CHAPTER 3

E-commerce Infrastructure: The Internet, Web, and Mobile Platform

LEARNING OBJECTIVES

After reading this chapter, you will be able to:

- Discuss the origins of, and the key technology concepts behind, the Internet.
- Explain the current structure of the Internet.
- Understand the limitations of today's Internet and the potential capabilities of the Internet of the future.
- Understand how the Web works.
- Describe how Internet and web features and services support e-commerce.
- Understand the impact of mobile applications.

The Apple Watch:

Bringing the Internet of Things to Your Wrist

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Apple has a rich history of disrupting the technology landscape, dating back to the Mac computer and its revolutionary graphical user interface in the mid-1980s. More recently, we all know about the impact the iPod, iPhone, and iPad have had on our daily lives and on society in general. In 2015, Apple unveiled its most recent attempt at disruptive, groundbreaking technology in the post-Steve Jobs era: the Apple Watch. While so far the Watch has yet to garner the same results as the other iconic Apple products, it has sold relatively well and still offers strong potential to join that group in the future.

The Apple Watch is one of the latest examples of wearable computing, a fast-developing field with potential applications in healthcare, medicine, fitness, the military, gaming, and many other areas, especially those requiring the use of both hands. Defined broadly as any electronic technology incorporated into clothing and wearable accessories, examples of wearable technology include wristbands and watches, smart clothing and footwear, and smart glasses. Until recently, wearable technology has been too bulky or unwieldy to be useful, but the proliferation of smaller, more compact, more powerful devices and the resulting improvements in computing power have made wearable computing possible.

Analysts view wearable computing as an industry primed for explosive growth in the near future. According to market research firm IDC, over 100 million wearable computing devices will be shipped by the end of 2016; that number is projected to grow to over 210 million by 2020. The global market for wearable computing products is expected to grow to over $170 billion by 2021. However, the market for wearable computing is so new and evolving so quickly that even these projections could quickly become obsolete.

Sensing these trends earlier than most, Apple spent several years building and fine-tuning the Apple Watch before releasing it. Ironically, one of the guiding principles behind the development of the Watch is as a counter to the omnipresence of the smartphone, which Apple itself has driven. One of Apple's goals for the Watch is to act as a filter to much of the information overload of a smartphone, only notifying users when truly critical information requires attention. As a result, the Apple Watch prioritizes speed above depth of engagement. In its development, features that required longer than 10 seconds to use were scrapped in favor of shorter, more concise interactions.

Apple also placed its typical emphasis on elegance and simplicity of design when developing the Watch, both in its outward appearance and its underlying technology. The Watch is equipped with a scrolling wheel called the Digital Crown, which is faster than the touch screen for navigation. It also functions as a button that returns users to the home screen when pressed. Directly underneath the Digital Crown is the Apple Pay button, which allows Watch wearers to quickly pay for transactions. The prominence of the Apple Pay button on the Watch suggests that Apple wants the Watch to become a popular way to make mobile payments.

The Watch screen is a flexible retina display that uses a feature called Force Touch, which allows the Watch to detect the strength of each touch of the screen, performing different functions based on the force of the touch. On the back of the watch are four sensors, consisting of sapphire lenses and photodiode sensors that can monitor the user's vital signs and movements. Movement is used to control many functions of the Watch; for example, when receiving an incoming text message by lifting your arm to view the notification, lowering your arm again will hide the notification, saving it for later. The Watch comes in three price ranges, Sport, Watch, and Edition. Most Watch wearers will opt for the Sport, the basic $299 model, while the fashion-conscious (and deep-pocketed) may opt for the Edition, a gold-plated version of the Watch that costs between $10,000 to $17,000. There are a wide variety of options for watch faces, straps and strap sizes, and other add-ons.

Perhaps the most unique feature of the Apple Watch with regard to the user experience is the Taptic Engine, a form of haptic technology that applies gentle pressure to the skin to deliver information and alerts to the user. Wearers are alerted to different types of incoming information depending on the number, cadence, and force of the taps. Different taps designate incoming phone calls, upcoming meetings, text messages, and news alerts. When using GPS, different taps can designate different steps on the route. The Apple Watch might someday tap you to let you know that you're leaving the house without a winter coat on a cold day, or that your blood sugar is low and you need to eat.

For the time being, many critics of the device rightly point out that nearly all of what the Watch can do, the iPhone can also do, and often do better. On the other hand, because of its compatibility with apps and the Taptic Engine, the capabilities of the Watch in 2020 may be unrecognizable compared to its capabilities in 2016. For instance, sensors in the Watch may be used to differentiate the Watch from the iPhone and iPad, although the new versions of the iPhone are also being equipped with haptic technology.

Major retailers and other app developers have lined up in droves to create Apple Watch apps, despite the fact that the mobile shopping experience can be quite limited on the Watch, and that advertising is limited to ten seconds or less along with all of its other features. The device launched with 3,500 apps already available, including many from major retailers such as eBay, Amazon, and Target. Some online retailers are experimenting with the ability to bookmark an item on the Watch for future viewing on a phone or desktop. Bricks-and-mortar retailers like JCPenney and Kohl's have also developed

SOURCES: "Deep Dive: The Apple Watch Series 2 Delivers on Last Year's Promise," by Michael deAgonia, Computerworld.com, October 21, 2016; "Booming Wearable Computing Market Could Disrupt Multiple Industries," Bccresearch.com, June 8, 2016; "A Year With the Apple Watch: What Works, What Doesn't, and What Lies Ahead?" by Andrew Cunningham, Arstechnica.com, April 22, 2016; "2016 Apple Watch Will Be Internal 'S' Upgrade, Major apps, and many of these retailers hope to add features that improve the in-store shopping experience for Watch wearers. Users might be able to use a retailer's Watch app to avoid long lines in stores, find items more efficiently with interactive store maps, and pay for their purchases with Apple Pay.

Although the functionality of the Watch may currently be slightly underwhelming, users appear to be extremely satisfied so far, with 97% of Watch wearers reporting satisfaction with their device. That was better than the first iterations of the iPad and the iPhone. The Apple Watch is also selling as well as the Fitbit, a popular fitness tool. Fitbit is also worn around the wrist, but it's considered a "basic" wearable because it cannot run third-party apps. The Apple Watch may grow to have most or all of Fitbit's functionality along with a host of other capabilities. On the other hand, Fitbits sell for as low as $100 for older models, and work with all types of smartphones, including Androids. The Apple Watch will have to contend with Fitbit and other niche devices from Samsung, Garmin and Xiaomi that may sacrifice some functionality for a much lower cost. Although Apple has not released recent sales figures for the Watch and instead groups them in a category with a host of other products, estimates show that Apple will lead the wearable computing market with just under half of market share in 2016. Nevertheless, most analysts project that thus far, sales have come in under expectations, and the device hasn't really captured the public's attention the way the iPad and iPhone did.

In the early going, Apple focused on making small tweaks, many of which are cosmetic, rather than making wholesale change to the Watch. However, in September 2016, Apple released the Apple Watch 2, with changes that are both internal and external, including a thinner profile, a larger battery, performance enhancements, the addition of extremely efficient micro-LED panels to replace its previous organic LED (OLED) screen, and GPS capability without the use of a nearby iPhone. As the device continues to mature, the Watch is likely to have the functionality that its users demand. Will it be a fitness and health tool? The new frontier in mobile payments? An indispensable in-store shopping buddy? A must-have complement to the iPhone? Or something completely unforeseen? Apple would prefer it be all of these, and become the next great Apple product; but the Watch has a ways to go, both in sales and functionality, until it reaches that level of success.

Design Changes to Wait Until 2017, Insider Says," by Neil Hughes, Appleinsider.com, April 11, 2016; "Apple Watch Isn't a Smash Hit, But It Could Be a Sleeper," by Jefferson Graham, *USA Today,* March 18, 2016; "Smartwatch Growth Predicted, Thanks Largely to Apple Watch," by Matt Hamblen, Computerworld.com, September 18, 2015; "The Apple Watch Is Already Crushing the Competition, According to a New Study," by Lisa Eadicicco, Businessinsider.com, August 27, 2015; "In Apple Watch Debut, Signs of a Familiar Path to Success," by Farhad Manjoo, *New York Times,* July 22, 2015; "How Ecommerce Marketers Are Adapting to the Apple Watch," by Eric Samson, Entrepreneur.com, June 03, 2015; "Are Wearables the Next In-Store Shopping Buddies?" eMarketer, Inc., May 29, 2015; "Are We Really Going to Shop From the Apple Watch? What Retail Apps are Trying to Achieve," by Rachel Arthur, *Forbes,* May 7, 2015; "IPhone Killer: The Secret History of the Apple Watch," David Pierce, Wired.com, April 2015; "Apple Watch Is Already Attracting E-Commerce Players," by Rebecca Borison, Thestreet.com, April 24, 2015; "Wearables: The Next Mobile Payment Device?" eMarketer, Inc., March 3, 2015; "Taptic, Haptics, and the Body Fantastic: The Real Apple Watch Revolution," by Brian S. Hall, Macworld.com, October 3, 2014; "Inside the Apple Watch: The Tech Behind Apple's New Wearable," by Adario Strange, Mashable.com, September 9, 2014.

This chapter examines the Internet, Web, and mobile platform of today and tomorrow, how they evolved, how they work, and how their present and future infrastructure enable new business opportunities.

The opening case illustrates the importance of understanding how the Internet and related technologies work, and being aware of what's new. The Internet and its underlying technology are not static phenomena, but instead continue to change over time. Computers have merged with cell phone services; broadband access in the home and broadband wireless access to the Internet via smartphones, tablet computers, and laptops are expanding rapidly; self-publishing via social networks and blogging now engages millions of Internet users; and software technologies such as cloud computing and smartphone apps are revolutionizing the way businesses are using the Internet. Looking forward a few years, the business strategies of the future will require a firm understanding of these technologies and new ones, such as different types of wearable technology like the Apple Watch profiled in the opening case, the Internet of Things, the "smart/connected" movement (smart homes, smart TVs, and connected cars), augmented and virtual reality, and artificial intelligence to deliver products and services to consumers. **Table 3.1** summarizes some of the most important developments in e-commerce infrastructure for 2016–2017.

3.1 THE INTERNET: TECHNOLOGY BACKGROUND

What is the Internet? Where did it come from, and how did it support the growth of the Web? What are the Internet's most important operating principles? How much do you really need to know about the technology of the Internet?

Let's take the last question first. The answer is: it depends on your career interests. If you are on a marketing career path, or general managerial business path, then you need to know the basics about Internet technology, which you'll learn in this and the following chapter. If you are on a technical career path and hope to become a web designer, or pursue a technical career in web infrastructure for businesses, you'll need to start with these basics and then build from there. You'll also need to know about the business side of e-commerce, which you will learn about throughout this book.

Internet
an interconnected network of thousands of networks and millions of computers linking businesses, educational institutions, government agencies, and individuals

As noted in Chapter 1, the **Internet** is an interconnected network of thousands of networks and millions of computers (sometimes called *host computers* or just *hosts*), linking businesses, educational institutions, government agencies, and individuals. The Internet provides approximately 3.3 billion people around the world (including about 267 million people in the United States) with services such as e-mail, apps, newsgroups, shopping, research, instant messaging, music, videos, and news (eMarketer, Inc., 2016a, 2016b). No single organization controls the Internet or how it functions, nor is it owned by anybody, yet it has provided the infrastructure for a transformation in commerce, scientific research, and culture. The word *Internet* is derived from the word *internetwork*, or the connecting together of two or more

TABLE 3.1	TRENDS IN E-COMMERCE INFRASTRUCTURE 2016–2017
BUSINESS	
• Mobile devices become the primary access point to social network services and a rapidly expanding social marketing and advertising platform, and create a foundation for location-based web services and business models. • Explosion of Internet content services and mobile access devices strains the business models of Internet backbone providers (the large telecommunication carriers). • The growth in cloud computing and bandwidth capacity enables new business models for distributing music, movies, and television. • Search becomes more social and local, enabling social and local commerce business models. • Big data produced by the Internet creates new business opportunities for firms with the analytic capability to understand it.	
TECHNOLOGY	
• Mobile devices such as smartphones and tablet computers have become the dominant mode of access to the Internet. The new client is mobile. • The explosion of mobile apps threatens the dominance of the Web as the main source of online software applications and leads some to claim the Web is dead. • Cloud computing reshapes computing and storage, and becomes an important force in the delivery of software applications and online content. • The Internet runs out of IPv4 addresses; the transition to IPv6 continues. • The decreased cost of storage and advances in database software lead to explosion in online data collection known as big data, and creates new business opportunities for firms with the analytic capability to understand it. • The Internet of Things, with millions of sensor-equipped devices connecting to the Internet, starts to become a reality, and is powering the development of smart connected "things" such as televisions, houses, cars, and wearable technology. • Augmented reality applications such as Pokemon GO, and virtual reality hardware such as Facebook's Oculus Rift, Google's Cardboard, and Samsung's Gear VR, begin to gain traction. • Interest in and funding of artificial intelligence technologies explode, with potential applications ranging from supply chain logistics, to self-driving cars, to consumer-oriented personal assistants. • HTML5 grows in popularity among publishers and developers and makes possible web applications that are just as visually rich and lively as native mobile apps.	
SOCIETY	
• Governance of the Internet becomes more involved with conflicts between nations; the United States gives up control over IANA, which administers the Internet's IP addressing system. • Government control over, and surveillance of, the Internet is expanded in most advanced nations, and in many nations the Internet is nearly completely controlled by government agencies. • The growing infrastructure for tracking online and mobile consumer behavior conflicts with individual claims to privacy and control over personal information.	

computer networks. The **Web** is one of the Internet's most popular services, providing access to billions, perhaps trillions, of web pages, which are documents created in a programming language called HTML that can contain text, graphics, audio, video, and other objects, as well as "hyperlinks" that permit users to jump easily from one page to another. Web pages are navigated using web browser software.

Web
one of the Internet's most popular services, providing access to billions, and perhaps trillions, of web pages

THE EVOLUTION OF THE INTERNET: 1961—THE PRESENT

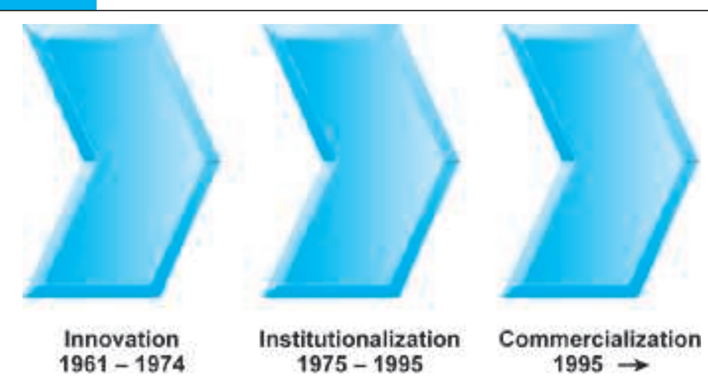
Although journalists talk glibly about "Internet" time—suggesting a fast-paced, nearly instant, worldwide global change mechanism—in fact, today's Internet had its start about 55 years ago and has slowly evolved since then.

The history of the Internet can be segmented into three phases (see **Figure 3.1**). During the *Innovation Phase,* from 1961 to 1974, the fundamental building blocks of the Internet—packet-switching hardware, a communications protocol called TCP/IP, and client/server computing (all described more fully later in this section)—were conceptualized and then implemented in actual hardware and software. The Internet's original purpose was to link large mainframe computers on different college campuses. This kind of one-to-one communication between campuses was previously possible only via the telephone system or private networks owned by the large computer manufacturers.

During the *Institutionalization Phase*, from 1975 to 1995, large institutions such as the U.S. Department of Defense (DoD) and the National Science Foundation (NSF) provided funding and legitimization for the fledging Internet. Once the concepts behind the Internet had been proven in several government-supported demonstration projects, the DoD contributed $1 million to further develop them into a robust military communications system. This effort created what was then called ARPANET (Advanced Research Projects Agency Network). In 1986, the NSF assumed responsibility for the development of a civilian Internet (then called NSFNET) and began a 10-year-long $200 million expansion program.

During the *Commercialization Phase*, from 1995 to the present, the U.S. government encouraged private corporations to take over and expand the Internet backbone as well as local service beyond military installations and college campuses to the rest of the population around the world. See **Table 3.2** for a closer look at the development of the Internet from 1961 on.

FIGURE 3.1 STAGES IN THE DEVELOPMENT OF THE INTERNET



The Internet has developed in three stages over approximately a 55-year period from 1961 to the present. In the Innovation stage, basic ideas and technologies were developed; in the Institutionalization stage, these ideas were brought to life; in the Commercialization stage, once the ideas and technologies had been proven, private companies brought the Internet to millions of people worldwide.

TABLE 3.2 DEVELOPMENT OF THE INTERNET TIMELINE

YEAR	EVENT	SIGNIFICANCE
INNOVATION PHASE 1961–1974		
1961	Leonard Kleinrock (MIT) publishes a paper on "packet switching" networks.	The concept of packet switching is born.
1962	J.C.R. Licklider (MIT) writes memo calling for an "Intergalactic Computer Network."	The vision of a global computer network is born.
1969	BBN Technologies awarded ARPA contract to build ARPANET.	The concept of a packet-switched network moves closer toward physical reality.
1969	The first packet-switched message is sent on ARPANET from UCLA to Stanford.	The communications hardware underlying the Internet is implemented for the first time. The initial ARPANET consisted of four routers (then called Interface Message Processors (IMPs)) at UCLA, Stanford, UCSB, and the University of Utah.
1972	E-mail is invented by Ray Tomlinson of BBN. Larry Roberts writes the first e-mail utility program permitting listing, forwarding, and responding to e-mails.	The first "killer app" of the Internet is born.
1973	Bob Metcalfe (Xerox PARC Labs) invents Ethernet and local area networks.	**Client/server computing is invented.** Ethernet permitted the development of local area networks and client/server computing in which thousands of fully functional desktop computers could be connected into a short-distance (<1,000 meters) network to share files, run applications, and send messages.
1974	"Open architecture" networking and TCP/IP concepts are presented in a paper by Vint Cerf (Stanford) and Bob Kahn (BBN).	**TCP/IP invented.** The conceptual foundation for a single common communications protocol that could potentially connect any of thousands of disparate local area networks and computers, and a common addressing scheme for all computers connected to the network, are born. Prior to this, computers could communicate only if they shared a common proprietary network architecture. With TCP/IP, computers and networks could work together regardless of their local operating systems or network protocols.
INSTITUTIONALIZATION PHASE 1975–1995		
1977	Lawrence Landweber envisions CSNET (Computer Science Network).	CSNET is a pioneering network for U.S. universities and industrial computer research groups that could not directly connect to ARPANET, and was a major milestone on the path to the development of the global Internet.
1980	TCP/IP is officially adopted as the DoD standard communications protocol.	The single largest computing organization in the world adopts TCP/IP and packet-switched network technology.
1980	Personal computers are invented.	Altair, Apple, and IBM personal desktop computers are invented. These computers become the foundation for today's Internet, affording millions of people access to the Internet and the Web.
1984	Apple Computer releases the HyperCard program as part of its graphical user interface operating system called Macintosh.	The concept of "hyperlinked" documents and records that permit the user to jump from one page or record to another is commercially introduced.

(continued)

TABLE 3.2 DEVELOPMENT OF THE INTERNET TIMELINE (CONTINUED)

YEAR	EVENT	SIGNIFICANCE
1984	Domain Name System (DNS) introduced.	DNS provides a user-friendly system for translating IP addresses into words that people can easily understand.
1989	Tim Berners-Lee of CERN in Switzerland proposes a worldwide network of hyperlinked documents based on a common markup language called HTML—HyperText Markup Language.	**The concept of an Internet-supported service called the World Wide Web based on HTML pages is born**. The Web would be constructed from "pages" created in a common markup language, with "hyperlinks" that permitted easy access among the pages.
1990	NSF plans and assumes responsibility for a civilian Internet backbone and creates NSFNET.[1] ARPANET is decommissioned.	The concept of a "civilian" Internet open to all is realized through nonmilitary funding by NSF.
1993	The first graphical web browser called Mosaic is invented by Marc Andreessen and others at the National Center for Supercomputing Applications at the University of Illinois.	Mosaic makes it very easy for ordinary users to connect to HTML documents anywhere on the Web. The browser-enabled Web takes off.
1994	Andreessen and Jim Clark form Netscape Corporation.	The first commercial web browser—Netscape—becomes available.
1994	The first banner advertisements appear on Hotwired.com in October 1994.	**The beginning of e-commerce**.
COMMERCIALIZATION PHASE 1995–PRESENT		
1995	NSF privatizes the backbone, and commercial carriers take over backbone operation.	**The fully commercial civilian Internet is born**. Major long-haul networks such as AT&T, Sprint, GTE, UUNet, and MCI take over operation of the backbone. Network Solutions (a private firm) is given a monopoly to assign Internet addresses.
1995	Jeff Bezos founds Amazon; Pierre Omidyar forms AuctionWeb (eBay).	E-commerce begins in earnest with pure online retail stores and auctions.
1998	The U.S. federal government encourages the founding of the Internet Corporation for Assigned Names and Numbers (ICANN).	Governance over domain names and addresses passes to a private nonprofit international organization.
1999	The first full-service Internet-only bank, First Internet Bank of Indiana, opens for business.	Business on the Web extends into traditional services.
2003	The Internet2 Abilene high-speed network is upgraded to 10 Gbps.	A major milestone toward the development of ultra-high-speed transcontinental networks several times faster than the existing backbone is achieved.
2005	NSF proposes the Global Environment for Network Innovations (GENI) initiative to develop new core functionality for the Internet.	Recognition that future Internet security and functionality needs may require the thorough rethinking of existing Internet technology.
2006	The U.S. Senate Committee on Commerce, Science, and Transportation holds hearings on "Network Neutrality."	The debate grows over differential pricing based on utilization that pits backbone utility owners against online content and service providers and device makers.

[1] "Backbone" refers to the U.S. domestic trunk lines that carry the heavy traffic across the nation, from one metropolitan area to another. Universities are given responsibility for developing their own campus networks that must be connected to the national backbone.

TABLE 3.2 DEVELOPMENT OF THE INTERNET TIMELINE (CONTINUED)

YEAR	EVENT	SIGNIFICANCE
2007	The Apple iPhone is introduced.	The introduction of the iPhone represents the beginning of the development of a viable mobile platform that will ultimately transform the way people interact with the Internet.
2008	The Internet Society (ISOC) identifies Trust and Identity as a primary design element for every layer of the Internet, and launches an initiative to address these issues.	The leading Internet policy group recognizes the current Internet is threatened by breaches of security and trust that are built into the existing network.
2008	Internet "cloud computing" becomes a billion-dollar industry.	Internet capacity is sufficient to support on-demand computing resources (processing and storage), as well as software applications, for large corporations and individuals.
2009	Internet-enabled smartphones become a major new web access platform.	Smartphones extend the reach and range of the Internet to more closely realize the promise of the Internet anywhere, anytime, anyplace.
2009	Broadband stimulus package and Broadband Data Improvement Act enacted.	President Obama signs stimulus package containing $7.2 billion for the expansion of broadband access in the United States.
2011	ICANN expands domain name system.	ICANN agrees to permit the expansion of generic top-level domain names from about 300 to potentially thousands using any word in any language.
2012	World IPv6 Launch day.	Major Internet service providers (ISPs), home networking equipment manufacturers, and online companies begin to permanently enable IPv6 for their products and services as of June 6, 2012.
2013	The Internet of Things (IoT) starts to become a reality.	Internet technology spreads beyond the computer and mobile device to anything that can be equipped with sensors, leading to predictions that up to 100–200 billion uniquely identifiable objects will be connected to the Internet by 2020.
2014	Apple introduces Apple Pay and Apple Watch.	Apple Pay is likely to become the first widely adopted mobile payment system; Apple Watch may usher in a new era of wearable Internet-connected technology and is a further harbinger of the Internet of Things.
2015	Federal Communications Commission adopts regulations mandating net neutrality.	ISPs are required to treat all data on the Internet equally and are not allowed to discriminate or charge differentially based on user, content, site, platform, application, type of equipment, or mode of communication.
2016	FCC proposes "Open Set Top Box" rules; net neutrality regulations upheld by U.S. Court of Appeals.	FCC continues to promote concept of an open Internet, despite continued resistance from telecommunications industry.

SOURCES: Based on Leiner et al., 2000; Zakon, 2005; Gross, 2005; Geni.net, 2007; ISOC.org, 2010; Arstechnica.com, 2010; ICANN, 2011a; Internet Society, 2012; IEEE Computer Society, 2013; Craig, 2016.

THE INTERNET: KEY TECHNOLOGY CONCEPTS

In 1995, the Federal Networking Council (FNC) passed a resolution formally defining the term *Internet* as a network that uses the IP addressing scheme, supports the Transmission Control Protocol (TCP), and makes services available to users much like a telephone system makes voice and data services available to the public (see **Figure 3.2**).

Behind this formal definition are three extremely important concepts that are the basis for understanding the Internet: packet switching, the TCP/IP communications protocol, and client/server computing. Although the Internet has evolved and changed dramatically in the last 35 years, these three concepts are at the core of the way the Internet functions today and are the foundation for the Internet of the future.

packet switching
a method of slicing digital messages into packets, sending the packets along different communication paths as they become available, and then reassembling the packets once they arrive at their destination

packets
the discrete units into which digital messages are sliced for transmission over the Internet

Packet Switching

Packet switching is a method of slicing digital messages into discrete units called **packets**, sending the packets along different communication paths as they become available, and then reassembling the packets once they arrive at their destination (see **Figure 3.3**). Prior to the development of packet switching, early computer networks used leased, dedicated telephone circuits to communicate with terminals and other computers. In circuit-switched networks such as the telephone system, a complete point-to-point circuit is put together, and then communication can proceed. However, these "dedicated" circuit-switching techniques were expensive and wasted available communications capacity—the circuit would be maintained regardless of whether any data was being sent. For nearly 70% of the time, a dedicated voice circuit is not being fully used because of pauses between words and delays in assembling the circuit

FIGURE 3.2 RESOLUTION OF THE FEDERAL NETWORKING COUNCIL

"The Federal Networking Council (FNC) agrees that the following language reflects our definition of the term 'Internet.'

