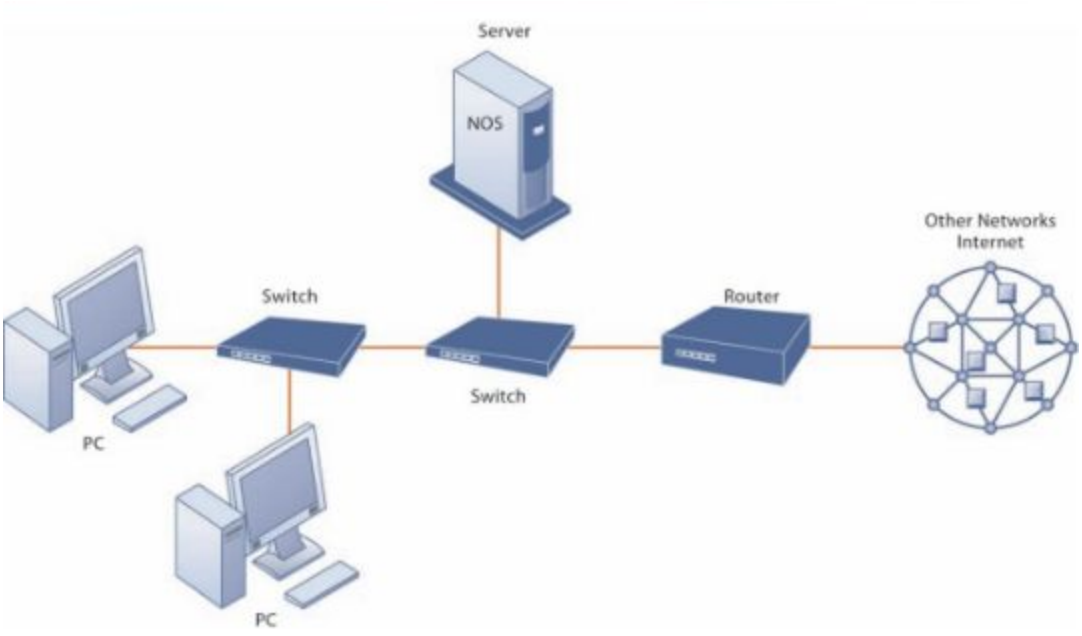
Chapter- 7

Telecommunications, the Internet, and Wireless Technology

🔖 Topic- 11.1: What are the principal components of telecommunications networks and key networking technologies?

11.1.1: What is a Computer Network?

If you had to connect the computers for two or more employees in the same office, you would need a computer network. In its simplest form, a network consists of two or more connected computers. Figure 7. 1illustrates the major hardware, software, and transmission components in a simple network: a client computer and a dedicated server computer, network interfaces, a connection medium, network operating system software, and either a hub or a switch. Each computer on the network contains a network interface device to link the computer to the network. The connection medium for linking network components can be a telephone wire, coaxial cable, or radio signal in the case of cell phone and wireless local area networks (Wi-Fi networks).



The network operating system (NOS) routes and manages communications on the network and coordinates network resources. It can reside on every computer in the network or primarily on a dedicated server computer for all the applications on the network. A server is a computer on a network that performs important network functions for client computers, such as displaying web pages, storing data, and storing the network operating system (hence controlling the network). Microsoft Windows Server, Linux, and Novell Open Enterprise Server are the most widely used network operating systems.

Most networks also contain a switch or a hub acting as a connection point between the computers. Hubs are simple devices that connect network components, sending a packet of data to all other connected devices. A switch has more intelligence than a hub and can filter and forward data to a specified destination on the network.

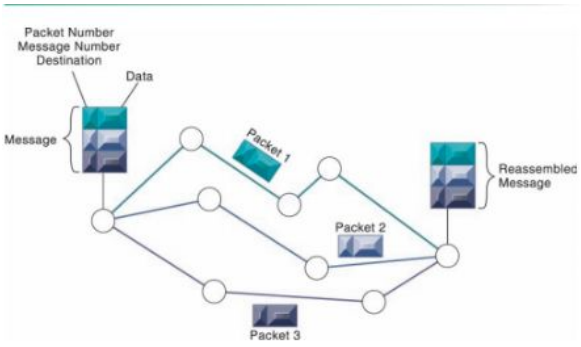
What if you want to communicate with another network, such as the Internet? You would need a router. A router is a communications processor that routes packets of data through different networks, ensuring that the data sent get to the correct address. Network switches and routers have proprietary software built into their hardware for directing the movement of data on the network. This can create network bottlenecks and makes the process of configuring a network more complicated and time-consuming. Software-defined networking (SDN) is a new networking approach in which many of these control functions are managed by one central program, which can run on inexpensive commodity servers that are separate from the network devices themselves. This is especially helpful in a cloud computing environment with many pieces of hardware because it allows a network administrator to manage traffic loads in a flexible and more efficient manner.

