Google Fiber	52.2/54.6 Mbps	• Uses glass fibers • Electric signal converted to light • Minimizes data deterioration
Mobile	• AT&T Wireless • Verizon Wireless • Sprint • T-Mobile	22.7/8.5 Mbps† (Q1-Q2 2017)	• Transmitted via mobile phone networks and spectrum • No physical cable needed from end-user
Satellite	• HughesNet • Viasat Internet	10.7/2.9 Mbps	• Slower speeds, but substantially wide range of coverage • Mostly used in rural areas

**Source: Broadband Now, **Source: FCC Measuring Broadband America 2016, †Source: Ookla Speed Report 2017*

The Need for Speed

Understanding Internet Speed & Data Caps

The speed of broadband Internet is measured in megabits per second (Mbps). A bit is the smallest unit of processable information, and 8 bits constitute 1 Byte. From an end users' perspective, these two can cause confusion as 'bit' is commonly used to depict 'speed' while Byte is typically used to depict 'size' of a file. Typically, ISPs provide information about both speed and volume of data transfers available with a service plan (i.e., amount of data available for a month). Understanding this difference is useful when discerning the various offers available from your ISPs. Different applications use different amounts of data ***(Error! Reference source not found.)***, and a few ISPs also provide tools for estimating the size of your data usage. For more in-depth and easier introduction to these concepts, follow this link for an informative video clip.

Download Speed & Upload Speed

When using the Internet, there are two streams of data flow: (1) download and (2) upload. Download speed is the pace at which data (e.g., websites, programs, music, film, etc.) are transferred from another source to your device. On the other hand, upload speed is the speed at which data are transmitted to other computers or servers (e.g., speed when uploading a video on YouTube, a picture on Instagram, etc.) from you. The FCC standard defines broadband service as an Internet connection service that provides at least 25 Mbps of download speed and 3 Mbps of upload speed.

The latest FCC data from 2016 indicate that maximum advertised download speeds for household services from ISPs range from 6 Mbps to 300 Mbps. Meanwhile the maximum advertised upload speeds range from 0.8 Mbps to 75 Mbps. Typically, broadband upload speeds are much slower than download speeds. This is because people generally do far more downloading than uploading, and ISPs engineer their networks to accommodate this.

Broadband speeds vary greatly depending on technology, location, applications and other factors. Because of this, it may be more helpful to focus on "acceptable broadband" speeds, which are the speeds necessary to meet the particular demands of any given market segment, such as schools, homes, businesses or medical centers.

Actual speed

Most broadband services operate on shared lines or towers at some point in the connection, which means many users in different homes/businesses can be using the same line or tower at the same time. This can potentially slow your Internet usage at peak times, especially if a particular provider favors certain types of Internet traffic over others (perhaps video streaming over peer-to-peer file sharing).

There are many other reasons why you won't always get your advertised speed. While advertised download speeds tend to start at around 10Mbps, they can range broadly (e.g., one person's 10 Mbps connection can average anything from 1 – 8 Mbps or slower).

One of the reasons for this is that not all infrastructure is built equally: some still incorporate older technology. For instance, in the case of DSL, this technology relies on copper wires built for transmitting only audio data. This inherently puts DSL broadband at a disadvantage in terms of data deterioration rate and capacity.

Speed Benchmark & Broadband Deployment

The FCC's 2015 Broadband Progress Report changed the definition of broadband by raising the minimum **download** speeds needed from 4 Mbps to 25 Mbps, and the minimum **upload** speed from 1 Mbps to 3 Mbps, which effectively tripled the number of U.S. households without broadband access. The agency's latest 2018 Broadband Deployment Report retained such higher standard. Their action underscores the changing standards for what people consider to be optimal speeds and capacities. *Figure 1* displays some median speeds by technology type.

The 2018 Report differentiated *mobile* broadband standards: the agency did not set a single speed benchmark for high speed mobile Internet connection (i.e., 4G LTE), but rather used two different benchmarks: (1) a minimum advertised speed of 5 Mbps download and 1 Mbps upload; and (2) a third-party speed test data with

a median of 10 Mbps download and 3 Mbps upload or higher. *Figure 2* displays average speeds of fixed and mobile broadband.

As of year-end 2016, 92.3% of U.S. population had fixed broadband access meeting the current FCC definitions. Rural areas and tribal lands lag in fixed broadband deployment compared to urban areas. Only 69.3% of the rural population and 64.6% of tribal land populations had access to fixed broadband whereas 97.9% of urban population had a benchmark connection. Refer to the actual report for further in-depth information.

