

Understanding Computers in a Changing Society

5e

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Chapter 8 Advances in Technology

Learning Objectives

1. Describe what the computer of the future might look like, including some examples of emerging types of hardware.
2. Understand the effect that emerging computer technologies, such as nanotechnology, quantum computers, and optical computers, may have on the computer of the future.
3. Name some emerging wired and wireless networking technologies.
4. Explain what is meant by the term “artificial intelligence” (AI) and list some AI applications.

Learning Objectives

5. List some new and upcoming technological advances in medicine.
6. Name some new and upcoming technological advances in the military.
7. Discuss potential societal implications of emerging technologies.

Overview

- This chapter covers:
 - The computer of the future
 - Emerging networking technologies
 - Artificial intelligence (AI)
 - Technological advancements in medicine and the military
 - Societal implications of emerging technologies

The Computer of the Future

- Emerging Hardware
 - Emerging Input Devices
 - Keyboard dock
 - Gesture-based devices
 - Wii remote
 - Surface computing
 - Combination of multi-touch input from multiple users and object recognition
 - Microsoft Surface
 - 2D barcodes
 - Designed to be used by consumers with mobile phones

The Computer of the Future

- Augmented Reality
 - Mobile phone app
 - Computer generated images overlaid on top of real-time images
- Near Field Communication (NFC)
 - Uses RFID technology to assist communication between devices
 - Transferring payment information, receipts, boarding passes, etc.
 - Vending machines are increasing going cashless using NFC

The Computer of the Future



KEYBOARD DOCKS



SURFACE COMPUTERS



2D BARCODE READERS

FIGURE 8-1

Examples of emerging input devices.

The Computer of the Future

- Emerging Processing Technologies
 - New designs for motherboards and CPUs
 - Multi-core CPUs
 - USB 3.0
 - More than 10 times the speed of USB 2.0
 - Flexible electronic components
 - Three-dimensional (3D) chips
 - Components are layered, cutting down on required surface area
 - World's first 3D transistor just announced

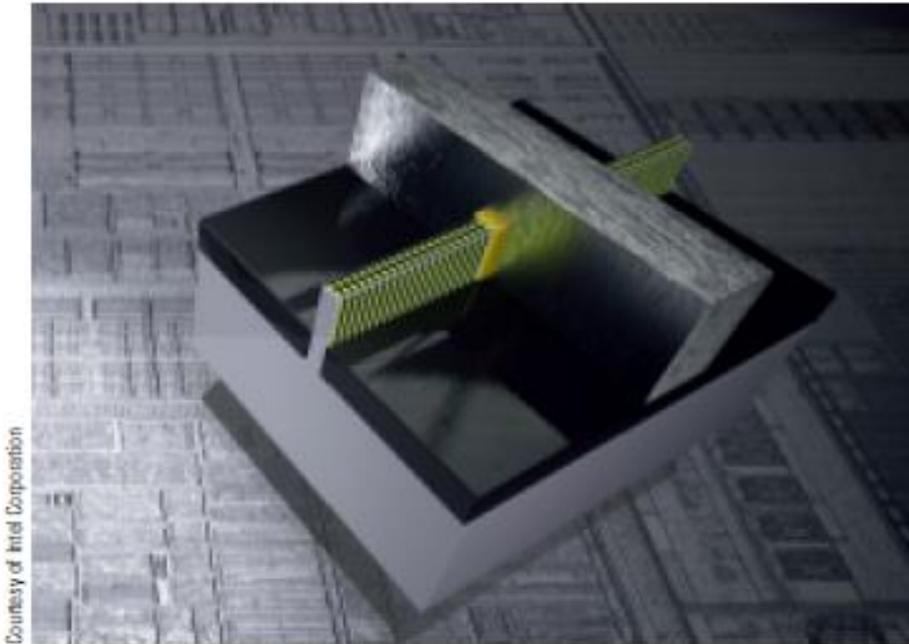


FIGURE 8-2
Flexible processors.

The Computers of the Future

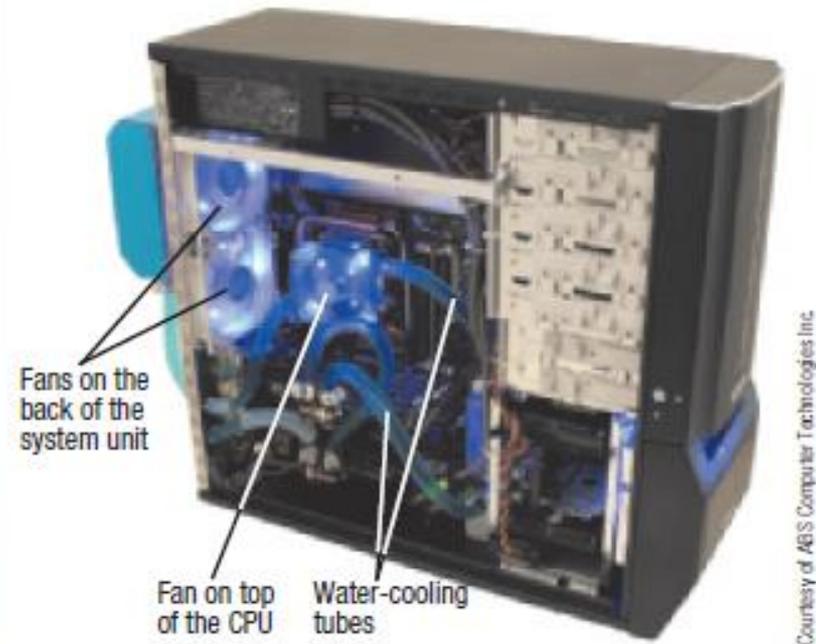
- Heat is a hurdle in 3D chip development
 - » Heat can damage components
 - » IBM's water-cooling system works in conjunction with traditional fans and heat sinks to allow cooler chips to run faster
 - » Cooling system is liquid filled tubes that draw heat away from processors

The Computers of the Future



3D CHIPS

In this 3D transistor, the electrical current (represented by the yellow dots) flows on three sides of a vertical fin.



