Networks and Cloud Computing

Network Fundamentals

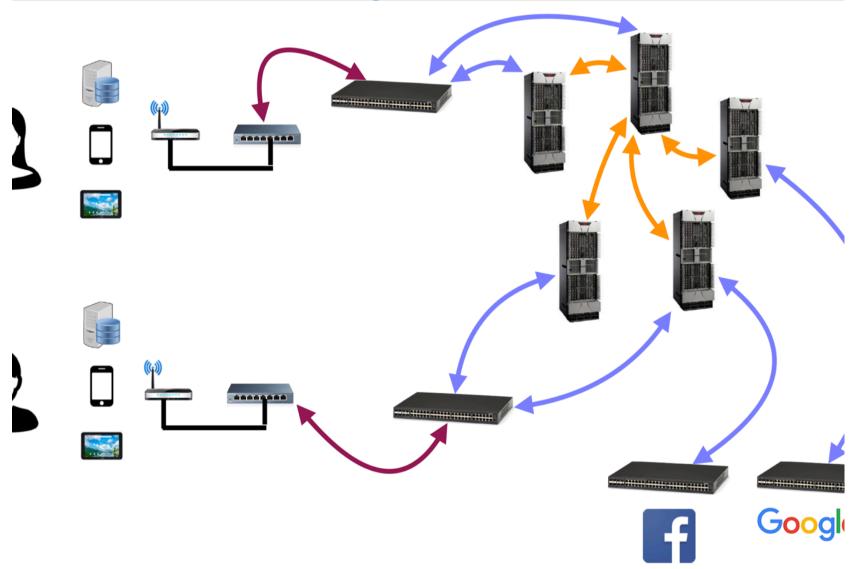
- Computer network: the communications media, devices, and software needed to connect two or more computer systems or devices
- Network nodes: the computers and devices on the networks
- Organizations can use networks to share hardware, programs, and databases

What is a computer network?

A set of network elements connected together, that implement a set of protocols for the purpose of sharing resources at the end hosts

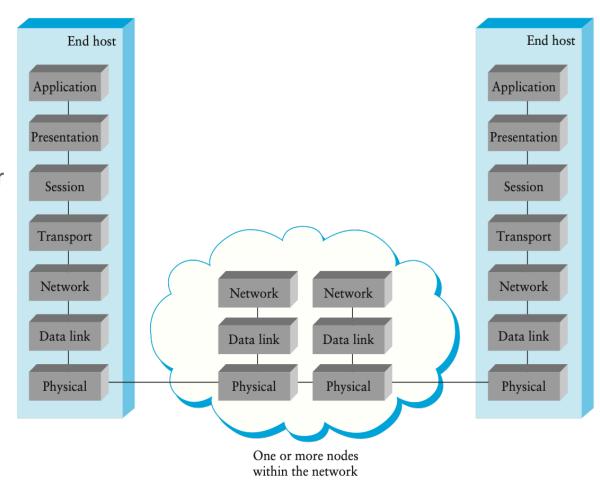
- Three important components:
 - Core infrastructure:
 - A set of network elements connected together
 - Protocols:
 - Needed to use the network
 - Purpose:
 - Sharing resources at the end hosts (computing devices)

What is a computer network?



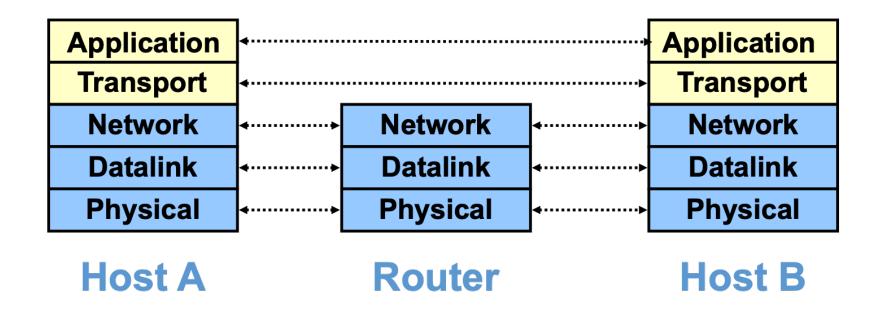
OSI Reference Model

- OSI: Open Systems
 Interconnection
- 7 layers X. protocol specifications for each layer
- Acts like a reference model rather than a real-world protocol graph
- First three layers are implemented in all nodes



Simple diagram

- Lower three layers implemented everywhere
- Top two layers implemented only at hosts



- Network topology
 - The shape or structure of a network, including the arrangement of the communications links and hardware devices on the network
- Three most common network topologies
 - Star network
 - Bus network
 - Mesh network