11.1.2:Key Digital Networking Technologies

Contemporary digital networks and the Internet are based on three key technologies: client/server computing, the use of packet switching, and the development of widely used communications standards (the most important of which is Transmission Control Protocol/Internet Protocol, or TCP/IP) for linking disparate networks and computers.

- **Client/Server Computing** Client/server computing, is a distributed computing model in which some of the processing power is located within small, inexpensive client computers and resides literally on desktops or laptops or in handheld devices. These powerful clients are linked to one another through a network that is controlled by a network server computer. The server sets the rules of communication for the network and provides every client with an address so others can find it on the network.

- **Packet Switching**, Packet switching is a method of slicing digital messages into parcels called packets, sending the packets along different communication paths as they become available and then reassembling the packets once they arrive at their destinations (see Figure 7. 3). Prior to the development of packet switching, computer networks used leased, dedicated telephone circuits to communicate with other computers in remote locations. In circuit-switched networks, such as the telephone system, a complete point-to-point circuit is assembled, and then communication can proceed. These dedicated circuit-switching



techniques were expensive and wasted available communications capacity—the circuit was maintained regardless of whether any data were being sent.

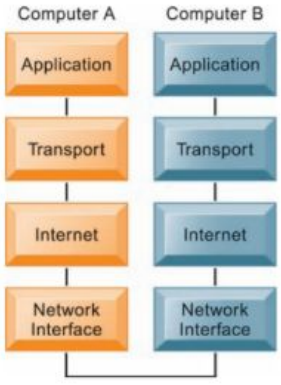
11.1.3: TCP/IP and Connectivity

In a typical telecommunications network, diverse hardware and software components need to work together to transmit information. Different components in a network communicate with each other by adhering to a common set of rules called protocols. A protocol is a set of rules and procedures governing transmission of information between two points in a network. In the past, diverse proprietary and incompatible protocols often forced business firms to purchase computing and communications equipment from a single vendor. However, today, corporate networks are increasingly using a single, common, worldwide standard called Transmission Control Protocol/Internet Protocol (TCP/IP). TCP/IP was developed during the early 1970s to support the U.S. Department of Defense Advanced Research Projects Agency (DARPA) efforts to help scientists transmit data among different types of computers over long distances.

TCP/IP uses a suite of protocols, the main ones being TCP and IP. TCP refers to the Transmission Control Protocol, which handles the movement of data between computers. TCP establishes a connection between the computers, sequences the transfer of packets, and acknowledges the packets sent. IP refers to the Internet Protocol (IP), which is responsible for the delivery of packets and includes the disassembling and reassembling of packets during transmission. Figure 7. 4illustrates the four-layered Department of Defense reference model for TCP/IP, and the layers are described as follows.

- **Application layer**. The Application layer enables client application programs to access the other layers and defines the protocols that applications use to exchange data. One of these application protocols is the Hypertext Transfer Protocol (HTTP), which is used to transfer web page files.

FIGURE 7.4 THE TRANSMISSION CONTROL PROTOCOL/INTERNET PROTOCOL (TCP/IP) REFERENCE MODEL



- **Transport layer**. The Transport layer is responsible for providing the Application layer with communication and packet services. This layer includes TCP and other protocols.
- **Internet layer**. The Internet layer is responsible for addressing, routing, and packaging data packets called IP datagrams. The Internet Protocol is one of the protocols used in this layer.

- **Network Interface layer**. At the bottom of the reference model, the Network Interface layer is responsible for placing packets on and receiving them from the network medium, which could be any networking technology.

Two computers using TCP/IP can communicate even if they are based on different hardware and software platforms. Data sent from one computer to the other passes downward through all four layers, starting with the sending computer's Application layer and passing through the Network Interface layer. After the data reaches the recipient host computer, they travel up the layers and are reassembled into a format the receiving computer can use. If the receiving computer finds a damaged packet, it asks the sending computer to retransmit it. This process is reversed when the receiving computer responds.

🔖 Topic- 11.2: What are the different types of networks?

11.2.1: Signals: Digital Versus Analog Types of Networks

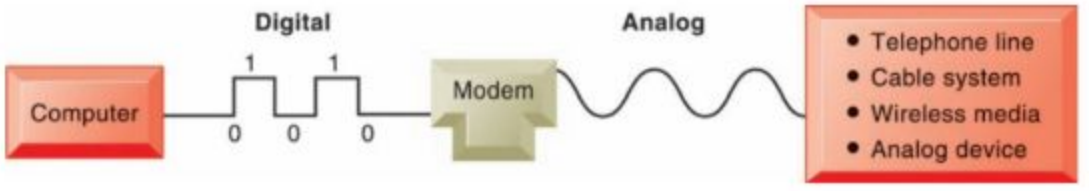
There are two ways to communicate a message in a network: an analog signal or a digital signal. An analog signal is represented by a continuous waveform that passes through a communications medium and has been used for voice communication. The most common analog devices are the telephone handset, the speaker on your computer, or your iPod earphone, all of which create analog waveforms that your ear can hear.