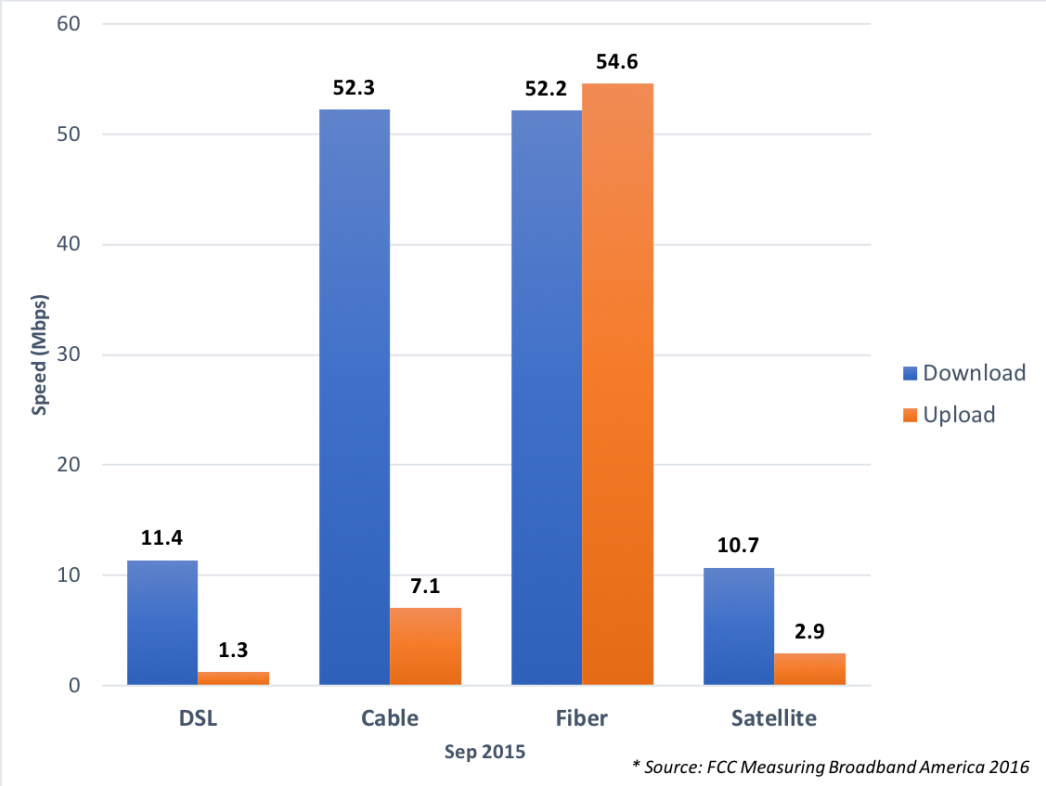

FIGURE 1. MEDIAN DOWNLOAD & UPLOAD BROADBAND SPEED (SEP. 2015)

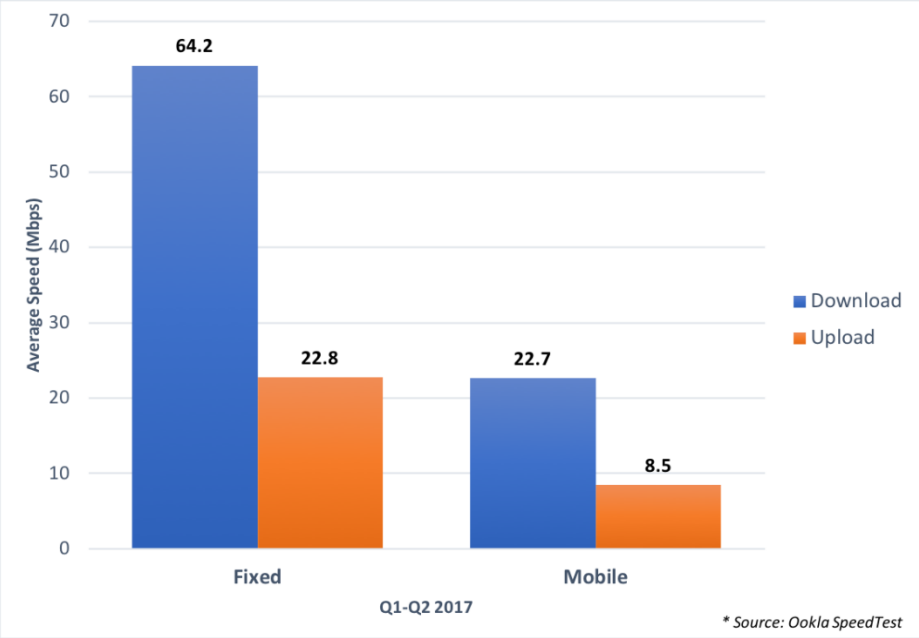

FIGURE 2. AVERAGE DOWNLOAD & UPLOAD SPEED OF FIXED AND MOBILE BROADBAND (Q1-Q2 2017)