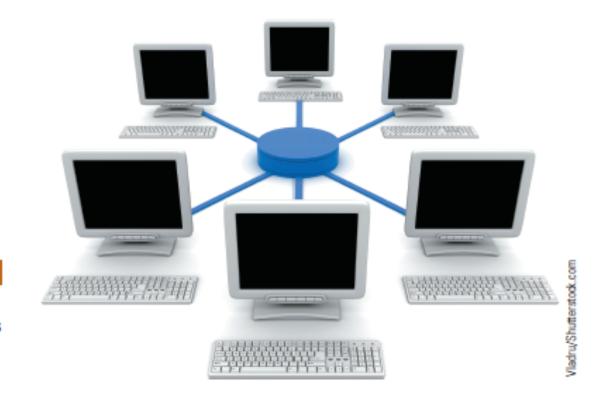


FIGURE 6.1

Star network

In a star network, all network devices connect to one another through a single central hub node.

FIGURE 6.2

Bus network

In a bus network, all network devices are connected to a common backbone that serves as a shared communications medium.

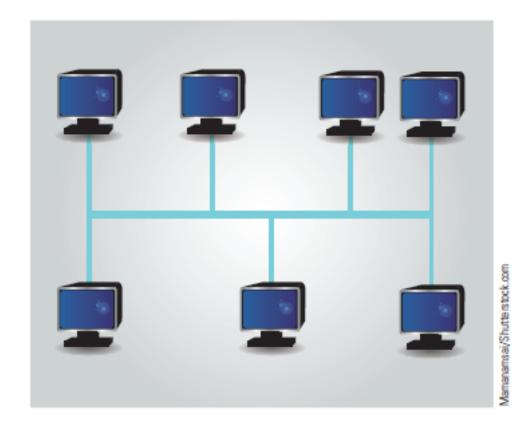




FIGURE 6.3

Mesh network

Mesh networks use multiple access points to link a series of devices that speak to each other to form a network connection across a large area.

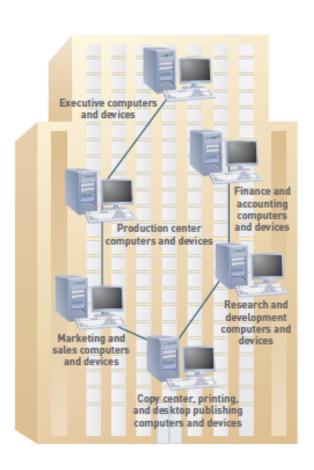
Network Types

- A personal area network (PAN) supports the interconnection of information technology close to one person
- A local area network (LAN) connects computer systems and devices within a small area (e.g., an office or a home)
- A metropolitan area network (MAN) connects users and their devices in an area that spans a campus or city

Network Types

FIGURE 6.4 Typical LAN

All network users within an office building can connect to each other's devices for rapid communication. For instance, a user in research and development could send a document from her computer to be printed at a printer located in the desktop publishing center. Most computer labs employ a LAN to enable the users to share the use of high-speed and/or color printers and plotters as well as to download software applications and save files.



Network Types

- A wide area network (WAN) connects large geographic regions
- WANs consist of:
 - Computer equipment owned by the user
 - Data communications equipment and telecommunications links provided by various carriers and service providers
- Communications may involve transborder data flow

Client/Server Systems

- Client/server architecture features multiple computer platforms dedicated to special functions, e.g., database management, printing, or communications
- A client is any computer that sends messages requesting services from the servers on the network
- A database server sends only the data that meets a specific query—not the entire file

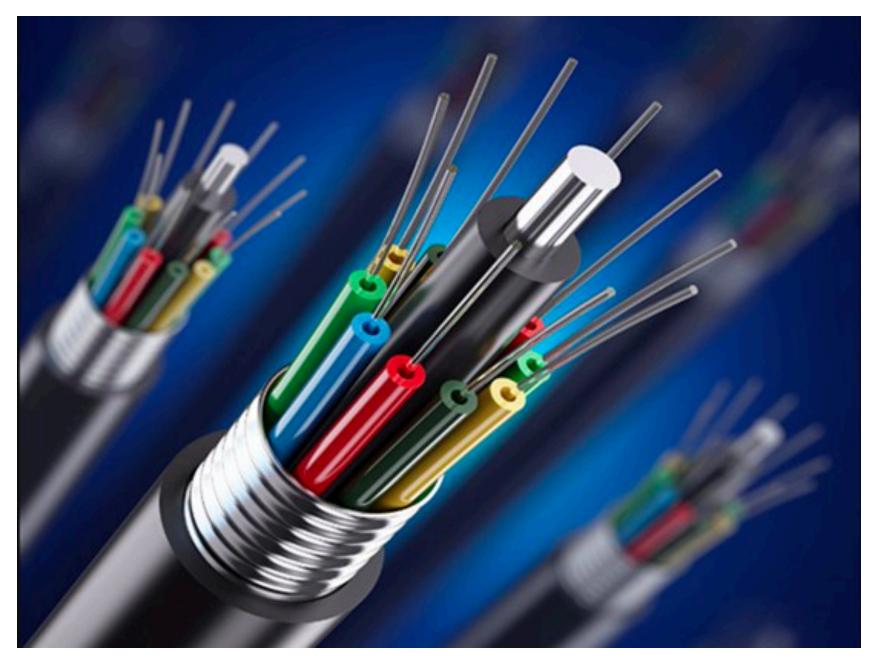
Channel Bandwidth

- Channel bandwidth: the rate at which data is exchanged
 - Usually measured in bits/sec
- Broadband communications: a relative term; a telecommunications system that can transmit data very quickly