'Internet' refers to the global information system that—

(i) is logically linked together by a globally unique address space based on the Internet Protocol (IP) or its subsequent extensions/follow-ons;

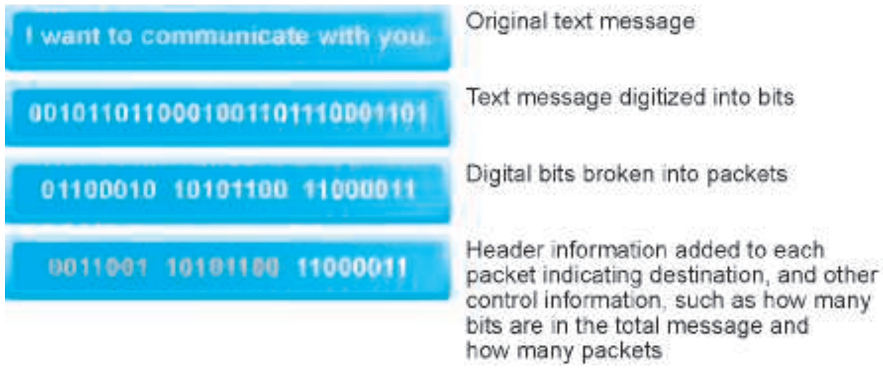
(ii) is able to support communications using the Transmission Control Protocol/Internet Protocol (TCP/IP) suite or its subsequent extensions/follow-ons, and/or other IP-compatible protocols; and

(iii) provides, uses or makes accessible, either publicly or privately, high level services layered on the communications and related infrastructure described herein."

Last modified on October 30, 1995.

SOURCE: Federal Networking Council, 1995

FIGURE 3.3 PACKET SWITCHING



In packet switching, digital messages are divided into fixed-length packets of bits (generally about 1,500 bytes). Header information indicates both the origin and the ultimate destination address of the packet, the size of the message, and the number of packets the receiving node should expect. Because the receipt of each packet is acknowledged by the receiving computer, for a considerable amount of time, the network is not passing information, only acknowledgments, producing a delay called latency.

segments, both of which increase the length of time required to find and connect circuits. A better technology was needed.

The first book on packet switching was written by Leonard Kleinrock in 1964 (Kleinrock, 1964), and the technique was further developed by others in the defense research labs of both the United States and England. With packet switching, the communications capacity of a network can be increased by a factor of 100 or more. (The communications capacity of a digital network is measured in terms of bits per second.[2]) Imagine if the gas mileage of your car went from 15 miles per gallon to 1,500 miles per gallon—all without changing too much of the car!

In packet-switched networks, messages are first broken down into packets. Appended to each packet are digital codes that indicate a source address (the origination point) and a destination address, as well as sequencing information and error-control information for the packet. Rather than being sent directly to the destination address, in a packet network, the packets travel from computer to computer until they reach their destination. These computers are called routers. A **router** is a special-purpose computer that interconnects the different computer networks that make up the Internet and routes packets along to their ultimate destination as they travel. To ensure that packets take the best available path toward their destination, routers use a computer program called a **routing algorithm**.

router
special-purpose computer that interconnects the computer networks that make up the Internet and routes packets to their ultimate destination as they travel the Internet

routing algorithm
computer program that ensures that packets take the best available path toward their destination

Packet switching does not require a dedicated circuit, but can make use of any spare capacity that is available on any of several hundred circuits. Packet switching

[2] A bit is a binary digit, 0 or 1. A string of eight bits constitutes a byte. A home telephone dial-up modem connects to the Internet usually at 56 Kbps (56,000 bits per second). Mbps refers to millions of bits per second, whereas Gbps refers to billions of bits per second.

makes nearly full use of almost all available communication lines and capacity. Moreover, if some lines are disabled or too busy, the packets can be sent on any available line that eventually leads to the destination point.

protocol
set of rules and standards for data transfer

Transmission Control Protocol/Internet Protocol (TCP/IP)
core communications protocol for the Internet

TCP
establishes connections among sending and receiving computers and handles assembly and reassembly of packets

IP
provides the Internet's addressing scheme and is responsible for delivery of packets

Network Interface Layer
responsible for placing packets on and receiving them from the network medium

Internet Layer
responsible for addressing, packaging, and routing messages on the Internet

Transport Layer
responsible for providing communication with other protocols within TCP/IP suite

Application Layer
includes protocols used to provide user services or exchange data

Border Gateway Protocol
enables exchange of routing information among systems on the Internet

Transmission Control Protocol/Internet Protocol (TCP/IP)

While packet switching was an enormous advance in communications capacity, there was no universally agreed-upon method for breaking up digital messages into packets, routing them to the proper address, and then reassembling them into a coherent message. This was like having a system for producing stamps but no postal system (a series of post offices and a set of addresses). The answer was to develop a **protocol** (a set of rules and standards for data transfer) to govern the formatting, ordering, compressing, and error-checking of messages, as well as specify the speed of transmission and means by which devices on the network will indicate they have stopped sending and/or receiving messages.

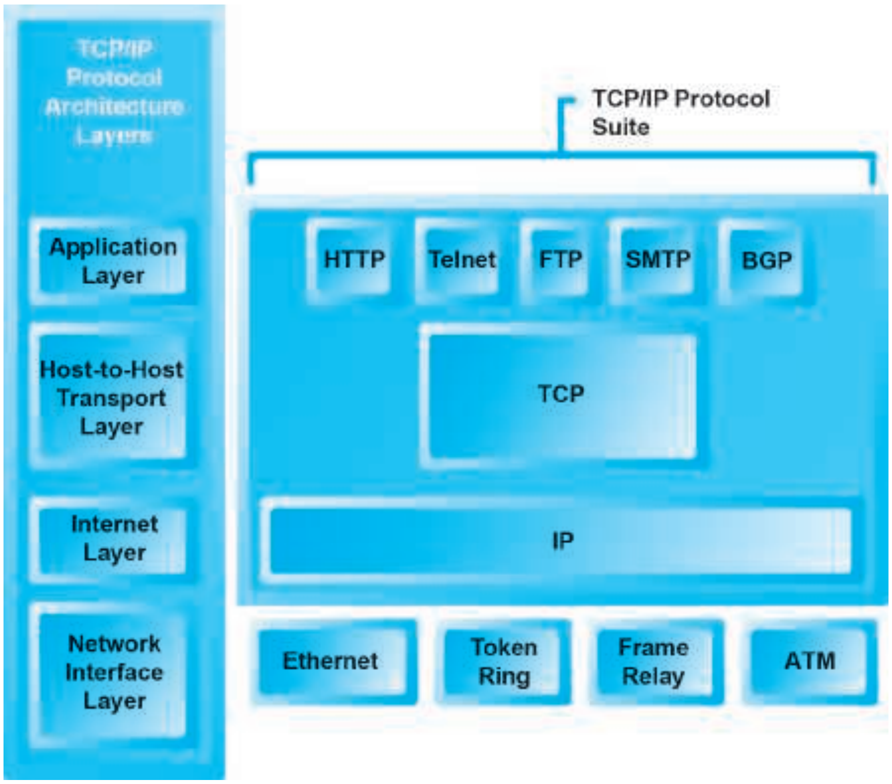
Transmission Control Protocol/Internet Protocol (TCP/IP) has become the core communications protocol for the Internet (Cerf and Kahn, 1974). **TCP** establishes the connections among sending and receiving computers, and makes sure that packets sent by one computer are received in the same sequence by the other, without any packets missing. **IP** provides the Internet's addressing scheme and is responsible for the actual delivery of the packets.

TCP/IP is divided into four separate layers, with each layer handling a different aspect of the communication problem (see **Figure 3.4**). The **Network Interface Layer** is responsible for placing packets on and receiving them from the network medium, which could be a LAN (Ethernet) or Token Ring network, or other network technology. TCP/IP is independent from any local network technology and can adapt to changes at the local level. The **Internet Layer** is responsible for addressing, packaging, and routing messages on the Internet. The **Transport Layer** is responsible for providing communication with other protocols (applications) within the TCP/IP protocol suite by acknowledging and sequencing the packets to and from the applications. The **Application Layer** includes a variety of protocols used to provide user services or exchange data. One of the most important is the **Border Gateway Protocol (BGP)**, which enables the exchange of routing information among different autonomous systems on the Internet. BGP uses TCP as its transport protocol. Other important protocols included in the Application layer include HyperText Transfer Protocol (HTTP), File Transfer Protocol (FTP), and Simple Mail Transfer Protocol (SMTP), all of which we will discuss later in this chapter.

IP Addresses

The IP addressing scheme answers the question "How can billions of computers attached to the Internet communicate with one another?" The answer is that every computer connected to the Internet must be assigned an address—otherwise it cannot send or receive TCP packets. For instance, when you sign onto the Internet using a dial-up, DSL, or cable modem, your computer is assigned a temporary address by your

FIGURE 3.4 THE TCP/IP ARCHITECTURE AND PROTOCOL SUITE



TCP/IP is an industry-standard suite of protocols for large internetworks. The purpose of TCP/IP is to provide high-speed communication network links.

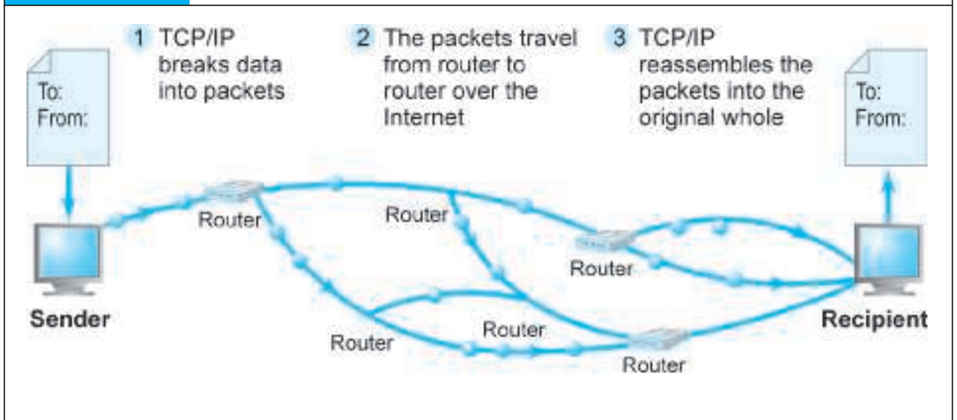
Internet Service Provider. Most corporate and university computers attached to a local area network have a permanent IP address.

There are two versions of IP currently in use: IPv4 and IPv6. An **IPv4 Internet address** is a 32-bit number that appears as a series of four separate numbers marked off by periods, such as 64.49.254.91. Each of the four numbers can range from 0–255. This "dotted quad" addressing scheme supports up to about 4 billion addresses (2 to the 32nd power). In a typical Class C network, the first three sets of numbers identify the network (in the preceding example, 64.49.254 is the local area network identification) and the last number (91) identifies a specific computer.

IPv4 Internet address
Internet address expressed as a 32-bit number that appears as a series of four separate numbers marked off by periods, such as 64.49.254.91

Because many large corporate and government domains have been given millions of IP addresses each (to accommodate their current and future work forces), and with all the new networks and new Internet-enabled devices requiring unique IP addresses being attached to the Internet, the number of IPv4 addresses available to be assigned has shrunk significantly. Registries for North America, Europe, Asia, and Latin

FIGURE 3.5 ROUTING INTERNET MESSAGES: TCP/IP AND PACKET SWITCHING



The Internet uses packet-switched networks and the TCP/IP communications protocol to send, route, and assemble messages. Messages are broken into packets, and packets from the same message can travel along different routes.

America have all essentially run out. IPv6 was created to address this problem. An **IPv6 Internet address** is 128 bits, so it can support up to 2^{128} (3.4×10^{38}) addresses, many more than IPv4. According to Akamai, in the United States, about 20% of Internet traffic now occurs over IPv6. Belgium leads the way globally, with over 40% of Internet traffic converted to IPv6 (Akamai, 2016a).

IPv6 Internet address
Internet address expressed as a 128-bit number

Figure 3.5 illustrates how TCP/IP and packet switching work together to send data over the Internet.

Domain Names, DNS, and URLs

domain name
IP address expressed in natural language

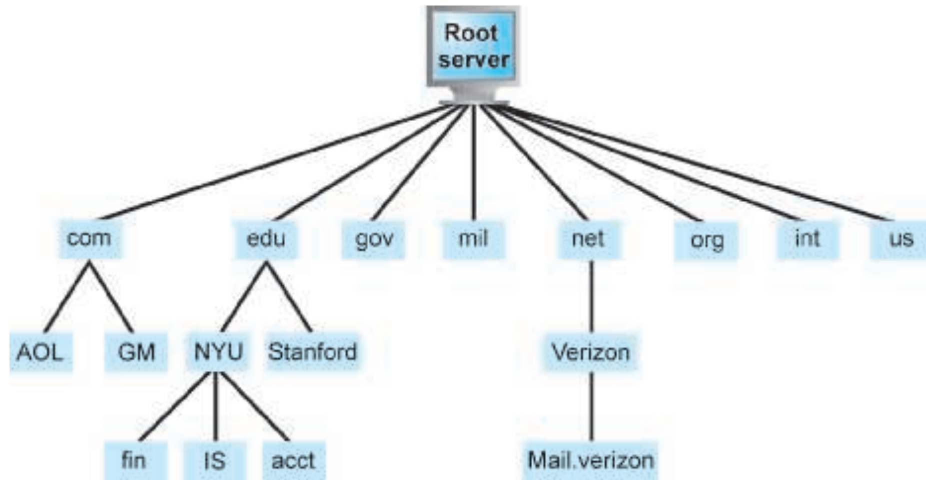
Domain Name System (DNS)
system for expressing numeric IP addresses in natural language

Uniform Resource Locator (URL)
the address used by a web browser to identify the location of content on the Web

Most people cannot remember 32-bit numbers. An IP address can be represented by a natural language convention called a **domain name**. The **Domain Name System (DNS)** allows expressions such as Cnet.com to stand for a numeric IP address (cnet.com's numeric IP is 216.239.113.101).[3] A **Uniform Resource Locator (URL)**, which is the address used by a web browser to identify the location of content on the Web, also uses a domain name as part of the URL. A typical URL contains the protocol to be used when accessing the address, followed by its location. For instance, the URL http://www.azimuth-interactive.com/flash_test refers to the IP address 208.148.84.1 with the domain name "azimuth-interactive.com" and the protocol being used to access the address, HTTP. A resource called "flash_test" is located on the server directory path /flash_test. A URL can have from two to four parts; for example, name1.name2.name3.org. We discuss domain names and URLs further in Section 3.4.

[3] You can check the IP address of any domain name on the Internet. If using a Windows operating system, open the command prompt. Type ping <Domain Name>. You will receive the IP address in return.

FIGURE 3.6 THE HIERARCHICAL DOMAIN NAME SYSTEM



The Domain Name System is a hierarchical namespace with a root server at the top. Top-level domains appear next and identify the organization type (such as .com, .gov, .org, etc.) or geographic location (such as .uk [Great Britain] or .ca [Canada]). Second-level servers for each top-level domain assign and register second-level domain names for organizations and individuals such as IBM.com, Microsoft.com, and Stanford.edu. Finally, third-level domains identify a particular computer or group of computers within an organization, e.g., www.finance.nyu.edu.

Figure 3.6 illustrates the Domain Name System and **Table 3.3** summarizes the important components of the Internet addressing scheme.

Client/Server Computing

While packet switching exploded the available communications capacity and TCP/IP provided the communications rules and regulations, it took a revolution in

TABLE 3.3 PIECES OF THE INTERNET PUZZLE: NAMES AND ADDRESSES

IP addresses	Every device connected to the Internet must have a unique address number called an Internet Protocol (IP) address.
Domain names	The Domain Name System allows expressions such as Pearsoned.com (Pearson Education's website) to stand for numeric IP locations.
DNS servers	DNS servers are databases that keep track of IP addresses and domain names on the Internet.
Root servers	Root servers are central directories that list all domain names currently in use for specific domains; for example, the .com root server. DNS servers consult root servers to look up unfamiliar domain names when routing traffic.

computing to bring about today's Internet and the Web. That revolution is called client/server computing and without it, the Web—in all its richness—would not exist. **Client/server computing** is a model of computing in which **client** computers are connected in a network with one or more **servers**, which are computers that are dedicated to performing common functions that the client computers on the network need, such as file storage, software applications, printing, and Internet access. The client computers are themselves sufficiently powerful to accomplish complex tasks. Servers are networked computers dedicated to common functions that the client computers on the network need, such as file storage, software applications, utility programs that provide web connections, and printers (see **Figure 3.7**). The Internet is a giant example of client/server computing in which millions of web servers located around the world can be easily accessed by millions of client computers, also located throughout the world.

client/server computing
a model of computing in which client computers are connected in a network together with one or more servers

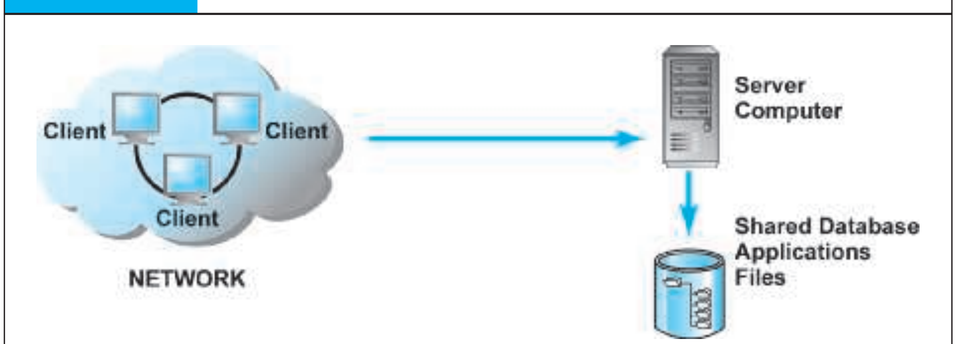
client
a powerful desktop computer that is part of a network

server
networked computer dedicated to common functions that the client computers on the network need

To appreciate what client/server computing makes possible, you must understand what preceded it. In the mainframe computing environment of the 1960s and 1970s, computing power was very expensive and limited. For instance, the largest commercial mainframes of the late 1960s had 128k of RAM and 10-megabyte disk drives, and occupied hundreds of square feet. There was insufficient computing capacity to support graphics or color in text documents, let alone sound files, video, or hyperlinked documents. In this period, computing was entirely centralized: all work was done by a single mainframe computer, and users were connected to the mainframe using terminals.

With the development of personal computers and local area networks during the late 1970s and early 1980s, client/server computing became possible. Client/server computing has many advantages over centralized mainframe computing. For instance, it is easy to expand capacity by adding servers and clients. Also, client/server networks are less vulnerable than centralized computing architectures. If one server goes down,

FIGURE 3.7 THE CLIENT/SERVER COMPUTING MODEL



In the client/server model of computing, client computers are connected in a network together with one or more servers.

backup or mirror servers can pick up the slack; if a client computer is inoperable, the rest of the network continues operating. Moreover, processing load is balanced over many powerful smaller computers rather than being concentrated in a single huge computer that performs processing for everyone. Both software and hardware in client/server environments can be built more simply and economically.

In 2016, there are an estimated 1.8 billion "traditional" personal computers in use around the world (Cox, 2016). Personal computing capabilities have also moved to smartphones and tablet computers (all much "thinner" clients with a bit less computing horsepower, and limited memory, but which rely on Internet servers to accomplish their tasks). In the process, more computer processing will be performed by central servers.

THE NEW CLIENT: THE MOBILE PLATFORM

There's a new client in town. The primary means of accessing the Internet both in the United States and worldwide is now through highly portable smartphones and tablet computers, and not traditional desktop or laptop PCs. This means that the primary platform for e-commerce products and services is also changing to a mobile platform.

The change in hardware has reached a tipping point. The form factor of PCs has changed from desktops to laptops and tablet computers such as the iPad (and more than 100 other competitors). Tablets are lighter, do not require a complex operating system, and rely on the Internet cloud to provide processing and storage. In the United States, about 155 million people access the Internet using a tablet computer (eMarketer, Inc., 2016c).

Smartphones are a disruptive technology that radically alters the personal computing and e-commerce landscape. Smartphones have created a major shift in computer processors and software that has disrupted the dual monopolies long established by Intel and Microsoft, whose chips, operating systems, and software applications began dominating the PC market in 1982. Few smartphones use Intel chips, which power 90% of the world's PCs; only a small percentage of smartphones use Microsoft's operating system (Windows Mobile). Instead, smartphone manufacturers either purchase operating systems such as Symbian, the world leader, or build their own, such as Apple's iPhone iOS, typically based on Linux and Java platforms. Smartphones do not use power-hungry hard drives but instead use flash memory chips with storage up to 128 gigabytes that also require much less power. In 2016, over 210 million Americans use mobile phones to access the Internet (eMarketer, Inc., 2016d).

The mobile platform has profound implications for e-commerce because it influences how, where, and when consumers shop and buy.

THE INTERNET "CLOUD COMPUTING" MODEL: HARDWARE AND SOFTWARE AS A SERVICE

Cloud computing is a model of computing in which computer processing, storage, software, and other services are provided as a shared pool of virtualized resources over the Internet. These "clouds" of computing resources can be accessed on an as-needed

cloud computing
model of computing in which computer processing, storage, software, and other services are provided as a shared pool of virtualized resources over the Internet

FIGURE 3.8 THE CLOUD COMPUTING MODEL

In the cloud computing model, hardware and software services are provided on the Internet by vendors operating very large server farms and data centers.

basis from any connected device and location. **Figure 3.8** illustrates the cloud computing concept.

The U.S. National Institute of Standards and Technology (NIST) defines cloud computing as having the following essential characteristics:

- **On-demand self-service:** Consumers can obtain computing capabilities such as server time or network storage as needed automatically on their own.
- **Ubiquitous network access:** Cloud resources can be accessed using standard network and Internet devices, including mobile platforms.
- **Location-independent resource pooling:** Computing resources are pooled to serve multiple users, with different virtual resources dynamically assigned according to user demand. The user generally does not know where the computing resources are located.
- **Rapid elasticity:** Computing resources can be rapidly provisioned, increased, or decreased to meet changing user demand.
- **Measured service:** Charges for cloud resources are based on the amount of resources actually used.

Cloud computing consists of three basic types of services:

- **Infrastructure as a service (IaaS):** Customers use processing, storage, networking, and other computing resources from third-party providers called cloud service providers (CSPs) to run their information systems. For example, Amazon used the spare capacity of its information technology infrastructure to develop Amazon Web Services (AWS), which offers a cloud environment for a myriad of different IT infrastructure services. See **Table 3.4** for a description of the range of services that AWS offers, such as its Simple Storage Service (S3) for storing customers' data and

TABLE 3.4 AMAZON WEB SERVICES

NAME	DESCRIPTION
COMPUTING SERVICES	
Elastic Compute Cloud (EC2)	Scalable cloud computing services
Elastic Load Balancing (ELB)	Distributes incoming application traffic among multiple EC2 instances
STORAGE SERVICES	
Simple Storage Service (S3)	Data storage infrastructure
Glacier	Low-cost archival and backup storage
DATABASE SERVICES	
DynamoDB	NoSQL database service
Redshift	Petabyte-scale data warehouse service
Relational Database Service (RDS)	Relational database service for MySQL, Oracle, SQL Server, and PostgreSQL databases
ElastiCache	In-memory cache in the cloud
SimpleDB	Non-relational data store
NETWORKING AND CONTENT DELIVERY SERVICES	
Route 53	DNS service in the cloud, enabling business to direct Internet traffic to web applications
Virtual Private Cloud (VPC)	Creates a VPN between the Amazon cloud and a company's existing IT infrastructure
CloudFront	Content delivery services
Direct Connect	Provides alternative to using the Internet to access AWS cloud services
ANALYTICS	
Elastic MapReduce (EMR)	Web service that enables users to perform data-intensive tasks
Kinesis	Big Data service for real-time data streaming ingestion and processing
APPLICATION SERVICES	
AppStream	Provides streaming services for applications and games from the cloud
CloudSearch	Search service that can be integrated by developers into applications
MESSAGING SERVICES	
Simple Email Service (SES)	Cloud e-mail sending service
Simple Notification Service (SNS)	Push messaging service
Simple Queue Service (SQS)	Queue for storing messages as they travel between computers

(continued)

TABLE 3.4	AMAZON WEB SERVICES (CONT.)
DEPLOYMENT AND MANAGEMENT SERVICES	
Identity and Access Management (IAM)	Enables securely controlled access to AWS services
CloudWatch	Monitoring service
Elastic Beanstalk	Service for deploying and scaling web applications and services developed with Java, .Net, PHP, Python, Ruby, and Node.js
CloudFormation	Service that allows developers an easy way to create a collection of related AWS resources
MOBILE	
Cognito	Allows developers to securely manage and synchronize app data for users across mobile devices
Mobile Analytics	Can collect and process billions of events from millions of users a day
PAYMENT SERVICES	
Flexible Payment Service (FPS)	Payment services for developers
DevPay	Online billing and account management service for developers who create an Amazon cloud application
MISCELLANEOUS	
Amazon Mechanical Turk	Marketplace for work that requires human intelligence
Alexa Web Information Service	Provides web traffic data and information for developers

its Elastic Compute Cloud (EC2) service for running applications. Users pay only for the amount of computing and storage capacity they actually use.

- **Software as a service (SaaS):** Customers use software hosted by the vendor on the vendor's cloud infrastructure and delivered as a service over a network. Leading SaaS examples are Google Apps, which provides common business applications online, and Salesforce.com, which provides customer relationship management and related software services over the Internet. Both charge users an annual subscription fee, although Google Apps also has a pared-down free version. Users access these applications from a web browser, and the data and software are maintained on the providers' remote servers.
- **Platform as a service (PaaS):** Customers use infrastructure and programming tools supported by the CSP to develop their own applications. For example, IBM offers Bluemix for software development and testing on its cloud infrastructure. Another example is Salesforce.com's Force.com, which allows developers to build applications that are hosted on its servers as a service.

public cloud
third-party service providers that own and manage large, scalable data centers that offer computing, data storage, and high speed Internet to multiple customers who pay for only the resources they use

A cloud can be private, public, or hybrid. A **public cloud** is owned and maintained by CSPs, such as Amazon Web Services, IBM, HP, and Dell, and made available to multiple customers, who pay only for the resources they use. A public cloud offers relatively secure enterprise-class reliability at significant cost savings. Because organizations using public clouds do not own the infrastructure, they do not have to make large investments in their own hardware and software. Instead, they purchase their computing services from remote providers and pay only for the amount of computing power they actually use (utility computing) or are billed on a monthly or annual subscription basis. The term *on-demand computing* is also used to describe such services. As such, public clouds are ideal environments for small and medium-sized businesses who cannot afford to fully develop their own infrastructure; for applications requiring high performance, scalability, and availability; for new application development and testing; and for companies that have occasional large computing projects. Gartner estimates that spending on public cloud services worldwide will grow over 15% in 2016, to $204 billion (Gartner, Inc., 2016a). Companies such as Google, Apple, Dropbox, and others also offer public clouds as a consumer service for online storage of data, music, and photos. Google Drive, Dropbox, and Apple iCloud are leading examples of this type of consumer cloud service.