WATER-COOLING SYSTEMS

Water-cooling systems can be used in conjunction with fans and heat sinks to cool the inside of the computer.

FIGURE 8-3

Emerging processing technologies.

The Computers of the Future

- Terascale Computing
 - The ability of computers to process at least one trillion floating-point operations per second (one teraflop)
 - Research focused on multi-core processors with tens to hundreds of cores used with multithreaded hardware and software
- Nonvolatile RAM (NVRAM)
 - Memory that retains data when power to the computer is cut off
 - » Memristor-based RAM and Magnetoresistive RAM

The Computers of the Future

- Emerging Output Devices
 - 3D display screens
 - Use filters, prisms, lenses and other technologies to create a 3D effect
 - Has both consumer and industrial applications
 - Wearable personal displays
 - Typically built into glasses
 - Project images from portable device to the glasses
 - 3D projectors
 - Display holograms

The Computers of the Future

- Pico projectors
 - Pocket-size
 - Display on any flat surface
 - Typically connect to a mobile device or portable computer
 - Can be built into mobile devices
- 3-D printers
 - Used when permanent 3D output is required

The Computers of the Future



3D WEARABLE DISPLAYS

Images from the mobile device connected to the eyeglasses (such as the text message shown here) are displayed on top of the user's normal vision.



PICO PROJECTORS

Images from a mobile device (such as the mobile phone shown here) are projected onto any surface.



3D PRINTERS

Used to print items (such as plastic parts or models) in 3D.

FIGURE 8-4

Examples of emerging output devices.

The Computers of the Future

- Organic light emitting diode (OLED) displays
 - Use a layer of organic material that emits light when electric current is applied
 - Do not use backlighting
 - Wide viewing angle, low energy consumption, longer battery life
 - More energy efficient than LCDs
 - Beginning to be used with digital cameras, portable digital media players, mobile phones, and TVs

The Computers of the Future

- Special types of OLEDs
 - Flexible OLED (FOLED) displays
 - » Built on flexible surfaces
 - Transparent OLED (TOLED) displays
 - » Transparent and emits light toward the top and bottom of the display surface
- Interferometric modulator displays (IMOD)
 - Complex mirror that uses external light
 - Images are bright and clear even in direct sunlight

The Computers of the Future

- Emerging print applications involve the use of ink-jet technology
 - Used for dispensing liquid metals, aroma, computer chips, other circuitry
 - “Printing” human tissue and other organic materials for medical purposes
- Integration of printers into other devices

The Computers of the Future



FOLEDs

Used to create flexible displays on plastic or another type of flexible material.



IMODs

Display is bright and readable, even in direct sunlight.

Courtesy of QUALCOMM MEMS Technologies, Inc.



INTEGRATED PRINTERS

This printer uses no ink and is integrated into the digital camera to print digital photographs.

Courtesy ZINK Imaging

FIGURE 8-5

Examples of emerging display and printer technologies.

The Computers of the Future

- Emerging Storage Devices
 - Hard drive technologies are improving to increase capacity
 - Perpendicular Magnetic Recording (PMR)
 - Heat-Assisted Magnetic Recording (HAMR)
 - USB Flash Drives and Cloud Storage
 - Norm for transporting documents to different locations

The Computers of the Future

- Flash Memory Cards
 - Normal for mobile devices
 - Embedded Flash memory
 - » Growing trend
 - » Flash memory chips are embedded directly into consumer products and mobile devices
 - » Used in special backup products for mobile devices

The Computers of the Future



EMBEDDED FLASH MEMORY

This portable tablet contains embedded flash memory.

MOBILE DEVICE STORAGE SYSTEMS

This backup/charging system uses an SD card.

FIGURE 8-6

Mobile devices are increasingly utilizing flash memory media for storage.

The Computers of the Future

- Holographic Storage
 - High-capacity storage
 - Uses multiple blue laser beams to store data in three dimensions
 - Discs currently hold 300 GB each; 1.6 TB cartridges expected in near future
 - Best suited for use with large amounts of data that need to be stored or retrieved quickly but rarely changed

The Computers of the Future

HOW HOLOGRAPHIC STORAGE WORKS

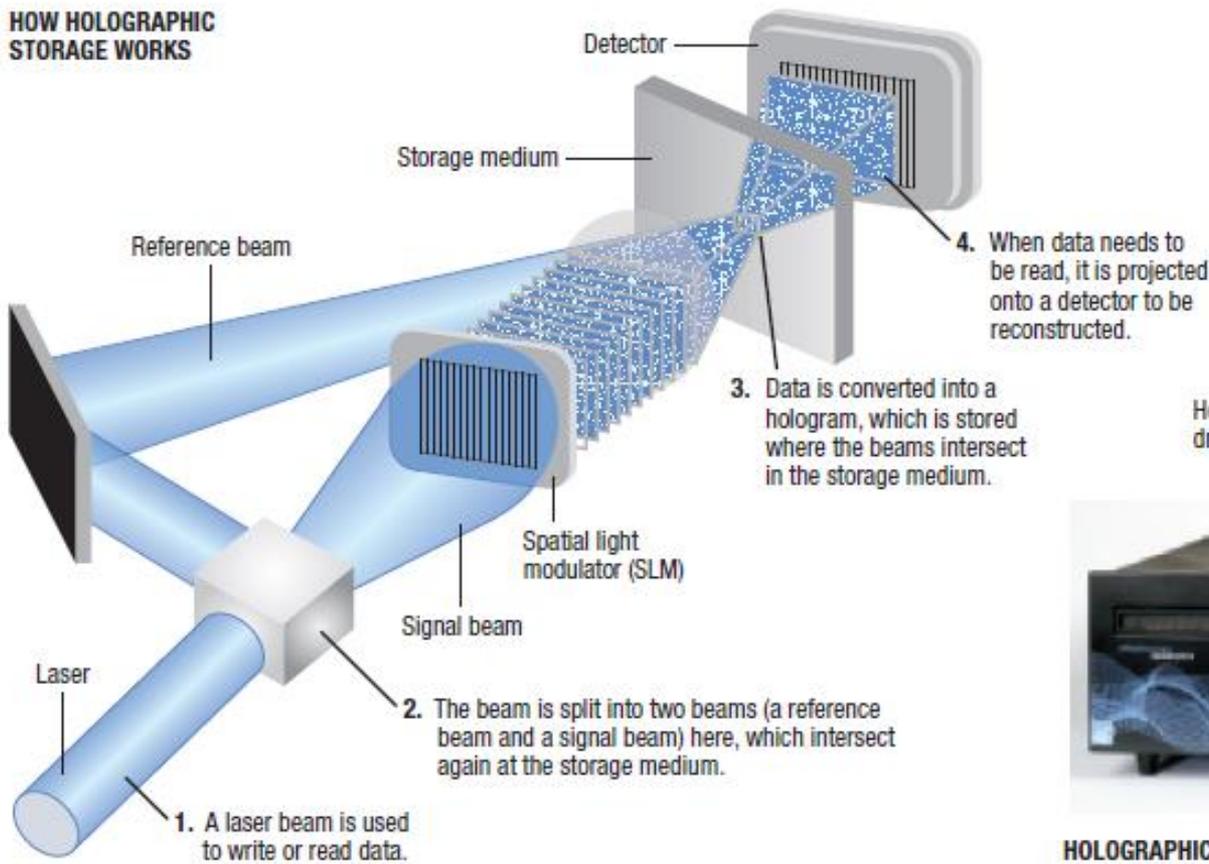
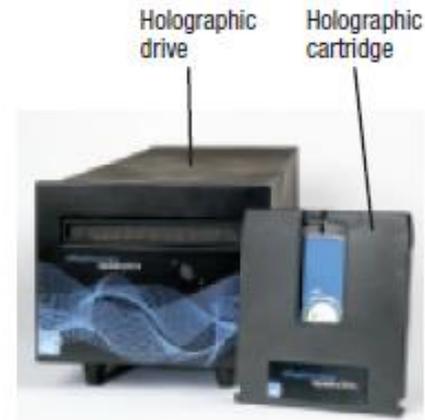