- Two broad categories
 - Guided (wired) transmission media: signals are guided along a solid medium
 - Wireless: the signal is broadcast over airwaves as a form of electromagnetic radiation

TABLE 6.1 Guided transmission media types

Media Form	Description	Advantages	Disadvantages
Twisted-pair wire	Twisted pairs of copper wire, shielded or unshielded; used for telephone service	Widely available	Limitations on transmission speed and distance
Coaxial cable	Inner conductor wire surrounded by insulation	Cleaner and faster data trans- mission than twisted-pair wire	More expensive than twisted-pair wire
Fiber-optic cable	Many extremely thin strands of glass bound together in a sheath- ing; uses light beams to transmit signals	Diameter of cable is much smal- ler than coaxial cable; less dis- tortion of signal; capable of high transmission rates	Expensive to pur- chase and install



IE 5602 ICT for Industrial Engineering

- Wireless Technologies
 - Wireless transmission involves the broadcast of communications in one of three frequency ranges
 - -Radio, microwave, or infrared frequencies
 - In some cases, use of wireless communications is regulated
 - -The signal must be broadcast within a specific frequency range to avoid interference with other wireless transmissions

TABLE 6.2 Frequency ranges used for wireless communications

Technology	Description	Advantages	Disadvantages
Radio frequency range	Operates in the 3 KHz- 300 MHz range	Supports mobile users; costs are dropping	Signal is highly susceptible to interception
Microwave— terrestrial and satel- lite frequency range	High-frequency radio signal (300 MHz–300 GHz) sent through the atmosphere and space (often involves com- munications satellites)	Avoids cost and effort to lay cable or wires; capable of high-speed transmission	Must have unobstructed line of sight between sender and receiver; signal is highly sus- ceptible to interception
Infrared frequency range	Signals in the 300 GHz– 400 THz frequency range	Lets you move, remove, and install devices without expensive wiring	Must have unobstructed line of sight between sender and receiver; transmission is effec- tive only for short distances

- Near field communication (NFC): a very short-range wireless connectivity technology
 - Designed for consumer electronics, cell phones, and credit cards
- Bluetooth: a wireless communications specification that describes how cell phones, computers, personal digital assistants, etc., can be interconnected
- Wi-Fi
 - A wireless telecommunications technology brand owned by the Wi-Fi Alliance
 - Employs a wireless access point (a transmitter with an antenna) that receives the signal and decodes it
 - -Translates signals into a radio signal and sends it to device's wireless adapter

TABLE 6.3 IEEE 802.11 wireless local area networking standards

Wireless Networking Protocol	Maximum Data Rate per Data Stream	Comments
IEEE 802.11a	54 Mbps	Transmits at 5 GHz, which means it is incompatible with 802.11b and 802.11g
IEEE 802.11b	11 Mbps	First widely accepted wireless network standard and transmits at 2.4 GHz; equipment using this protocol may occasionally suffer from interference from microwave ovens, cordless telephones, and Bluetooth devices
IEEE 802.11g	54 Mbps	Equipment using this protocol transmits at 2.4 GHz and may occasionally suffer from interference from microwave ovens, cordless telephones, and Bluetooth devices
IEEE 802.11n	300 Mbps	Employs multiple input, multiple output (MIMO) technology, which allows multiple data streams to be transmitted over the same channel using the same bandwidth that is used for only a single data stream in 802.11a/b/g
IEEE 802.11ac	400 Mbps-1.3 Gbps	An 802.11 standard that provides higher data transmission speeds and more stable connections; it can transmit at either 2.4 GHz or 5 GHz

https://en.wikipedia.org/wiki/IEEE_802.11

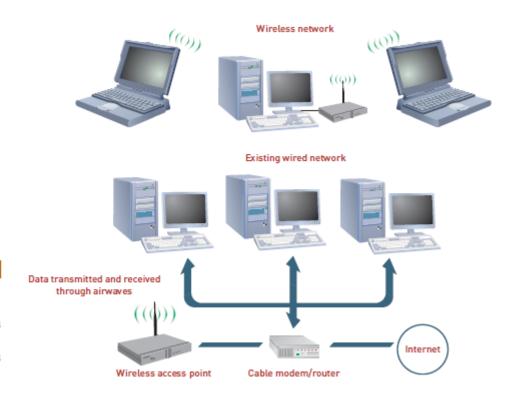


FIGURE **6.7** Wi-Fi network

In a Wi-Fi network, the user's computer, smartphone, or cell phone has a wireless adapter that translates data into a radio signal and transmits it using an antenna.