A **private cloud** provides similar options as a public cloud but is operated solely for the benefit of a single tenant. It might be managed by the organization or a third party and hosted either internally or externally. Like public clouds, private clouds can allocate storage, computing power, or other resources seamlessly to provide computing resources on an as-needed basis. Companies that have stringent regulatory compliance or specialized licensing requirements that necessitate high security, such as financial services or healthcare companies, or that want flexible information technology resources and a cloud service model while retaining control over their own IT infrastructure, are gravitating toward these private clouds.

private cloud
provides similar options as public cloud but only to a single tenant

Large firms are most likely to adopt a **hybrid cloud** computing model, in which they use their own infrastructure for their most essential core activities and adopt public cloud computing for less-critical systems or for additional processing capacity during peak business periods. **Table 3.5** compares the three cloud computing models.

hybrid cloud
offers customers both a public cloud and a private cloud

TABLE 3.5 CLOUD COMPUTING MODELS COMPARED

TYPE OF CLOUD	DESCRIPTION	MANAGED BY	USES
Public cloud	Third-party service offering computing, storage, and software services to multiple customers	Third-party service providers (CSPs)	Companies without major privacy concerns Companies seeking pay-as-you-go IT services Companies lacking IT resources and expertise
Private cloud	Cloud infrastructure operated solely for a single organization and hosted either internally or externally	In-house IT or private third-party host	Companies with stringent privacy and security requirements Companies that must have control over data sovereignty
Hybrid cloud	Combination of private and public cloud services that remain separate entities	In-house IT, private host, third-party providers	Companies requiring some in-house control of IT that are also willing to assign part of their IT infrastructures to a public cloud partition on their IT infrastructures

Cloud computing will gradually shift firms from having a fixed infrastructure capacity toward a more flexible infrastructure, some of it owned by the firm, and some of it rented from giant data centers owned by CSPs.

Cloud computing has some drawbacks. Unless users make provisions for storing their data locally, the responsibility for data storage and control is in the hands of the provider. Some companies worry about the security risks related to entrusting their critical data and systems to an outside vendor that also works with other companies. Companies expect their systems to be available 24/7 and do not want to suffer any loss of business capability if cloud infrastructures malfunction. Nevertheless, the trend is for companies to shift more of their computer processing and storage to some form of cloud infrastructure.

Cloud computing has many significant implications for e-commerce. For e-commerce firms, cloud computing radically reduces the cost of building and operating websites because the necessary hardware infrastructure and software can be licensed as a service from CSPs at a fraction of the cost of purchasing these services as products. This means firms can adopt "pay-as-you-go" and "pay-as-you-grow" strategies when building out their websites. For instance, according to Amazon, hundreds of thousands of customers use Amazon Web Services. For individuals, cloud computing means you no longer need a powerful laptop or desktop computer to engage in e-commerce or other activities. Instead, you can use much less-expensive tablet computers or smartphones that cost a few hundred dollars. For corporations, cloud computing means that a significant part of hardware and software costs (infrastructure costs) can be reduced because firms can obtain these services online for a fraction of the cost of owning, and they do not have to hire an IT staff to support the infrastructure.

OTHER INTERNET PROTOCOLS AND UTILITY PROGRAMS

There are many other Internet protocols and utility programs that provide services to users in the form of Internet applications that run on Internet clients and servers. These Internet services are based on universally accepted protocols—or standards—that are available to everyone who uses the Internet. They are not owned by any organization, but they are services that have been developed over many years and made available to all Internet users.

HyperText Transfer Protocol (HTTP)
the Internet protocol used for transferring web pages

HyperText Transfer Protocol (HTTP) is the Internet protocol used to transfer web pages (described in the following section). HTTP was developed by the World Wide Web Consortium (W3C) and the Internet Engineering Task Force (IETF). HTTP runs in the Application Layer of the TCP/IP model shown in Figure 3.4 on page 119. An HTTP session begins when a client's browser requests a resource, such as a web page, from a remote Internet server. When the server responds by sending the page requested, the HTTP session for that object ends. Because web pages may have many objects on them—graphics, sound or video files, frames, and so forth—each object must be requested by a separate HTTP message. For more information about HTTP, you can consult RFC 2616, which details the standards for HTTP/1.1, the version of HTTP most commonly used today (Internet Society, 1999). (An RFC is a document published by the Internet Society [ISOC] or one of the other organizations involved in Internet governance that sets forth the standards for various Internet-related technologies. You will learn more about the organizations involved in setting standards for the Internet later in the chapter.) An updated version of HTTP, known as HTTP/2, was published as RFC 7540 in May 2015 (IETF, 2015). HTTP/2 addresses a number of HTTP 1.1 shortcomings and is designed to enhance performance by eliminating the need to open multiple TCP connections between a client and server (known as multiplexing), allowing servers to push resources to a client without the client having to request them (known as server push), and reducing the HTTP header size (header compression). HTTP/2 will also have security benefits, with improved performance for encrypted data running over HTTP/2. HTTP/2 is supported by almost all the leading web browsers, but as of August 2016, it has only been adopted by around 10% of the top 10 million websites, in part due to the challenges involved for organizations in transitioning their applications from HTTP to HTTP/2 (Akamai, 2016; W3techs.com, 2016).

E-mail is one of the oldest, most important, and frequently used Internet services. Like HTTP, the various Internet protocols used to handle e-mail all run in the Application Layer of TCP/IP. **Simple Mail Transfer Protocol (SMTP)** is the Internet protocol used to send e-mail to a server. SMTP is a relatively simple, text-based protocol that was developed in the early 1980s. SMTP handles only the sending of e-mail. To retrieve e-mail from a server, the client computer uses either **Post Office Protocol 3 (POP3)** or **Internet Message Access Protocol (IMAP)**. You can set POP3 to retrieve e-mail messages from the server and then delete the messages on the server, or retain them on the server. IMAP is a more current e-mail protocol. IMAP allows users to search, organize, and filter their mail prior to downloading it from the server.

File Transfer Protocol (FTP) is one of the original Internet services. FTP runs in TCP/IP's Application Layer and permits users to transfer files from a server to their client computer, and vice versa. The files can be documents, programs, or large database files. FTP is the fastest and most convenient way to transfer files larger than 1 megabyte, which some e-mail servers will not accept. More information about FTP is available in RFC 959 (Internet Society, 1985).

Telnet is a network protocol that also runs in TCP/IP's Application Layer and is used to allow remote login on another computer. The term Telnet also refers to the Telnet program, which provides the client part of the protocol and enables the client to emulate a mainframe computer terminal. (The industry-standard terminals defined in the days of mainframe computing are VT-52, VT-100, and IBM 3250.) You can then attach yourself to a computer on the Internet that supports Telnet and run programs or download files from that computer. Telnet was the first "remote work" program that permitted users to work on a computer from a remote location.

Secure Sockets Layer (SSL)/Transport Layer Security (TLS) are protocols that operate between the Transport and Application Layers of TCP/IP and secure communications between the client and the server. SSL/TLS helps secure e-commerce communications and payments through a variety of techniques, such as message encryption and digital signatures, that we will discuss further in Chapter 5.

Simple Mail Transfer Protocol (SMTP)
the Internet protocol used to send mail to a server

Post Office Protocol 3 (POP3)
a protocol used by the client to retrieve mail from an Internet server

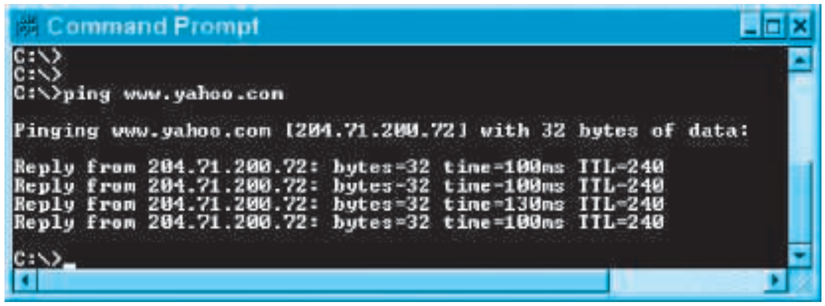
Internet Message Access Protocol (IMAP)
a more current e-mail protocol that allows users to search, organize, and filter their mail prior to downloading it from the server

File Transfer Protocol (FTP)
one of the original Internet services. Part of the TCP/IP protocol that permits users to transfer files from the server to their client computer, and vice versa

Telnet
a terminal emulation program that runs in TCP/IP

Secure Sockets Layer (SSL) /Transport Layer Security (TLS)
protocols that secure communications between the client and the server

FIGURE 3.9 THE RESULT OF A PING



A ping is used to verify an address and test the speed of the round trip from a client computer to a host and back.

SOURCE: Command Prompt, Microsoft Windows, Microsoft Corporation.

Ping
a program that allows you to check the connection between your client and the server

Packet InterNet Groper (Ping) is a utility program that allows you to check the connection between a client computer and a TCP/IP network (see **Figure 3.9**). Ping will also tell you the time it takes for the server to respond, giving you some idea about the speed of the server and the Internet at that moment. You can run Ping from the command prompt on a personal computer with a Windows operating system by typing: ping <domain name>. Ping can also be used to slow down or even crash a domain server by sending it millions of ping requests.

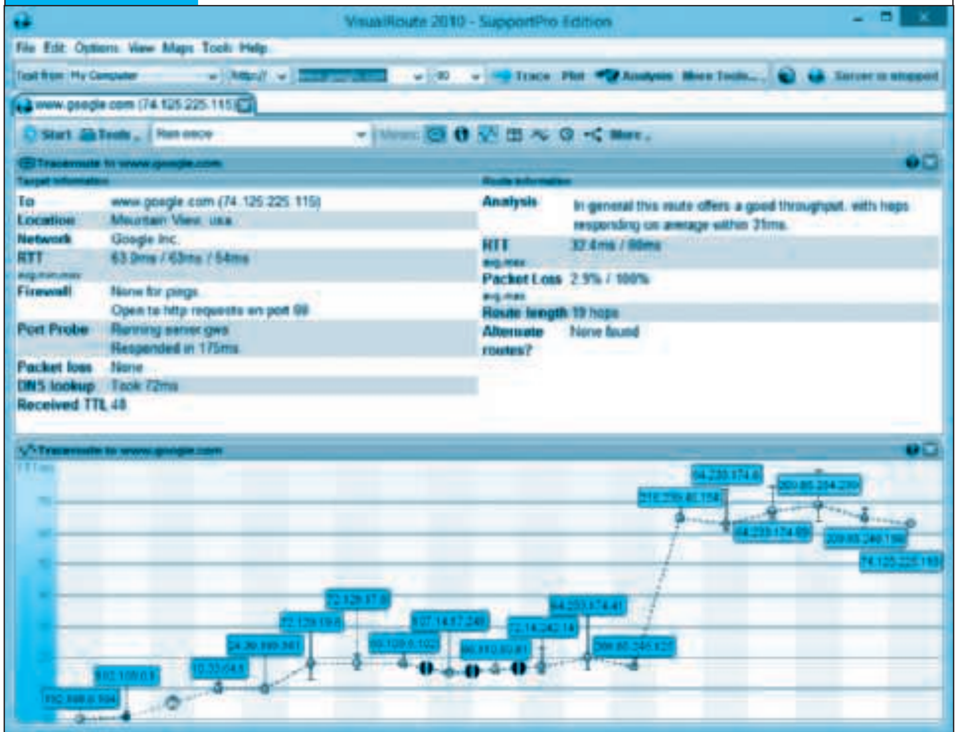
Tracert
one of several route-tracing utilities that allow you to follow the path of a message you send from your client to a remote computer on the Internet

Tracert is one of several route-tracing utilities that allow you to follow the path of a message you send from your client to a remote computer on the Internet. **Figure 3.10** shows the result of a message sent to a remote host using a visual route-tracing program called VisualRoute (available from Visualware).

3.2 THE INTERNET TODAY

In 2016, there are an estimated 3.3 billion Internet users worldwide, up from 100 million users at year-end 1997. While this is a huge number, it still represents less than half (about 45%) of the world's population (eMarketer, Inc., 2016a). Although Internet user growth has slowed in the United States and Western Europe to about 1%–2% annually, worldwide, the growth rate is about 7%, with the highest growth areas being the Middle East/Africa and Asia-Pacific (both still growing at over 8%). By 2020, it is expected that there will be over 3.9 billion Internet users worldwide. One would think the Internet would be overloaded with such incredible growth; however, this has not been true for several reasons. First, client/server computing is highly extensible. By simply adding servers and clients, the population of Internet users can grow indefinitely. Second, the Internet architecture is built in layers so that each layer can change without disturbing developments in other layers. For instance, the technology used to move messages through the Internet can go through radical changes to make service faster without being disruptive to your desktop applications running on the Internet.

FIGURE 3.10 TRACING THE ROUTE A MESSAGE TAKES ON THE INTERNET



VisualRoute and other tracing programs provide some insight into how the Internet uses packet switching. This particular message traveled to a Google server in Mountain View, California.

SOURCE: © Visualware, Inc., 2014.

Figure 3.11 illustrates the "hourglass" and layered architecture of the Internet. The Internet can be viewed conceptually as having four layers: Network Technology Substrates, Transport Services and Representation Standards, Middleware Services, and Applications.[4] The **Network Technology Substrate layer** is composed of telecommunications networks and protocols. The **Transport Services and Representation Standards layer** houses the TCP/IP protocol. The **Applications layer** contains client applications such as the Web, e-mail, and audio or video playback. The **Middleware Services layer** is the glue that ties the applications to the communications networks and includes such services as security, authentication, addresses, and storage repositories. Users work with applications (such as e-mail) and rarely become aware of middleware that operates in the background. Because all layers use TCP/IP and other common standards linking all four layers, it is possible for there to be significant

Network Technology Substrate layer
layer of Internet technology that is composed of telecommunications networks and protocols

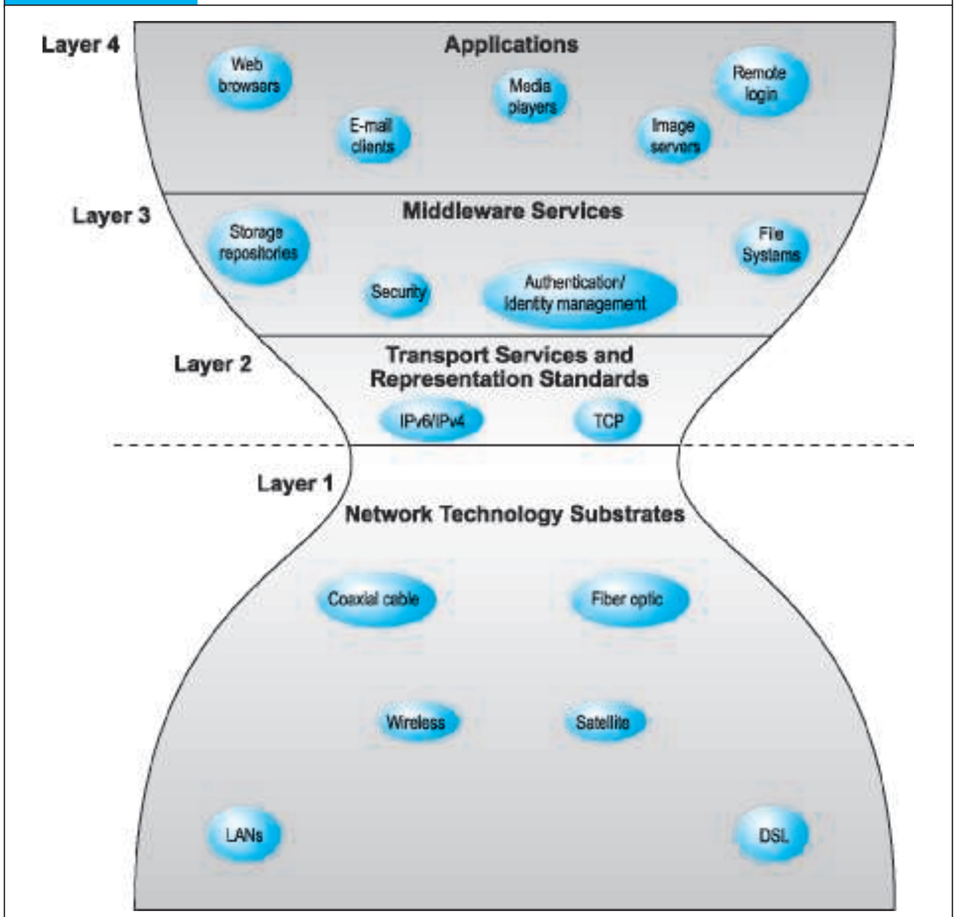
Transport Services and Representation Standards layer
layer of Internet architecture that houses the TCP/IP protocol

Applications layer
layer of Internet architecture that contains client applications

Middleware Services layer
the "glue" that ties the applications to the communications networks and includes such services as security, authentication, addresses, and storage repositories

[4] Recall that the TCP/IP communications protocol also has layers, not to be confused with the Internet architecture layers.

FIGURE 3.11 THE HOURGLASS MODEL OF THE INTERNET



The Internet can be characterized as an hourglass modular structure with a lower layer containing the bit-carrying infrastructure (including cables and switches) and an upper layer containing user applications such as e-mail and the Web. In the narrow waist are transportation protocols such as TCP/IP.

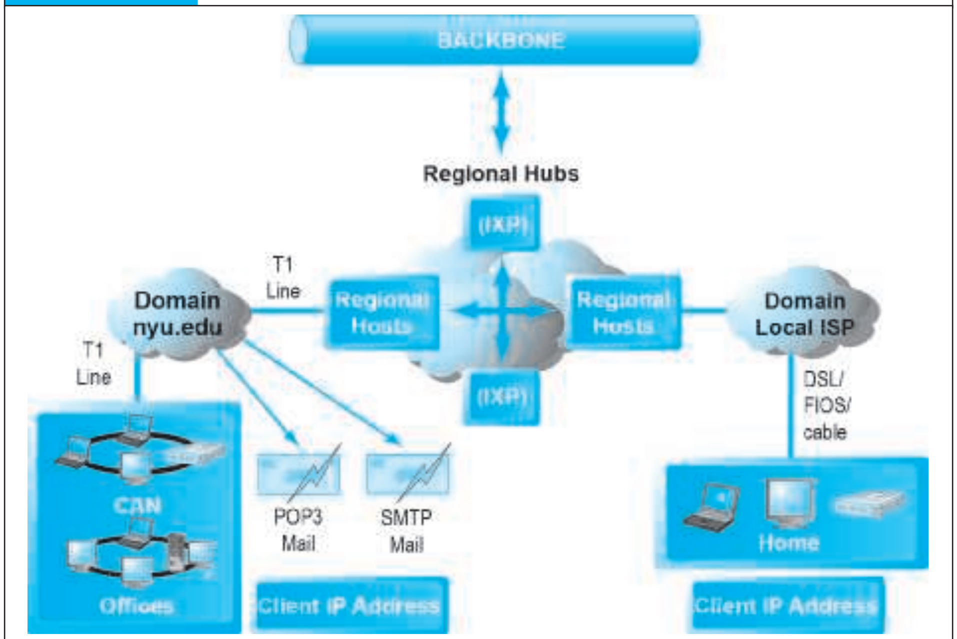
changes in the Network Technology Substrate layer without forcing changes in the Applications layer.

THE INTERNET BACKBONE

Tier 1 Internet Service Providers (Tier 1 ISPs) own and control the major long-haul fiber-optic cable networks comprising the Internet's backbone

Figure 3.12 illustrates some of the main physical elements of today's physical Internet. Originally, the Internet had a single backbone, but today's Internet is woven together from numerous privately owned networks comprised of high-bandwidth fiber-optic cable that are physically connected with each other and that transfer information from one private network to another. These long-haul fiber-optic networks are owned by firms sometimes referred to as **Tier 1 Internet Service Providers (Tier 1 ISPs)** (also sometimes called *transit ISPs*) (see **Table 3.6**). Tier 1 ISPs have "peering"

FIGURE 3.12 INTERNET NETWORK ARCHITECTURE



Today's Internet has a multi-tiered open network architecture featuring multiple backbones, regional hubs, campus/corporate area networks, and local client computers.

arrangements with other Tier 1 ISPs to allow Internet traffic to flow through each other's cables and equipment without charge. Tier 1 ISPs deal only with other Tier 1 or Tier 2 ISPs (described in the next section) and not with end consumers.

For the sake of simplicity, we will refer to these networks of backbones as a single "backbone." The **backbone** has been likened to a giant pipeline that transports data around the world in milliseconds. In the United States, the backbone is composed entirely of fiber-optic cable with bandwidths ranging from 155 Mbps to 2.5 Gbps. **Bandwidth** measures how much data can be transferred over a communications medium within a fixed period of time and is usually expressed in bits per second (Bps), kilobits (thousands of bits) per second (Kbps), megabits (millions of bits) per second (Mbps), or gigabits (billions of bits) per second (Gbps).

backbone
high-bandwidth fiber-optic cable that transports data across the Internet

bandwidth
measures how much data can be transferred over a communications medium within a fixed period of time; is usually expressed in bits per second (bps), kilobits per second (Kbps), megabits per second (Mbps), or gigabits per second (Gbps)

TABLE 3.6 MAJOR U.S. TIER 1 (TRANSIT) INTERNET SERVICE PROVIDERS

AT&T	Sprint
CenturyLink	Verizon
Cogent Communications	Zayo Group
Level 3 Communications	

Connections to other continents are made via a combination of undersea fiber-optic cable and satellite links. Increasingly, rather than leasing bandwidth from Tier 1 ISPs, Internet giants such as Google, Microsoft, and Facebook are laying down their own fiber-optic networks. For instance, Google has one cable stretching from the California to Japan and another connecting the United States to Brazil, while Facebook and Microsoft have allied to lay a cable across the Atlantic, connecting Virginia to Spain. The backbone in foreign countries typically is operated by a mixture of private and public owners. The backbone has built-in redundancy so that if one part breaks down, data can be rerouted to another part of the backbone. **Redundancy** refers to multiple duplicate devices and paths in a network. A recent study of the Internet's physical structure in the United States has created one of the first maps of the Internet's long-haul fiber network as it currently exists. The map reveals that, not surprisingly, there are dense networks of fiber in the Northeast and coastal areas of the United States, while there is a pronounced absence of infrastructure in the Upper Plains and Four Corners regions. The U.S. Department of Homeland Security has made the map, as well as the data that underlies it, available to government, private, and public researchers, believing that doing so could make the Internet more resilient by improving knowledge (Simonite, 2015; Durairajan et al., 2015).

redundancy
multiple duplicate devices and paths in a network

INTERNET EXCHANGE POINTS

In the United States, there are a number of regional hubs where Tier 1 ISPs physically connect with one another and/or with regional (Tier 2) ISPs. Tier 2 ISPs exchange Internet traffic both through peering arrangements as well as by purchasing Internet transit, and they connect Tier 1 ISPs with Tier 3 ISPs, which provide Internet access to consumers and business. Tier 3 ISPs are described further in the next section. These hubs were originally called Network Access Points (NAPs) or Metropolitan Area Exchanges (MAEs), but now are more commonly referred to as **Internet Exchange Points (IXPs)** (see **Figure 3.13**).

Internet Exchange Point (IXP)
hub where the backbone intersects with local and regional networks and where backbone owners connect with one another

TIER 3 INTERNET SERVICE PROVIDERS

The firms that provide the lowest level of service in the multi-tiered Internet architecture by leasing Internet access to home owners, small businesses, and some large institutions are sometimes called **Tier 3 Internet Service Providers (ISPs)**. Tier 3 ISPs are retail providers. They deal with "the last mile of service" to the curb—homes and business offices. Tier 3 ISPs typically connect to IXPs with high-speed telephone or cable lines (45 Mbps and higher).

Tier 3 Internet Service Provider (Tier 3 ISP)
firm that provides the lowest level of service in the multi-tiered Internet architecture by leasing Internet access to home owners, small businesses, and some large institutions

Three companies, Comcast, Verizon, and Time Warner Cable, together control almost half of the "last mile" wired infrastructure in the United States. Other major Tier 3 ISPs include AT&T, Charter (which is poised to move up the ladder with a proposed purchase, currently awaiting federal approval, of Time Warner Cable and Bright House Networks), Altice (Optimum Online), Cox, Sprint, and CenturyLink. There are also thousands of much smaller, local access ISPs. If you have home or small business Internet access, a Tier 3 ISP likely provides the service to you. (It's important to note that many Tier 3 ISPs are also Tier I ISPs; the two roles are not mutually exclusive.)

FIGURE 3.13 SOME MAJOR U.S. INTERNET EXCHANGE POINTS (IXPs)

Region	Name	Location	Operator
EAST	Boston Internet Exchange (BOSIX)	Boston	Markley
	New York International Internet Exchange (NYIIX)	New York	Telehouse
	Peering and Internet Exchange (PAIX)	New York, Virginia, Atlanta	Equinix
	NAP of the Americas	Miami	Verizon Terremark
CENTRAL	Any2 Exchange	Chicago	CoreSite
	Peering and Internet Exchange (PAIX)	Dallas	Equinix
	Midwest Internet Cooperative Exchange (MICE)	Minneapolis	Members
WEST	Peering and Internet Exchange (PAIX)	Seattle, Palo Alto	Equinix
	Los Angeles International Internet Exchange (LAIIX)	Los Angeles	Telehouse
	Any2 Exchange	San Jose, Los Angeles	CoreSite
	Seattle Internet Exchange (SIX)	Seattle	Members

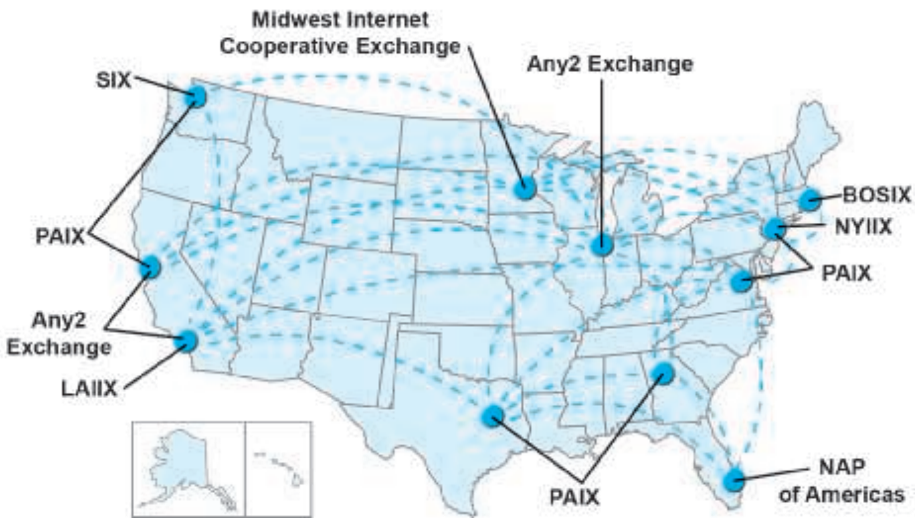


TABLE 3.7 INTERNET ACCESS SERVICE LEVELS AND BANDWIDTH CHOICES

SERVICE	COST/MONTH	DOWNLOAD SPEED
Telephone modem	$10–$25	30–56 Kbps
DSL	$20–$30	1–15 Mbps
FiOS	$50–$300	25 Mbps–500 Mbps
Cable Internet	$35–$199	1 Mbps–500 Mbps
Satellite	$39–$129	5–15 Mbps
T1	$200–$300	1.54 Mbps
T3	$2,500–$10,000	45 Mbps

Satellite firms also offer Internet access, especially in remote areas where broadband service is not available.

narrowband
the traditional telephone modem connection, now operating at 56.6 Kbps

broadband
refers to any communication technology that permits clients to play streaming audio and video files at acceptable speeds

Table 3.7 summarizes the variety of services, speeds, and costs of Internet access available to consumers and businesses. There are two types of service: narrowband and broadband. **Narrowband** service is the traditional telephone modem connection now operating at 56.6 Kbps (although the actual throughput hovers around 30 Kbps due to line noise that causes extensive resending of packets). This used to be the most common form of connection worldwide but it has been largely replaced by broadband connections in the United States, Europe, and Asia. Broadband service is based on DSL (including high speed fiber-optic service), cable, telephone (T1 and T3 lines), and satellite technologies. **Broadband**, in the context of Internet service, refers to any communication technology that permits clients to play streaming audio and video files at acceptable speeds. In January 2015, the U.S. Federal Communications Commission updated its broadband benchmark speeds to 25 Mbps for downloads and 3 Mbps for uploads. According to Akamai, the global average connection speed in 2016 was 6.3 Mbps, and the global average peak connection speed was 34.7 Mbps. The United States ranks 16th with an 15.3 Mbps average connection speed (South Korea leads, at 29.9 Mbps) and 22nd with a 67.8 Mbps average peak connection speed (Singapore leads, at 146.9 Mbps) (Akamai, 2016c). The FCC found that 17% of all Americans lack access to 25 Mbps/3 Mbps service, and that rural America is particularly underserved, with more than half lacking such access (Federal Communication Commission, 2015). In the United States, broadband users surpassed dial-up users in 2004, and in 2016, there are an estimated 92 million broadband households (over 75% of all households) (eMarketer, Inc., 2016e).