FIGURE 8-7

Holographic storage. Holographic drives store up to one million bits of data in a single flash of light.



HOLOGRAPHIC DRIVES AND CARTRIDGES

Courtesy of Signal Labs

The Computers of the Future

- The Impact of Nanotechnology
 - Nanotechnology
 - Creating computer components, machines, and other structures less than 100 nanometers in size
 - Today's CPU components fit this definition
 - Components in the future may need to be built at an atomic or molecular level
 - Research is leading towards new products in many areas
 - Nickel-based nanodots
 - Nanogenerators

The Computers of the Future

- Carbon Nanotubes (CNT)
 - Tiny hollow tubes made up of carbon atoms
 - Used in a variety of computer and consumer products
 - Conduct electricity better than copper
 - Stronger than steel
 - Conduct heat better than diamonds
 - Transmit electronic impulses faster than silicon
 - Lithium ion batteries that use nanotubes are available now
 - Nanotube-based display screens and memory are in development

The Computers of the Future

- Developing Nanotechnology
 - » Carbon nanotubes and DNA molecules to make smaller, more powerful, and more energy-efficient computer chips
 - » Product development in areas of TV's, solar cells, light bulbs
 - » Also used in automobile panels, airplanes, tennis rackets, racing bikes, surfboards
- Recent Developments
 - » Nanoparticles that can remove contaminants from water sources

The Computers of the Future

- » Nanosensors that can detect small amounts of cancer-causing toxins or cancer drugs inside single living cells
- Possible Future Applications
 - » Disposing of e-trash
 - » Microscopic devices that enter the bloodstream to perform tests or irradiate cancerous tumors
 - » Improved military uniforms that protect against bullets and germ warfare
 - » Complete organic computers are a long way off