- Microwave Transmission
 - Microwave is a high-frequency (300 MHz–300 GHz) signal sent through the air
 - Common forms of satellite communications:
 - -Geostationary satellite
 - -Low earth orbit (LEO) satellite

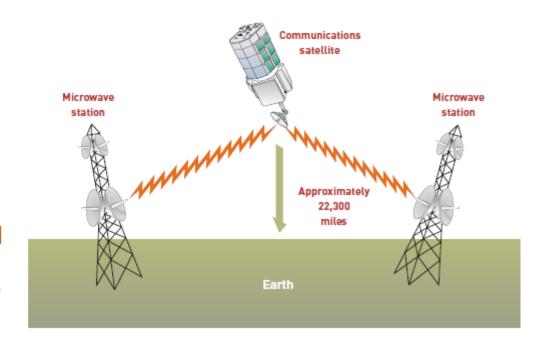


FIGURE 6.8

Satellite transmission

Communications satellites are relay stations that receive signals from one Earth station and rebroadcast them to another.

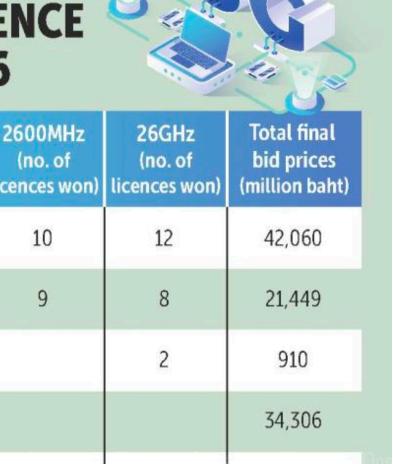
- Historical perspective
 - IG (first generation) of wireless communications standards: originated in the 1980s; based on analog communications
 - 2G (second generation) employed fully digital networks; superseded IG networks in the early 1990s
 - 3G supports wireless voice and broadband speed data communications in a mobile environment at speeds of 2 to 4 Mbps
 - 4G wireless provides increased data transmission rates
 - -3 to 20 times the speed of 3G networks for mobile devices
 - 4G networks are based on Long Term Evolution (LTE)
 - -LTE is a standard for wireless communications for mobile phones based on packet switching

- 5G Wireless Communications
 - Expected characteristics
 - -Higher data transmission rates
 - -Lower power consumption
 - -Higher connect reliability and more coverage
 - -Lower infrastructure costs
 - Commercial widely deployment expected to start by 2019

RESULTS OF 5G LICENCE AUCTION ON FEB 16

Spectrum

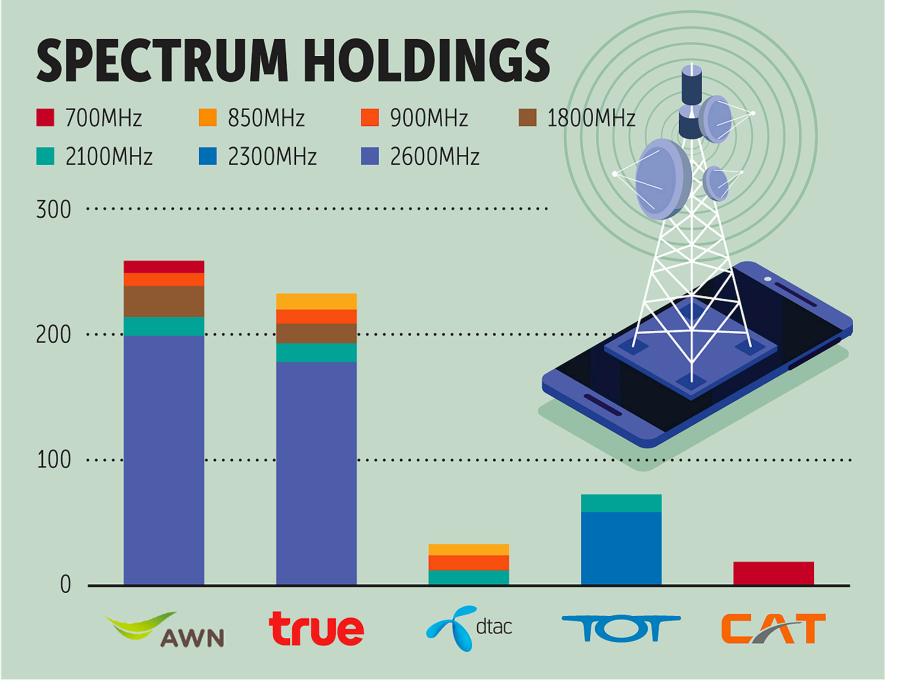
700MHz



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(no. of (no. of Bidder licences won) licences won) AWN AWN 10 true 9 TUC dtac DTN CAT TOT TOT 4 1,795 Total 100,520