The actual throughput of data will depend on a variety of factors including noise in the line and the number of subscribers requesting service. Service-level speeds quoted are typically only for downloads of Internet content; upload speeds tend to be slower, although a number of broadband ISPs have plans that offer the same upload as download speed. T1 and T3 lines are publicly regulated utility lines that offer a guaranteed level of service, but the actual throughput of the other forms of Internet service is not guaranteed.

Digital Subscriber Line (DSL) service is a telephone technology that provides high-speed access to the Internet through ordinary telephone lines found in a home or business. Service levels typically range from about .5 to 15 Mbps. DSL service requires that customers live within two miles (about 4,000 meters) of a neighborhood telephone switching center. In order to compete with cable companies, telephone companies now also offer an advanced form of DSL called **FiOS (fiber-optic service)** that provides up to 500 Mbps to homes and businesses.

Digital Subscriber Line (DSL)
delivers high-speed access through ordinary telephone lines found in homes or businesses

FiOS (fiber-optic service)
a form of DSL that provides speeds of up to 500 Mbps

Cable Internet refers to a cable television technology that piggybacks digital access to the Internet using the same analog or digital video cable providing television signals to a home. Cable Internet is a major broadband alternative to DSL service, generally providing faster speeds and a "triple play" subscription: telephone, television, and Internet for a single monthly payment. However, the available bandwidth of cable Internet is shared with others in the neighborhood using the same cable. When many people are attempting to access the Internet over the cable at the same time, speeds may slow and performance will suffer. Cable Internet services typically range from 1 Mbps up to 500 Mbps. Comcast, Time Warner Cable, Charter, Cox, and Altice (Optimum Online) are some of the major cable Internet providers.

cable Internet
piggybacks digital access to the Internet on top of the analog video cable providing television signals to a home

T1 and T3 are international telephone standards for digital communication. **T1** lines offer guaranteed delivery at 1.54 Mbps, while **T3** lines offer 45 Mbps. T1 lines cost about $200–$300 per month, and T3 lines around $2500–$6000 per month. These are leased, dedicated, guaranteed lines suitable for corporations, government agencies, and businesses such as ISPs requiring high-speed guaranteed service levels.

T1
an international telephone standard for digital communication that offers guaranteed delivery at 1.54 Mbps

T3
an international telephone standard for digital communication that offers guaranteed delivery at 45 Mbps

Satellite Internet is offered by satellite companies that provide high-speed broadband Internet access primarily to homes and offices located in rural areas where DSL or cable Internet access is not available. Access speeds and monthly costs are comparable to DSL and cable, but typically require a higher initial payment for installation of a small (18-inch) satellite dish. Upload speeds tend to be slower, typically 1–5 Mbps. Satellite providers typically have policies that limit the total megabytes of data that a single account can download within a set period, usually monthly. The major satellite providers are Dish, HughesNet, and Exede. In August 2016, Facebook announced plans to launch a satellite aimed at bringing Internet connectivity to parts of sub-Saharan Africa, but those plans were put on hold when the SpaceX rocket that was to launch the satellite exploded while being tested during pre-launch activities.

satellite Internet
high-speed broadband Internet access provided via satellite

Nearly all business firms and government agencies have broadband connections to the Internet. Demand for broadband service has grown so rapidly because it greatly speeds up the process of downloading web pages and large video and audio files (see **Table 3.8**). As the quality of Internet service offerings continues to expand, the demand for broadband access will continue to swell.

CAMPUS/CORPORATE AREA NETWORKS

Campus/corporate area networks (CANs) are generally local area networks operating within a single organization—such as New York University or Microsoft Corporation. In fact, most large organizations have hundreds of such local area networks.

campus/corporate area network (CAN)
generally, a local area network operating within a single organization that leases access to the Web directly from regional and national carriers

TABLE 3.8 TIME TO DOWNLOAD A 10-MEGABYTE FILE BY TYPE OF INTERNET SERVICE

TYPE OF INTERNET SERVICE	TIME TO DOWNLOAD
NARROWBAND SERVICES	
Telephone modem	25 minutes
BROADBAND SERVICES	
DSL @ 1 Mbps	1.33 minutes
Cable Internet @ 10 Mbps	8 seconds
T1	52 seconds
T3	2 seconds

These organizations are sufficiently large that they lease access to the Web directly from regional and national carriers. These local area networks generally are running Ethernet (a local area network protocol) and have network operating systems such as Windows Server or Linux that permit desktop clients to connect to the Internet through a local Internet server attached to their campus networks. Connection speeds in campus area networks are in the range of 10–100 Mbps to the desktop.

INTRANETS

intranet
a TCP/IP network located within a single organization for purposes of communications and information processing

The very same Internet technologies that make it possible to operate a worldwide public network can also be used by private and government organizations as internal networks. An **intranet** is a TCP/IP network located within a single organization for purposes of communications and information processing. Internet technologies are generally far less expensive than proprietary networks, and there is a global source of new applications that can run on intranets. In fact, all the applications available on the public Internet can be used in private intranets. The largest provider of local area network software is Microsoft, followed by open source Linux, both of which use TCP/IP networking protocols.

WHO GOVERNS THE INTERNET?

Aficionados and journalists often claim that the Internet is governed by no one, and indeed cannot be governed, and that it is inherently above and beyond the law. What these people forget is that the Internet runs over private and public telecommunications facilities that are themselves governed by laws, and subject to the same pressures as all telecommunications carriers. In fact, the Internet is tied into a complex web of governing bodies, national governments, and international professional societies. There is no one single governing organization that controls activity on the Internet.

Instead, there are a number of organizations that influence the system and monitor its operations. Among the governing bodies of the Internet are:

- The *Internet Corporation for Assigned Names and Numbers (ICANN)*, which coordinates the Internet's systems of unique identifiers: IP addresses, protocol parameter registries, and the top-level domain systems. ICANN was created in 1998 as a nonprofit organization and manages the *Internet Assigned Numbers Authority (IANA)*, which is in charge of assigning IP addresses.
- The *Internet Engineering Task Force (IETF)*, which is an open international community of network operators, vendors, and researchers concerned with the evolution of the Internet architecture and operation of the Internet. The IETF has a number of working groups, organized into several different areas, that develop and promote Internet standards, which influence the way people use and manage the Internet.
- The *Internet Research Task Force (IRTF)*, which focuses on the evolution of the Internet. The IRTF has a number of long-term research groups working on various topics such as Internet protocols, applications, applications, and technology.
- The *Internet Engineering Steering Group (IESG)*, which is responsible for technical management of IETF activities and the Internet standards process.
- The *Internet Architecture Board (IAB)*, which helps define the overall architecture of the Internet and oversees the IETF and IRTF.
- The *Internet Society (ISOC)*, which is a consortium of corporations, government agencies, and nonprofit organizations that monitors Internet policies and practices.
- The *Internet Governance Forum (IGF)*, which is a multi-stakeholder open forum for debate on issues related to Internet governance.
- The *World Wide Web Consortium (W3C)*, which is a largely academic group that sets HTML and other programming standards for the Web.
- The *Internet Network Operators Groups (NOGs),* which are informal groups that are made up of ISPs, IXPs, and others that discuss and attempt to influence matters related to Internet operations and regulation.

While none of these organizations has actual control over the Internet and how it functions, they can and do influence government agencies, major network owners, ISPs, corporations, and software developers with the goal of keeping the Internet operating as efficiently as possible. ICANN comes closest to being a manager of the Internet and reflects the powerful role that the U.S. Department of Commerce has played historically in Internet governance. The United States has been responsible for the IANA function since the beginning of the Internet. After the creation of ICANN, however, the expectation was the function would eventually be transferred out of the U.S. government's control. In 2006, however, the U.S. Department of Commerce announced that the U.S. government would retain oversight over the root servers, contrary to initial expectations. There were several reasons for this move, including the use of the Internet for basic communications services by terrorist groups and the uncertainty that might be caused should an international body take over. In 2008, the Department of Commerce reaffirmed this stance, stating that it did not have any plans to transition management of the authoritative root zone file to ICANN (U.S. Department of Commerce, 2008). At the same time, growing Internet powers China and Russia were lobbying for more functions of the Internet to be brought under the control of the United Nations, raising fears that governance of the Internet could become even more politicized (Pfanner, 2012). In 2014, the United States, under continued pressure from other countries, finally announced its willingness to transition control of IANA, provided that certain stipulations are met, including that the organization managing the IANA functions not be specifically controlled by any other government or inter-governmental organization (such as the United Nations). The transition took place on October 1, 2016.

In addition to these professional bodies, the Internet must also conform to the laws of the sovereign nation-states in which it operates, as well as the technical infrastructures that exist within each nation-state. Although in the early years of the Internet there was very little legislative or executive interference, this situation is changing as the Internet plays a growing role in the distribution of information and knowledge, including content that some find objectionable.

Read *Insight on Society: Government Regulation and Surveillance of the Internet* for a further look at the issue of censorship of Internet content and substance.

3.3 THE FUTURE INTERNET INFRASTRUCTURE

The Internet is changing as new technologies appear and new applications are developed. The next era of the Internet is being built today by private corporations, universities, and government agencies. To appreciate the potential benefits of the Internet of the future, you must first understand the limitations of the Internet's current infrastructure.

LIMITATIONS OF THE CURRENT INTERNET

Much of the Internet's current infrastructure is several decades old (equivalent to a century in Internet time). It suffers from a number of limitations, including:

- *Bandwidth limitations*. There is insufficient capacity throughout the backbone, the metropolitan switching centers, and most importantly, the "last mile" to the house and small businesses. The result is slow peak-hour service (congestion) and a limited ability to handle high volumes of video and voice traffic.
- *Quality of service limitations*. Today's information packets take a circuitous route to get to their final destinations. This creates the phenomenon of **latency**—delays in messages caused by the uneven flow of information packets through the network. In the case of e-mail, latency is not noticeable. However, with streaming video and synchronous communication, such as a telephone call, latency is noticeable to the user and perceived as "jerkiness" in movies or delays in voice communication. Today's Internet uses "best-effort" quality of service (QoS), which makes no guarantees about when or whether data will be delivered, and provides each packet with the same level of service, no matter who the user is or what type of data is

latency
delays in messages caused by the uneven flow of information packets through the network

INSIGHT ON SOCIETY

GOVERNMENT REGULATION AND SURVEILLANCE OF THE INTERNET

Hardly a week goes by without reports that a massive protest has occurred in the streets of a big city somewhere in the world. Invariably, the Internet, social media, and mobile phones are either blamed or praised for enabling these popular expressions of discontent with political regimes, corrupt officials, unemployment, or wealth inequality. Such events encourage us to think of the Internet and the Web as an extraordinary technology unleashing torrents of human creativity, innovation, expression, popular rebellion, and sometimes, even democracy.

How ironic then that the same Internet has also spawned an explosion in government control and surveillance of individuals on the Internet. Totalitarian dictators of the mid-twentieth century would have given their eyeteeth for a technology such as this, that can track what millions of people do, say, think, and search for in billions of e-mails, searches, blogs, and Facebook posts every day.

In the early years of the Internet and the Web, many people assumed that because the Internet is so widely dispersed, it must be difficult to control or monitor. But the reality is quite different. We now know that just about all governments assert some kind of control and surveillance over Internet content and messages, and in many nations this control over the Internet and the people who use it is very extensive.

While the Internet is a decentralized network, Internet traffic in all countries runs through large fiber-optic trunk lines that are controlled by national authorities or private firms. In China, there are three such lines, and China requires the companies that own these lines to configure their routers for both internal and external service requests. When a request originates in China for a web page in Chicago, Chinese routers examine the request to see if the site is on a blacklist, and then examine words in the requested web page to see if it contains blacklisted terms. The system is often referred to as "The Great Firewall of China" (but formally by China as the "Golden Shield") and was implemented with the assistance of Cisco Systems (the U.S. firm that is the largest manufacturer of routers in the world), Juniper Networks, and California-based Blue Coat (now owned by Symantec), which provides deep packet inspection software. A number of other U.S. Internet firms have also been involved in China's censorship and surveillance efforts.

Over the past several years, China has strengthened and extended its regulation of the Internet in the name of social stability. Recently passed legislation allows web users to be jailed for up to three years if they post defamatory rumors that are read by more than 5,000 people. China has also issued rules to restrict the dissemination of political news and opinions on instant messaging applications such as WeChat, a text messaging app similar to Twitter and WhatsApp. Users are required to post political opinions and news only to state-authorized media outlets and are required to use their own names when establishing accounts. In 2016, China issued new rules barring foreign companies or their affiliates from publishing online content without government approval. It also began to subject online programs to the same censorship regulations as regular TV shows. In July 2016, it said it would punish websites that publish unverified social media content as news, and ordered several of the most popular Chinese portals, such as Sinu, Sohu, and NetEase, to cease original news reporting.

(continued)

While China is often criticized for its extensive Internet controls, other countries are not far behind. Iran's Internet surveillance of its citizens is considered by security experts to be one of the world's most sophisticated mechanisms for controlling and censoring the Internet, allowing it to examine the content of individual online communications on a massive scale. The Iranian system goes beyond merely preventing access to specific sites such as Google, Twitter, and Facebook and reportedly also utilizes deep packet inspection. Deep packet inspection allows governments to read messages, alter their contents for disinformation purposes, and identify senders and recipients. It is accomplished by installing computers in the line between users and ISPs, opening up every digitized packet, inspecting for keywords and images, reconstructing the message, and sending it on. This is done for all Internet traffic including Skype, Facebook, e-mail, tweets, and messages sent to proxy servers. In 2016, Iran announced that it had completed the first stage of establishing an isolated, domestic version of the Internet, purportedly one that will be faster and less costly, but which subjects its users to even more heightened surveillance.

In Russia, a 2014 law allows the government to close websites without a court decision if the General Prosecutor's office declares the material on a site to be "extremist." Russia also regulates the blogosphere, requiring bloggers with more than 3,000 daily readers to register their real names and contact information with Russia's communications regulator. In 2015, Russia passed laws requiring domestic Internet companies to store their data on Russian soil, allowing the government to control it and limit access, and in July 2016, passed additional laws that provide for mandatory data retention by ISPs and telecommunications providers for between 6 months and three years, require those companies to provide access to all such data without a warrant, and also require a government backdoor that will enable it to access all encrypted communications.

Turkey is another country that has increasingly attempted to control and censor Internet content. These efforts have increased after the terrorist attack on Istanbul's Ataturk Airport and the failed coup against President Recep Tayyip Erdogan.

But it is not just totalitarian nations that have sought to regulate and surveil the Internet. Both Europe and the United States have, at various times, also taken steps to control access to certain websites, censor web content, and engage in extensive surveillance of communications. For instance, Great Britain has a list of blocked sites, as do Germany, France, and Australia. The United States and European countries generally ban the sale, distribution, and/or possession of online child pornography. France, Germany, and Austria all bar the online sale of Nazi memorabilia. Even in South Korea, one of the world's most wired countries, there are restrictions on content that is deemed subversive and harmful to the public order.

In response to terrorism threats and other crimes, European governments and the U.S. government also perform deep packet inspection on e-mail and text communications of terrorist suspects. This surveillance is not limited to cross-border international data flows and includes large-scale domestic surveillance and analysis of routine e-mail, tweets, and other messages. In 2013, National Security Agency (NSA) contractor Edward Snowden made headlines by leaking classified NSA documents shedding light on the NSA's PRISM program, which allowed the agency access to the servers of major Internet companies such as Facebook, Google, Apple, Microsoft, and many others. Additionally, the documents revealed the existence of the NSA's XKeyscore program, which allows analysts to search databases of e-mails, chats, and browsing histories of individual citizens without any authorization. Warrants, court clearance, or other forms of legal documentation are not required for analysts to use the technology. Snowden's documents also showed spy agencies were tapping data from smartphone apps like Candy Crush, and most others, and that the NSA was tapping the flow of personal user information between Google and Yahoo. The NSA claimed that the program was only used to monitor foreign intelligence targets and that the information it collects has assisted in apprehending terrorists. The FBI also has an Internet surveillance unit, the National Domestic Communications Assistance Center. The NDCAC's mission is to assist in the development of new surveillance technologies that will allow authorities to increase the interception of Internet, wireless, and VoIP communications.

In 2016, many European powers moved ahead with plans to fortify their online surveillance with new start-of-the-art networks. In England, potential new laws would force Internet service companies to maintain "Internet connection records" that would be subject to review by law enforcement at any time. In response to multiple terror attacks on French soils in 2015, the French government passed very similar rules that force ISPs to maintain browsing data, as well as additional provisions for surveillance of phone calls, e-mails, and all mobile phone communications. And De-Cix, the world's largest IXP, pushed back against the German government regarding requests to allow surveillance of all communications passing through its Frankfurt hub. De-Cix sued the German intelligence service for what it views as illegal overreach, but the German government hopes to pass new laws that would legitimize the practice, just as England, France, and other nations have done.

However, in the United States, efforts are underway to curb domestic and international counter-terrorist agencies like the NSA from conducting dragnet surveillance of the entire American population, strengthen court oversight of surveillance, limit surveillance to specific individuals, and ease disclosure rules for Internet firms who receive requests from government agencies. In 2015, Congress passed the USA Freedom Act, which limits the bulk collection of Americans' phone records. However, equally concerted efforts are underway to expand these types of spying powers. For instance, the Obama administration has expanded the NSA's ability to perform warrantless wiretaps on suspected malicious hackers, allowing them to monitor international Internet traffic from these suspects as well as domestic traffic. Concerns about the use of the Internet and other methods of encrypted communications by the Islamic State to recruit new members and engage in terrorism have further heightened the tension.

SOURCES: "World's Biggest Internet Hub Sues German Government Over Surveillance," by David Meyer, *Fortune*, September 16, 2016; "Iran Launches New 'National Internet' That Censors Content, Encourages Regime Surveillance," Thetower.org, August 30, 2016; "China Clamps Down on Online News Reporting," by Michael Forsythe, *New York Times,* July 25, 2016; "Russia Asks for the Impossible with Its New Surveillance Laws," by Eva Galperin and Danny O'Brien, Eff.org, July 19, 2016; "China Cracks Down on News Reports Spread via Social Media," by Edward Wong and Vanessa Pia, July 5, 2016; "Britain to Pay Billions for Monster Internet Surveillance Network," by Duncan Campbell, Computerweekly.com, March 21, 2016; "China Cracks Down on Online Television," by Amy Qin, *New York Times*, March 3, 2016; "New Chinese Rules on Foreign Firms' Online Content," by David Barboza and Paul Mozer, *New York Times*, February 19, 2016; "ISIS Influence on Web Prompts Second Thoughts on First Amendment," by Erik Eckholm, *New York Times,* December 7, 2015; "France Has a Powerful and Controversial New Surveillance Law," by Arik Hesseldahl, Recode.net, November 14, 2015 "Freedom on the Net 2015," Freedomhouse.org, October 28, 2015; "Russian Data Law Fuels Web Surveillance Fears," by Shaun Walker, *The Guardian,* September 1, 2015; "China Passes New National Security Law Extending Control Over Internet," *The Guardian,* July 1, 2015; "Hunting for Hackers, N.S.A. Secretly Expands Internet Spying at U.S. Border," by Charlie Savage et al., *New York Times,* June 4, 2015; "The State of Surveillance in Iran," by Arta Shams, Ifex.org, May 22, 2015; "House Moves to Curb Government Surveillance of Phone, Internet Records," by Cristina Maza, Csmonitor.com, May 1, 2015; "Turkey's Parliament Issues Contested Security, Surveillance Laws," Bloombergnews.com, March 27, 2015; "Russia Forces Its Popular Bloggers to Register—Or Else," by Ilya Khrennikov, Bloomberg.com, August 19, 2014; "NSA Top Lawyer Says Tech Giants Knew About Data Collection," Cnet.com, March 19, 2014; "Documents Say NSA Pretends to Be Facebook in Surveillance," by Reed Albergotti, *Wall Street Journal*, March 12, 2014; "Amid Flow of Leaks, Turkey Moves to Crimp Internet," by Tim Arango and Ceylan Yeginsu, *New York Times*, February 6, 2014; "Spy Agencies Tap Data Streaming From Phone Apps," by James Glanz, Jeff Larson, and Andrew Lehren, *New York Times*, January 27, 2014; "NSA Surveillance Covers 75 Percent of U.S. Internet Traffic: WSJ," by Reuters, News.Yahoo.com, August 20, 2013; "New Snowden Leak: NSA Program Taps All You Do Online," by Amanda Wills, Mashable.com, August 1, 2013; "Snowden: NSA Collects 'Everything,' Including Content of Emails," by Eyder Peralta, NPR.org, June 17, 2013; "FBI Quietly Forms Secret Net-Surveillance Unit," by Declan McCullagh, News.cnet.com, May 22, 2012.

contained in the packet. A higher level of service quality is required if the Internet is to keep expanding into new services, such as video on demand and telephony.

- *Network architecture limitations*. Today, a thousand requests for a single music track from a central server will result in a thousand efforts by the server to download the music to each requesting client. This slows down network performance, as the same music track is sent out a thousand times to clients that might be located in the same metropolitan area. This is very different from television, where the program is broadcast once to millions of homes.
- *Wired Internet*. The Internet is still largely based on cables—fiber-optic and coaxial copper cables. Copper cables use a centuries-old technology, and fiber-optic cable is expensive to place underground. The wired nature of the Internet restricts mobility of users although it is changing rapidly as Wi-Fi hotspots proliferate, and cellular phone technology advances. However, cellular systems are often overloaded due to the growth in the number of smartphones.

Now imagine an Internet at least 1,000 times as powerful as today's Internet, one that is not subjected to the limitations of bandwidth, protocols, architecture, physical connections, and language detailed previously. Welcome to the world of the future Internet, and the next generation of e-commerce services and products!

THE INTERNET2® PROJECT

Internet2®
advanced networking consortium of more than 450 member institutions working in partnership to facilitate the development, deployment, and use of revolutionary Internet technologies

Internet2® is an advanced networking consortium of more than 450 member institutions including universities, corporations, government research agencies, and not-for-profit networking organizations, all working in partnership to facilitate the development, deployment, and use of revolutionary Internet technologies. The broader Internet2 community includes more than 90,000 institutions across the United States and international networking partners in more than 100 countries. Internet2's work is a continuation of the kind of cooperation among government, private, and educational organizations that created the original Internet.

The advanced networks created and in use by Internet2 members provide an environment in which new technologies can be tested and enhanced. For instance, Internet2 provides a next-generation, nationwide 100 gigabit-per-second network that not only makes available a reliable production services platform for current high-performance needs but also creates a powerful experimental platform for the development of new network capabilities. See **Table 3.9** to get some sense of just how fast a 100-Gbps network is in terms of data transmission times. The fourth generation of this network, built through a federal stimulus grant from the National Telecommunications and Information Administration's Broadband Technology Opportunities Program, has now been deployed. The hybrid optical and packet network provides 8.8 terabits of capacity with the ability to seamlessly scale as requirements grow, includes over 15,000 miles of owned fiber optic cable, and reaches into underserved areas of the country, supporting connectivity for approximately 200,000 U.S. community anchor institutions (schools, local libraries, and museums), and enabling them to provide citizens across the country with telemedicine, distance learning, and other advanced applications not possible with consumer-grade Internet services. The infrastructure supports a wide range of IP and optical services already available today and also will stimulate a new

TABLE 3.9 HOW FAST IS A 100-GBPS NETWORK?

DATA	TIME TO TRANSMIT
8.5 million electronic records	1 minute
300,000 X-rays	1 minute
1.8 million e-books simultaneously downloaded	2 minute

generation of innovative services. The goal is to create an intelligent global ecosystem that will enable researchers, scientists, and others to "turn on" high-capacity network connections whenever and wherever they are needed. **Table 3.10** describes some of the projects that Internet2's 100-Gbps network is enabling. Other initiatives involve science and engineering (advanced network applications in support of distributed lab environments, remote access to rare scientific instruments, and distributed large-scale computation and data access), health sciences and health networks (telemedicine, medical and biological research, and health education and awareness), and arts and humanities (collaborative live performances, master classes, remote auditions, and interactive performing arts education and media events).

