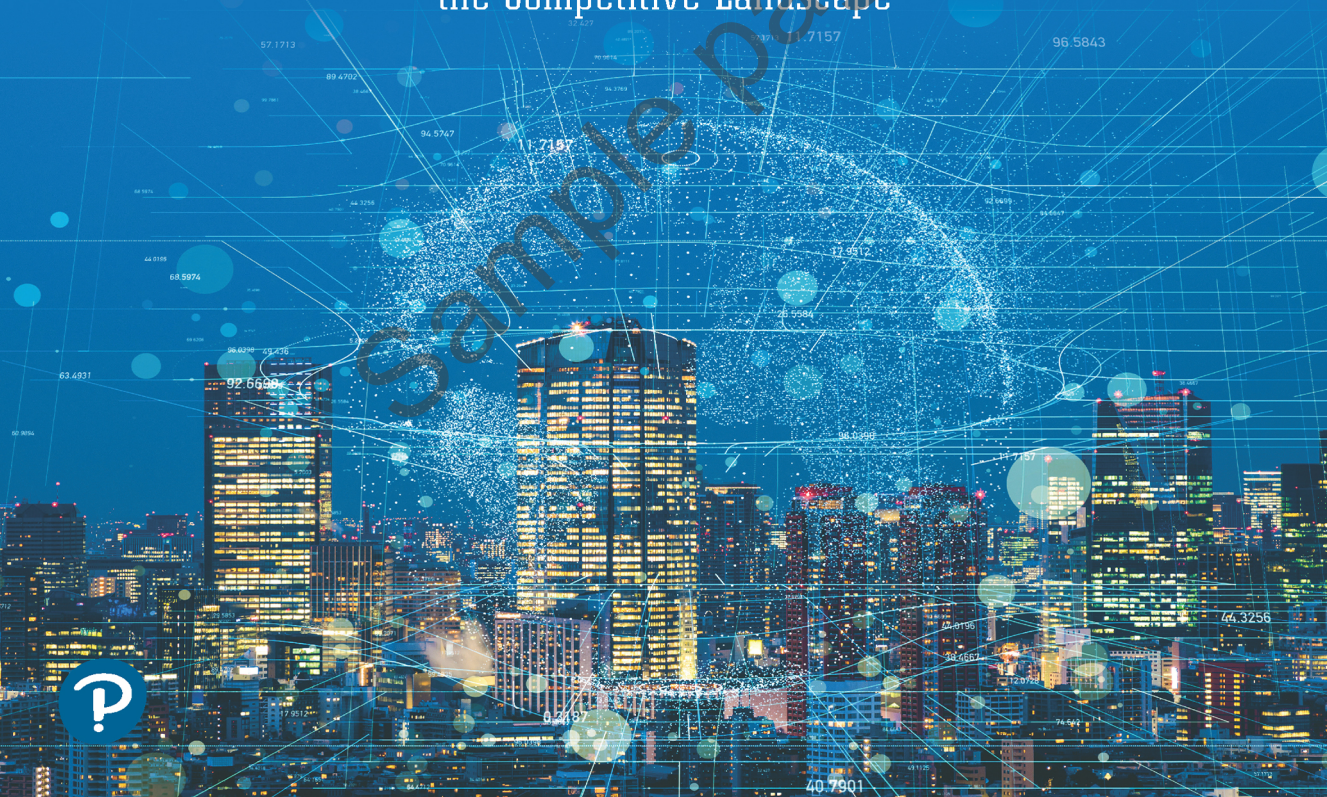


Annabel Z. Dodd

THE
ESSENTIAL GUIDE to
TELECOMMUNICATIONS

S I X T H E D I T I O N

A Completely Revised Bestseller: Extensively Updated Coverage
of Wi-Fi, LTE Advanced, 5G, Broadband, Security Technologies, and
the Competitive Landscape



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6 The Internet

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INTRODUCTION

The Internet is the single most important innovation of the 21st century. It's a ubiquitous network available in much of the world, and a disruptive technology that has displaced many traditional retail businesses and services. It has created the perception that the world is smaller and changed how we communicate, shop, and spend leisure time. It has upended numerous industries, shrunk distances, led to new industries, and enabled improved communications across countries, between countries, and between continents. According to an international university student from China:

I am my parent's only child, and the ability to make free video calls over the Internet to them weekly is the thing that most helps me stay in touch with them and share my experiences. Knowing that I will chat with them every week makes my parents and myself less lonely.