Source: NBTC **BKP**graphics



Sources: NBTC, Fitch Solutions

Communications Hardware

TABLE 6.4 Common communications devices

Device	Function	
Modem	Translates data from a digital form (as it is stored in the computer) into an analog signal that can be transmitted over ordinary telephone lines	
Fax modem	Combines a fax with a modem; facsimile devices, commonly called fax devices, allow businesses to transmit text, graphs, photographs, and other digital files via standard telephone lines	
Multiplexer	Allows several communications signals to be transmitted over a single communications medium at the same time, thus saving expensive long-distance communications costs	
PBX (private branch exchange)	Manages both voice and data transfer within a building and to outside lines; PBXs can be used to connect hundreds of internal phone lines to a few outside phone company lines	
Front-end processor	Manages communications to and from a computer system serving many people	
Switch	Uses the physical device address in each incoming message on the network to determine which output port it should forward the message to reach another device on the same network	
Bridge	Connects one LAN to another LAN where both LANs use the same communications protocol	
Router	Forwards data packets across two or more distinct networks toward their destinations through a process known as routing; often, an Internet service provider (ISP) installs a router in a subscriber's home that connects the ISP's network to the network within the home	
Gateway	Serves as an entrance to another network, such as the Internet	

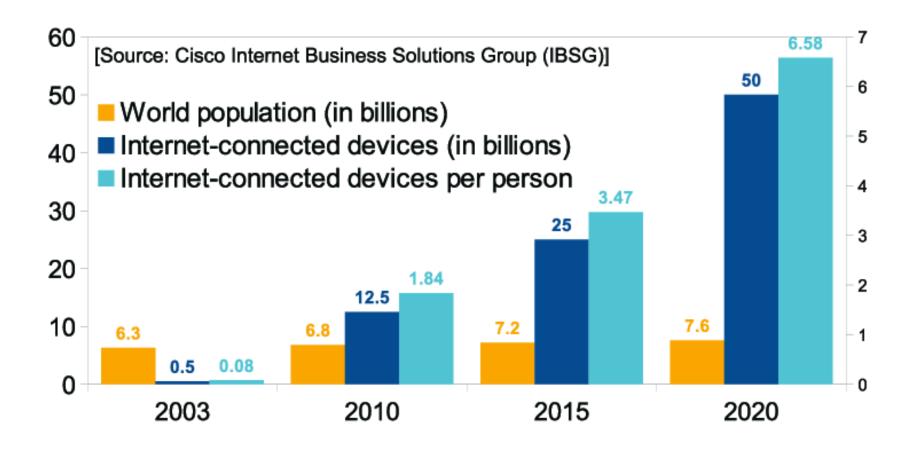
Communications Software

- Network operating system (NOS)
 - Systems software that controls the computer systems and devices on a network
 - Linux, UNIX, Windows Server, and Mac OS X are common NOSs
- Network-management software:
 - Protects software from being copied, modified, or downloaded illegally
 - Locates telecommunications errors and potential network problems

Communications Software

- Software-Defined Networking (SDN)
 - An emerging approach to networking
 - Allows network administrators to have programmable central control of the network via a controller without requiring physical access to all the network devices
 - Google is implementing Andromeda
 - -The underlying SDN architecture that will enable Google's cloud computing services to scale better, more cheaply and more quickly

The Internet and World Wide Web



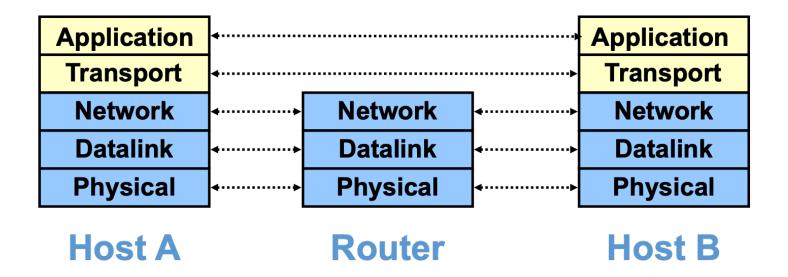
The Internet and World Wide Web

- The Internet is international in scope with users on every continent
- Internet sites have a profound impact on world politics
- Internet censorship
 - Some countries try to control Internet content and services
- ARPANET
 - Ancestor of the Internet
 - Project started by the U.S. Department of Defense (DoD) in 1969
- Internet Protocol (IP) enables computers to route communications traffic from one network to another