The Computers of the Future

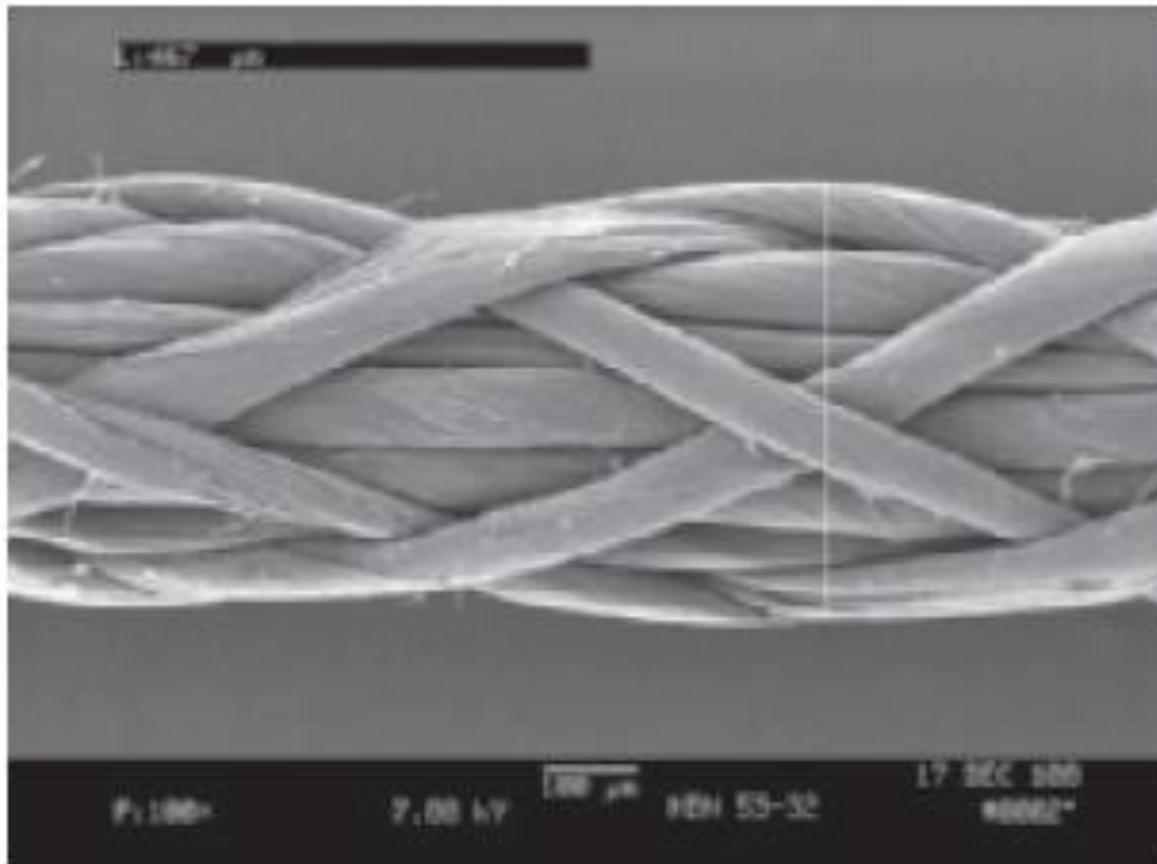


FIGURE 8-8

Carbon nanotubes. This is a magnified image of a nanotube fiber, which is made up of trillions of "spun" nanotubes.

The Computers of the Future

- Quantum and Optical Computers
 - Quantum Computing
 - Applies quantum physics and mechanics to computers, going beyond traditional physics to work at the subatomic level
 - Utilizes atoms or nuclei working together as qubits (quantum bits)
 - Qubits function as the computer's processor and memory
 - Each qubit can represent more than the two states (1 and 0) at a time used with electronic bits

The Computers of the Future

- Quantum computers can perform computations on many numbers at a time, making them, theoretically, faster than conventional computers
- Quantum computers are in the pioneering stage, but working quantum computers do exist
- May eventually consist of a thimbleful of liquid whose atoms are used to perform computations as instructed by an external device
- Are not well suited for general computing, but are ideal for encryption and code breaking

The Computers of the Future

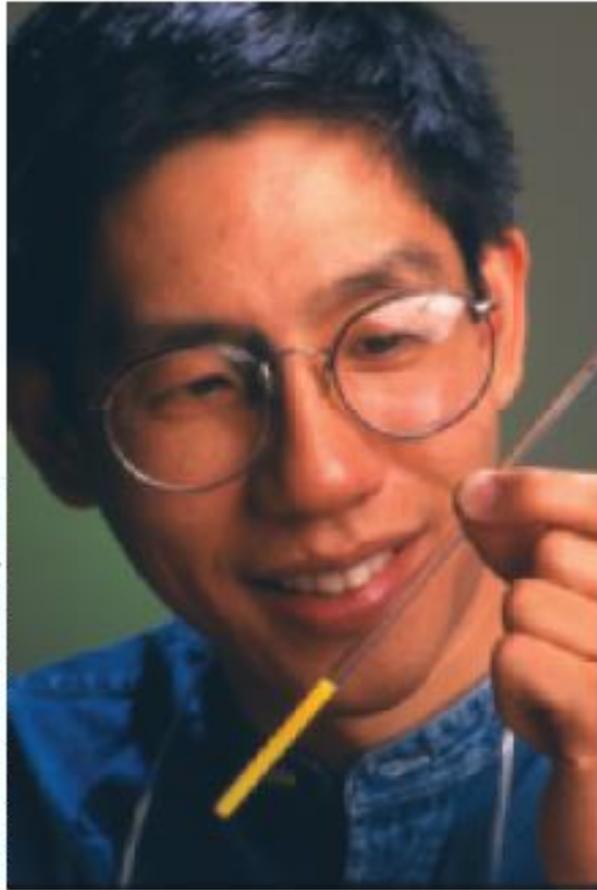


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FIGURE 8-9
Quantum computers.
The vial of liquid shown here contains the 7-qubit computer used by IBM researchers in 2001 to perform the most complicated computation by a quantum computer to date—factoring the number 15.

The Computers of the Future

- Optical Computing
 - Optical Chips
 - Use light waves to transmit data
- Optical Computer
 - A computer that uses light (such as laser beams or infrared beams) to perform digital computations
 - Could be much smaller and faster than electronic computers; currently being developed by some researchers
 - Opto-electronic technology already being used to improve fiber-optic communications and is expected to be used to speed up communications with computers

The Computers of the Future

– Nanolasers

- Recent break through by researchers
- Very small lasers grown on a silicon surface
- Could possibly be used in processors and other computer components

Emerging Networking Technologies

- Improvements are constantly being made to wired and wireless networking technologies to:
 - Increase speed and connectivity options for local area networks (LANs) and Internet connections
 - Support the continued growth in Internet-based multimedia and communications
 - Voice over IP (VoIP)
 - VOD and mobile TV
 - Telepresence videoconferencing

FIGURE 8-10
Telepresence
videoconferencing.



Life-size video images of remote participants appear on the display screen.

Courtesy Cisco Systems, Inc.

Emerging Networking Technologies

- Geobrowsing and GPS monitoring systems
- Web-based computing—Cloud Computing
 - Chrome OS—first cloud operating system