Technologies used in the Internet are radically changing the ways consumers access and view movies and television shows and negatively affected movie theater attendance. People can now view high-definition movies and television on their widescreen TVs in the comfort of their living rooms. Many additionally have high-end audio systems to supplement their viewing experience. Increases in the number of people using streaming, the high video and audio quality, and improvements in actual content have all precipitated large decreases in the numbers of adults that go to movie theaters and lower profits for movie theaters. Attendance at movie theaters has dropped steadily since 2016 and is expected to continue dropping as more people adopt streaming.

The Internet has radically changed how companies conduct commerce. The Internet is the main vehicle by which businesses contact customers, handle customer service, and interact with internal staff. The Internet is particularly attractive to young people, many of whom grew up with the Internet as a part of their daily lives. Web sites that are well designed and make it easy for customers to find what they need and to check out, lessen customers' desire to actually speak with or e-mail a customer service rep. A well-designed, easy-to-use web site, an extranet, saves costs for businesses. Extranets are online e-commerce sites where consultants, partners, and customers access particular databases and services.

The Internet is not a single entity. It is made up of multiple large networks connected to each other by routers and switches and with growing amounts of capacity enabled by the following advancements: fiber-optic cabling, and more powerful servers and computer chips, all of which have resulted in higher-capacity broadband fiber-optic networks.

Streaming is a major disrupter of home entertainment and pay-TV. It has been enabled by both the Internet and home Wi-Fi. The number of people using streaming services has grown every year since Netflix first offered it in 2007 and many analysts expressed skepticism over its future. Streaming is widely available worldwide in

developed countries in Asia, Europe, the Americas, and some countries in Africa. The rise of streaming has caused the bankruptcy of Blockbuster and other DVD retailers, and decreased the number of people subscribing to cable TV packages. Importantly, it's changed the way people get their home entertainment.

Because of its acceptance, pay-TV providers now offer their own streaming services with content they create, own, or lease. For example, Verizon owns Yahoo!, and AOL, which they merged into their Oath unit, and AT&T, which owns DirecTV, purchased Time Warner, the owner of HBO. Furthermore, Comcast owns NBC and Universal, with its cache of movies and television shows. Thus, the three largest broadband providers own and create content through their subsidiaries. This results in competition between content providers Amazon, Netflix, and other streaming content companies including Facebook, and large telephone, cable TV, and satellite companies over which Amazon, Netflix, and others stream movies to homes and apartments. This often creates a situation where pay TV providers compete with the very organizations that stream movies and TV shows over their networks.

To prevent large telecoms from slowing down or blocking competitors' content, the Obama era FCC instituted *network neutrality*. Under network neutrality rules, owners of broadband (pay-TV providers) are not allowed to slow down or block competitors' content. Cable TV providers, however, lobbied for the elimination of network neutrality, stating that they should be compensated for carrying streaming traffic. The Federal Communications Commission eliminated network neutrality in 2017. However, their ruling is being adjudicated in courts and in legislatures in the United States.

Worldwide connectivity has led to the challenges of keeping networks secure and information private. Organizations, individual subscribers, and governments grapple with keeping information secure and employees' and customers' personal data private. Hackers know how internal networks are architected and where to look for vulnerabilities. Furthermore, malicious employees and staff errors add another layer of complexity in maintaining secure networks. Keeping enterprises 100 percent secure is almost impossible. Hacking is profitable and not often punished. Thus, hackers have a huge incentive to steal information they sell, or otherwise profit from illegal tampering with businesses' computer data and networks. It's an ongoing race between hackers finding new and novel ways to interrupt and steal information and to damage and hijack networks, vs. enterprises and governments keeping networks safe.

WHAT IS THE INTERNET?

The term Internet is derived from *inter* and *network*. It's a vast network of globally interconnected networks. If one part of the Internet is down, routers send traffic on alternate routes. It's a survivable, robust network with parts of it able to function during natural disasters and attacks. The United States Department of Defense funded the original Internet with the intention of having a robust network able to survive an attack

or national disaster. They awarded money to the University of California at Santa Barbara for the purpose of developing a resilient network. In addition, faculty in the IT department at the University of Michigan collaborated on new protocols to be used in the Internet.

At that time, 1969 until the mid-1990s, researchers at universities and government agencies were the main users of the Internet. They used it to collaborate on research. Additionally, staff at universities used the Internet to access early forms of electronic mail (e-mail) using arcane commands such as `k` to display the previous message and `n` to display the next message. Logging into the Internet and using e-mail acquired a user-friendly interface when Tim Burners Lee developed the Nexus *browser* in 1989. Examples of browsers include Chrome, Internet Explorer, and Safari. Mosaic and Netscape were early browsers. Easily accessible, user-friendly browsers are a large part of the reason that the Internet was widely adopted.