A digital signal is a discrete, binary waveform rather than a continuous waveform. Digital signals communicate information as strings of two discrete states: one bits and zero bits, which are represented as on-off electrical pulses. Computers use digital signals and require a modem to convert these digital signals into analog signals that can be sent over (or received from) telephone lines, cable lines, or wireless media that use analog signals (see Figure 7. 5). Modem stands for modulator-demodulator. Cable modems connect your computer to the Internet by using a cable network. DSL modems connect your computer to the Internet using a telephone company's landline network. Wireless modems perform the same function as traditional modems, connecting your computer to a wireless network that could be a cell phone network or a Wi-Fi network.

11.2.2: Types of Networks

There are many kinds of networks and ways of classifying them. One way of looking at networks is in terms of their geographic scope (see Table 7. 1).

FIGURE 7.5 FUNCTIONS OF THE MODEM



A modem is a device that translates digital signals into analog form (and vice versa) so that computers can transmit data over analog networks such as telephone and cable networks.

Local Area Networks

If you work in a business that uses networking, you are probably connecting to other employees and groups via a local area network. A local area network (LAN) is designed to connect personal computers and other digital devices within a half-mile or 500-meter radius. LANs typically connect a few computers in a small office, all the computers in one building, or all the computers in several buildings in close

proximity. LANs also are used to link to long-distance wide area networks (WANs, described later in this section) and other networks around the world, using the Internet.

Review Figure 7. 1 , which could serve as a model for a small LAN that might be used in an office. One computer is a dedicated network, providing users with access to shared computing resources in the network, including software programs and data files.

The server determines who gets access to what and in which sequence. The router connects the LAN to other networks, which could be the Internet, or another corporate network, so that the LAN can exchange information with networks external to it. The most common LAN operating systems are Windows, Linux, and Novell.

Ethernet is the dominant LAN standard at the physical network level, specifying the physical medium to carry signals between computers, access control rules, and a standardized set of bits that carry data over the system. Originally, Ethernet supported a data transfer rate of 10 megabits per second (Mbps). Newer versions, such as Gigabit Ethernet, support a data transfer rate of 1 gigabit per second (Gbps).

The LAN illustrated in Figure 7. 1uses a client/server architecture by which the network operating system resides primarily on a single server, and the server provides much of the control and resources for the network. Alternatively, LANs may use a peer-to-peer architecture. A peer-to-peer network treats all processors equally and is used primarily in small networks with 10 or fewer users. The various computers on the network can exchange data by direct access and can share peripheral devices without going through a separate server. Larger LANs have many clients and multiple servers, with separate servers for specific services such as storing and managing files and databases (file servers or database servers), managing printers (print servers), storing and managing e-mail (mail servers), or storing and managing web pages (web servers).

Metropolitan and Wide Area Networks

Wide area networks (WANs) span broad geographical distances—entire regions, states, continents, or the entire globe. The most universal and powerful WAN is the Internet. Computers connect to a WAN through public networks, such as the telephone system or private cable systems, or through leased lines or satellites. A metropolitan area network (MAN) is a network that spans a metropolitan area, usually a city and its major suburbs. Its geographic scope falls between a WAN and a LAN.

11.2.3: Transmission Media and Transmission Speed

TRANSMISSION MEDIUM	DESCRIPTION	SPEED
Twisted pair wire (CAT 5)	Strands of copper wire twisted in pairs for voice and data communications. CAT 5 is the most common 10 Mbps LAN cable. Maximum recommended run of 100 meters.	10–100+ Mbps
Coaxial cable	Thickly insulated copper wire, which is capable of high-speed data transmission and less subject to interference than twisted wire. Currently used for cable TV and for networks with longer runs (more than 100 meters).	Up to 1 Gbps
Fiber-optic cable	Strands of clear glass fiber, transmitting data as pulses of light generated by lasers. Useful for high-speed transmission of large quantities of data. More expensive than other physical transmission media and harder to install; often used for network backbone.	15 Mbps to 6+ Tbps
Wireless transmission media	Based on radio signals of various frequencies and includes both terrestrial and satellite microwave systems and cellular networks. Used for long-distance, wireless communication and Internet access.	Up to 600+ Mbps

🔖 Topic- 12.1: How do the Internet and Internet technology work, and how do they support communication and e-business?