- Internet backbone: one of the Internet's high-speed, longdistance communications links
- IP protocol
 - The set of rules used to pass packets from one host to another
- Transmission Control Protocol (TCP): the widely used transport layer protocol that most Internet applications use with IP
- IP address: a 64-bit number that identifies a computer on the Internet

Simple diagram

- Lower three layers implemented everywhere
- Top two layers implemented only at hosts



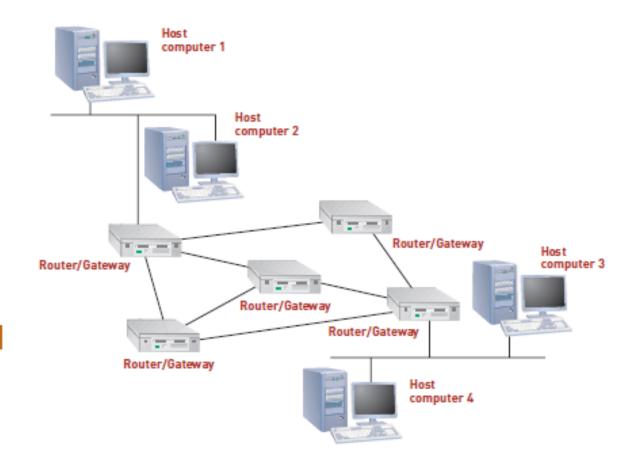


FIGURE 6.10

Routing messages over the Internet

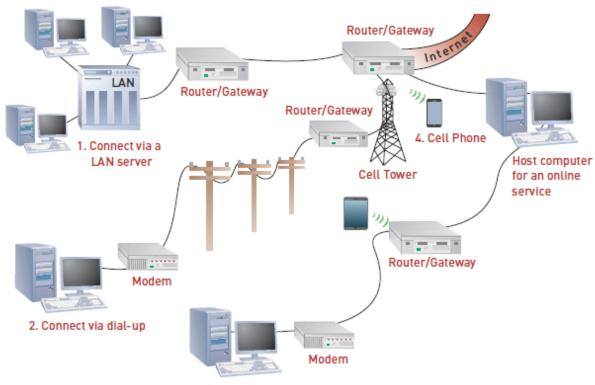
Data is transmitted from one host computer to another on the Internet.

- Uniform Resource Locator (URL): a Web address that specifies the exact location of a Web page using letters and words that map to an IP address and a host location
- Internet Corporation for Assigned Names and Numbers (ICANN) is responsible for managing IP addresses and Internet domain names
 - Domain names must adhere to strict rules

Accessing the Internet

- Connecting via LAN server
 - Connection method of businesses and organizations that manage a local area network (LAN)
- Connecting via Internet service providers
 - Internet service provider (ISP) is any organization that provides Internet access to people
 - You must have an account with the service provider along with software and devices that support a connection via TCP/IP

Accessing the Internet



3. Connect via high-speed service

FIGURE 6.11

Several ways to access the Internet

Users can access the Internet in several ways, including using a LAN server, telephone lines, a highspeed service, or a wireless network.

Accessing the Internet

- Dial-up Internet connection uses modem and standard phone line
- Other options include:
 - Cable modem connections
 - DSL connections
 - Satellite connections
- Wireless Connection
 - Internet service over cellular and Wi-Fi networks has become common

- The Internet
 - The infrastructure on which the Web exists
 - Made up of computers, network hardware such as routers and fiber-optic cables, software, and the TCP/IP protocols
- The World Wide Web (Web)
 - Consists of server and client software, the hypertext transfer protocol (http), standards, and markup languages that combine to deliver information and services over the Internet

- Hyperlink: highlighted text or graphics in a Web document that, when clicked, opens a new Web page
- Web browser: Web client software used to view Web pages
 - Examples: Internet Explorer, Firefox, Chrome, and Safari
- Web site: a collection of pages on one particular topic, accessed under one Web domain

- Hypertext Markup Language (HTML): the standard page description language for Web pages
 - Tells the browser how to display font characteristics, paragraph formatting, page layout, image placement, hyperlinks, and the content of a Web page
- HTML tags tell the Web browser how to format text and elements to be inserted
- Extensible Markup Language (XML): a markup language designed to transport and store data on the Web

- Cascading Style Sheets (CSS): a file or portion of an HTML file that defines the visual appearance of content in a Web page
 - Uses special HTML tags to globally define characteristics for a variety of page elements as well as how those elements are laid out on the Web page

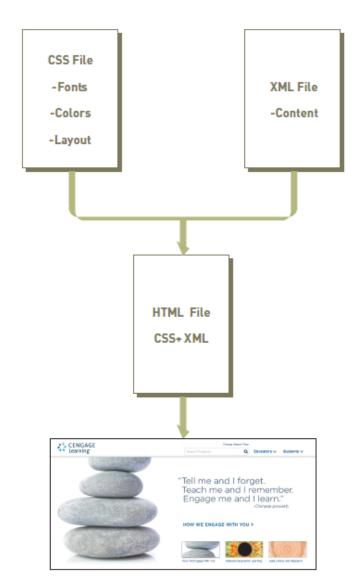


FIGURE 6.14

XML, CSS, and HTML

Today's Web sites are created using XML to define content, CSS to define the visual style, and HTML to put it all together.