Features of the Internet

The following are some of the most prominent features of the Internet:

- It uses a common set of IP protocols
- It is a packet network
- Routers send packets on the least congested routes
- Routers send packets around disabled, broken links
- It has defined protocols, such as IPv4 and IPv6 for addressing
- It can grow to keep up with growing amounts of traffic
- The backbone is made up of fiber-optical cabling connected to electronics in which capacity can be increased, often using software at remote data centers
- The United States federal government does not regulate the Internet
- Because of the simplicity of its protocols, IP, TCP, and HTML markup language, the entire world can communicate over the Internet
- Voice, video, and data are transmitted on the Internet
- Carriers exchange traffic at peering points

Protocols Used on the Internet

The single most important factor in the worldwide spread of the Internet is the standard, easily implemented protocols used on the Internet. Worldwide, all countries use

the same IP protocols to transmit data across their sections of the Internet. This means that people access broadband in a uniform way regardless of their location. When the Internet was designed, simplicity was purposely kept in mind so that the networks could be uniformly and easily duplicated. The fact that these designs are accepted worldwide has been a critical factor in adoption.

The following are examples of the Internet protocols:

- **Internet Protocol:** IP is a “best effort” protocol. When a message is sent over the Internet, it is broken up into packets. Each packet is sent on a different route and reassembled at the receiving end in the correct order. If there is congestion the router drops packets. The dropped packets are not resent. This is why IP is known as a best effort transmission protocol.
- **HTTP:** HyperText Transport Protocol links are the standard way documents are moved around the Internet.
- **HTML:** HyperText Markup Language is used to compose web pages. It is not, strictly speaking, a protocol.
- **TCP:** Transmission Control Protocol provides error checking on messages sent over the Internet. It is a connection-oriented protocol. Messages are sent between sending and receiving computers on the Internet that communicate whether the message was received or whether errors occurred. If there are errors, bits are retransmitted.
- **IPv4 and IPv6:** Internet Protocol v4 and v6 define the numeric structure of Internet addresses. The newer IPv6 was launched in 2012. It specifies longer addresses and is being implemented by Internet providers and telephone companies. It has capacity for more IP addresses than the shorter IPv4 structure.

The Impact of Capacity—The Availability of Broadband Networks

An important factor in the wide use of the Internet in everyday life and business is the availability of high-capacity broadband and cellular services. This availability exists in Western Europe, North America, much of Asia, parts of Africa, and in the Middle East. The capacity and availability of the networks that make up the Internet are enabled by technologies such as fiber-optic cabling and the supporting electronics connected to it: lower-cost, smaller graphical processor chips in wireless handsets and laptops; faster computers; and improved compression to support multimedia video streaming and high-capacity content downloads. These improvements, along with search engines, enhance the user experience for consumers and businesses alike, as do improvements in web site designs.

The Public Network Prior to the Internet

At the time the Internet was developed and through the 1990s, the public switched telephone network, which carried only voice, was made up of large central offices called *tandem offices*. Smaller central offices were connected in a hub-and-spoke design to each tandem office. If the tandem office crashed, all the local central offices were also out of service. The designers of the Internet wanted to avoid this centralized control where an outage at a central or tandem office disabled large swaths of the public telephone network.

The Internet—A Distributed Network with No Central Control

The Internet is a distributed network with no single ISP (Internet Service Provider) or other entity controlling it. It's a distributed network in which multiple carriers manage particular parts of the network. If a router crashes, other routers send traffic along alternate paths in the Internet's backbone. The backbone is the part of the Internet that carries traffic across the country between cities and states, and between countries.

Although the Internet was designed to function when any route crashes, if the central databases that hold IP addresses are disabled, the Internet won't function. See the section "The Criticality of Root Servers" below for information on root servers.

Largest Carriers Worldwide—Backbone Providers

The telephone companies with the largest Internet backbones in the United States are Sprint, Verizon, CenturyLink (through its purchase of Level3), and AT&T. There are a number of local carriers (ISPs) that connect users to the Internet because no single provider has service everywhere.