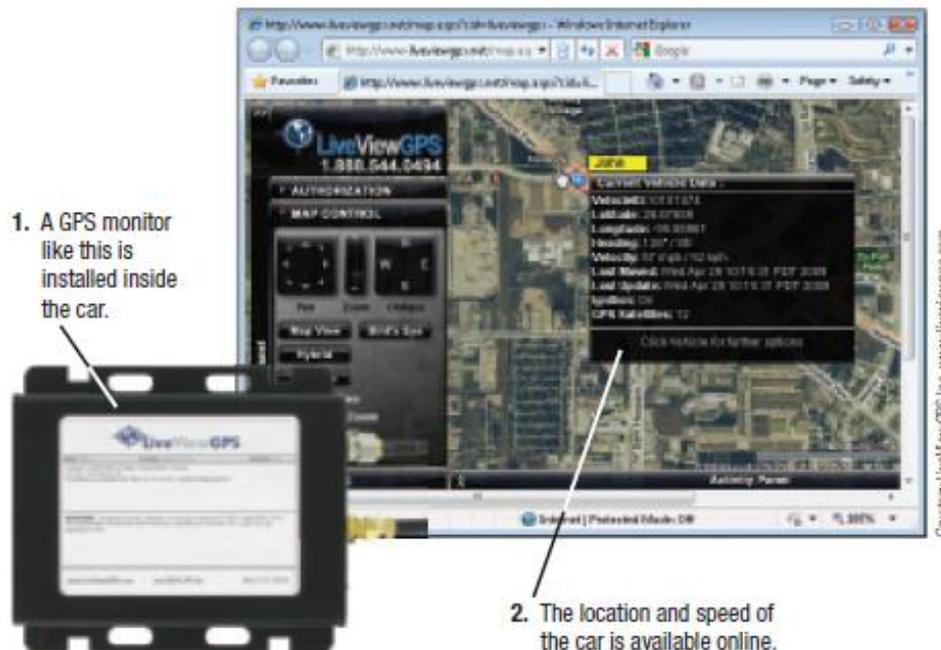


FIGURE 8-11
GPS-based vehicle monitoring systems. Allow parents or employers to track a vehicle in real time.

Emerging Networking Technologies

- Wired Networking Improvements
 - Ethernet
 - The most widely used networking protocol
 - Fast Ethernet
 - » LAN standard
 - » Supports data transfer rates up to 100 Mbps
 - Gigabit Ethernet
 - » Data transfers at 1000 Mbps (1 Gbps)
 - 10 Gigabit Ethernet
 - » Data transfers at 10 Gbps

Emerging Networking Technologies

- 40 Gigabit and 100 Gigabit Ethernet standard expected soon
- Terabit Ethernet is now under development
- Power over Ethernet (PoE)
 - Allows both electrical power and data to be sent over standard Ethernet cables
 - Most often used in business networks
 - Requires special hardware and devices designed for PoE
 - Eliminates the need for devices to be near a power outlet

Emerging Networking Technologies

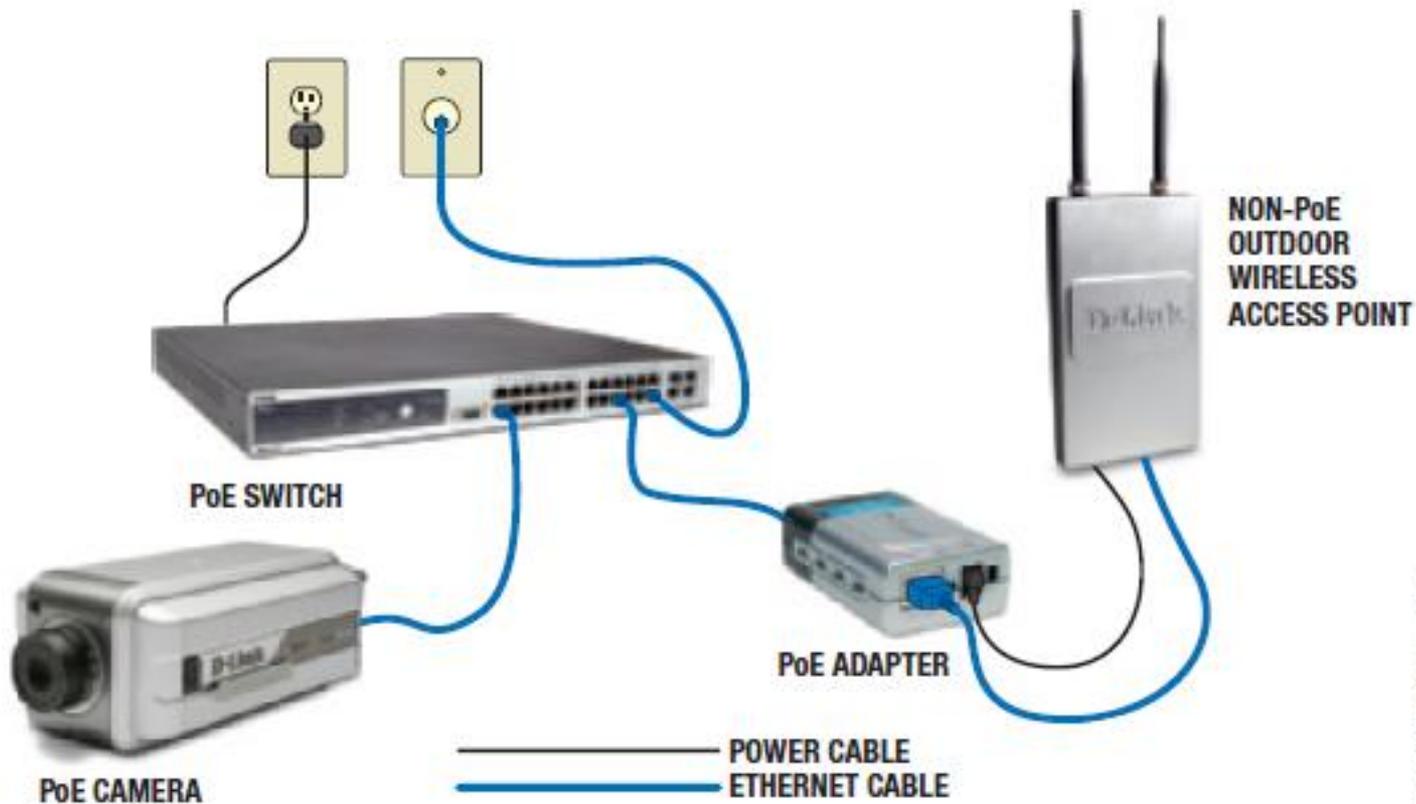


FIGURE 8-12
With Power over Ethernet (PoE), devices are powered through the Ethernet connection.

Courtesy D-Link Systems, Inc.