Web Programming Languages

- JavaScript
 - A popular programming language for client-side applications
 - Use to create Web pages that respond to user actions
- Java
 - An object-oriented programming language from Sun Microsystems based on C++
 - Allows small programs (applets) to be embedded within an HTML document

Web Programming Languages

- Other client-side programming languages include:
 - ASP.NET
 - (
 - (++
 - Perl
 - PHP
 - Python

Web Services

- Standards and tools that streamline and simplify communication among Web sites
- XML
 - The key to Web services
 - Used within a Web page to describe and transfer data between Web service applications
- Amazon Web Services (AWS)
 - Basic infrastructure that Amazon employs to make the contents of its online catalog available to other Web sites or software applications

Developing Web Content and Applications

- Popular tools for creating Web pages and managing Web sites
- Many products make it easy to develop Web content and interconnect Web services
 - Example: Microsoft's .NET platform which allows developers to use various programming languages to create and run programs

- Web 2.0 and the Social Web
 - Web 2.0: the Web as a computing platform that supports software applications and the sharing of information among users
 - Social networking Web sites enable users to share information abut themselves and to find, meet, and converse with others

- News
 - The Web is a powerful tool for keeping informed about local, state, national, and global news
- Education and Training
 - Web is ideally suited as a tool for sharing information and a primary repository of information on all subjects
 - Distance education offers classes via the Web
- Job Information
 - Providing information about a businesses and its products via
 Web site and social media increases the company's exposure and reputation
 - The Web is an excellent source of job-related information
 - Examples: www.linkedin.com, www.monster.com, and www.careerbuilder.com

- Search Engines and Web Research
 - Search engine
 - -Information on the Web is found by specifying keywords
 - -The market is dominated by Google
 - Search engine optimization (SEO) is a process for driving traffic to a Web site by using techniques that improve the site's ranking in search results
 - Online research databases allow visitors to search for information in thousands of journal, magazine, and newspaper articles

- Instant messaging
 - Online, real-time communication between two or more people who are connected via the Internet
- Microblogging, Status Updates, and News Feeds
 - Twitter allows users to send short text updates from a smartphone or a Web browser to their Twitter followers
 - Popularity of Twitter has caused social networks, such as Facebook, LinkedIn, and Tumbler, to include Twitter-like news or blog post feeds

- Conferencing
 - The Internet has made it possible for those involved in teleconferences to share computer desktops
 - GoToMeeting enables employees to attend training without leaving their assigned stations
 - Cisco WebEX, Zoom, Google Meet and Skype allow video chats

- Blogging and Podcasting
 - Web log (blog): a Web site that people can create and use to write about their observations, experiences, and opinions on a wide range of topics
 - Video log (vlog): blogging with video content
 - Podcast: an audio broadcast over the Internet
- Online Media and Entertainment
 - Content streaming: a method of transferring large media files over the Internet
 - -The data stream of voice and pictures plays continuously as the file is being downloaded
 - Music
 - -Internet radio is digitally delivered to your computer over the Internet

- Online Media and Entertainment (cont'd)
 - Movies, Video, and Television
 - -Hulu Web site and Internet-based television platforms (e.g., Netflix and Joost) provide television programming
 - -Vudu provides access to online movies
 - -YouTube supports the online sharing of user-created videos
 - Online Games and Entertainment
 - -The market for Internet gaming is very competitive and constantly changing
 - -Many video games are available online

- Shopping Online
 - Shopping on the Web can be convenient, easy, and cost effective
 - Retail stores provide access to many products that may be unavailable in local stores
 - Online clearinghouses, Web auctions, and marketplaces provide a platform for businesses and individuals to sell their products and belongings
 - eBay is the most popular online auction/marketplace
 - Businesses benefit from shopping online

- Travel, Geolocation, and Navigation
 - The Web has had a profound effect on the travel industry and the way people plan and prepare for trips
 - Mapping and geolocation tools
 - -Google Maps, Bing Maps, HERE Map and OpenStreetMap
 - Geographic information systems (GIS) provide geographic information layered over a map

Intranets and Extranets

- Intranet: an internal corporate network built using Internet and World Wide Web standards and technologies
- Extranet: a network based on Web technologies that links resources of a company's intranet with its customers, suppliers, or other business partners
- Virtual private network (VPN): A secure connection between two points on the Internet
- Tunneling: the process by which VPNs transfer information by encapsulating traffic in IP packets over the Internet