According to the May 24, 2017, article by Antoine Gara in the *Forbes* online article, "The World's Largest Telecom Companies: AT&T & Verizon Top China Telecom," the following are the largest telephone companies by total revenue worldwide. The list includes their headquarters locations. However, most of them have services in other countries as well:

- AT&T—U.S.
- Verizon—U.S.
- China Mobile—Hong Kong, China
- Nippon Telegraph & Telecom—Japan
- Softbank—Japan

- Deutsche Telekom—Germany
- Telefonica—Spain
- KDDI—Japan
- China Telecom—China

Using Search Engines to Unleash Vast Stores of Information

The introduction of sophisticated search engines by organizations such as Google, Microsoft, and Yahoo! (part of Verizon) made browsing the Internet convenient by organizing the enormous amounts of information available on the Internet. Search engines from Google and Baidu in China and others including DuckDuck Go Search, Bing (part of Microsoft), Dogpile Search, Yippy Search, and Webopedia Search earn revenue from advertising on their sites and from ranking companies that pay fees for higher placements (rankings) in search results.

Page ranking refers to the placement on a web page of search results. Ranking a product or service higher places it closer to the top of search results, with a higher likelihood of people clicking on the link. In addition to paying for higher ranks, ranking is done by analyzing the number of other sites that link to a particular site. For example, if someone searches for Greek restaurants in San Francisco, the Google engine looks at and ranks the restaurants partially on how many sites link to particular Greek restaurants in San Francisco and the type of sites linking to it.

Google not only earns the highest search-engine-based advertising revenue in the United States, but because of its many acquisitions, it has the potential to skew results of searches in favor of its own sites. When search results are returned, search engines such as Google can rank their own sites higher than those of competitors. Google's search engines are located in hundreds of countries worldwide in addition to its presence in the United States.

Over the years, Google's owner Alphabet acquired many software companies, including the following:

- Zagat (restaurant and hotel reviews)
- Android operating system software for smartphones
- Adsense (Google's network for advertising sales)
- DoubleClick (advertising network used to target ads to particular classes of people)
- Google Maps (GPS plus local guides and advertising)

- Keyhole Technologies, Zipdash Inc., and Where2 LL2 (software that forms the basis of Google Maps)
- ITA (airline flight aggregation information)
- Motorola Mobility (mobile devices; patents for mobile services)
- YouTube (online videos and streaming TV)
- Waze GPS (global positioning service)
- Zipdash (now part of Google's location services)

In addition to possibly skewing search results toward their own sites, search engines have implications for privacy. Marketers can determine the following based on terms people search on:

- Gender
- Income Range
- Health
- Type of computer (Mac or Microsoft Windows)
- Location

This information may be shared with advertisers who target ads at particular demographics based on search history. For example, they might show pop-up and sidebar ads on the Internet based on people's purchasing history. See the section "Privacy" below.

Search Engines—Mathematical Algorithms and Page Ranking

Google, a unit of Alphabet, attracts the most search engine traffic worldwide. Baidu in China is second and Microsoft's Bing and Verizon's Yahoo! are third and fourth respectively. Search software uses mathematical algorithms and page ranking to determine search results. Proprietary mathematical algorithms analyze keywords, titles, site structures, and descriptions to determine which sites fit the search terms specified by Internet users. They look at headlines, bolding, and the proximity of words to each other for relevance of textual data on the page.

Search engines have massive indexes (lists) in databases of past searches and URLs, or locations of web sites. They additionally have the ability to find and add new web sites and discover sites that are removed. This is done by *spiders*, software

that continuously and automatically crawl through the Internet looking for new and updated sites.

Search Revenue—Advertising, Page Ranking, and Software Licensing

Google has the largest revenue from search worldwide, primarily from advertising on its sites. As reported by its parent company, Alphabet, it had \$26 billion in total sales for the quarter ending June 30, 2017. Of that total, \$25.8 billion was from search: advertising, software licensing, and page ranking.

Search companies earn revenue by a combination of ads, favorable ranking of web sites in search results, and licensing software to other search companies and to enterprises. Large enterprises deploy the licensed search software to assist staff in finding information on health and retirement benefits, information about departments, and directories of employee addresses and telephone numbers.

Investigations into Google Search Practices

In June 2017, the European Union fined Google \$5 billion for favoring its own companies in search results. The European Union judged that Google demoted rivals' links in favor of its own company's links and search results. This is important because the top 10 ranked search results receive about 90 percent of all clicks. The EU's investigation was prompted by complaints from EU companies, that search results were skewed in Google's favor and that EU companies' results were demoted to lower rankings on search result pages. For example, Google might rank its own flight information service higher than a competitive flight information service. The EU complaint stated in part that Google was using anti-competitive tactics to take advantage of its 90 percent market share in searches.