11.1.1: What is the Internet?

The Internet is the world's most extensive public communication system. It's also the world's largest implementation of client/server computing and Internetworking, linking millions of individual networks all over the world. This global network of networks began in the early 1970s as a U.S. Department of Defense network to link scientists and university professors around the world. Most homes and small businesses connect to the Internet by subscribing to an Internet service provider. An Internet service provider (ISP) is a commercial organization with a permanent connection to the Internet that sells temporary connections to retail subscribers. EarthLink, NetZero, AT&T, and Time Warner are ISPs. Individuals also connect to the Internet through their business firms, universities, or research centers that have designated Internet domains.

There is a variety of services for ISP Internet connections. Connecting via a traditional telephone line and modem, at a speed of 56.6 kilobits per second (Kbps), used to be the most common form of connection worldwide, but broadband connections have largely replaced it. Digital subscriber line, cable, satellite Internet connections, and T lines provide these broadband services. Digital subscriber line (DSL) technologies operate over existing telephone lines to carry voice, data, and video at transmission rates ranging from 385 Kbps all the way up to 40 Mbps, depending on usage patterns and distance. Cable Internet connections provided by cable television vendors use digital cable coaxial lines to deliver high-speed Internet access to homes and businesses. They can provide high-speed access to the Internet of up to 50 Mbps, although most providers offer service ranging from 1 Mbps to 6 Mbps. Where DSL and cable services are unavailable, it is possible to access the Internet via satellite, although some satellite Internet connections have slower upload speeds than other broadband services. T1 and T3 are international telephone standards for digital communication. They are leased, dedicated lines suitable for businesses or government agencies requiring high-speed guaranteed service levels. T1 lines offer guaranteed delivery at 1.54 Mbps, and T3 lines offer delivery at 45 Mbps. The Internet does not provide similar guaranteed service levels but, simply, best effort.

12.1.2: Internet Addressing and Architecture

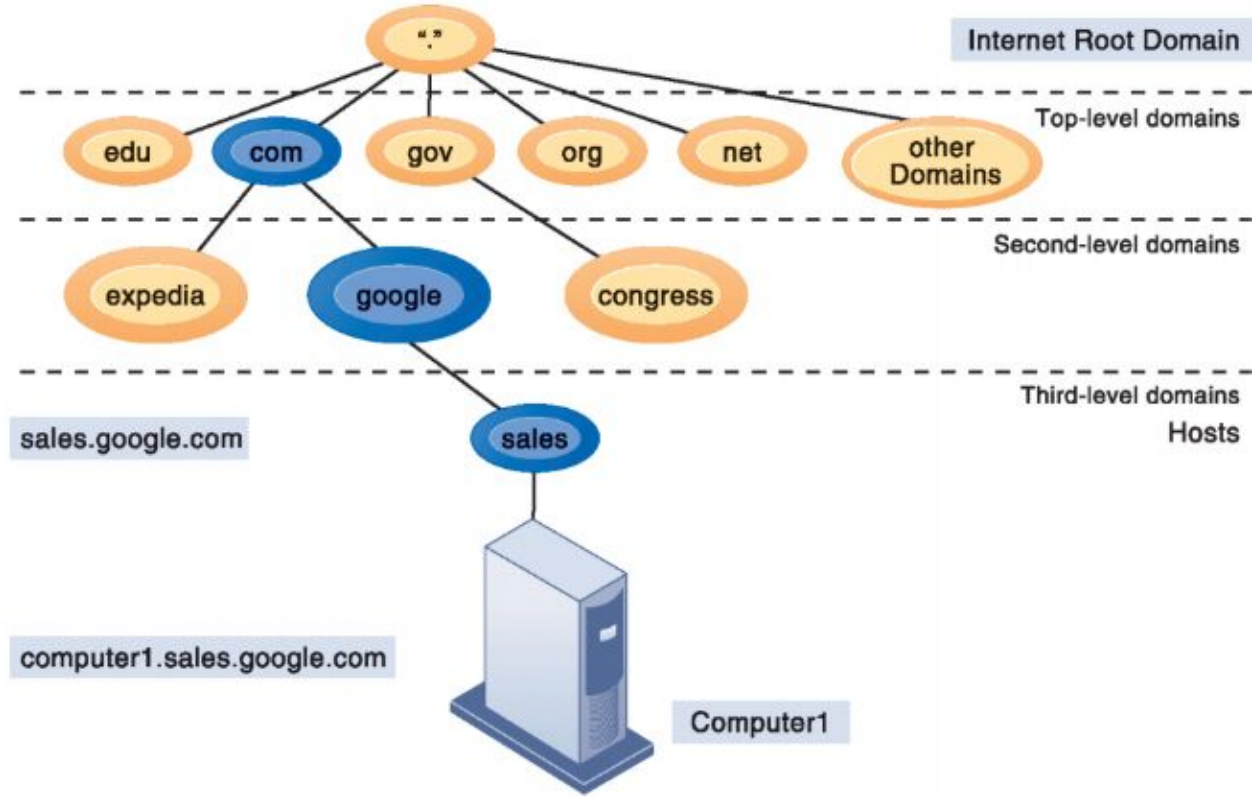
The Internet is based on the TCP/IP networking protocol suite described earlier in this chapter . Every computer on the Internet is assigned a unique Internet Protocol (IP) address, which currently is a 32-bit number represented by four strings of numbers ranging from 0 to 255 separated by periods. For instance, the IP address of www.microsoft.com is 207.46.250.119.