Emerging Networking Technologies

- Phoneline and Powerline standards are continually being improved to support faster speeds
 - Computers can be networked through existing telephone jacks and power outlets
 - G.hn standard
- Broadband over power lines (BPL)
 - Delivers broadband Internet to homes using existing outdoor power lines
 - Based on the Powerline standard
 - Requires additional hardware on power poles
 - Potentially offers broadband access to any home or business with access to electricity

Emerging Networking Technologies

- Wireless Networking Improvements
 - Wi-Fi (wireless fidelity)
 - Family of wireless networks using the IEEE standard 802.11
 - Current standard for wireless networks in home, office, and public Wi-Fi hotspots
 - Built into most portable computers sold today
 - Incorporated into many everyday products
 - Designed for medium-range data transfers
 - Limitations include a relatively limited range and other wireless technologies are being developed for specific purposes

Emerging Networking Technologies

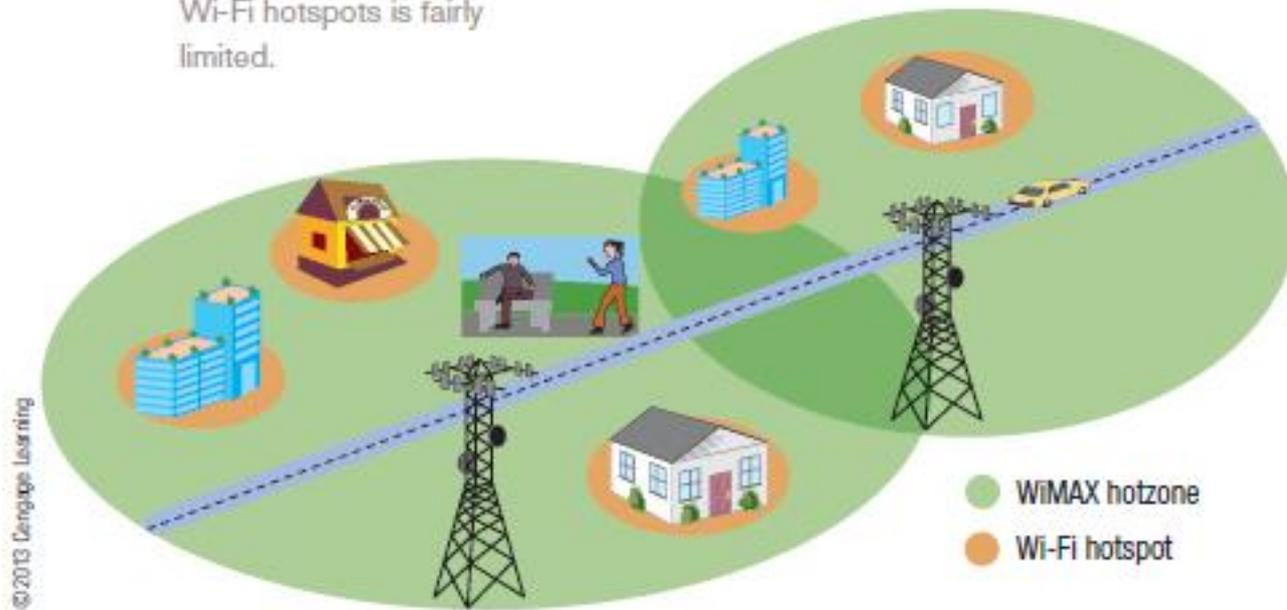
- WiMAX
 - Worldwide Interoperability for Microwave Access
 - A relatively new standard that is faster and has a larger range than Wi-Fi
 - Designed to provide Internet access to a fixed location, but with a larger coverage area
 - Mobile WiMAX
 - Designed to bring fast wireless networking to users via mobile phone, computer, or other WiMAX-enabled device

Emerging Networking Technologies

FIGURE 8-13

WiMAX vs. Wi-Fi.

WiMAX hotzones can provide service to anyone in the hotzone, including mobile users, while the range of Wi-Fi hotspots is fairly limited.



Emerging Networking Technologies

- 3G/4G Cellular Standards
 - 3G is the current standard for cellular networks
 - Designed to support both data and voice
 - 4G networks are emerging
 - Mobile WiMAX
 - Long Term Evolution (LTE)
- Short-range Wireless Standards
 - Bluetooth
 - The original wireless standard designed for short-range connections between devices



FIGURE 8-14
Mobile broadband allows access to multimedia content.

Emerging Networking Technologies

- Wireless USB
 - Designed to connect peripheral devices
 - Similar to Bluetooth, but transfers data more quickly
 - Wireless USB hub/Wireless USB adaptor
- Wi-Fi Direct
 - Enables Wi-Fi devices to connect directly to each other without additional network hardware
 - Considered competitor to Bluetooth because of speed

Emerging Networking Technologies

- Other Standards
 - Ultra Wideband (UWB)
 - WirelessHD
 - TransferJet

Emerging Networking Technologies

CATEGORY	EXAMPLES	INTENDED PURPOSE	RANGE
Short range	Bluetooth Wireless USB	To connect peripheral devices to a mobile phone or computer.	33 feet–200 feet
	Ultra Wideband (UWB) WirelessHD (WiHD) TransferJet WiGig	To connect and transfer multimedia content between home consumer electronic devices (computers, TVs, DVD players, etc.).	1 inch–33 feet
Medium range	Wi-Fi (802.11)	To connect computers and other devices to a local area network.	100–300 feet indoors; 300–900 feet outdoors
	Wi-Fi Direct	To connect computers and other devices directly together.	600 feet
Long range	WiMAX Mobile WiMAX	To provide Internet access to a large geographic area for fixed and/or mobile users.	6 miles non-line of sight; 30 miles line of sight
	Cellular standards	To connect mobile phones and mobile devices to a cellular network for telephone and Internet service.	10 miles

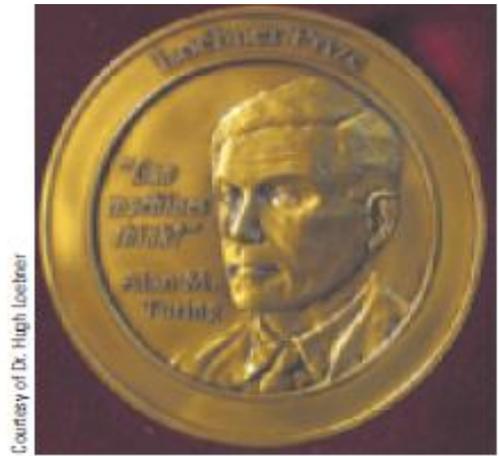
FIGURE 8-15
Summary of common wireless networking standards.