THE FIRST MILE AND THE LAST MILE

The Internet2 project is just the tip of the iceberg when it comes to future enhancements to the Internet. In 2007, the NSF began work on the Global Environment for Network Innovations (GENI) initiative. GENI is a unique virtual laboratory for exploring future internets at scale. GENI aims to promote innovations in network science, security technologies, services, and applications. GENI is a partnership of leading

TABLE 3.10 PROJECTS BEING ENABLED BY INTERNET2'S 100-GBPS NETWORK

PROJECT	DESCRIPTION
XSEDE (Extreme Science and Engineering Discovery Environment)	XSEDE is a collection of integrated, advanced digital resources and services that enables scientists to interactively share computing resources, data, and expertise. XSEDE supports over 8,000 members of the scientific community, and 16 supercomputers. In 2013, XSEDE upgraded from a 10-Gbps network to Internet2's 100-Gbps network. In 2016, the NSF awarded XSEDE $110 million in funding to enable it to continue to provide advanced cyberinfrastructure resources and services to the nation's scientists and engineers.
CloudLab	Cloud computing test beds based at the University of Utah, Clemson, and the University of Wisconsin-Madison, connected by Internet2's 100-Gbps network. Focusing on the development of novel cloud architectures and new cloud computing applications. Enables researchers to build their own clouds and experiment with applications such as real-time disaster response and medical record security.
University of Florida	Support for Compact Muon Solenoid (CMS) experiments at CERN's Hadron collider (contributed to discovery of the Higgs boson particle, which earned 2013 Nobel Prize).

academic centers and private corporations such as Cisco, IBM, and HP, among many others. To date, awards have been made to 83 academic/industry teams for various projects to build, integrate, and operate early prototypes of the GENI virtual laboratory (Geni.net, 2014). Between 2015 and 2017, GENI will transition from being overseen by NSF's GENI Project Office to a community governance model (Geni.net, 2016).

The most significant privately initiated (but often government-influenced) changes are coming in two areas: fiber-optic trunk line bandwidth and wireless Internet services. Fiber optics is concerned with the first mile or backbone Internet services that carry bulk traffic long distances. Wireless Internet is concerned with the last mile—from the larger Internet to the user's smartphone, tablet computer, or laptop.

Fiber Optics and the Bandwidth Explosion in the First Mile

fiber-optic cable
consists of up to hundreds of strands of glass or plastic that use light to transmit data

Fiber-optic cable consists of up to hundreds of strands of glass that use light to transmit data. It often replaces existing coaxial and twisted pair cabling because it can transmit much more data at faster speeds, with less interference and better data security. Fiber-optic cable is also thinner and lighter, taking up less space during installation. The hope is to use fiber optics to expand network bandwidth capacity in order to prepare for the expected increases in web traffic once next-generation Internet services are widely adopted.

Telecommunication firms have made substantial investments in global, national, and regional fiber optic cable systems in the last decade. For instance, Verizon has spent over $23 billion since 2004, building and expanding its FiOS fiber-optic Internet service that can provide speeds of up to 500 Mbps, and currently has about 6.6 million FiOS customers. In 2012, Google joined the fray with Google Fiber, a 1-Gbps fiber-optic network, that is currently available in 7 cities. This installed base of fiber-optic cable represents a vast digital highway that is currently being exploited by YouTube (Google), Facebook, and other high-bandwidth applications. But despite the interest in fiber, only about 12.3% of U.S. homes had fiber connections as of 2015, a much lower percentage than a number of other countries around the world (Buckley, 2015; Richter, 2016). **Table 3.11** illustrates several optical bandwidth standards and compares them to traditional T lines.

The Last Mile: Mobile Internet Access

Fiber-optic networks carry the long-haul bulk traffic of the Internet and play an important role in bringing high-speed broadband to the household and small business. The goal of the Internet2 and GENI projects is to bring gigabit and ultimately terabit bandwidth to the household over the next 20 years. But along with fiber optics, arguably the most significant development for the Internet and Web has been the emergence of mobile Internet access.

Wireless Internet is concerned with the last mile of Internet access to the user's home, office, car, smartphone, or tablet computer, anywhere they are located. Up until 2000, the last-mile access to the Internet—with the exception of a small satellite Internet connect population—was bound up in land lines of some sort: copper coaxial TV cables or telephone lines or, in some cases, fiber-optic lines to the office. Today,

TABLE 3.11	HIGH-SPEED OPTICAL BANDWIDTH STANDARDS
STANDARD	**SPEED**
T1	1.544 Mbps
T3	43.232 Mbps
OC-3	155 Mbps
OC-12	622 Mbps
OC-48	2.5 Gbps
OC-192	10 Gbps
OC-768	40 Gbps

Note: "OC" stands for Optical Carrier and is used to specify the speed of fiber-optic networks conforming to the SONET standard. SONET (Synchronous Optical Networks) includes a set of signal rate multiples for transmitting digital signals on optical fiber. The base rate (OC-1) is 51.84 Mbps.

in comparison, high-speed cell phone networks and Wi-Fi network hotspots provide a major alternative.

Today, sales of desktop computers have been eclipsed by sales of smartphones and tablet and ultramobile laptop computers with built-in wireless networking functionality. Clearly, a large part of the Internet is now mobile, access-anywhere broadband service for the delivery of video, music, and web search. According to eMarketer, there are over 210 million mobile Internet users in the United States in 2016 (about 65% of the population), and almost 2.5 billion worldwide (eMarketer, Inc., 2016f).

Telephone-based versus Computer Network-based Wireless Internet Access

There are two different basic types of wireless Internet connectivity: telephone-based and computer network-based systems.

Telephone-based wireless Internet access connects the user to a global telephone system (land, satellite, and microwave) that has a long history of dealing with millions of users simultaneously and already has in place a large-scale transaction billing system and related infrastructure. Cellular telephones and the telephone industry are currently the largest providers of wireless access to the Internet today. Around 1.5 billion smartphones are expected to be sold worldwide in 2016 (Gartner, Inc., 2016b). Smartphones combine the functionality of a cell phone with that of a laptop computer with Wi-Fi capability. This makes it possible to combine in one device music, video, web access, and telephone service. Tablet computers can also access cellular networks. **Table 3.12** summarizes the various telephone technologies currently being used and under development for wireless Internet access. 5G wireless is the next frontier. Although official standards are not expected to be fully rolled out for a few years, telecommunications companies will likely start to introduce technology branded as "5G" as soon as 2017.

TABLE 3.12 WIRELESS INTERNET ACCESS TELEPHONE TECHNOLOGIES

TECHNOLOGY	SPEED	DESCRIPTION	PLAYERS
3G (THIRD GENERATION)			
CDMA2000 EV-DO HSPA (W-CDMA)	144 Kbps–2 Mbps	High-speed, mobile, always on for e-mail, browsing, and instant messaging. Implementing technologies include versions of CDMA2000 EV-DO (used by CDMA providers) and HSPDA (used by GSM providers). Nearly as fast as Wi-Fi.	Verizon, Sprint, AT&T, T-Mobile, Vodafone
3.5G (3G+)			
CDMA2000 EV-DO, Rev.B	Up to 14.4 Mbps	Enhanced version of CDMA 2000 EV-DO.	Verizon, Sprint
HSPA+	Up to 11 Mbps	Enhanced version of HSPA.	AT&T, T-Mobile
4G (FOURTH GENERATION)			
Long-Term Evolution (LTE)	Up to 100 Mbps	True broadband on cell phone; lower latency than previous generations.	AT&T, Verizon, Sprint, T-Mobile (in 2013)
5G (FIFTH GENERATION)			
Standards under development; expected by 2020	Up to 10 Gbps	Goals include 1–10 Gbps connectivity; sub-1 millisecond latency enabling services such as autonomous driving, augmented reality, virtual reality, and immersive/tactile Internet.	Ericsson, SK Telecom, Huawei, Samsung, NTT DoCoMo, Verizon, national governments

Wi-Fi
Wireless standard for Ethernet networks with greater speed and range than Bluetooth

Wireless local area network (WLAN)-based Internet access derives from a completely different background from telephone-based wireless Internet access. Popularly known as **Wi-Fi**, WLANs are based on computer local area networks where the task is to connect client computers (generally stationary) to server computers within local areas of, say, a few hundred meters. Wi-Fi functions by sending radio signals that are broadcast over the airwaves using certain radio frequency ranges (2.4 GHz to 5.875 GHz, depending on the type of standard involved). The major technologies here are the various versions of the Wi-Fi standard, WiMax, and Bluetooth (see **Table 3.13**).

In a Wi-Fi network, a *wireless access point* (also known as a "hot spot") connects to the Internet directly via a broadband connection (cable, DSL telephone, or T1 line) and then transmits a radio signal to a transmitter/receiver installed in a tablet or laptop computer or smartphone. **Figure 3.14** illustrates how a Wi-Fi network works.

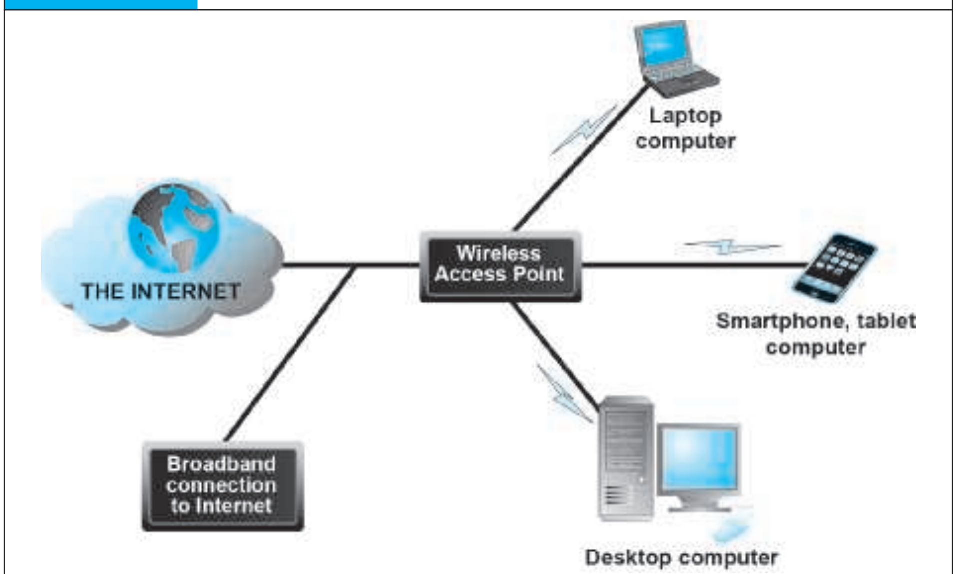
Wi-Fi provided under the 802.11 a/b/g/n specifications offers high-bandwidth capacity from 11 Mbps up to a maximum of 7 Gbps—far greater than any 3G or 4G service currently in existence—but has a limited range of 300 meters, with the exception of WiMax discussed below. Wi-Fi is also exceptionally inexpensive. The cost of creating a corporate Wi-Fi network in a single 14-story building with an access point for each floor is less than $100 an access point. It would cost well over $500,000 to

TABLE 3.13 WIRELESS NETWORK INTERNET ACCESS TECHNOLOGIES

TECHNOLOGY	RANGE/SPEED	DESCRIPTION	PLAYERS
Wi-Fi (IEEE 802.11 a/b/g/n)	300 feet/11–70 Mbps	Evolving high-speed, fixed broadband wireless local area network for commercial and residential use	Linksys, Cisco, and other Wi-Fi router manufacturers; entrepreneurial network developers
802.11ac	500 Mbps–1 Gbps		
802.11ad	less than 10 meters/ up to 7 Gbps		
WiMax (IEEE 802.16)	30 miles/50–70 Mbps	High-speed, medium-range, broadband wireless metropolitan area network	Clearwire, Sprint, Fujitsu, Intel, Alcatel, Proxim
Bluetooth (wireless personal area network)	1–30 meters/1–3 Mbps	Modest-speed, low-power, short-range connection of digital devices	Sony Ericsson, Nokia, Apple, HP, and other device makers

wire the same building with Ethernet cable. IEEE 802.11ac is a version of the 802.11 specification adopted in December 2013 that provides for effective throughputs of 500 Mbps to over 1 Gbps. The newest standard, IEEE 802.11ad, provides for theoretical maximum throughput up to 7 Gbps. The first 802.11ad devices began shipping at the beginning of 2016. Next-generation Wi-Fi standards currently being worked on by

FIGURE 3.14 WI-FI NETWORKS



In a Wi-Fi network, wireless access points connect to the Internet using a land-based broadband connection. Clients, which could be desktops, laptops, tablet computers, or smartphones, connect to the access point using radio signals.

the IEEE 802.11 Working Group include 802.11ay, which deals with 60 GHz wireless operations, and will provide for data rates of up to 20 Gbps, and 802.11ax, aimed at high-efficiency WLANs used for stadiums and other areas where many people want to access a Wi-Fi network at the same time. A next-generation 802.11ah standard aimed at the Internet of Things is also being developed (Weiss, 2015; Hsu, 2015).

While initially a grass roots, "hippies and hackers" public access technology, billions of dollars have subsequently been poured into private ventures seeking to create for-profit Wi-Fi networks. One of the most prominent networks has been created by Boingo Wireless with more than 1 million hotspots around the globe. Optimum WiFi (available to Optimum Online customers for free) also offers over 1.5 million hotspots around the world. AT&T Wi-Fi Services (formerly Wayport) has another large network that provides Wi-Fi service at hotels, airports, McDonald's, and IHOP restaurants, and Hertz airport rental offices, with thousands of hotspots throughout the United States. T-Mobile and Sprint also have nationwide Wi-Fi services at Starbucks coffee shops and thousands of other public locations. Apple, in turn, has made Wi-Fi automatically available to iPhone and iPad devices as an alternative to the more expensive and much slower 3G and 4G cellular systems. In 2015, for the first time, a majority (51%) of mobile Internet traffic originated from Wi-Fi rather than cellular systems, and it is expected that Wi-Fi will be carrying over half of all Internet traffic by 2019 (Cisco, 2016).

Bluetooth
technology standard for short-range wireless communication under 30 feet

A second WLAN technology for connecting to the Internet, and for connecting Internet devices to one another, is called Bluetooth. **Bluetooth** is a personal connectivity technology that enables links between mobile devices and connectivity to the Internet (Bluetooth.com, 2016). Bluetooth is the universal cable cutter, promising to get rid of the tangled mess of wires, cradles, and special attachments that plague the current world of personal computing. With Bluetooth, users can wear a wireless earbud, share files in a hallway or conference room, synchronize their smartphone with their laptop without a cable, send a document to a printer, and even pay a restaurant bill from the table to a Bluetooth-equipped cash register. Bluetooth is also an unregulated media operating in the 2.4 GHz spectrum but with a very limited range of 30 feet or less. It uses a frequency hopping signal with up to 1,600 hops per second over 79 frequencies, giving it good protection from interference and interception. Bluetooth-equipped devices constantly scan their environments looking for connections to compatible devices. Today, almost all mobile devices are Bluetooth-enabled. Bluetooth may also play a role in the future as a platform for the Internet of Things (see page 152).

INTERNET ACCESS DRONES

A new method of providing Internet access to areas that are not well served by wired or cellular networks is being explored by companies such as Google and Facebook. Both companies have recently purchased companies that make drones (unmanned aircraft/satellites) that may be used to provide Internet access to remote parts of the world.

In 2014, Google purchased Titan Aerospace, which makes solar-powered drones that can fly for several years at 65,000 feet. Google is reportedly experimenting with using drones to deliver 5G wireless Internet service. Google is also experimenting with high-altitude balloons with its Project Loon. Google envisions a network of balloons circling high above the earth in the stratosphere, establishing a ring of uninterrupted connectivity. In 2014, Google sent a prototype of a networked hot-air balloon around the world in 22 days, even taking photos for its Street View program, and in 2015, the government of Sri Lanka announced that Sri Lanka would be the first country to use Project Loon to provide universal Internet access across Sri Lanka. In August 2016, Google is reportedly taking steps to move Project Loon from a research project into a profitable business.

In a similar effort, Facebook has put together the Facebook Connectivity Lab, where engineers are focusing on solar-powered drones, satellites, and infrared lasers capable of providing Internet access. To propel that effort, Facebook purchased the British company Ascenta, whose founders helped create the world's longest flying solar-powered drone. In 2016, Facebook completed a full-scale test flight of its first Internet access solar-powered drone, Aquila. Created from carbon fiber, the drone has the wingspan of a Boeing 737 but weighs less than a small car, and is designed to fly at 60,000 to 90,000 feet for up to three months at a time. It reportedly uses a laser communications system that can beam data from the sky.

THE FUTURE INTERNET

The increased bandwidth and expanded wireless network connectivity of the Internet of the future will result in benefits beyond faster access and richer communications. First-mile enhancements created by fiber-optic networks will enhance reliability and quality of Internet transmissions and create new business models and opportunities. Some of the major benefits of these technological advancements include latency solutions, guaranteed service levels, lower error rates, and declining costs. Widespread wireless access to the Internet will also essentially double or even triple the size of the online shopping marketspace because consumers will be able to shop and make purchases just about anywhere. This is equivalent to doubling the physical floor space of all shopping malls in America. We describe some of these benefits in more detail in the following sections.

Latency Solutions

One of the challenges of packet switching, where data is divided into chunks and then sent separately to meet again at the destination, is that the Internet does not differentiate between high-priority packets, such as video clips, and those of lower priority, such as self-contained e-mail messages. Because the packets cannot yet be simultaneously reassembled, the result can be distorted audio and video streams.

Differentiated quality of service (**diffserv**) is a technology that assigns levels of priority to packets based on the type of data being transmitted. Video conference packets, for example, which need to reach their destination almost instantaneously, receive much higher priority than e-mail messages. In the end, the quality of video and audio will skyrocket without undue stress on the network. Differential service is very controversial because it means some users may get more bandwidth than others, and potentially they may have to pay a higher price for more bandwidth.

differentiated quality of service (diffserv)
a new technology that assigns levels of priority to packets based on the type of data being transmitted

Guaranteed Service Levels and Lower Error Rates

In today's Internet, there is no service-level guarantee and no way to purchase the right to move data through the Internet at a fixed pace. Today's Internet promises only "best effort." The Internet is democratic—it speeds or slows everyone's traffic alike. In the future, it might be possible to purchase the right to move data through the network at a guaranteed speed in return for higher fees.

Declining Costs

As the Internet pipeline is upgraded, the availability of broadband service will expand beyond major metropolitan areas, significantly reducing the cost of access. More users mean lower cost, as products and technology catch on in the mass market. Higher volume usage enables providers to lower the cost of both access devices, or clients, and the service required to use such products. Both broadband and wireless service fees are expected to decline as geographic service areas increase, in part due to competition for that business.

The Internet of Things

Internet of Things (IoT)
Use of the Internet to connect a wide variety of devices, machines, and sensors

No discussion of the future Internet would be complete without mentioning the **Internet of Things (IoT)**, also sometimes referred to as the Industrial Internet. Internet technology is spreading beyond the desktop, laptop, and tablet computer, and beyond the smartphone, to consumer electronics, electrical appliances, cars, medical devices, utility systems, machines of all types, even clothing—just about anything that can be equipped with sensors that can collect data and connect to the Internet, enabling the data to be analyzed with data analytics software.

IoT builds on a foundation of existing technologies, such as radio frequency identification (RFID) tags, and is being enabled by the availability of low-cost sensors, the drop in price of data storage, the development of "big data" analytics software that can work with trillions of pieces of data, as well as implementation of IPv6, which will allow Internet addresses to be assigned to all of these new devices. Although IoT devices don't necessarily have to be wireless, most use wireless communications technology previously discussed, such as cellular networks, Wi-Fi, Bluetooth, or other wireless protocols such as ZigBee or Z-Wave, to connect either directly or via a mobile app to the Internet (often a cloud service).

IoT technology is powering the development of "smart" connected "things"— televisions, houses, and cars, as well as wearable technology—clothing and devices like the Apple Watch, profiled in the opening case. Smart televisions that integrate directly with the Internet and can run apps have become very popular, with more than half (52%) of all U.S. Internet homes having at least one TV connected to the Internet (NPD Group Inc, 2016). Smart houses have attracted even more interest, fueled by Google's purchase of Nest Labs for $3.2 billion in 2014. Nest Labs makes smart thermostats, home security cameras, and smoke and carbon monoxide alarms. In 2015, Nest Labs announced that it was making Nest Weave, a protocol it had developed that enables appliances, thermostats, door locks, and other devices to communicate with each other and other Nest products, available to third-party developers and manufacturers. Apple announced a smart home platform that it calls HomeKit in 2014. HomeKit is a framework and network protocol for controlling devices in the home that is programmed directly into Apple's iOS software for iPhones and iPads, and is integrated with Siri, Apple's voice-activated artificial intelligence assistant. By 2016, a number of devices had been designed specifically for use with HomeKit, such as a smart thermostat, a smart deadbolt lock, a home sensor that provides temperature, humidity, and air quality readings, and an iDevices switch that enables you to turn electronic devices on and off using Siri. Many cable companies such as Time Warner Cable, Comcast, and AT&T already offer connected home systems that include appliances and lights. All in all, the global market for smart house products is expected to grow from about $47 billion in 2015 to over $120 billion by 2022 (Research and Markets, 2016).

In September 2014, as discussed in the chapter-opening case, Apple introduced the Apple Watch. The Apple Watch features a fitness/activity tracker similar to offerings from Fitbit, Nike+, FuelBand, and Jawbone Up, is able to access a wide variety of apps, and also works with Apple Pay, Apple's mobile payment service. A number of other manufacturers, such as Samsung, LG, Motorola, and Swatch, have also introduced smartwatches. Wearable computing is expected to grow into a $170 billion business by 2021.

Connected cars that have built-in Internet access have also arrived (see the *Insight on Technology* case, *Are Connected Cars the Next Hot Entertainment Vehicle?* in Chapter 2). Here too, Google and Apple are major players. In 2014, Google announced the Open Automotive Alliance, a group of leading automakers and technology companies focused on bringing the Android platform to cars. Shortly thereafter, Apple announced CarPlay, a software platform that synchronizes iPhones to the car's infotainment system. Android Auto and CarPlay-enabled vehicles began to be introduced in 2015, and have become more widely available in 2016. Connected cars are likely to be integrated with smart home initiatives in the future. Already, iControl, which provides the software underlying automated home systems from Comcast, TimeWarner, ADT, and others, has entered into a partnership with Zubie, a provider of connected car services. The next frontier on the connected car front is the the self-driving car, combining IoT and artificial intelligence technologies. Many Internet technology companies, ranging from giants such as Google, Baidu (China's version of Google), Uber, and Intel to start-ups like Drive.ai and Mobileye, have jumped into the fray alongside automotive companies such as Tesla, BMW, Volvo, GM, Ford, and others, with the goal of offering self-driving, autonomous cars by 2019 or sooner.

Despite all of the IoT activity, however, interoperability remains a major concern. As with many technologies in the early stages of development, many organizations are fighting to create the standards that participants in the market will follow. The AllSeen Alliance, formed by Qualcomm in 2013 with 50 other companies, including Microsoft and Cisco, is one group that hopes to create an open source standard. Membership in the Alliance has soared since its initial founding and in 2016, it has over 200 members. Another group, the Open Connectivity Foundation (formerly the Open Interconnect Consortium), formed in 2014 by Intel, Broadcom, Dell, and others apparently not happy with the AllSeen effort, has also seen its membership soar to over 200 members. A different group, the Industrial Internet Consortium, has been formed by AT&T,

Cisco, GE, IBM, and Intel to focus on engineering standards for industrial assets. The Wolfram Connected Devices Project is aimed at developing a database of IoT devices, and currently includes more than 3,000. And as with many other types of Internet-related technology, Google with its Android operating system and Apple with AirPlay wireless streaming protocol may be trying to create their own standards.

Other concerns include security and privacy. Security experts believe that IoT devices could potentially be a security disaster, with the potential for malware being spread through a connected network, and difficulty in issuing patches to devices, leaving them vulnerable (Internet Society, 2015). Data from stand-alone smart devices can reveal much personal detail about a consumer's life, and if those devices are all ultimately interconnected, there will be little that is truly private.

Although challenges remain before the Internet of Things is fully realized, it is coming closer and closer to fruition. As of 2016, experts estimate that there are anywhere from 6.4 billion to 9 billion IoT devices (not including smartphones, tablets, or desktop computers), with some projecting as many as 100 billion connected IoT devices and global economic impact of more than $11 trillion by 2025 (Nordstrom, 2016; Internet Society, 2015).

3.4 THE WEB

Without the Web, there would be no e-commerce. The invention of the Web brought an extraordinary expansion of digital services to millions of amateur computer users, including color text and pages, formatted text, pictures, animations, video, and sound. In short, the Web makes nearly all the rich elements of human expression needed to establish a commercial marketplace available to nontechnical computer users worldwide.

While the Internet was born in the 1960s, the Web was not invented until 1989–1991 by Dr. Tim Berners-Lee of the European Particle Physics Laboratory, better known as CERN (Berners-Lee et al., 1994). Several earlier authors—such as Vannevar Bush (in 1945) and Ted Nelson (in the 1960s)—had suggested the possibility of organizing knowledge as a set of interconnected pages that users could freely browse (Bush, 1945; Ziff Davis Publishing, 1998). Berners-Lee and his associates at CERN built on these ideas and developed the initial versions of HTML, HTTP, a web server, and a browser, the four essential components of the Web.

First, Berners-Lee wrote a computer program that allowed formatted pages within his own computer to be linked using keywords (hyperlinks). Clicking on a keyword in a document would immediately move him to another document. Berners-Lee created the pages using a modified version of a powerful text markup language called Standard Generalized Markup Language (SGML).

Berners-Lee called this language HyperText Markup Language, or HTML. He then came up with the idea of storing his HTML pages on the Internet. Remote client computers could access these pages by using HTTP (introduced earlier in Section 3.1 and described more fully in the next section). But these early web pages still appeared as black and white text pages with hyperlinks expressed inside brackets. The early Web was based on text only; the original web browser only provided a line interface.

Information shared on the Web remained text-based until 1993, when Marc Andreessen and others at the National Center for Supercomputing Applications (NCSA) at the University of Illinois created a web browser with a graphical user interface (GUI) called **Mosaic** that made it possible to view documents on the Web graphically—using colored backgrounds, images, and even primitive animations. Mosaic was a software program that could run on any graphically based interface such as Macintosh, Windows, or Unix. The Mosaic browser software read the HTML text on a web page and displayed it as a graphical interface document within a GUI operating system such as Windows or Macintosh. Liberated from simple black and white text pages, HTML pages could now be viewed by anyone in the world who could operate a mouse and use a Macintosh or PC.