The Domain Name System

Because it would be incredibly difficult for Internet users to remember strings of 12 numbers, the Domain Name System (DNS) converts domain names to IP addresses. The domain name is the English-like name that corresponds to the unique 32-bit numeric IP address for each computer connected to the Internet. DNS servers maintain a database containing IP addresses mapped to their corresponding domain names. To access a computer on the Internet, users need only specify its domain name.

DNS has a hierarchical structure (see Figure 7. 6). At the top of the DNS hierarchy is the root domain. The child domain of the root is called a top-level domain, and the child domain of a top-level domain is called a second-level domain. Top-level domains are two- and three-character names you are familiar with from surfing the web, for example, .com, .edu, .gov, and the various country codes such as .ca for Canada or .it for Italy. Second-level domains have two parts, designating a top-level name and a second-level name—such as buy.com, nyu.edu , or amazon.ca . A host name at the bottom of the hierarchy designates a specific computer on either the Internet or a private network. The following list shows the most common domain extensions currently available and officially approved. Countries also have domain names such as uk, .au, and .fr (United Kingdom, Australia, and France, respectively), and there is a new class of internationalized top-level domains that use non-English characters. In the future, this list will expand to include many more types of organizations and industries.

FIGURE 7.6 THE DOMAIN NAME SYSTEM



- .com Commercial organizations/businesses
- .edu Educational institutions
- .gov U.S. government agencies
- .mil U.S. military
- .net Network computers
- .org Any type of organization
- .biz Business firms
- .info Information providers

Internet Architecture and Governance

Internet data traffic is carried over transcontinental high-speed backbone networks that generally operate in the range of 155 Mbps to 2.5 Gbps (see Figure 7. 7). These trunk lines are typically owned by long-distance telephone companies (called network service providers) or by national governments. Local connection lines are owned by regional telephone and cable television companies in the United States and in other countries that connect retail users in homes and businesses to the Internet. The regional networks lease access to ISPs, private companies, and government institutions.

The Future Internet: IPV6 and Internet2

The Internet was not originally designed to handle the transmission of massive quantities of data and billions of users. Because of sheer Internet population growth, the world is about to run out of available IP addresses using the old addressing convention. The old addressing system is being replaced by a new version of the IP addressing schema called IPv6 (Internet Protocol version 6), which contains 128-bit addresses (2 to the power of 128), or more than a quadrillion possible unique addresses. IPv6 is compatible with most modems and routers sold today, and IPv6 will fall back to the old addressing system if IPv6 is not available on local networks. The transition to IPv6 will take several years as systems replace older equipment.

Internet2 is an advanced networking consortium representing more than 500 U.S. universities, private businesses, and government agencies working with 66,000 institutions across the United States and international networking partners from more than 100 countries. To connect these communities, Internet2 developed a high-capacity, 100 Gbps network that serves as a test bed for leading-edge technologies that may eventually migrate to the public Internet, including large-scale network performance measurement and management tools, secure identity and access management tools, and capabilities such as scheduling high-bandwidth, high-performance circuits.

12.1.3: Internet Services and Communication Tools

The Internet is based on client/server technology. Individuals using the Internet control what they do through client applications on their computers, such as web browser software. The data, including e-mail messages and web pages, are stored on servers. A client uses the Internet to request information from a particular web server on a distant computer, and the server sends the requested information back to the

client over the Internet. Client platforms today include not only PCs and other computers but also smartphones and tablets.

Internet Services

A client computer connecting to the Internet has access to a variety of services. These services include email, chatting and instant messaging, electronic discussion groups, Telnet, File Transfer Protocol (FTP), and the web. Table 7. 3 provides a brief description of these services. Each Internet service is implemented by one or more software programs. All the services may run on a single server computer, or different services may be allocated to different machines. Figure 7. 8illustrates one way these services can be arranged in a multitiered client/server architecture. E-mail enables messages to be exchanged from computer to computer, with capabilities for routing messages to multiple recipients, forwarding messages, and attaching text documents or multimedia files to messages. Most e-mail today is sent through the Internet. The cost of e-mail is far lower than equivalent voice, postal, or overnight delivery costs, and e-mail messages arrive anywhere in the world in a matter of seconds.