- Internet of Things (IoT)
 - A network of physical objects (things) embedded with sensors, processors, software, and network connectivity capability to enable them to exchange data with the manufacturer of the device, device operators, and other connected devices
- Sensor: a device that is capable of sensing something about its surroundings such as
 - Pressure, temperature, humidity, pH level, motion, vibration, or level of light



1. Sensors gather data



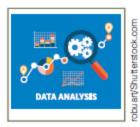
2. Data passes over network



 Data from across the IoT Is gathered and storedoften in the cloud



 Data is combined with other data from other systems



5. Data is analyzed to gain insights Into operation of devices on IoT



6. Alerts sent to people, Enterprise systems, or IoT Devices based on these insights

The Internet of Things

The IoT is a network of physical objects or "things" embedded with sensors, processors, software, and network connectivity capability to enable them to exchange data with the manufacturer of the device, device operators, and other connected devices.

- Examples of using sensors and the IoT to monitor and control key operational activities:
 - Asset monitoring
 - Construction
 - Agriculture
 - Manufacturing
 - Monitoring parking spaces
 - Predictive Maintenance
 - Retailing
 - Traffic monitoring

TABLE **6.7** Types of IoT applications

Type of IoT Application	Degree of Sensing	Degree of Action
Connect and monitor	Individual devices each gathering a small amount of data	Enables manual monitoring using simple threshold-based exception alerting
Control and react	Individual devices each gathering a small amount of data	Automatic monitoring combined with remote control with trend analysis and reporting
Predict and adapt	External data is used to augment sensor data	Data used to preform predictive analysis and initiate preemptive action
Transform and explore	Sensor and external data used to provide new insights	New business models, products, and services are created

Cloud Computing

- Cloud computing: a computing environment in which software and storage are provided as an Internet service and accessed with a Web browser
- Advantages to businesses:
 - Businesses can save on system design, installation, and maintenance
 - Increased efficiency and reduce the costs of new product and service launches
 - Employees can access corporate systems from any Internetconnected computer

Public Cloud Computing

- A service provider owns and manages the infrastructure with cloud user organizations (tenants) accessing slices of shared hardware resource via the Internet
- Public cloud computing can be a faster, cheaper, and more agile approach to building and managing your own IT infrastructure
- However, data security is a key concern
 - Because when using a public cloud computing service, you are relying on someone else to safeguard your data

Public Cloud Computing

- Cloud computing can be divided into three main types of services:
 - Infrastructure as a service (laaS)
 - Software as a service (SaaS)
 - Platform as a Service (PaaS)

Public Cloud Computing

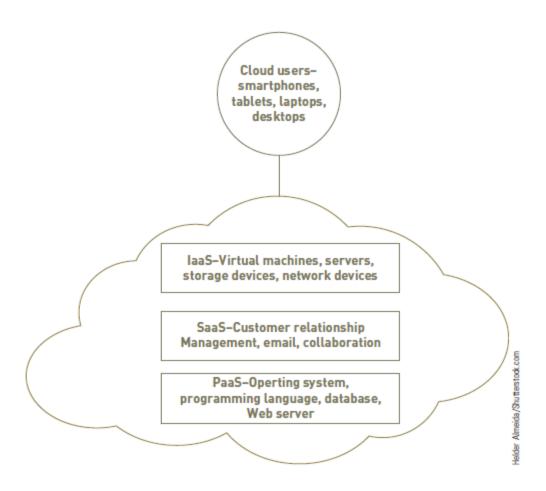


FIGURE 6.27

The cloud computing environment

Cloud computing can be divided into three main types of services: infrastructure as a service (laaS), software as a service (SaaS), and platform as a service (PaaS).

Private Cloud Computing

- Private cloud environment
 - A single tenant cloud
 - Organization often implement due to concerns that their data will not be secure in a public cloud
 - Can be divided into two types:
 - -On-premise private cloud
 - -Service provider managed private cloud

Hybrid Cloud Computing

- Hybrid cloud
 - Composed of both private and public clouds integrated through networking
 - Organizations typically use the public cloud to run applications with less sensitive security requirements
 - Runs more critical applications on the private portion of the hybrid cloud

Summary

- A network has many fundamental components, which enable people to meet personal and organizational objectives
- Together, the Internet and the World Wide Web provide a highly effective infrastructure for delivering and accessing information and services
- Organizations are using the Internet of Things (IoT) to capture and analyze streams of sensor data to detect patterns and anomalies in order to have a considerable impact on the event outcome
- Cloud computing provides access to state-of-the-art technology at a fraction of the cost of ownership and without the lengthy delays that can occur when an organization tries to acquire its own resources