As a result of the EU fine and agreement, Google stated that it would let companies bid for the top placement in search, rather than ranking search results by links to products retailers who had paid Google to rank high in searches. Google further agreed to make some changes in its search shopping methodologies, and to stop promoting its own shopping services while demoting rivals' comparison sites.

The EU left it up to Google to create its own solutions to these issues. Per EU competition commissioner Margrethe Vestager, if the EU is not satisfied with Google's changes made within 90 days of the fine, the EU will fine Google up to 5 percent of its total global search revenue each day. The EU hired accounting firm KPMG and search engine optimization marketing company Mavens to monitor Google's search results for compliance with the EU agreement. Despite this agreement, Google has stated that it will continue to challenge the fine in the courts.

In addition to the EU's investigation into Google's search practices, in 2016 the EU filed anti-trust charges against Google over its dominant position in search on Android operating system mobile phones and tablet computers. The complaint alleged that Google is monopolistic in requiring that Android phone manufacturers pre-load the Google Chrome browser and Google Search on phones. The charges are further based on Google's practice of offering financial incentives to carriers and manufacturers to make Google's search services the only pre-loaded search on mobile phones. In 2016, Russia filed a similar anti-trust complaint against Google's policies on mobile phones and tablet computers. In 2017, Google and Russia reached a settlement where Google agreed to pay Russia \$7.8 million to settle the claim.

Internet2—A Non-Commercial Outgrowth of the Internet

Internet2 is the predecessor of the Internet. In contrast to the public Internet, it is a non-profit private network. Internet2 was established as a way for university and research professionals to collaborate over a private connected network. Internet2 is the largest private network in the world. The scope of Internet2 has grown from university and research organizations to include corporations, and private and governmental national research entities in over 100 countries.

A core group of Internet2 technology staff maintain and upgrade the network to include high data rate services including SDN and Gigabit Ethernet. In addition to the local data centers at members' locations, Internet2 maintains a central data center at Indiana University. An important focus of operations at the data center is maintaining the security and privacy of information transmitted over Internet2 links.

In the United States, Internet2 drops are located in metropolitan areas on the east and west coasts, as well as throughout populated areas along the southern coast. There are fewer Internet2 locations in less densely populated cities in the midwest.

Collaboration and research data transmitted over Internet2 includes cooperation between branches of large universities. For example, many universities now have branches throughout urban and rural areas, as well as in distant cities of large countries. Internet2 also links university sites in distant continents. Scientists and researchers are able to partner with distant colleagues on designing new drugs and other innovative technologies using Internet2 links.

STREAMING—A DISRUPTIVE TECHNOLOGY.....

Streaming media, also called Over-the-Top (OTT), refers to television, movies, and music streamed directly to people's homes and apartments from the Internet. OTT streaming has had and is continuing to have a direct impact on decreased cable TV

and broadcast TV revenues and is a leading cause in the decline of movie theater attendance as more people abandon cable TV and move to Netflix, Amazon, and YouTube TV for movies and TV shows.

Growth in Streaming

Streaming entertainment from the Web to televisions is a key application that is growing year after year and causing losses for pay-TV (cable TV, telephone companies, and satellite TV) providers. However, not all subscribers that stream have “cut the cord” on all pay-TV. According to an October 27, 2017, article by Wayne Friedman in *TELEVISIONNewsDaily*, “53% of U.S. broadband homes subscribe to pay TV as well as to OTT streaming.” But streaming hours grew 100 percent from 2016 to 2017, according to the article, “Streaming Hours Up Over 100% in 2017, Study Says,” by Alex Weprin. The article cited Conviva for the statistics and for the statement that live sports were an important driver of the increase.

However, in increasing numbers, subscribers are canceling their pay-TV service. According to a September 13, 2017, *Variety* article by Todd Spangler, “Cord-Cutting Explodes: 22 Million U.S. Adults Will Have Canceled Cable, Satellite TV by End of 2017,” the 22 million people that have canceled their pay service is a cumulative total of subscribers that rely entirely on streaming options. These statistics were credited to eMarketer. Added to these losses is the fact that growing numbers of children and young adults are growing up assuming that they can access all their television shows and movies on their mobile devices and computers via streaming. To wit, a September 15, 2017, *USA Today* article cited statistics from Videology that 9 percent of Millennials plan to cancel their cable TV subscriptions in 2017. This does not include the young adults, college students, and children who already rely entirely on streaming.