Mosaic
Web browser with a graphical user interface (GUI) that made it possible to view documents on the Web graphically

Aside from making the content of web pages colorful and available to the world's population, the graphical web browser created the possibility of **universal computing**, the sharing of files, information, graphics, sound, video, and other objects across all computer platforms in the world, regardless of operating system. A browser could be made for each of the major operating systems, and the web pages created for one system, say, Windows, would also be displayed exactly the same, or nearly the same, on computers running the Macintosh or Unix operating systems. As long as each operating system had a Mosaic browser, the same web pages could be used on all the different types of computers and operating systems. This meant that no matter what kind of computer you used, anywhere in the world, you would see the same web pages. The browser and the Web have introduced us to a whole new world of computing and information management that was unthinkable prior to 1993.

universal computing
the sharing of files, information, graphics, sound, video, and other objects across all computer platforms in the world, regardless of operating system

In 1994, Andreessen and Jim Clark founded Netscape, which created the first commercial browser, **Netscape Navigator**. Although Mosaic had been distributed free of charge, Netscape initially charged for its software. In August 1995, Microsoft Corporation released its own free version of a browser, called **Internet Explorer**. In the ensuing years, Netscape fell from a 100% market share to less than .5% in 2009. The fate of Netscape illustrates an important e-commerce business lesson. Innovators usually are not long-term winners, whereas smart followers often have the assets needed for long-term survival. Much of the Netscape browser code survives today in the Firefox browser produced by Mozilla, a nonprofit heavily funded by Google.

Netscape Navigator
the first commercial web browser

Internet Explorer
Microsoft's web browser

HYPERTEXT

Web pages can be accessed through the Internet because the web browser software on your PC can request web pages stored on an Internet host server using the HTTP protocol. **Hypertext** is a way of formatting pages with embedded links that connect documents to one another and that also link pages to other objects such as sound, video, or animation files. When you click on a graphic and a video clip plays, you have clicked on a hyperlink. For example, when you type a web address in your browser such as http://www.sec.gov, your browser sends an HTTP request to the sec.gov server requesting the home page of sec.gov.

hypertext
a way of formatting pages with embedded links that connect documents to one another, and that also link pages to other objects such as sound, video, or animation files

HTTP is the first set of letters at the start of every web address, followed by the domain name. The domain name specifies the organization's server computer that is housing the document. Most companies have a domain name that is the same as or closely related to their official corporate name. The directory path and document name are two more pieces of information within the web address that help the browser track down the requested page. Together, the address is called a Uniform Resource Locator, or URL. When typed into a browser, a URL tells it exactly where to look for the information. For example, in the following URL:

http://www.megacorp.com/content/features/082602.html

http = the protocol used to display web pages

www.megacorp.com = domain name

content/features = the directory path that identifies where on the domain web server the page is stored

082602.html = the document name and its format (an HTML page)

The most common domain extensions (known as general top-level domains, or gTLDs) currently available and officially sanctioned by ICANN are shown in **Table 3.14**. Countries also have domain names, such as .uk, .au, and .fr (United Kingdom, Australia, and France, respectively). These are sometimes referred to as country-code top-level domains, or ccTLDs. In 2008, ICANN approved a significant expansion of gTLDs, with potential new domains representing cities (such as .berlin), regions (.africa), ethnicity (.eus), industry/activities (such as .health), and even brands (such as .deloitte). In 2009, ICANN began the process of implementing these guidelines. In 2011, ICANN removed nearly all restrictions on domain names, thereby greatly expanding the number of different domain names available. As of August 2016, over 1,150 gTLDs have been applied for, acquired, and launched. The new gTLDs are in multiple languages and scripts/characters (including Arabic, Chinese, Japanese, and Russian) and include geographic place names such as .nyc, .london, and .paris; business identifiers such as .restaurant, .realtor, .technology, and .lawyer; brand names such as .bmw and .suzuki; and a whole host of other descriptive names.

MARKUP LANGUAGES

Although the most common web page formatting language is HTML, the concept behind document formatting actually had its roots in the 1960s with the development of Generalized Markup Language (GML).

HyperText Markup Language (HTML)
GML that is relatively easy to use in web page design. HTML provides web page designers with a fixed set of markup "tags" that are used to format a web page

HyperText Markup Language (HTML)

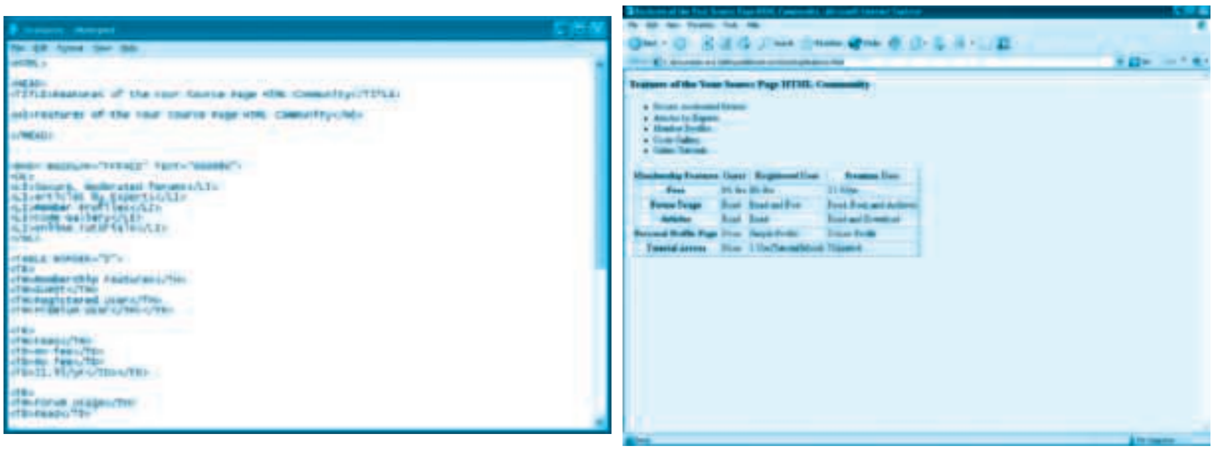
HyperText Markup Language (HTML) is a GML that is relatively easy to use. HTML provides web page designers with a fixed set of markup "tags" that are used to format a web page (see **Figure 3.15**). When these tags are inserted into a web page, they are read by the browser and interpreted into a page display. You can see the source HTML

TABLE 3.14 EXAMPLES OF TOP-LEVEL DOMAINS

GENERAL TOP-LEVEL DOMAIN (GTLD)	YEAR(S) INTRODUCED	PURPOSE	SPONSOR/ OPERATOR
.com	1980s	Unrestricted (but intended for commercial registrants)	VeriSign
.edu	1980s	U.S. educational institutions	Educause
.gov	1980s	U.S. government	U.S. General Services Administration
.mil	1980s	U.S. military	U.S. Department of Defense Network Information Center
.net	1980s	Unrestricted (but originally intended for network providers, etc.)	VeriSign
.org	1980s	Unrestricted (but intended for organizations that do not fit elsewhere)	Public Interest Registry (was operated by VeriSign until December 31, 2002)
.int	1998	Organizations established by international treaties between governments	Internet Assigned Numbers Authority (IANA)
.aero	2001	Air-transport industry	Societé Internationale de Telecommunications Aeronautiques SC (SITA)
.biz	2001	Businesses	NeuLevel
.coop	2001	Cooperatives	DotCooperation LLC
.info	2001	Unrestricted use	Afilias LLC
.museum	2001	Museums	Museum Domain Name Association (MuseDoma)
.name	2001	For registration by individuals	Global Name Registry Ltd.
.pro	2002	Accountants, lawyers, physicians, and other professionals	RegistryPro Ltd
.jobs	2005	Job search	Employ Media LLC
.travel	2005	Travel search	Tralliance Corporation
.mobi	2005	Websites specifically designed for mobile phones	mTLD Top Level Domain, Ltd.
.cat	2005	Individuals, organizations, and companies that promote the Catalan language and culture	Fundació puntCAT
.asia	2006	Regional domain for companies, organizations, and individuals based in Asia	DotAsia Organization
.tel	2006	Telephone numbers and other contact information	ICM Registry
.xxx	2010	New top-level domain for pornographic content	None yet approved

SOURCE: Based on data from ICANN, 2011b.

FIGURE 3.15 EXAMPLE HTML CODE (A) AND WEB PAGE (B)



(a) (b)

HTML is a text markup language used to create web pages. It has a fixed set of "tags" that are used to tell the browser software how to present the content on screen. The HTML shown in Figure 3.15 (a) creates the web page seen in Figure 3.15 (b).

SOURCES: (A) Notepad, Microsoft Windows, Microsoft Corporation; (B) Internet Explorer, Microsoft Windows, Microsoft Corporation.

code for any web page by simply clicking on the "Page Source" command found in all browsers. In Figure 3.15, the HTML code in the first screen produces the display in the second screen.

HTML defines the structure and style of a document, including the headings, graphic positioning, tables, and text formatting. Since its introduction, the major browsers have continuously added features to HTML to enable programmers to further refine their page layouts. Unfortunately, some browser enhancements may work only in one company's browser. Whenever you build an e-commerce site, you should take care that the pages can be viewed by the major browsers, even outdated versions of browsers. HTML web pages can be created with any text editor, such as Notepad or WordPad, using Microsoft Word (simply save the Word document as a web page), or any one of several web page development tools such as Microsoft Expression Web or Adobe Dreamweaver CC.[5]

The most recent version of HTML is HTML5. HTML5 introduces features like video playback and drag-and-drop that in the past were provided by plug-ins like Adobe Flash. HTML5 is also used in the development of mobile websites and mobile apps, and is an important tool in both responsive web design and adaptive web delivery, all of which are discussed more fully in Chapter 4. The *Insight on Technology* case, *The Rise of HTML5,* examines the increasing use of HTML5.

[5] A detailed discussion of how to use HTML is beyond the scope of this text.

INSIGHT ON TECHNOLOGY

THE RISE OF HTML5

In 2010, Apple founder Steve Jobs lambasted Adobe Flash for its poor security, poor performance on mobile devices, and for being an energy hog. Jobs instead trumpeted HTML5 as the preferred method for displaying video online. Fast forward to 2016. Two years after its official ratification by the W3C, the Web's standards-setting organization, HTML5 has become a de facto standard, proving once again Jobs' uncanny ability to see and perhaps shape the future.

HTML5 has become a catch-all term that encompasses not only the video element but also the use of the newest versions of Cascading Style Sheets (CSS3) and JavaScript, and another new tool, HTML5 Canvas, that is used with a set of JavaScript functions to render simple animations, which reduces page load time. HTML5 provides not only device independence, but can also access the built-in functionality of mobile devices, such as GPS and swiping, enabling the creation of web-based mobile apps that can replicate the native app experience. Web-based mobile apps (HTML5 apps) work just like web pages, with page content, including graphics, images, and video, loaded into the browser from a web server, rather than residing in the mobile device hardware like a native app. This concept has been embraced by mobile developers who naturally dream of being able to reach all platforms with a single product.

For businesses, the cost savings of HTML5 are obvious. A single HTML5 app requires far less effort to build than multiple native apps for the iOS, Android, Windows Phone, and other platforms. HTML5 apps can more easily be linked to and shared on social networks, encouraging viral distribution. Some HTML5 apps can even be designed so that they can be run on mobile devices when they are offline. Differences in how apps run across different platforms and workarounds are eliminated. In the past, HTML5 apps couldn't approach the smooth and speedy user experience of a native app, but thanks to advancements in the underlying technologies behind HTML5 and improvements in the expertise of HTML5 developers, that is no longer the case. Flash also requires installation, whereas HTML5 does not.

In 2014, the Interactive Advertising Bureau (IAB), together with a number of the largest online publishers and advertising firms, urged advertisers to implement HTML5 as the standard for mobile ads in order to guarantee that ads will run and look good on different platforms, and in 2015 released guidelines that fully embrace HTML5, citing interoperability and the improved effectiveness of HTML5 ads. The rise of HTML5 has mirrored the growth of the mobile platform as it supplants Flash, which was developed for the desktop, as the preferred media delivery platform on the Web. During this time, Flash has continued to struggle with critical security vulnerabilities. In response, the online advertising industry has responded by reducing or eliminating the use of Flash. For instance, in 2016, Facebook mandated HTML5 instead of Flash for all videos posted to its site, reporting improved loading times, fewer bugs, and better engagement, and Google signaled a shift towards HTML5 by blocking Flash advertisements from autoplaying in Chrome, in part due to their notorious security issues. In 2016, Chrome began to automatically block any non-visible Flash content, like tracking cookies, and by year's end, HTML5 will be the "default" for Chrome, except where sites only support Flash. Google also announced that its display ads would be 100 percent HTML5 by the beginning of 2017. Mozilla Firefox made a similar announcement shortly thereafter regarding non-visible Flash content and its own plans to make HTML5 its default by 2017, meaning that over 80% of the web browser market is now blocking Flash. Apple's

(continued)

Safari browser, one of the first to impose restrictions on Flash, has taken steps to prevent sites offering both Flash and HTML5 from displaying Flash content. Twitch, one of the largest sites still using Flash video streaming, announced it would begin a switch to HTML5 in 2016, just as YouTube did a year earlier. The moves from these advertising and tech juggernauts have solidified the downfall of Flash and the rise of HTML5 as the future of advertising. Even Adobe itself has begun to recommend that content creators use HTML5 instead of Flash and has renamed its Flash Professional tool to 'Adobe Animate CC,' adding HTML5 support and the ability to convert Flash advertisements to HTML5.

Retailers have taken notice. One example of a company using HTML5 with success is Rakuten Shopping, an online retailer that offers a wide variety of goods online, and is currently ranked as one of Internet Retailer's top 30 mobile retailers. Using HTML5 has enabled Rakuten to shift away from using cookies to store customer attributes and has lightened the load on its servers.

Another example is the *Financial Times,* whose HTML5 app has proven to be an important driver for FT's business. FT first switched from a native app to HTML5 in 2011, in part to make maintaining the app across multiple platforms and devices easier. In 2013, FT rolled out a redesign of the app, featuring even more videos and personalization features.

In fact, according to Indeed, which searches millions of jobs from thousands of different job sites, "HTML5" continues to be one of the fastest growing keywords found in online job postings. Many online advertisers that have relied heavily on Flash are also struggling to adapt to the emergence of HTML5 ads, which are larger in size and require testing on more platforms. Content creators and advertisers alike are also uneager to manage two different formats. In the past, they only had to deal with Flash, and many have been unwilling to make the transition just yet.

However, even given all its benefits, HTML5 is not without flaws. For instance, HTML5 has not consistently supported digital rights management (DRM). In the past, media companies developed their own copy protection standards based on geographical region and/or whether payment had been proffered. These were enforced through their own media players. Because HTML5 does not require plug-ins to play video (or audio), and further, because HTML5 is an official W3C standard charged with remaining vendor neutral, this presents a challenge to HTML5 developers. HTML5 also allows websites to track how much battery power their site visitors have remaining. This feature was implemented so that sites could warn users to recharge their battery, but the reporting is so detailed that sites can determine what sites you've come from last solely based on your battery information, presenting privacy concerns. However, the security issues with HTML5 pale in comparison to those associated with Flash, and it's still early in the development cycle for HTML5.

SOURCES: "Google Nixes Flash, Embraces HTML5 in Chrome Browser," by Paul Krill, Infoworld.com, August 11, 2016; "Publishers Must Embrace Transition From Flash to HTML5 Before It's Too Late," by Brian DeFrancesco, Publishersdaily.com, August 5, 2016; "Firefox Sets Kill-Flash Schedule," by Gregg Keizer, Infoworld.com, July 22, 2016; "Twitch Begins Shift from Flash to HTML5 with Closed Beta," by Devin Coldewey, Techcrunch.com, July 14, 2016; "Safari 10 To Turn Off Flash by Default," by John Ribeiro, Infoworld.com, June 15, 2016; "As Flash Apocalypse Approaches, Here are HTML5 Rules of Thumb to Keep in Mind," by Barry Levine, Marketingland.com, May 26, 2016; "Facebook's Website Now Uses HTML5 Instead of Flash for All Videos," by Chris Welch, Theverge.com, December 18, 2015; "Why We Chose to Move to HTML5 Video," by Daniel Baulig, Code.facebook.com, December 18, 2015; "Adobe Tells Developers to Use HTML5 Instead of Flash," by Fahmida Y. Rashid, Infoworld.com, December 2, 2015; "Adobe Bows to HTML5 and Renames Its Flash Professional App," by Steve Dent, Engadget.com, December 1, 2015; "Transforming the Web with HTML5," by Christina Mulligan, Sdtimes.com, October 5, 2015; "With Digital Ads Shifting to HTML5, the Industry Now Has a New Set of Guidelines," by Christopher Heine, Adweek.com, September 28, 2015; "HTML5 Looks Good in Light of Google, Facebook and IAB Moves," by Carl Weinschenk, September 22, 2015; "How Your Smartphone's Battery Life Can Be Used to Invade Your Privacy," by Alex Hern, *The Guardian,* August 4, 2015; "RIP Flash: Why HTML5 Will Finally Take Over Video and the Web This Year," by Erika Trautman, Thenextweb.com, April 19, 2014; "Financial Times: 'There Is No Drawback to Working in HTML5'," by Stuart Dredge, Theguardian.com, April 29, 2013; "Adobe's Flash Surrender Proves Steve Jobs and Apple Were Right All Along with HTML5," by Nigam Arora, *Forbes*, November, 9, 2011.

FIGURE 3.16 A SIMPLE XML DOCUMENT

```
<?xml version="1.0"?>
<note>
<to>George</to>
<from>Carol</from>
<heading>Just a Reminder</heading>
<body>Don't forget to order the groceries from FreshDirect!</body>
</note>
```

The tags in this simple XML document, such as <note>, <to>, and <from>, are used to describe data and information, rather than the look and feel of the document.

eXtensible Markup Language (XML)

eXtensible Markup Language (XML) takes web document formatting a giant leap forward. XML is a markup language specification developed by the W3C that is similar to HTML, but has a very different purpose. Whereas the purpose of HTML is to control the "look and feel" and display of data on the web page, XML is designed to describe data and information. For example, consider the sample XML document in **Figure 3.16**. The first line in the sample document is the XML declaration, which is always included; it defines the XML version of the document. In this case, the document conforms to the 1.0 specification of XML. The next line defines the first element of the document (the root element): <note>. The next four lines define four child elements of the root (to, from, heading, and body). The last line defines the end of the root element. Notice that XML says nothing about how to display the data, or how the text should look on the screen. HTML is used for information display in combination with XML, which is used for data description.

eXtensible Markup Language (XML)
a markup language specification developed by the World Wide Web Consortium (W3C) that is designed to describe data and information

Figure 3.17 shows how XML can be used to define a database of company names in a company directory. Tags such as <Company>, <Name>, and <Specialty> can be defined for a single firm, or an entire industry. On an elementary level, XML is extraordinarily easy to learn and is very similar to HTML except that you can make up your own tags. At a deeper level, XML has a rich syntax and an enormous set of software tools, which make XML ideal for storing and communicating many types of data on the Web.

XML is "extensible," which means the tags used to describe and display data are defined by the user, whereas in HTML the tags are limited and predefined. XML can also transform information into new formats, such as by importing information from a database and displaying it as a table. With XML, information can be analyzed and displayed selectively, making it a more powerful alternative to HTML. This means that business firms, or entire industries, can describe all of their invoices, accounts payable, payroll records, and financial information using a web-compatible markup language. Once described, these business documents can be stored on intranet web servers and shared throughout the corporation.

Really Simple Syndication (RSS) is an XML format that allows users to have digital content, including text, articles, blogs, and podcast audio files, automatically

Really Simple Syndication (RSS)
program that allows users to have digital content, including text, articles, blogs, and podcast audio files, automatically sent to their computers over the Internet

FIGURE 3.17 SAMPLE XML CODE FOR A COMPANY DIRECTORY

```
<?xml version="1.0"?>
<Companies>
    <Company>
           <Name>Azimuth Interactive Inc.</Name>
        <Specialties>
                  <Specialty>HTML development</Specialty>
                    <Specialty>technical documentation</Specialty>
                 <Specialty>ROBO Help</Specialty>
                  <Country>United States</Country>
        </Specialties>
       <Location>
                  <Country>United States</Country>
               <State />
                <City>Chicago</City>
       </Location>
              <Telephone>301-555-1212</Telephone>
    </Company>
    <Company>
       ...
    </Company>
   ...
</Companies>
```

This XML document uses tags to define a database of company names.

sent to their computers over the Internet. An RSS aggregator software application that you install on your computer gathers material from the websites and blogs that you tell it to scan and brings new information from those sites to you. Sometimes this is referred to as "syndicated" content because it is distributed by news organizations and other syndicators (or distributors). Users download an RSS aggregator and then "subscribe" to the RSS "feeds." When you go to your RSS aggregator's page, it will display the most recent updates for each channel to which you have subscribed. RSS has rocketed from a "techie" pastime to a broad-based movement. Although Google has closed down Google Reader, a popular RSS product, a number of other RSS reader options remain, including Feedly, Reeder, and NewsBlur.

WEB SERVERS AND CLIENTS

We have already described client/server computing and the revolution in computing architecture brought about by client/server computing. You already know that a server is a computer attached to a network that stores files, controls peripheral devices, interfaces with the outside world—including the Internet—and does some processing for other computers on the network.

web server software
software that enables a computer to deliver web pages written in HTML to client computers on a network that request this service by sending an HTTP request

But what is a web server? **Web server software** refers to the software that enables a computer to deliver web pages written in HTML to client computers on a network that request this service by sending an HTTP request. Apache, which works with Linux and Unix operating systems, is the most commonly used type of web server software. Microsoft's Internet Information Services (IIS) also has significant market share (Netcraft, 2016).

Aside from responding to requests for web pages, all web servers provide some additional basic capabilities such as the following:

- *Security services*—These consist mainly of authentication services that verify that the person trying to access the site is authorized to do so. For websites that process payment transactions, the web server also supports SSL and TLS, the protocols for transmitting and receiving information securely over the Internet. When private information such as names, phone numbers, addresses, and credit card data needs to be provided to a website, the web server uses SSL to ensure that the data passing back and forth from the browser to the server is not compromised.
- *FTP*—This protocol allows users to transfer files to and from the server. Some sites limit file uploads to the web server, while others restrict downloads, depending on the user's identity.
- *Search engine*—Just as search engine sites enable users to search the entire Web for particular documents, search engine modules within the basic web server software package enable indexing of the site's web pages and content and permit easy keyword searching of the site's content. When conducting a search, a search engine makes use of an index, which is a list of all the documents on the server. The search term is compared to the index to identify likely matches.
- *Data capture*—Web servers are also helpful at monitoring site traffic, capturing information on who has visited a site, how long the user stayed there, the date and time of each visit, and which specific pages on the server were accessed. This information is compiled and saved in a log file, which can then be analyzed. By analyzing a log file, a site manager can find out the total number of visitors, the average length of each visit, and the most popular destinations, or web pages.

The term *web server* is also used to refer to the physical computer that runs web server software. Leading manufacturers of web server computers include Lenovo, Dell, and Hewlett-Packard. Although any desktop computer can run web server software, it is best to use a computer that has been optimized for this purpose. To be a web server, a computer must have the web server software installed and be connected to the Internet. Every public web server computer has an IP address. For example, if you type http://www.pearsonhighered.com/laudon in your browser, the browser software sends a request for HTTP service to the web server whose domain name is pearsonhighered.com. The server then locates the page named "laudon" on its hard drive, sends the page back to your browser, and displays it on your screen. Of course, firms also can use web servers for strictly internal local area networking in intranets.

Aside from the generic web server software packages, there are actually many types of specialized servers on the Web, from **database servers** that access specific information within a database, to **ad servers** that deliver targeted banner ads, to **mail servers** that provide e-mail messages, and **video servers** that provide video clips. At a small e-commerce site, all of these software packages might be running on a single computer, with a single processor. At a large corporate site, there may be hundreds or thousands of discrete server computers, many with multiple processors, running specialized web server functions. We discuss the architecture of e-commerce sites in greater detail in Chapter 4.

database server
server designed to access specific information within a database

ad server
server designed to deliver targeted banner ads

mail server
server that provides e-mail messages

video server
server that serves video clips

web client
any computing device attached to the Internet that is capable of making HTTP requests and displaying HTML pages, most commonly a Windows PC or Macintosh

A **web client**, on the other hand, is any computing device attached to the Internet that is capable of making HTTP requests and displaying HTML pages. The most common client is a Windows or Macintosh desktop computer, with various flavors of Unix/Linux computers a distant third. However, the fastest growing category of web clients is not computers at all, but mobile devices. In general, a web client can be any device—including a printer, refrigerator, stove, home lighting system, or automobile instrument panel—capable of sending and receiving information from a web server.

WEB BROWSERS

web browser
software program whose primary purpose is to display web pages

A **web browser** is a software program whose primary purpose is to display web pages. Browsers also have added features, such as e-mail and newsgroups (an online discussion group or forum). As of July 2016, the leading desktop web browser is Google's Chrome, a small, yet technologically advanced open source browser, with about 51% of the market. Chrome is also the leading mobile/tablet browser, with about a 52% share of that market. The second most popular desktop browser is Microsoft's Internet Explorer, with about a 30% share. However, Internet Explorer's share of the mobile/tablet market is miniscule, with less than a 2% share. Mozilla Firefox is in third place in the desktop browser marketplace, with only about 8% share. It has less than a 1% share of the mobile/tablet browser market. First released in 2004, Firefox is a free, open source web browser for the Windows, Linux, and Macintosh operating systems, based on Mozilla open source code (which originally provided the code for Netscape). It is small and fast and offers many features such as pop-up blocking and tabbed browsing. Apple's Safari browser has only about a 4.5% share of the desktop browser market, but is the second most popular mobile/tablet browser, with a 28% share, due in large part to its use on iPhones and iPads (Marketshare.hitslink.com, 2016a, 2016b). In 2015, Microsoft introduced Edge, an entirely new browser bundled with its new operating system, Windows 10. Edge was designed to replace Internet Explorer. However, despite the popularity of Windows 10, Edge has thus far been largely ignored by Windows 10 adopters and has been installed on only about 5% of desktops.

3.5 THE INTERNET AND THE WEB: FEATURES AND SERVICES

The Internet and the Web have spawned a number of powerful software applications upon which the foundations of e-commerce are built. You can think of all these as web services, and it is interesting as you read along to compare these services to other traditional media such as television or print media. If you do, you will quickly realize the richness of the Internet environment.

COMMUNICATION TOOLS

The Internet and Web provide a number of communication tools that enable people around the globe to communicate with one another, both on a one-to-one basis as well as a one-to-many basis. Communication tools include e-mail, messaging applications, online message boards (forums), Internet telephony applications, and video conferencing, video chatting, and telepresence. We'll look at each of these in a bit more depth in the following sections.