Artificial Intelligence (AI)

- What is Artificial intelligence (AI)
 - The science and engineering of making intelligent machines
 - Creating intelligent devices controlled by intelligent software – machines that think and act like intelligent humans
 - Turing Test
 - A test of AI
 - An observer interacts electronically with a human and a computer by sending them questions and reviewing the typed responses
 - If the observer repeatedly cannot tell which of the responses is human and which is machine, the machine is viewed as intelligent

Artificial Intelligence (AI)

- Loebner Prize
 - Includes a gold medal to be awarded to the developer of the first computer to pass the Turing Test
 - Has not yet been awarded
- Early advances in AI were in area of game playing, namely chess
 - Today's chess-playing programs can beat chess masters



Courtesy of Dr. Hugh Loebner

FIGURE 8-16
The Loebner Prize gold medal has yet to be awarded.

Artificial Intelligence (AI)

- AI Applications
 - Contain some aspects of AI though tend to mimic human intelligence
 - IBM's Watson computer
 - Intelligent Agents
 - Programs that perform specific tasks to help make a user's work environment more efficient or entertaining
 - Application assistants
 - Shopping bots
 - Entertainment bots
 - Chatterbots

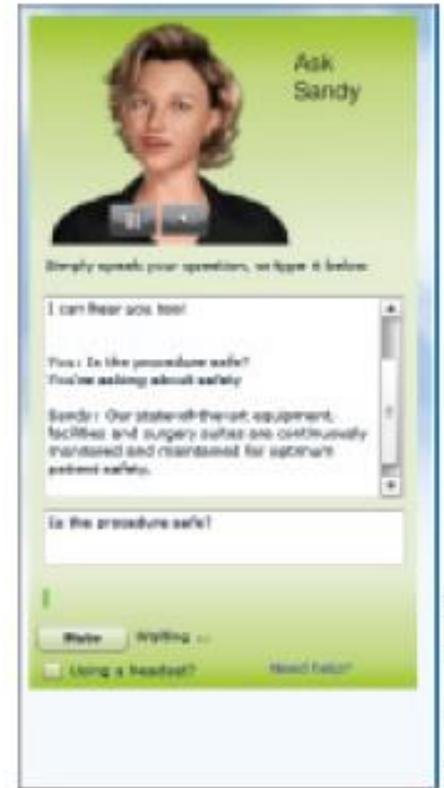


FIGURE 8-18
A Web page
chatterbot.

Artificial Intelligence (AI)

- Expert Systems
 - Software programs that can make decisions and draw conclusions, similar to a human expert
 - Two main components
 - Knowledge base
 - » Database with facts and rules
 - Inference engine
 - » Software program that applies the rules to the data stored in the knowledge base

Artificial Intelligence (AI)

- Widely used for many tasks
 - Diagnosing illness
 - Financial forecasting
 - Scheduling routes for delivery vehicles
 - Credit authorizations

Artificial Intelligence (AI)

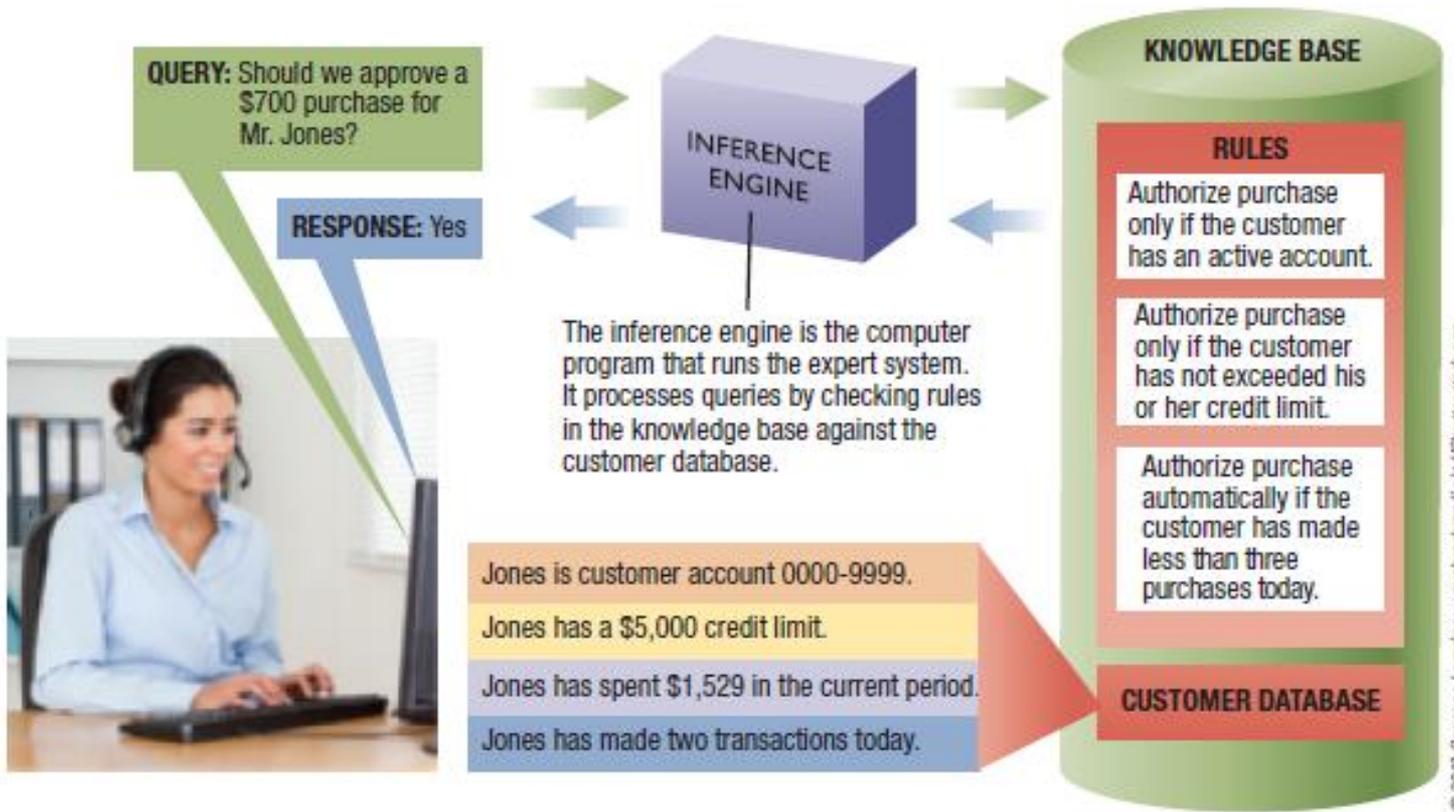


FIGURE 8-19
An expert system
at work.