Additional studies have tracked the rise of streaming and the decline in pay-TV usage:

- A 2017 survey conducted by Hub Entertainment Research found that 52 percent of respondents watched their favorite shows online rather than through their cable TV set-top box. This causes lower revenue for cable TV as subscribers sign up for lower cost, less inclusive pay-TV packages. This statistic was published in *DigitalNews* in an article published on November 9, 2017, by Alex Weprin, “Study OTT Overtakes Set-Top Box as Source for Favorite Shows.”
- A survey done by Videology found that only one third of Millennial males intend to subscribe to pay-TV in 2017. Adam Levy cited these statistics in a September 15, 2017, article in *USA Today* titled, “Cost Is Not Why More Millennials Than Ever Are Cutting the Cord.”

Easier Set-Up and Increased Internet Uptake

When over-the-top streaming was first available in 2007, accessing it from traditional televisions was complicated because at that time most televisions did not have the HDMI (High Definition Multimedia Interface) ports needed for set-top boxes such as Apple TVs and Roku. With the universal availability of HDMI ports on new televisions, this requirement is no longer a major impediment to the adoption of streaming. In addition, increased capacity in broadband networks and growth in broadband adoption are factors in the growth of streaming. According to Netflix, Inc. CFO David B. Wells on their October 16, 2017, third-quarter earnings call:

I think, in general, it is the continued adoption of Internet entertainment that is driving our growth.

Accessing Streaming—Connected TVs, Game Consoles, and Mobile Devices

Subscribers access streaming media on mobile devices as well as on flat-panel televisions. Streaming movies and TV shows to tablet computers and smartphones is particularly useful when traveling. In addition, university students who may not have television in their dorms often stream to laptop computers, smartphones, and tablet computers. An additional option for connecting to streaming service is via game consoles connected to televisions. Subscribers to streaming can easily log into their streaming service from game consoles such as the Sony Wii and the PlayStation Vue. Two examples of services compatible with game consoles are Netflix and Hulu movies and TV shows, which have been made compatible with game consoles so that they can be streamed directly to them.

Another way streaming is becoming more widely available is via Internet-connected televisions, also referred to as smart TVs. Internet-connected televisions have menu-driven screens for surfing the Internet and selecting programming. New smart TVs also have Roku software integrated. This eliminates the requirement for an HDMI cable and a physical set-top box because Roku features are built into the TV. Consumers can use the televisions' remote controls to click on icons from sites such as Netflix, Amazon, and Hulu to stream movies and television shows to their TV. These televisions connect to the Internet via home wireless networks or by connecting Ethernet cabling to the Ethernet port on their television. The cable is then plugged into their Wi-Fi router and their cable TV or broadband modem.

Set-Top Boxes for OTT Streams

Apple TV, Roku, Google Chrome, and Amazon Fire are examples of set-top boxes made expressly for over-the-top streaming. Each of these devices has software with options for accessing content from a specific list of providers. The set-top boxes plug into the HDMI (High Definition Multimedia Interface) port on flat screen televisions. Streaming content is sent to subscribers' set-top boxes via their Wi-Fi networks.

Roku's Business Model

Roku set-top boxes were first available in 2007 when Roku was a unit of Netflix. Netflix sold it in 2009 because they were concerned that owning a streaming device might put them in conflict with hardware providers such as Apple. Netflix traffic accounts for a third of content streamed over Roku set-top boxes. And Roku leases space in Netflix's headquarters location in Los Gatos California.

While Roku sells the most streaming devices in the United States, ahead of Amazon, Google, and Apple, the majority of its annual revenue is not from hardware sales. Rather, Roku makes the bulk of its revenue from platform sales. Platform sales consist of advertising, sales of its partners' content sold through Roku's software, and subscriptions on its hardware. It additionally has its own streaming service from which customers can stream movies and TV shows.

In addition to streaming on connected TVs and its set-top boxes, Roku has put its name on co-branded televisions manufactured by Insignia, Sharp, TCL, and others. These televisions have Roku software pre-installed, which enables consumers to use Roku without adding an external set-top box. Televisions with embedded Roku software display the Roku menu at start-up. Embedding software in televisions is a way to keep customers tied to Roku.

Another way that Roku makes content available is by formatting a selection of movies and TV for mobile operating systems. Customers that stream to mobile smartphone and tablet computers download a Roku app (a small application) to their mobile device. Movies and TV shows streamed to smartphones and tablets are formatted to appear on the particular device and operating system used on the device to which the movie, TV shows or music are streamed.