E-mail

Since its earliest days, **electronic mail**, or **e-mail**, has been the most-used application of the Internet. Worldwide, there are over 2.6 billion e-mail users, sending over 2.15 billion e-mails a day. There are an estimated 1.7 billion mobile e-mail users worldwide, with over 65% of all e-mail users worldwide accessing e-mail on a mobile device (Radicati Group, 2016). Estimates vary on the amount of spam, ranging from 40% to 90%. E-mail marketing and spam are examined in more depth in Chapter 6.

electronic mail (e-mail)
the most-used application of the Internet. Uses a series of protocols to enable messages containing text, images, sound, and video clips to be transferred from one Internet user to another

E-mail uses a series of protocols to enable messages containing text, images, sound, and video clips to be transferred from one Internet user to another. Because of its flexibility and speed, it is now the most popular form of business communication—more popular than the phone, fax, or snail mail (the U.S. Postal Service). In addition to text typed within the message, e-mail also allows **attachments**, which are files inserted within the e-mail message. The files can be documents, images, sounds, or video clips.

attachment
a file inserted within an e-mail message

Messaging Applications

Instant messaging (IM) allows you to send messages in real time,unlike e-mail, which has a time lag of several seconds to minutes between when messages are sent and received. IM displays text entered almost instantaneously. Recipients can then respond immediately to the sender the same way, making the communication more like a live conversation than is possible through e-mail. To use IM, users create a buddy list they want to communicate with, and then enter short text messages that their buddies will receive instantly (if they are online at the time). And although text remains the primary communication mechanism in IM, more advanced systems also provide voice and video chat functionality. Instant messaging over the Internet competes with cell phone Short Message Service (SMS) and Multimedia Messaging Service (MMS) texting, which is far more expensive than IM. Major IM systems include Skype, Yahoo Messenger, Google Hangouts, and AIM (AOL Instant Messenger). IM systems were initially developed as proprietary systems, with competing firms offering versions that did not work with one another. Today, there still is no built-in interoperability among the major IM systems.

instant messaging (IM)
displays text entered almost instantaneously. Recipients can then respond immediately to the sender the same way, making the communication more like a live conversation than is possible through e-mail

Mobile messaging apps, such as Facebook Messenger, WhatsApp (purchased by Facebook for $22 billion in 2014), Snapchat (which allows users to send pictures, videos, and texts that will disappear after a short period of time), Kik, Viber, and others have also become wildly popular, providing competition for both traditional desktop IM systems and SMS text messaging. In the United States in 2016, over 130 million people (about 40% of the population) use mobile messaging apps, and companies are increasingly turning their attention to using these apps to market their brands (eMarketer, Inc., 2016g).

Online Message Boards

online message board
a web application that allows Internet users to communicate with each other, although not in real time

An **online message board** (also referred to as a forum, bulletin board, discussion board, discussion group, or simply a board or forum) is a web application that enables Internet users to communicate with each other, although not in real time. A message board provides a container for various discussions (or "threads") started (or "posted") by members of the board, and depending on the permissions granted to board members by the board's administrator, enables a person to start a thread and reply to other people's threads. Most message board software allows more than one message board to be created. The board administrator typically can edit, delete, move, or otherwise modify any thread on the board. Unlike an electronic mailing list (such as a listserv), which automatically sends new messages to a subscriber, an online message board typically requires that the member visit the board to check for new posts. Some boards offer an "e-mail notification" feature that notifies users that a new post of interest to them has been made.

Internet Telephony

If the telephone system were to be built from scratch today, it would be an Internet-based, packet-switched network using TCP/IP because it would be less expensive and more efficient than the alternative existing system, which involves a mix of circuit-switched legs with a digital backbone. In fact, AT&T has begun testing all-digital IP phone networks in several U.S. cities. Likewise, if cable television systems were built from scratch today, they most likely would use Internet technologies for the same reasons.

IP telephony
a general term for the technologies that use VoIP and the Internet's packet-switched network to transmit voice and other forms of audio communication over the Internet

Voice over Internet Protocol (VoIP)
protocol that allows for transmission of voice and other forms of audio communication over the Internet

IP telephony is a general term for the technologies that use **Voice over Internet Protocol (VoIP)** and the Internet's packet-switched network to transmit voice, fax, and other forms of audio communication over the Internet. VoIP can be used over a traditional handset as well as over a mobile device. VoIP avoids the long distance charges imposed by traditional phone companies.

There were about 230 million residential VoIP subscribers worldwide in 2015, and in the United States, more than half of residential customers are now using VoIP, and this number is expanding rapidly as cable systems provide telephone service as part of their "triple play": voice, Internet, and TV as a single package. This number is dwarfed, however, by the number of mobile VoIP subscribers, which has grown explosively over the last several years, fueled by the rampant growth of mobile messaging apps that now also provide free VoIP services, such as Facebook Messenger, WhatsApp (also owned by Facebook), Viber (owned by Japanese e-commerce giant Rakuten), WeChat, Line, KakaoTalk, and others (IHS, 2016; BuddeComm, 2016).

VoIP is a disruptive technology. In the past, voice and fax were the exclusive provenance of the regulated telephone networks. With the convergence of the Internet and telephony, however, this dominance is already starting to change, with local and long distance telephone providers and cable companies becoming ISPs, and ISPs getting into the phone market. Key players in the VoIP market include independent service providers such as VoIP pioneers Vonage and Skype (now owned by Microsoft), as well as traditional players such as telephone and cable companies that have moved aggressively into the market. Skype currently dominates the international market.

Skype carries over 3 billion minutes per day (translating into about 90 billion minutes per month) from 300 million users around the world (Anurag, 2016).

Video Conferencing, Video Chatting, and Telepresence

Internet video conferencing is accessible to anyone with a broadband Internet connection and a web camera (webcam). The most widely used web conferencing suite of tools is WebEx (now owned by Cisco). VoIP companies such as Skype and ooVoo also provide more limited web conferencing capabilities, commonly referred to as video chatting. Apple's FaceTime is another video chatting technology available for iOS mobile devices with a forward-facing camera and Macintosh computers equipped with Apple's version of a webcam, called a FaceTime camera.

Telepresence takes video conferencing up several notches. Rather than single persons "meeting" by using webcams, telepresence creates an environment in a room using multiple cameras and screens, which surround the users. The experience is uncanny and strange at first because as you look at the people in the screens, they are looking directly at you. Broadcast quality and higher screen resolutions help create the effect. Users have the sensation of "being in the presence of their colleagues" in a way that is not true for traditional webcam meetings. Providers of telepresence software and hardware include Cisco, LifeSize, BlueJeans Network, and Polycom ATX.

SEARCH ENGINES

Search engines identify web pages that appear to match keywords, also called queries, entered by a user and then provide a list of the best matches (search results). Almost 85% of U.S. Internet users regularly use search engines from either desktop or mobile devices, and they generate around 16 billion queries a month on desktop computers, about 10.2 billion of which are conducted using Google. Desktop search volume is declining, as more and more search activity moves to mobile devices. In fact, Google has reported that mobile search queries exceeded desktop queries in the United States and numerous other countries for the first time in 2015 (eMarketer, Inc., 2016h, 2016i; Sterling, 2016). There are hundreds of different search engines, but the vast majority of the search results are supplied by the top three providers: Google, Microsoft's Bing, and Yahoo. Google currently has about 64% of the desktop search market based on number of searches, followed by Microsoft's Bing, with about 22%, and Yahoo with about 12%.

search engine
identifies web pages that appear to match keywords, also called queries, entered by the user and then provides a list of the best matches

Web search engines started out in the early 1990s shortly after Netscape released the first commercial web browser. Early search engines were relatively simple software programs that roamed the nascent Web, visiting pages and gathering information about the content of each web page. These early programs were called variously crawlers, spiders, and wanderers; the first full-text crawler that indexed the contents of an entire web page was called WebCrawler, released in 1994. AltaVista (1995), one of the first widely used search engines, was the first to allow "natural language" queries such as "history of web search engines" rather than "history + web + search engine."

The first search engines employed simple keyword indexes of all the web pages visited. They would count the number of times a word appeared on the web page, and store this information in an index. These search engines could be easily fooled by web designers who simply repeated words on their home pages. The real innovations in search engine development occurred through a program funded by the Department of Defense called the Digital Library Initiative, designed to help the Pentagon find research papers in large databases. Stanford, Berkeley, and three other universities became hotbeds of web search innovations in the mid-1990s. At Stanford in 1994, two computer science students, David Filo and Jerry Yang, created a hand-selected list of their favorite web pages and called it "Yet Another Hierarchical Officious Oracle," or Yahoo!. Yahoo initially was not a real search engine, but rather an edited selection of web sites organized by categories the editors found useful. Yahoo later developed "true" search engine capabilities.

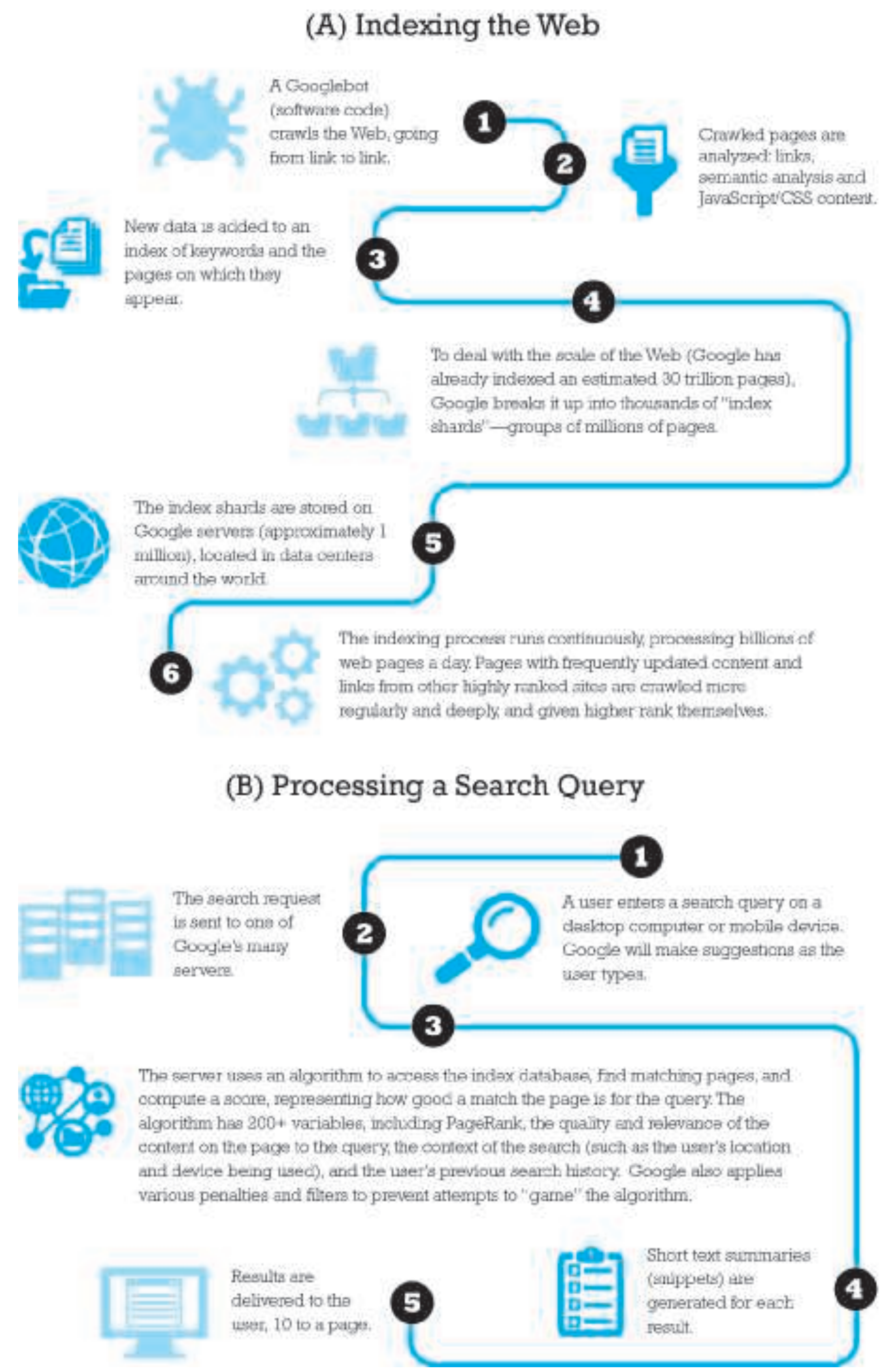
In 1998, Larry Page and Sergey Brin, two Stanford computer science students, released their first version of the Google search engine. This search engine was different: not only did it index each web page's words, but Page had discovered that the AltaVista search engine not only collected keywords from sites but also calculated what other sites linked to each page. By looking at the URLs on each web page, they could calculate an index of popularity. AltaVista did nothing with this information. Page took this idea and made it a central factor in ranking a web page's appropriateness to a search query. He patented the idea of a web page ranking system (PageRank System), which essentially measures the popularity of the web page. Brin contributed a unique web crawler program that indexed not just keywords on a web page, but combinations of words (such as authors and their article titles). These two ideas became the foundation for the Google search engine (Brandt, 2004). **Figure 3.18(A)** illustrates how Google indexes the Web. **Figure 3.18(B)** shows you what happens when you enter a search query.

Initially, few understood how to make money from search engines. That changed in 2000 when Goto.com (later Overture) allowed advertisers to bid for placement on their search engine results, and Google followed suit in 2003 with its AdWords program, which allowed advertisers to bid for placement of short text ads on Google search results. The spectacular increase in Internet advertising revenues (which have been growing at around 20%–25% annually over the last few years) has helped search engines transform themselves into major shopping tools and created an entire new industry called "search engine marketing."

When users enter a search term at Google, Bing, Yahoo, or any of the other websites serviced by these search engines, they receive two types of listings: sponsored links, for which advertisers have paid to be listed (usually at the top of the search results page), and unsponsored "organic" search results. Advertisers can also purchase small text ads on the right side of the search results page. In addition, search engines have extended their services to include news, maps, satellite images, computer images, e-mail, group calendars, group meeting tools, and indexes of scholarly papers.

Although the major search engines are used for locating general information of interest to users, search engines have also become a crucial tool within e-commerce sites. Customers can more easily search for the product information they want with the help of an internal search program; the difference is that within websites, the search engine is limited to finding matches from that one site. For instance, more online shoppers use Amazon's internal search engine to look for products than conducting a

FIGURE 3.18 **HOW GOOGLE WORKS**



product search using Google, a fact noted by Google's executive chairman Eric Schmidt, who believes that Amazon search poses a significant threat to Google (Mangalindan, 2014). Pinterest hopes to challenge Google in the realm of visual search, as discussed in the closing case study in Chapter 1.

DOWNLOADABLE AND STREAMING MEDIA

download
transfers a file from a web server and stores it on a computer for later use

streaming media
enables video, music, and other large-bandwidth files to be sent to a user in a variety of ways that enable the user to play the files as they are being delivered

When you **download** a file from the Web, the file is transferred from a web server and is stored on your computer for later use. With the low-bandwidth connections of the early Internet, audio and video files were difficult to download, but with the huge growth in broadband connections, these files are not only commonplace but today constitute the majority of web traffic. **Streaming media** is an alternative to downloaded media and enables video, music, and other large-bandwidth files to be sent to a user in a variety of ways that enable the user to play the files as they are being delivered. In some situations, the files are broken into chunks and served by specialized video servers to client software that puts the chunks together and plays the video. In other situations, a single large file is delivered from a standard web server to a user who can begin playing the video before the entire file is delivered. Streamed files must be viewed in real time; they cannot be stored on client hard drives without special software. Streamed files are "played" by a software program such as Windows Media Player, Apple QuickTime, Adobe Flash, and Real Player. There are a number of tools used to create streaming files, including HTML5 and Adobe Flash, as well as technologies specifically adapted for the mobile platform such as the Meerkat and Periscope apps. As the capacity of the Internet grows, streaming media will play an even larger role in e-commerce.

Spurred on by the worldwide sales of more than 2.5 billion iOS (iPhones, iPads, and iPod Touches) and Android devices, the Internet has become a virtual digital river of music, audio, and video files. The Apple iTunes store is probably the most well-known repository of digital music online, with a catalog of more than 43 million songs worldwide in its catalog as of September 2016. Google Play offers over 35 million, and there are hundreds of other sites offering music downloads as well. In addition, streaming music services and Internet radio, such as Apple Music, Spotify, Pandora, Amazon Prime Music, Tidal, and hundreds of others, add to the bandwidth devoted to the delivery of online music.

podcast
an audio presentation—such as a radio show, audio from a movie, or simply a personal audio presentation—stored online as a digital media file

Podcasting (the name originates from a mashup of the word "iPod" and the word "broadcasting") is also surging in popularity. A **podcast** is an audio presentation—such as a radio show, audio from a conference, or simply a personal presentation—stored online as digital media file. Listeners can download the file and play it on their mobile devices or computers. Podcasting has transitioned from an amateur independent producer media in the "pirate radio" tradition to a professional news and talk content distribution channel. For instance, This American Life's *Serial* podcast has been downloaded over 175 million times. NPR is the top U.S. producer of podcasts, with an aggregate monthly audience of almost 8 million, followed by WNYC Studios, a NYC-based public broadcasting organization, with a monthly audience of about 6 million (Podtrac, Inc., 2016).

Online video viewing has also exploded in popularity. In 2016, for instance, there are around 215 million Americans that watch streaming or downloaded video content on a desktop or mobile device at least once a month (eMarketer, Inc., 2016j). Cisco estimates that consumer Internet video traffic constituted a whopping 70% of all consumer Internet traffic in 2015, and this percentage is expected to grow to 82% by 2020 (Cisco, 2016b). The Internet has become a major distribution channel for movies, television shows, and sporting events (see Chapter 10). Another common type of Internet video is provided by YouTube, with more than 1 billion users worldwide, who each day watch hundreds of millions of hours of video content, ranging from a wide variety of user-generated content, to branded content from major corporations, music videos, original programming, and more. Sites such as YouTube, Metacafe, and Facebook have popularized user-generated video streaming. Many apps such as Instagram, Twitter, Snapchat, and others also include video capabilities.

Online advertisers increasingly use video to attract viewers. Companies that want to demonstrate use of their products have found video clips to be extremely effective. Streaming video segments used in web ads and news stories are perhaps the most frequently used streaming services. High-quality interactive video and audio makes sales presentations and demonstrations more effective and lifelike and enables companies to develop new forms of customer support.

WEB 2.0 APPLICATIONS AND SERVICES

Today's broadband Internet infrastructure has greatly expanded the services available to users. These capabilities have formed the basis for new business models. Web 2.0 applications and services are "social" in nature because they support communication among individuals within groups or social networks.

Online Social Networks

Online social networks are services that support communication within networks of friends, colleagues, and entire professions. Online social networks have developed very large worldwide audiences (over 2.3 billion people in 2016, almost one-third of the world's population) and form the basis for new advertising platforms and for social e-commerce (see Chapters 6, 7, and 11). The largest social networks are Facebook (1.7 billion monthly active users worldwide), Instagram (500 million members worldwide), LinkedIn (more than 450 million members worldwide), Twitter (more than 310 million active users worldwide), and Pinterest (over 110 million active users). These networks rely on user-generated content (messages, photos, and videos) and emphasize sharing of content. All of these features require significant broadband Internet connectivity and equally large cloud computing facilities to store content.

Blogs

A **blog** (originally called a **weblog**) is a personal web page that typically contains a series of chronological entries (newest to oldest) by its author, and links to related web pages. The blog may include a blogroll (a collection of links to other blogs) and

blog
personal web page that is created by an individual or corporation to communicate with readers

trackbacks (a list of entries in other blogs that refer to a post on the first blog). Most blogs allow readers to post comments on the blog entries as well. The act of creating a blog is often referred to as "blogging." Blogs are either hosted by a third-party site such as WordPress, Tumblr, Blogger, LiveJournal, TypePad, and Xanga, or prospective bloggers can download software such as Movable Type to create a blog that is hosted by the user's ISP. Blog pages are usually variations on templates provided by the blogging service or software and hence require no knowledge of HTML. Therefore, millions of people without HTML skills of any kind can post their own web pages, and share content with friends and relatives. The totality of blog-related websites is often referred to as the "blogosphere."

Blogs have become hugely popular. Tumblr and Wordpress together hosted over 400 million blogs as of September 2016, so it is likely that the total number is significantly higher. According to eMarketer, there are an estimated 29 million active U.S. bloggers, and 81 million U.S. blog readers (eMarketer, Inc., 2916k, 2016l). No one knows how many of these blogs are kept up to date or are just yesterday's news. And no one knows how many of these blogs have a readership greater than one (the blog author). In fact, there are so many blogs you need a search engine just to find them, or you can just go to a list of the most popular 100 blogs and dig in.

Wikis

wiki
web application that allows a user to easily add and edit content on a web page

A **wiki** is a web application that allows a user to easily add and edit content on a web page. (The term wiki derives from the "wiki wiki" (quick or fast) shuttle buses at Honolulu Airport.) Wiki software enables documents to be written collectively and collaboratively. Most wiki systems are open source, server-side systems that store content in a relational database. The software typically provides a template that defines layout and elements common to all pages, displays user-editable source code (usually plain text), and then renders the content into an HTML-based page for display in a web browser. Some wiki software allows only basic text formatting, whereas others allow the use of tables, images, or even interactive elements, such as polls and games. Because wikis by their very nature are very open in allowing anyone to make changes to a page, most wikis provide a means to verify the validity of changes via a "Recent Changes" page, which enables members of the wiki community to monitor and review the work of other users, correct mistakes, and hopefully deter "vandalism."

The most well-known wiki is Wikipedia, an online encyclopedia that contains more than 40 million articles in 294 different languages on a variety of topics. The Wikimedia Foundation, which operates Wikipedia, also operates a variety of related projects, including Wikibooks, a collection of collaboratively written free textbooks and manuals; Wikinews, a free content news source; and Wiktionary, a collaborative project to produce a free multilingual dictionary in every language, with definitions, etymologies, pronunciations, quotations, and synonyms.

VIRTUAL REALITY AND AUGMENTED REALITY

virtual reality (VR)
involves fully immersing users within a virtual world, typically through the use of a head-mounted display (HMD) connected to headphones and other devices

In 2016, virtual reality and augmented reality technologies began to enter the consumer market and attract significant attention. **Virtual reality (VR)** involves fully immersing users within a virtual world, typically through the use of a head-mounted display (HMD) connected to headphones and other devices that enable navigation through the experience and allowing users to feel as if they are actually present within the virtual world. High-end VR devices designed to be used with PCs or gaming systems include Facebook's Oculus Rift, HTC's Vive, and Sony's PlayStation VR. Samsung's Gear VR and Google Cardboard are examples of lower-cost, mobile, entry-level devices. A number of publishers are experimented with VR content that can use these lower-cost devices. For example, the New York Times has a VR mobile app that viewers can use with Google Cardboard to view VR films and advertisements that feature 360-degree video. By 2020, some analysts estimate that there will be almost 155 million virtual reality users worldwide (with around 135 million using a smartphone-powered device and another 20 million a higher-end PC/game console-related device). **Augmented reality (AR)** involves overlaying virtual objects over the real world, via smartphones, tablets, or HMDs. Perhaps the highest profile use of AR thus far has been its use in Nintendo's Pokemon GO game. Other uses include Snapchat's Lenses feature, which uses facial recognition technology and 3-D models that allow users to augment their selfies by overlaying animations or other images on top of them, and "try-before-you-buy" apps created for beauty and fashion brands (eMarketer, Inc., 2016m).

augmented reality (AR)
involves overlaying virtual objects over the real world, via smartphones, tablets or HMDs.

INTELLIGENT PERSONAL ASSISTANTS

The idea of having a conversation with a computer, having it understand you and be able to carry out tasks according to your direction, has long been a part of science fiction, from the 1968 Hollywood movie *2001: A Space Odyssey*, to an old Apple promotional video depicting a professor using his personal digital assistant to organize his life, gather data, and place orders at restaurants. That was all fantasy. But Apple's Siri, billed as an intelligent personal assistant and knowledge navigator and released in 2011, has many of the capabilities of the computer assistants found in fiction. Siri has a natural language, conversational interface, situational awareness, and is capable of carrying out many tasks based on verbal commands by delegating requests to a variety of different web services. For instance, you can ask Siri to find a restaurant nearby that serves Italian food. Siri may show you an ad for a local restaurant in the process. Once you have identified a restaurant you would like to eat at, you can ask Siri to make a reservation using OpenTable. You can also ask Siri to place an appointment on your calendar, search for airline flights, and figure out what's the fastest route between your current location and a destination using public transit. The answers are not always completely accurate, but critics have been impressed with its uncanny abilities. Siri is currently available on the Apple Watch, the iPhone 4S and later versions, iPads with Retina display, the iPad Mini, and iPod Touches (fifth generation and later versions).

In 2012, Google released its version of an intelligent assistant for Android-based smartphones, which it calls Google Now. Google Now is part of the Google Search mobile application. While Google Now has many of the capabilities of Apple's Siri, it attempts to go further by predicting what users may need based on situational awareness, including physical location, time of day, previous location history, calendar, and expressed interests based on previous activity, as described in its patent application (United States Patent Office, 2012). For instance, if you often search for a particular musician or style of music, Google Now might provide recommendations for similar music. If it knows that you go to a health club every other day, Google Now will remind you not to schedule events during these periods. If it knows that you typically read articles about health issues, the system might monitor Google News for similar articles and make recommendations. In 2016, Google unveiled Google Assistant, a similar virtual assistant for its Allo chat app and integrated into its Google Home products and its new Pixel phones. Other intelligent personal assistants include Samsung's S Voice, LG's Voice Mate, and Microsoft's Cortana. The *Insight on Business* case, *AI, Intelligent Assistants, and Chatbots*, focuses on the increasing use of AI technologies in e-commerce.

3.6 MOBILE APPS: THE NEXT BIG THING IS HERE

When Steve Jobs introduced the iPhone in January 2007, no one, including himself, envisioned that the device would launch a software revolution or become a major e-commerce platform, let alone a game platform, advertising platform, and general media platform for television shows, movies, videos, and e-books. The iPhone's original primary functions, beyond being a cell phone, were to be a camera, text messaging device, and web browser. What Apple initially lacked for the iPhone were software applications ("apps") that would take full advantage of its computing capabilities. The solution was apps developed by outside developers. In July 2008, Apple introduced the App Store, which provides a platform for the distribution and sale of apps by Apple as well as by independent developers. Around the same time, Google was developing Android as an open source operating system for mobile devices. In October 2008, the first smartphone using Android was released, and Google launched the Android Market (now called Google Play) as the official app store for Android. In 2010, tablet computers such as Apple's iPad and the Samsung Galaxy Tab, which provided additional platforms for mobile apps, were introduced.

As of June 2016, more than 130 billion apps have been downloaded from the App Store, and there are over 2 million approved apps available for download. There are over 2 million apps available for Android devices on Google Play as well. And while the number of cumulative downloads of Android apps is not publicly available, Google has announced that Android users downloaded over 65 billion apps between May 2015 and May 2016 alone.