TABLE 2. APPROXIMATE DATA USAGE BY APPLICATION TYPES

Type	100 MB	500 MB	1 GB	5 GB	100 GB
Email *(Text only)*	5,000	25,000	50,000	250,000	5,000,000
Web Surfing *(Hours)*	6.7 hours	33.3 hours	66.7 hours	333.3 hours	6,666.7 hours
Music Download	25	125	250	1,250	25,000
Photo Upload to Social Media	20	100	200	1,000	20,000
SD Video Stream *(Hours)*	8.5 min	42.7 min	1.4 hours	7.1 hours	142.9 hours
HD Video Stream *(Hours)*	2.4 min	12 min	24 min	2 hours	40 hours
4K Video Stream *(Hours)*	1 min	5 min	10.3 min	51 min	17 hours
Online Gameplay *(Hours)*	8.3 hours	41.7 hours	83.3 hours	416.7 hours	8,333.3 hours

**Calculated based on AT&T estimate guideline (https://www.att.com/esupport/data-calculator/index.jsp)*

Table 2 displays some popular applications and how much data are required to use them.

Broadband Uses

Broadband Usage Domains

Broadband technologies continuously improve the amount, diversity, and speed of data communicated through our network infrastructures. In our contemporary broadband environment, massive amounts of data in diverse forms (e.g., audio, video, text, etc.) can be communicated simultaneously in nearly real-time. Such capabilities have been implemented by and have become pivotal aspects not only to general consumers, but also to many industries such as:

- Telemedicine
- Teleworking
- E-Government
- Agriculture
- Distance Learning
- Public Safety – Emergency response, Public service messages
- National Security
- Small Business Assistance – Economic growth, New industry creation
- Tourism
- E-Commerce
- Entertainment

Benefits of Broadband

Benefits for Overall Society

Broadband allows faster and wider dissemination of knowledge and information. It improves efficiency and effectiveness of many industries through enhanced data and software communication capabilities. Furthermore, it opens up opportunities for new entrepreneurial ventures, consequently contributing to economic growth. Governments around the world increasingly view broadband as the "fourth utility" alongside water, heating and electricity, and the United Nations even declared access to broadband to be a human right. For example, several countries such as Finland, Estonia, and Spain declared broadband access to be a legal right.

The benefits of broadband have been shown by several studies, which demonstrate that broadband fosters GDP growth, creates jobs and stimulates innovation while also enabling improvements in education, health care and other social services.

Benefits for Underserved Communities

Mobile communications and broadband can be particularly helpful to the economies of rural areas, which are home to nearly three out of four of the world's poor. Expanding broadband networks to rural areas leads to

new opportunities for nonagricultural employment, better-paying agricultural jobs and greater overall productivity compensating in part for rural remoteness. Access to broadband could also foster small-business growth, allow citizens in remote areas to work from home, provide greater access to crop market prices and enable rural businesses to compete more effectively in world markets.

> ***"As people have broader social networks, which we know are abetted by things like Internet connectivity, their ability to seek information, their ability to make smart choices expands; it grows. So, those social networks, which we don't usually measure when we are talking about economic outcomes, are an amazingly significant input in the entire equation, that's something that broadband and that connectivity allows us to have."***
>
> *Sharon Strover, Washington D.C. Meeting on Rural Broadband*

Some of the immediate cases of social and public benefits of wider broadband deployment include:

- *Health Care Delivery*: Remoteness in rural areas challenges proper delivery of healthcare. Access to reliable broadband connection provides Internet-enabled healthcare services such as telemedicine to wider rural population. This could mitigate problems caused by physician shortages and close urban-rural gap in terms of getting healthcare services.
- *Improved Educational Opportunities*: Wider access to broadband service would let students expose themselves to new people, experiences and ideas. As increasing proportions of students' work involve online activities, improving broadband deployment could additionally bridge the homework gap for students experiencing difficulty in completing homework when they lack internet access at home, compared to those who have access.
- *E-government*: Greater dissemination of broadband connectivity and incorporating the Internet in various government services could allow those in rural areas to engage in diverse community activities much more easily.
- *Improved Entertainment*: Reliable broadband connection catalyzes access to oceans of multimedia content including entertainment (e.g., online video, game, etc.), news, and other information.
- *Business Efficiencies*: Utilization of Internet through broadband could enhance both individual and business productivity by making remote information gathering, communication and management easier and more efficient.