TABLE 7.3 MAJOR INTERNET SERVICES

CAPABILITY	FUNCTIONS SUPPORTED
E-mail	Person-to-person messaging; document sharing
Chatting and instant messaging	Interactive conversations
Newsgroups	Discussion groups on electronic bulletin boards
Telnet	Logging on to one computer system and doing work on another
File Transfer Protocol (FTP)	Transferring files from computer to computer
World Wide Web	Retrieving, formatting, and displaying information (including text, audio, graphics, and video) by using hypertext links

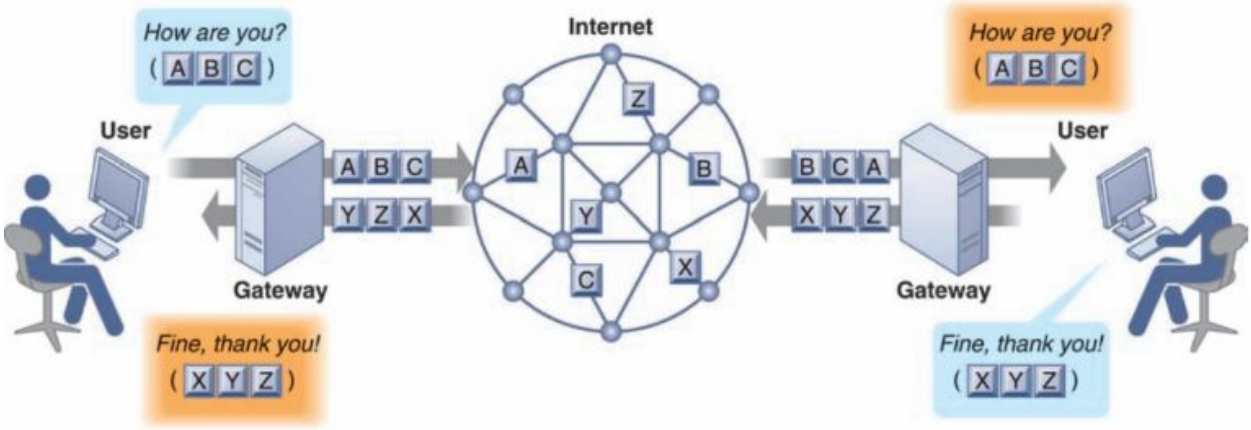
Chatting enables two or more people who are simultaneously connected to the Internet to hold live, interactive conversations. Chat systems now support voice and video chat as well as written conversations. Many online retail businesses offer chat services on their websites to attract visitors, to encourage repeat purchases, and to improve customer service.

Instant messaging is a type of chat service that enables participants to create their own private chat channels. The instant messaging system alerts the user whenever someone on his or her private list is online so that the user can initiate a chat session with other individuals. Instant messaging systems for consumers include Yahoo! Messenger, Google Hangouts, AOL Instant Messenger, and Facebook Chat. Companies concerned with security use proprietary communications and messaging systems such as IBM Sametime.

Voice over IP

The Internet has also become a popular platform for voice transmission and corporate networking. Voice over IP (VoIP) technology delivers voice information in digital form using packet switching, avoiding the tolls charged by local and long-distance telephone networks (see Figure 7. 9). Calls that would ordinarily be transmitted over public telephone networks travel over the corporate network based on the Internet protocol, or the public Internet. Voice calls can be made and received with a computer equipped with a microphone and speakers or with a VoIP-enabled telephone.

Cable firms such as Time Warner and Cablevision provide VoIP service bundled with their high-speed Internet and cable offerings. Skype offers free VoIP worldwide using a peer-to-peer network, and Google has its own free VoIP service. Although up-front investments are required for an IP phone system, VoIP can reduce communication and network management costs by 20 to 30 percent. For example, VoIP saves Virgin Entertainment Group $700,000 per year in long-distance bills. In addition to lowering long-distance costs and eliminating monthly fees for private lines, an IP network provides a single voice-data infrastructure for both telecommunications and computing services. Companies no longer have to maintain separate networks or provide support services and personnel for each type of network.



A VoIP phone call digitizes and breaks up a voice message into data packets that may travel along different routes before being reassembled at the final destination. A processor nearest the call's destination, called a gateway, arranges the packets in the proper order and directs them to the telephone number of the receiver or the IP address of the receiving computer.