The mobile app phenomenon has spawned a new digital ecosystem: tens of thousands of developers, a wildly popular hardware platform, and millions of consumers now using a mobile device to replace their clunky desktop-laptop Microsoft Windows computer and act as a digital media center as well. Mobile apps have even usurped TV as the most popular entertainment medium. A 2015 report from Flurry found that the average U.S. consumer now spends nearly 200 minutes per day within apps, well ahead of the 168 minutes spent watching TV. As recently as 2014, TV was still comfortably ahead of apps. More consumers are opting to consume media on their phones and tablet computers than ever before, which is more good news for app developers.

INSIGHT ON BUSINESS

AI, INTELLIGENT ASSISTANTS, AND CHATBOTS

Despite the frequent appearances of robots and advanced artificial intelligence (AI) in books and movies over the past several decades, real-world equivalents have lagged hopelessly behind. However, today's tech titans are doubling their efforts to improve AI technologies in an effort to get a jump on the competition. We may still be a long way away from R2-D2, but AI in the form of personalization systems, chatbots, and intelligent assistants is finally entering the mainstream.

AI systems of the past have had frustratingly limited capabilities. Asking them to perform tasks outside of their purpose or to interpret and respond to the variation and nuances of human language simply doesn't work. Even tools like search engines, which have the ability to distinguish between different types of language and queries, can't incorporate context.

Although companies like Amazon have made use of more complex forms of AI to power their personalization and recommendation engines, this mostly occurs behind the scenes—customers aren't interacting directly with these types of AI technologies. However, advances in natural language processing techniques have enabled Amazon to develop exciting new technologies like the Amazon Echo and its underlying AI technology, which Amazon calls Alexa. The Echo is marketed as a home assistant that can perform a variety of tasks using speech recognition, but is still in its infancy as a product. Currently, the Echo can update to-do lists, adjust home appliances, play games, and stream music, all controlled by voice.

Echo and Alexa are powered by these and other "skills," which function much like apps do on the iPhone, and which third-party developers are lining up in droves to develop. For example, 1-800-Flowers was one of the first large retailers to develop a skill that allows users to place orders by voice alone on any device running Alexa, including the Echo and the Amazon Fire TV. Although customers interested in using this capability must have account info, payment info, and addresses already on file, this represents a major breakthrough. Other companies developing skills for Alexa include Domino's, Capital One, Ford Motor, and many more. Amazon is hoping that in the future, people will be able to ask Alexa what they should buy and receive an intelligent, relevant response.

Although Echo and Alexa are perhaps the most visible sign of growth in artificial intelligence and natural language processing, the modern technological landscape is defined by its multitude of platforms. Retailers are trying to encourage their customers to do business with them on each and every one of them. Many of these platforms are text-based, and the number of people using messaging apps is skyrocketing in the United States, from 113 million in 2015 to a projected 177 million by 2019. To that end, companies have been rolling out "chatbots"—AI that can interact with users via text and automate many parts of the purchasing process that are currently manual, such as talking on the phone or navigating online menus.

Facebook Messenger is one of the most popular messaging apps, trailing only WhatsApp in monthly active users. Facebook M is a virtual assistant within Messenger launched in 2015 that can perform a variety of tasks via text, including making restaurant reservations, booking travel plans, and helping find birthday gifts. Facebook has also opened the Messenger platform to third-party chatbots from other companies, including the previously mentioned 1-800-Flowers as well

(continued)

as others like Uber. Increasingly, popular workplace messaging tool Slack has done the same with its platform, and companies like Taco Bell have developed tools like TacoBot that allow Slack users to order food through a brief text conversation.

Seemingly every prominent tech company and messaging platform has an AI that it hopes will dominate the emerging marketplace. Amazon has Alexa and Facebook has M; Apple has Siri, perhaps the best known intelligent assistant; Google has Google Now and Google Assistant; Microsoft has Cortana. Google also unveiled its Google Home appliance, which is modeled after the Echo but which reportedly has better conversational functionality and ability to integrate with home speakers. In the same vein, Samsung announced the Samsung Otto device, which comes equipped with features Echo lacks like an HD camera and facial recognition capability. These companies are all positioning themselves to take part in the impending boom in virtual assistant technologies. Analysts anticipate that virtual assistants of all types will have 1.8 billion active global users by 2021, up from 390 million in 2016.

Other players have emerged as well. The developers of the AI that powers Apple's Siri have developed a new platform called Viv that goes far beyond Siri's functionality. Viv can answer much more complicated questions than Siri, such as "Will it be warmer than 70 degrees near the Golden Gate Bridge after 5 PM the day after tomorrow?" Viv can also book flights by using your preferred airline, frequent flyer number, and seating preference, all without any human guidance, and might someday have the ability to automatically detect low fares.

A primary goal of all of these technologies is to facilitate sales. Intelligent personal assistants and chatbots might be able to understand what it is that we're looking for as consumers even when we're not sure how to phrase it or what we're even looking for. If AI continues to improve and people learn to trust technologies like chatbots, the importance of websites and native apps is likely to greatly diminish, and web search may also take a hit. That's part of the reason why Google has been so active in this area, perhaps sensing a threat to its core business model.

Interestingly, Microsoft has eight full-time writers who formulate Cortana's responses to user queries. The team's goal is for Cortana to exhibit the type of multi-dimensional intelligence that humans display—social intelligence, emotion, humor, and a point of view. Whichever intelligent assistant is most successful at this is likely to have a leg up on the others. Although these technologies still require plenty of human guidance (Facebook M reportedly has a staff of human customer service agents on hand to handle difficult queries), the time may finally have arrived where interacting directly with AI becomes a part of our everyday lives.

SOURCES: "What Alexa & AI Means for the Future of Commerce," by Richard MacManus, Richardmacmanus.com, August 25, 2016; "Why Dominos' Virtual Assistant Struggles to Understand Your Orders," by Clint Boulton, Cio.com, August 24, 2016; "What Retailers Need to Know, and Expect, About Virtual Digital Technology," by Judy Motti, Retailcustomerexperience.com, August 5, 2016; "3 Ways Artificial Intelligence Is Transforming E-commerce," by Ben Rossi, Information-age.com, July 18, 2016; "These Three Virtual Assistants Point the Way to the Future," by Mike Elgan, Computerworld.com, June 8, 2016; "The Search for the Killer Bot," by Sharon Gaudin, Casey Newton, Theverge.com, June 1, 2016; "When a Robot Books Your Airline Ticket," by Jane L. Levere, *New York Times,* May 30, 2016; "Google Makes Push Into Artificial Intelligence with New Offerings," by Jack Nicas, *Wall Street Journal,* May 18, 2016; "Google Home vs. Amazon Echo: Why Home Could Win," by Andrew Gebhart, Cnet.com, May 18, 2016; "New Siri Sibling Viv May Be Next Step in A.I. Evolution," Computerworld.com, May 11, 2016; "Siri-Creator Shows Off First Public Demo of Viv, 'The Intelligent Interface for Everything,'" by Lucas Matney, Techcrunch.com, May 9, 2016; "1-800-Flowers Chats Up Amazon's Alexa," by Allison Enright, Internetretailer.com, April 26, 2016; "The Chatbots are Coming - and They Want to Help You Buy Stuff," by Sarah Halzack, *Washington Post,* April 13, 2016; "What Can Chatbots Do for Ecommerce?" by Mike O'Brien, Clickz.com, April 11, 2016; "2 Ways Artificial Intelligence Is Changing Customer Engagement," by Randy Kohl, The-future-of-commerce.com, February 18, 2016; "How Real People Help Cortana, Siri, and Other Virtual Assistants Feel Alive," by Mike Elgan, Pcworld.com, February 1, 2016; "The North Face Brings AI to Ecommerce," by Rebecca Harris, Marketingmag.ca, January 12, 2016.

The implications of the app ecosystem for e-commerce are significant. The smartphone in your pocket or the tablet computer on your lap becomes not only a general-purpose computer, but also an always-present shopping tool for consumers, as well as an entirely new marketing and advertising platform for vendors. Early e-commerce applications using desktops and laptops were celebrated as allowing people to shop in their pajamas. Smartphones and tablets extend this range from pajamas to office desktops to trains, planes, and cars, all fully clothed. You can shop anywhere, shop everywhere, and shop all the time, in between talking, texting, watching video, and listening to music. Almost all of the top 100 brands have a presence in at least one of the major app stores, and more than 90% have an app in the Apple App Store. M-commerce in the form of purchases of retail and travel products and services via a mobile device is expected to generate over $180 billion in 2016, while downloads of mobile apps and in-app purchases are expected to generate over $10 billion (eMarketer, Inc., 2016n, 2016o, 2016p).

PLATFORMS FOR MOBILE APPLICATION DEVELOPMENT

Unlike mobile web sites, which can be accessed by any web-enabled mobile device, native apps, which are designed specifically to operate using the mobile device's hardware and operating system, are platform-specific. Applications for the iPhone, iPad, and other iOS devices are written in the Objective-C programming language using the iOS SDK (software developer kit). Applications for Android operating system–based phones typically are written using Java, although portions of the code may be in the C or C++ programming language. Applications for Windows mobile devices are written in C or C++. In addition to creating native apps using a programming language such as Objective C or Java, there are also hundreds of low-cost or open source app development toolkits that make creating cross-platform mobile apps relatively easy and inexpensive without having to use a device-specific programming language. See Section 4.6 in Chapter 4 for more information.

APP MARKETPLACES

Once written, applications are distributed through various marketplaces. Android apps for Android-based phones are distributed through Google Play, which is controlled by Google. iPhone applications are distributed through Apple's App Store. Microsoft operates the Windows Phone Marketplace for Windows mobile devices. Apps can also be purchased from third-party vendors such as Amazon's Appstore. It is important to distinguish "native" mobile apps, which run directly on a mobile device and rely on the device's internal operating system, from web apps, which install into your browser, although these can operate in a mobile environment as well.

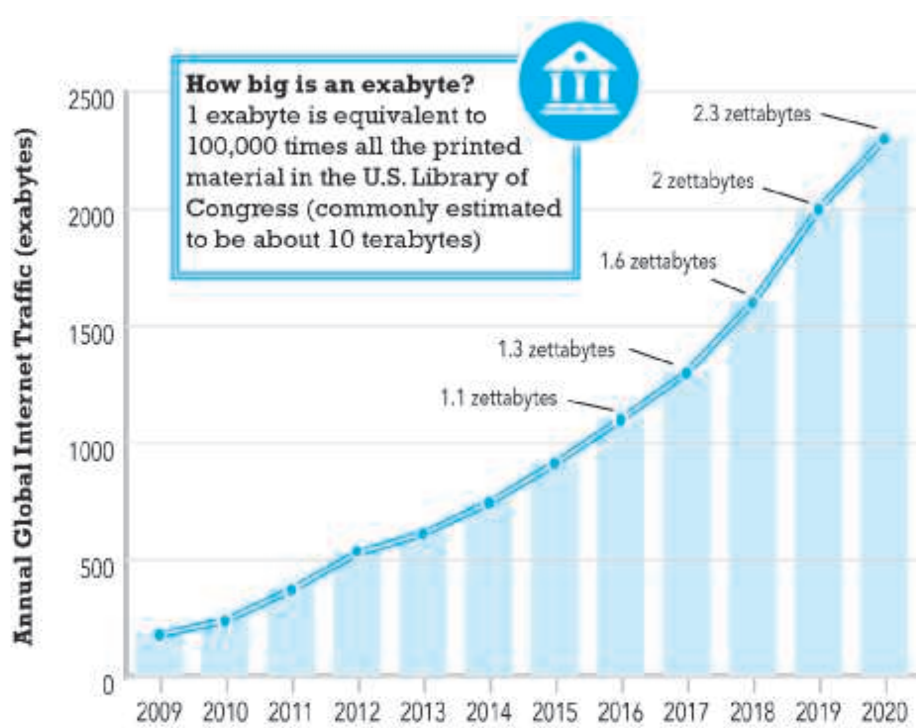
3.7 CASE STUDY

Akamai Technologies:

Attempting to Keep Supply Ahead of Demand

In 2016, the amount of Internet traffic generated by YouTube alone is greater than the amount of traffic on the entire Internet in 2000. Because of video streaming and the explosion in mobile devices demanding high-bandwidth applications, Internet traffic has increased over 500% since 2010 and is predicted to nearly triple by 2019 (see **Figure 3.19**). Internet video is now a majority of Internet traffic and will reach 82% by 2020, according to Cisco. Experts call services like YouTube, Netflix, and high definition streaming video "net bombs" because they threaten the effective operation of the Internet. Mobile platform traffic grew by almost 75% in 2015 and may soon push cellular networks and the Internet to their capacities.

FIGURE 3.19 THE GROWTH OF INTERNET TRAFFIC



Cisco estimates that annual global Internet traffic will be around 2.3 zettabytes in 2020: that's 2,300 exabytes, or, in other words, 23 with 19 zeroes behind it!

In today's broadband environment, the threshold of patience is very low. Increased video and audio customer expectations are bad news for anyone seeking to use the Web for delivery of high-quality multimedia content and high definition video. Akamai is one of the Web's major helpers, and an overwhelming majority of the Web's top companies use Akamai's services to speed the delivery of content. Akamai serves more than 30 terabits of web traffic per second.

Slow-loading web pages and content sometimes result from poor design, but more often than not, the problem stems from the underlying infrastructure of the Internet. The Internet is a collection of networks that has to pass information from one network to another. Sometimes the handoff is not smooth. Every 1,500-byte packet of information sent over the Internet must be verified by the receiving server and an acknowledgment sent to the sender. This slows down not only the distribution of content such as music, but also slows down interactive requests, such as purchases, that require the client computer to interact with an online shopping cart. Moreover, each packet may go through many different servers on its way to its final destination, multiplying by several orders of magnitude the number of acknowledgments required to move a packet from New York to San Francisco. The Internet today spends much of its time and capacity verifying packets, contributing to a problem called "latency" or delay. For this reason, a single e-mail with a 1-megabyte attached PDF file can create more than 50 megabytes of Internet traffic and data storage on servers, client hard drives, and network backup drives.

Akamai Technologies was founded by Tom Leighton, an MIT professor of applied mathematics, and Daniel Lewin, an MIT grad student, with the idea of expediting Internet traffic to overcome these limitations. Lewin's master's thesis was the theoretical starting point for the company. It described storing copies of web content such as pictures or video clips at many different locations around the Internet so that one could always retrieve a nearby copy, making web pages load faster.

Officially launched in August 1998, Akamai's current products are based on the Akamai Intelligent Platform, a cloud platform made up of over 216,000 servers in 120 countries within over 1,500 networks around the world, and all within a single network hop of 85% of all Internet users. Akamai software on these servers allows the platform to identify and block security threats and provide comprehensive knowledge of network conditions, as well as instant device-level detection and optimization. Akamai's site performance products allow customers to move their online content closer to end users so a user in New York City, for instance, will be served L.L.Bean pages from the New York Metro area Akamai servers, while users of the L.L.Bean site in San Francisco will be served pages from Akamai servers in San Francisco. Akamai has a wide range of large corporate and government clients: 1 out of every 3 global Fortune 500 companies, the top 30 media and entertainment companies, 96 of the top 100 online U.S. retailers, all branches of the U.S. military, all the major U.S. sports leagues, and so on. In 2015, Akamai delivers between 15% and 30% of all web traffic, and over 3 trillion daily Internet interactions. Other competitors in the content delivery network (CDN) industry include Limelight Networks, Level 3 Communications, and Mirror Image Internet.

Accomplishing this daunting task requires that Akamai monitor the entire Internet, locating potential sluggish areas and devising faster routes for information to travel. Frequently used portions of a client's website, or large video or audio files that would be difficult to send to users quickly, are stored on Akamai's servers. When a user requests a song or a video file, his or her request is redirected to an Akamai server nearby and the content is served from this local server. Akamai's servers are placed in Tier 1 backbone supplier networks, large ISPs, universities, and other networks. Akamai's software determines which server is optimal for the user and then transmits the "Akamaized" content locally. Web sites that are "Akamaized" can be delivered anywhere from 4 to 10 times as fast as non-Akamaized content. Akamai has developed a number of other business services based on its Internet savvy, including targeted advertising based on user location and zip code, content security, business intelligence, disaster recovery, on-demand bandwidth and computing capacity during spikes in Internet traffic, storage, global traffic management, and streaming services. You can see several interesting visualizations of the Internet that log basic real-time online activity by visiting the Akamai website.

The shift toward cloud computing and the mobile platform as well as the growing popularity of streaming video have provided Akamai with new growth opportunities. As more businesses and business models are moving to the Web, Akamai has seen its client base continue to grow beyond the most powerful Internet retailers and online content providers. In 2014, Akamai made a push to encourage Hollywood studios to use the cloud for feature films, touting its ability to handle uploads and downloads of large video files, to quickly convert files from one format to another, and to apply DRM protections. Establishing partnerships with movie studios represented big business for Akamai, with an increasing amount of media consumption taking place on mobile devices through the cloud. Akamai has also made agreements to become the primary content delivery platform for cloud service providers like Microsoft Azure and Google Cloud Platform.

However, the growth of streaming video has also created new challenges for Akamai, including increased competition from Comcast and Amazon, which have built competing content delivery services. Amazon's Cloudfront content delivery network is already bringing in $1.8 billion in revenues. Larger clients like Apple and Facebook are also increasingly shifting their content delivery operations away from Akamai's platforms and onto in-house content delivery networks. Reducing carbon emissions and energy expenditure as demand grows has been another challenge for Akamai. In response, the company has undertaking sweeping efforts to reduce its greenhouse gas emissions to below 2015 levels by 2020 despite significantly higher demand.

Akamai is also acutely aware of the increase in cybercrime as more traffic migrates to the Internet. Growth in Internet traffic is good news for Akamai, but the company must also now deal with politically motivated cyberattacks, organized crime online, and state-sponsored cyberwarfare. Akamai has continued to improve its Kona Site Defender tool, which offers a variety of security measures for Akamai clients. The tool protects against Distributed Denial of Service (DDoS) attacks and includes a firewall for web applications. In 2016, Akamai rolled out new improvements to Kona's web application firewall and analytics features. Akamai also upgraded Site Defender's Web Application Firewall feature and developed modifications to the tool that make it easier

SOURCES: "Facts & Figures," Akamai.com, accessed September 8, 2016; "Amazon, Comcast Content Delivery Network Push Could Hurt Akamai," by Reinhardt Krause, Investors.com, May 11, 2016; "Akamai Will Power Internet with Sun and Wind," by Nicola Peill-Moelter, Greenbiz.com, May 11, 2016; "Akamai Advances Kona Site Defender to Meet the Challenges Posed by Constantly Evolving Web Application and DDoS Threat Landscape," Akamai.com, February 29, 2016; "Akamai Shares Surge on Earnings Beat, Reorganization, Buybacks," by Wallace Witkowski, Marketwatch.com, February 9, 2016; "Google and Akamai Partner on Speeding Up Cloud Network," by Steven J. Vaughan-Nichols, Zdnet.com, November 20, 2015; "How Akamai Plans to Make a Comeback," Bloomberg.com, October 28, 2015; "Microsoft and Akamai Bring CDN to Azure Customers," by Sudheer Sirivara, Azure.microsoft.com,

for its users to use. With so many businesses now dependent on the uninterrupted flow of content over the Internet, Akamai is in a very strong position to sell security services to its customers. In 2015, Akamai partnered with top information security firm Trustwave to cross-sell each other's services and products, expanding their offerings and reaching even further. Akamai made a similar agreement with China Unicom, a provider of cloud services in the fast-growing Chinese market. Akamai has also set itself up for future growth by moving into areas of the world with less developed broadband infrastructure, such as the Middle East. In 2015, Akamai opened an office in Dubai, hoping to bolster its presence in an area where the adoption rate for broadband is skyrocketing.

In 2016, experiencing rapidly increasing demand from its clients for security tools, Akamai announced it would restructure its business into two distinct units, one focusing on content delivery and media, and the other on website security. The improvements in Akamai's security businesses have offset any slowdown in their content delivery business, as the company registered earnings well above analyst estimates in 2016 despite increased competition in content delivery. Akamai has plans to increase its suite of security tools going forward, with tools designed to protect employees from phishing and malware due to be released in 2017. While the future of its content delivery business is cloudier due to increased competition and the challenges of Internet growth, the company is still very profitable.

September 29, 2015; "Akamai Opens Dubai Office to Support Its Growing Middle East Business," Akamai.com, June 14, 2015; "Akamai, Trustwave to Promote, Sell Each Other's Security Services," by Sean Michael Kerner, Eweek.com, June 1, 2015; "Akamai and China Unicom Establish Strategic Cloud Services Partnership," Akamai.com, May 26, 2015; "Akamai Appeals to Hollywood Studios at NAB 2014," by Troy Dreier, Streamingmedia.com, April 7, 2014; "Akamai Completes Acquisition of Prolexic,"Akamai.com, February 18, 2014; "You Think the Internet Is Big Now? Akamai Needs to Grow 100-Fold," by Mathew Ingram, GigaOM.com, June 20, 2012; "Akamai Eyes Acceleration Boost for Mobile Content," by Stephen Lawson, *Computerworld*, March 20, 2012; "To Cash In on Wave of Web Attacks, Akamai Launches Standalone Security Business," by Andy Greenberg, Forbes.com, February 21, 2012.

Case Study Questions

1. Why does Akamai need to geographically disperse its servers to deliver its customers' web content?
2. If you wanted to deliver software content over the Internet, would you sign up for Akamai's service? Why or why not?
3. Do you think Internet users should be charged based on the amount of bandwidth they consume, or on a tiered plan where users would pay in rough proportion to their usage?

3.8 REVIEW

KEY CONCEPTS

- **Discuss the origins of, and the key technology concepts behind, the Internet.**
- The Internet has evolved from a collection of mainframe computers located on a few U.S. college campuses to an interconnected network of thousands of networks and millions of computers worldwide.
- The history of the Internet can be divided into three phases: the Innovation Phase (1961–1974), the Institutionalization Phase (1975–1995), and the Commercialization Phase (1995 to the present).

- Packet switching, TCP/IP, and client/server technology are key technology concepts behind the Internet.
- The mobile platform has become the primary means for accessing the Internet.
- Cloud computing refers to a model of computing in which firms and individuals obtain computing power and software applications over the Internet, rather than purchasing the hardware and software and installing it on their own computers.
- Internet protocols and utility programs such as BGP, HTTP, SMTP and POP, SSL and TLS, FTP, Telnet, Ping, and Tracert provide a number of Internet services.

■ Explain the current structure of the Internet.

- The main structural elements of the Internet are the backbone (composed primarily high-bandwidth fiber optic cable), IXPs (hubs that use high-speed switching computers to connect to the backbone), CANs (campus/corporate area networks), and ISPs (which deal with the "last mile" of service to homes and offices).
- *Governing bodies*, such as IAB, ICANN, IESG, IETF, ISOC, and W3C, have influence over the Internet and monitor its operations, although they do not control it.

■ Understand the limitations of today's Internet and the potential capabilities of the Internet of the future.

- To envision what the Internet of tomorrow will look like, we must first look at the limitations of today's Internet, which include bandwidth limitations, quality of service limitations, network architecture limitations, language limitations, and limitations arising from the wired nature of the Internet.
- Internet2 is a consortium working together to develop and test new technologies for potential use on the Internet. Other groups are working to expand Internet bandwidth via improvements to fiber optics. Wireless and cellular technologies are providing users of mobile devices with increased access to the Internet and its various services. The increased bandwidth and expanded connections will result in a number of benefits, including latency solutions; guaranteed service levels; lower error rates; and declining costs. The Internet of Things will be a big part of the Internet of the future, with more and more sensor-equipped machines and devices connected to the Internet.

■ Understand how the Web works.

- The Web was developed during 1989–1991 by Dr. Tim Berners-Lee, who created a computer program that allowed formatted pages stored on the Internet to be linked using keywords (hyperlinks). In 1993, Marc Andreessen created the first graphical web browser, which made it possible to view documents on the Web graphically and created the possibility of universal computing.
- The key concepts you need to be familiar with in order to understand how the Web works are hypertext, HTTP, URLs, HTML, XML, web server software, web clients, and web browsers.

■ Describe how Internet and web features and services support e-commerce.

- Together, the Internet and the Web make e-commerce possible by allowing computer users to access product and service information and to complete purchases online.
- Some of the specific features that support e-commerce include communication tools such as e-mail, messaging applications, online message boards, Internet telephony, video conferencing, video chatting, and telepresence; search engines; and downloadable and streaming media.
- Web 2.0 applications and services include social networks, blogs, and wikis.
- Virtual reality, augmented reality and artificial intelligence technologies have begun to enter the consumer market and attract significant attention.

■ Understand the impact of mobile applications.

- The mobile app phenomenon has spawned a new digital ecosystem.

- Smartphone and tablet users spent the majority of their time using mobile apps rather than the mobile Web.
- There are a variety of different platforms for mobile application development including Objective-C (for iOS devices), Java (Android smartphones), and C and C++ (Windows mobile devices).
- Mobile apps for the iPhone are distributed through Apple's App Store, for Android devices through Google Play, and for Windows mobile devices through Microsoft's Windows Phone Marketplace. There are also third-party vendors such as Amazon's Appstore.

QUESTIONS

1. What are the three basic building blocks of the Internet?
2. What is latency, and how does it interfere with Internet functioning?
3. Explain how packet switching works.
4. How is the TCP/IP protocol related to information transfer on the Internet?
5. What technological innovation made client/server computing possible?
6. What is cloud computing, and how has it impacted the Internet?
7. Why are smartphones a disruptive technology?
8. What role does a Tier 1 ISP play in Internet infrastructure?
9. What function do the IXPs serve?
10. What is the goal of the Internet2 project?
11. Compare and contrast intranets and the Internet as a whole.
12. What are some of the major limitations of today's Internet?
13. What are some of the challenges of policing the Internet? Who has the final say when it comes to content?
14. Compare and contrast the capabilities of Wi-Fi and cellular wireless networks.
15. What are the basic capabilities of a web server?
16. What are the major technological advancements that are anticipated to accompany the Internet of the future? Discuss the importance of each.
17. Why was the development of the browser so significant for the growth of the Web?
18. What advances and features does HTML5 offer?
19. Name and describe five services currently available through the Web.
20. Why are mobile apps the next big thing?

PROJECTS

1. Review the opening case on Apple Watch. What developments have occurred since this case was written in September 2016?

2. Call or visit the websites of a cable provider, DSL provider, and satellite provider to obtain information on their Internet services. Prepare a brief report summarizing the features, benefits, and costs of each. Which is the fastest? What, if any, are the downsides of selecting any of the three for Internet service (such as additional equipment purchases)?

3. Select two countries (excluding the United States) and prepare a short report describing their basic Internet infrastructure. Are they public or commercial? How and where do they connect to backbones within the United States?

4. Investigate the Internet of Things. Select one example and describe what it is and how it works.