In addition to the United States, Roku streaming players and software are sold under the Roku brand in Canada, Mexico, the United Kingdom, France, and the Republic of Ireland.

Keeping and Attracting Subscribers—The Criticality of Content

Quality content that appeals to a wide range of people is an important strategy in attracting and keeping subscribers. The number of over-the-top providers in the United States competing for subscribers is on the rise. Whereas in the early days of streaming, Netflix was able to license content from studios including Disney and Universal, as these contracts expired, many studios stopped licensing content to Netflix and others in favor of streaming their own offerings.

Both Amazon and Netflix are building up their collections of original content as well as attempting to license rights to content from other studios. Netflix announced plans at their October 2017 third quarter investor conference to spend up to \$8 billion in 2017 for original content. This is riskier than purchasing existing known hits, but with less licensed content available, it is a necessary strategy.

Disney, with whom Netflix previously had a contract, opted to not renew its licensing agreement with Netflix in 2017. Disney has instead started its own streaming service with content from its movies, TV shows, and its ESPN sports division. In 2017, Disney purchased the studio library of 21st Century Fox. The content that Disney gained includes Fox's movies (*Star Wars*, *Avatar*, and *X-Men*), television (*The Simpsons*, *This is Us* and *Modern Family*). Importantly, the Fox acquisition strengthens Disney's international presence in India and other non-European countries. In a similar strategy, Comcast purchased Universal Studios in 2011 for their NBC television and Universal Studios' libraries of movies. They recognized the importance of content to round out their offerings of cable TV service.

The issue of content is also complicated by the fact that some cable TV providers also own rights to movies and TV series and/or national broadcasters. In January 2011, Comcast received approval from United States regulators to purchase a controlling stake (51 percent) in NBC Universal, which owns Universal Media Studios and Universal Pictures' Focus Features; the NBC broadcast network; and cable networks USA, Bravo, and CNBC. It is part owner of the Weather Channel and majority owner of MSNBC.

Major content providers and a partial list of what they own include the following.

- Time Warner owned the most content in the United States and Canada. Some of its properties were HBO Films, CNN, New Line Cinema, 10 percent of Hulu, TBS, Turner Entertainment, and Warner Bros. Animation. It owns CW Television Network jointly with CBS Corporation. AT&T purchased Time Warner in 2018.
- Comcast with its NBCUniversal division owns NBC, MSNBC, NBCSN, E! CNBC, Telemundo, Bravo, USA Network, DreamWorks Animation, The Weather Channel, 30 percent of Hulu, and Universal Studios along with their parks and resorts. It is the largest broadcasting and cable television

conglomerate by revenue in the world. In 2018 it purchased Sky, a pay-TV service available throughout Europe.

- See below for Walt Disney Company's purchase of 21st Century Fox's library of films and television content.
- Viacom is an international cable TV and content company. It owns Comedy Central, MTV, Spike, Nickelodeon, VIVA, Paramount Pictures, BET, and VH1, as well as others. Privately owned National Amusements, Inc. owns a majority of Class A common stock in Viacom. National Amusements is controlled by the Sumner Redstone family, which also owns movie theater companies.
- CBS mainly produces commercial television and radio shows. It owns CW Television Network jointly with Warner Brothers, CBS films, Smithsonian Network, UPN, Infinity Broadcasting, Viacom Outdoor, Showtime Networks, Simon and Schuster Publishing, and Paramount's television studio. National Amusements is a parent company of CBS as well as Viacom.
- Sony Pictures Entertainment is a wholly owned subsidiary of Tokyo based Sony Corporation through its Sony Pictures Entertainment Division. It owns Columbia Pictures, TriStar Pictures, Sony Classic Pictures, Dutch production company 2waytraffic N.V., and Sony Pictures Animation. Sony also manufactures Bravia TVs, Blu-ray players, and the PlayStation game console. It offers its content through its Internet-connected televisions, Blu-ray players, and home entertainment systems.
- The Walt Disney Company owns the ABC broadcast network, ESPN, The Disney Channel, A&E Network, Touchstone Pictures, Lucasfilm, Maker Studios, Marvel Entertainment, and Pixar. It is part owner of Lifetime Entertainment, the History Channel, A&E Networks, and Freeform, 60 percent of Hulu, and 14 theme parks worldwide. In 2018 Disney purchased 21st Century Fox which included part ownership of National Geographic Partners. Blue Sky which produces and distributes motion pictures worldwide, its film libraries, and Fox Home Entertainment. The purchase did not include Fox's TV or sports stations. The Walt Disney Company is the second biggest conglomerate by revenue in the world.