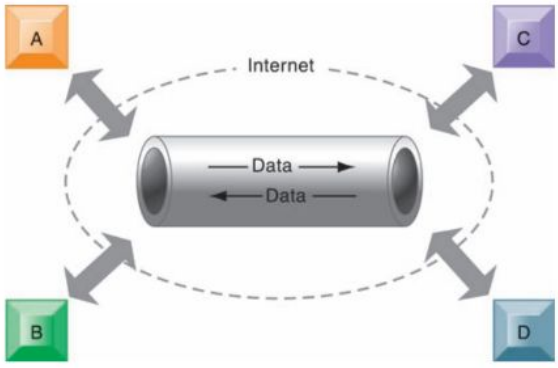
Unified Communications

In the past, each of the firm's networks for wired and wireless data, voice communications, and videoconferencing operated independently of each other and had to be managed separately by the information systems department. Now, however, firms can merge disparate communications modes into a single universally accessible service using unified communications technology. Unified communications integrates disparate channels for voice communications, data communications, instant messaging, e-mail, and electronic conferencing into a single experience by which users can seamlessly switch back and forth between different communication modes. Presence technology shows whether a person is available to receive a call. structured and unstructured data. Integrated presence technology lets team members e-mail, instant message, call, or videoconference with one click.

Virtual Private Networks

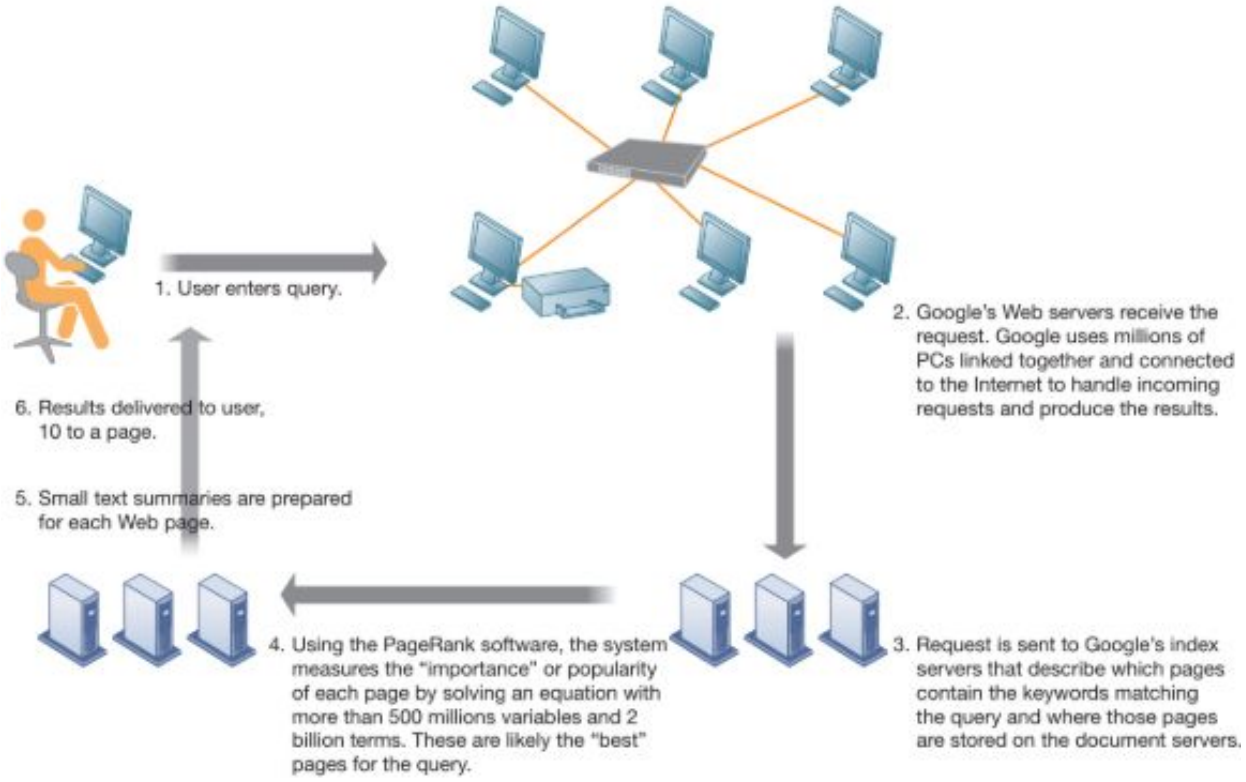
What if you had a marketing group charged with developing new products and services for your firm with members spread across the United States? You would want them to be able to email each other and communicate with the home office without any chance that outsiders could intercept the communications. In the past, one answer to this problem was to work with large private networking firms that offered secure, private, dedicated networks to customers, but this was an expensive solution. A much less expensive solution is to create a virtual private network within the public Internet. A virtual private network (VPN) is a secure, encrypted, private network that has been configured within a public network to take advantage of the economies of scale and management facilities of large networks, such as the Internet (see Figure 7. 10). A VPN provides your firm with secure, encrypted communications at a much lower cost than the same capabilities offered by traditional non-Internet providers that use their private networks to secure communications. VPNs also provide a network infrastructure for combining voice and data networks.

FIGURE 7.10 A VIRTUAL PRIVATE NETWORK USING THE INTERNET



This VPN is a private network of computers linked using a secure tunnel connection over the Internet. It protects data transmitted over the public Internet by encoding the data and wrapping them within the Internet protocol. By adding a wrapper around a network message to hide its content, organizations can create a private connection that travels through the public Internet.

Several competing protocols are used to protect data transmitted over the public Internet, including Point-to-Point Tunneling Protocol (PPTP). In a process called tunneling, packets of data are encrypted and wrapped inside IP packets. By adding this wrapper around a network message to hide its content, business firms create a private connection that travels through the public Internet.



The Google search engine is continuously crawling the web, indexing the content of each page, calculating its popularity, and storing the pages so that it can respond quickly to user requests to see a page. The entire process takes about half a second.

Web 2.0

Today's websites don't just contain static content—they enable people to collaborate, share information, and create new services and content online. These second-generation interactive Internet-based services are referred to as Web 2.0. If you have pinned a photo on Pinterest, posted a video to YouTube, created a blog, or added an app to your Facebook page, you've used some of these Web 2.0 services. Web 2.0 has four defining features: interactivity, real-time user control, social participation (sharing), and user-generated content. The technologies and services behind these features include cloud computing, software mashups and apps, blogs, RSS, wikis, and social networks. We have already described cloud computing, mashups, and apps in Chapter 5and introduced social networks.

A blog, the popular term for a weblog, is a personal website 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 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 can be hosted by a third-party service such as Blogger.com , TypePad.com , and Xanga.com , and blogging features have been incorporated into social networks such as Facebook and collaboration platforms such as IBM Notes. WordPress is a leading

open source blogging tool and content management system. Microblogging, used in Twitter, is a type of blogging that features short posts of 140 characters or fewer.

Blog pages are usually variations on templates provided by the blogging service or software. Therefore, millions of people without HTML skills of any kind can post their own web pages and share content with others. The totality of blog-related websites is often referred to as the blogosphere. Although blogs have become popular personal publishing tools, they also have business uses.

If you're an avid blog reader, you might use RSS to keep up with your favorite blogs without constantly checking them for updates. RSS, which stands for Really Simple Syndication or Rich Site Summary, pulls specified content from websites and feeds it automatically to users' computers. RSS reader software gathers material from the websites or blogs that you tell it to scan and brings new information from those sites to you. RSS readers are available through websites such as Google and Yahoo, and they have been incorporated into the major web browsers and email programs.

Blogs allow visitors to add comments to the original content, but they do not allow visitors to change the original posted material. Wikis, in contrast, are collaborative websites on which visitors can add, delete, or modify content, including the work of previous authors. Wiki comes from the Hawaiian word for quick
.

Wiki software typically provides a template that defines layout and elements common to all pages, displays user-editable software program code, and then renders the content into an HTML-based page for display in a web browser.

Social networking sites enable users to build communities of friends and professional colleagues. Members typically create a profile—a web page for posting photos, videos, audio files, and text—and then share these profiles with others on the service identified as their friends or contacts. Social networking sites are highly interactive, offer real-time user control, rely on user-generated content, and are broadly based on social participation and sharing of content and opinions. Leading social networking sites include Facebook, Twitter (with more than 1.6 billion and 310 million monthly active users, respectively, in 2016), and LinkedIn (for professional contacts).

Web 3.0 and the Future Web

The future of the Internet, so-called Web 3.0, is already visible. The key features of Web 3.0 are more tools for individuals to make sense out of the trillions of pages on the Internet, or the millions of apps available for smartphones and a visual, even three-dimensional (3D) Web where you can walk through pages in a 3D environment. Even closer in time is a pervasive web that controls everything from a city's traffic lights and water usage, to the lights in your living room, to your car's rear view mirror, not to mention managing your calendar and appointments. This is referred to as the Internet of Things and is based on billions of Internet connected sensors throughout our physical world. Objects, animals, or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

Firms such as General electric, IBM, HP, and Oracle, and hundreds of smaller start-ups, are exploring how to build smart machines, factories, and cities through extensive use of remote sensors and fast cloud computing. A related Web 3.0 development is the emerging Internet of People (IoP) based on sensors attached to clothing and personal effects that monitor physical states and locations of individuals. We provide more detail on this topic in the following section.