NOTE

A large part of the reason subscribers enjoy streaming is the absence of commercials in most offerings. Traditional network, cable TV, and satellite TV programs have 20 minutes of commercials in every hour of non-premium programs. The exceptions are pay-TV premium channels such as HBO and Starz for which subscribers pay extra fees.

A Snapshot of Companies that Offer Streaming

Although, it has the largest customer base of streaming customers worldwide, Netflix does have competition. According to market research group Parks Associates, there are over 200 streaming services in the United States alone. This statistic was published in the December 19, 2017, *Wall Street Journal* article by Sarah Rabil, “Streaming’s Goldrush Upends TV.” According to audience measurement firm CommScore as published in the April 10, 2017, TechCrunch.com article by Sarah Perez, “Netflix Reaches 75% of Streaming Users, but YouTube is Catching Up,” Netflix currently has 75 percent of customers that stream in the United States. The article further stated that of the Wi-Fi–equipped homes in the United States, 53 percent of them use streaming services. As more homes are equipped with Wi-Fi, the number of people streaming content will continue to grow.

And competitive streaming providers are gaining market share:

- Amazon offers free streaming for its Prime customers. Prime customers pay \$100 annually for no-fee fast deliveries, plus other privileges including free downloads to Amazon’s Kindle e-reader.
- Facebook Watch offers sports videos, short form videos of 5 to 10 minutes in length, and its own original content of 20- to 30-minute videos.
- Hulu offerings include content from broadcasters and access to live sporting and other events.
- HBO Now is free to people that subscribe to their pay HBO pay-TV offerings.
- Sling TV includes content from live broadcasts plus many pay-TV channels, and streaming sporting events.
- The Walt Disney Company has announced its intent to offer streaming channels with its own content including ESPN and 20th Century Fox’s original content, which it is purchasing from 21st Century Fox.
- Google’s YouTube TV includes broadcast stations and pay-TV channels such as ESPN and the Disney Channel.

Ad Revenue on Streaming Services

OTT streaming is available with subscription fees without commercials, or free but with commercials. Social network giant Facebook has announced its intention to offer longer form streaming video supported by advertising. Hulu, majority-owned by the Walt Disney Company and Comcast with minority ownership by AT&T, offers options for low-cost subscriptions that include ads or higher-cost subscriptions with limited, brief ads. Hulu has access to premium and broadcast TV content through its broadcast and studio owners’ libraries of content.

Streaming Worldwide

Streaming services are available in most regions worldwide, including Europe, India, China, North and South America, and parts of Africa. Netflix alone offers service in 190 countries worldwide. In developing countries such as India and where its available in Africa, coding techniques used in streaming media enable users with slow-speed mobile and wired broadband connections to receive television shows and movies of adequate resolution. Coding techniques that use compression to shrink the number of bits enable many subscribers that would otherwise not have access to receive an acceptable quality of streaming. According to Netflix Chief Product Officer, Gregory K. Peters:

Encodes we're using are super-efficient so that we can provide a really, really, high-quality video experience, and with lesser and less bits.

Netflix is a global entity with over-the-top streaming available worldwide. Its online streaming service is compatible with more than 100 formats on devices such as the Apple iPad and iPod, mobile handheld devices, Roku devices, and game consoles such as the Microsoft Xbox, Nintendo Wii, and Sony PlayStation.

Ease of Use and Technological Enablers

It is no longer necessary to connect laptops to high-definition televisions to stream movies from the Internet to the TV. Dedicated set-top devices such as the Roku and Apple TV are easily linked to flat-panel televisions via the High-Definition Multimedia Interface (HDMI) video interface and audio cable.

Significant technological improvements have occurred that enable multimedia streaming on the Internet in homes and consumer equipment that simplifies streaming to mobile devices and TVs. These innovations include the following:

- Dedicated electronic devices, such as set-top boxes from Apple TV and Roku that connect directly to televisions for streaming TV shows and movies from the Internet.
- Adaptive bit rate streaming software on content providers' and cloud servers that dynamically alter the speed of video streams to match consumer devices and bandwidth. This provides a more consistent video stream with fewer disruptions.
- Improvements with respect to in-home wireless Wi-Fi networks.
- The availability of Internet-connected televisions with icons on the start-up screen for Netflix, YouTube, Hulu, Amazon, Roku, and others that negate the requirement for a set-top box dedicated to streaming.