Artificial Intelligence (AI)

- Neural Networks
 - AI systems that attempt to imitate the way a human brain works
 - Designed to recognize patterns in data and make more progressive leaps in associations and predictions than conventional computer systems
 - Used in various areas
 - Handwriting, speech, and image recognition
 - Medical imaging and crime analysis
 - Biometric identification and vision systems

Artificial Intelligence (AI)



Courtesy of Cross match

FIGURE 8-20
Neural network systems. Often used in biometric identification systems, such as to analyze fingerprints.

Artificial Intelligence (AI)

- Robotics
 - The study of robots
 - Robots
 - Devices, controlled by a person or computer, that can move and react to sensory input
 - Generally used to replace human workers
 - » In high-precision but monotonous jobs
 - » In situations that are dangerous or impossible for people

Artificial Intelligence (AI)

- Robots used in business for a variety of purposes
 - » Looking for intruders, gas leaks, other hazards
 - » Working on factory assembly lines
 - » Mining coal, repairing oil rigs
 - » Locating survivors in collapsed buildings
 - » Facilitating teleconferencing
 - » Search and rescue missions, firefighting, manufacturing

Artificial Intelligence (AI)

– Personal robots

- » Entertainment robots make small talk, deliver messages, take photos or video, sing, dance, play games
- » Robotic pets
- » Household robots perform household tasks (vacuum floor, clean pool, mow lawn, etc.)
- » In the future, personal robots could become more humanoid and be able to perform more difficult tasks

Artificial Intelligence (AI)



Photo courtesy of KUKA Robotics Corporation

ASSEMBLY LINE ROBOTS



Courtesy of Touch Health, Inc.

VIDEOCONFERENCING ROBOTS



Courtesy of Wowwee Robotics™ PS Media™

TOY ROBOTS



Courtesy of iRobot

HOUSEHOLD ROBOTS

FIGURE 8-21
Business and personal robots.

Technological Advances in Medicine

- Electronic Monitoring and Electronic Implants
 - Some use RFID to monitor the status of objects to which a RFID tag is attached
 - Some use GPS to monitor the location of objects
 - Used in hospitals for patient ID, equipment tracking, drug ID, etc.
 - Used in home healthcare to transfer readings to a healthcare provider
 - Vital signs
 - Answers to questions



FIGURE 8-22
Home medical
monitoring systems.

Technological Advances in Medicine

- Electronic implants
 - Monitoring devices implanted inside an individual
 - Cardiac devices monitor and record heart rhythms
 - VeriChip
 - Small RFID tag implanted under a person's skin
 - Used for ID purposes



FIGURE 8-23
A VeriChip being tested with a reader before the VeriChip is implanted into an individual.

Technological Advances in Medicine

- Brain-to-computer interfacing (BCI)
 - The process of connecting a brain directly to a computer
 - Use of BCI to restore lost functionality and facilitate communications of severely disabled individuals is under development
 - Concern exists that this technology could be misused

Technological Advances in Medicine

- Telemedicine and Telesurgery
 - Telemedicine
 - Use of networking technology to provide medical information and services
 - Gives the ability to provide care remotely to people who could not otherwise have access
 - Enables remote diagnosis of patients and videoconferencing

Technological Advances in Medicine

- Telesurgery
 - A form of robot-assisted surgery in which the doctor's physical location is different from the patient's physical location and the doctor controls the robot remotely
 - Can be performed over the Internet
 - Gives closer view and more precision to the doctor
 - Allows for smaller incisions
 - Essential in providing service to remote areas
 - Will likely be needed for extensive space exploration

Technological Advances in Medicine



FIGURE 8-24
Examples of telemedicine applications.

REMOTE CONSULTATIONS

Using remote-controlled teleconferencing robots, physicians can "virtually" consult with patients or other physicians in a different physical location (left); the robot transmits video images and audio to and from the doctor (via his or her computer) in real time (right).

Technological Advances in Medicine



REMOTE DIAGNOSIS

At remote locations, such as this New York childcare center, trained employees provide physicians with the real-time data (sent via the Internet) they need to make a diagnosis.



TELESURGERY

Using voice or computer commands, surgeons can now perform operations via the Internet; a robotic system uses the surgeon's commands to operate on the patient.

FIGURE 8-24
Examples of telemedicine applications.

Technological Advances in the Military

- Battlefield Robots
 - Used in conflict areas
 - To investigate caves, buildings, trails, etc. to ensure those areas are safe for soldiers to enter
 - To locate and dispose of bombs, mines, and other explosive devices in the field
 - Are typically controlled by remotely by soldiers
 - Researchers are working to develop more autonomous robots that can navigate on their own

Technological Advances in the Military

- Exoskeleton Systems
 - Exoskeleton suit
 - Wearable robotic system designed to give additional physical capabilities and protection
 - Being developed for the military
 - Gives soldiers the ability to run faster
 - Enables soldiers to carry heavier items
 - Final versions may be light, bulletproof, and be able to solidify on command to act as a cast

Technological Advances in the Military



BATTLEFIELD ROBOTS

Designed to investigate hostile and inaccessible areas prior to human entry.



EXOSKELETON SYSTEMS

Designed to give soldiers enhanced mobility and endurance while carrying heavy loads.

FIGURE 8-25

Military robotic applications.

Societal Implications of Emerging Technology

- New technologies usually provide many benefit but not all advances are embraced by all individuals
 - Concerns include
 - Security and privacy issues
 - Trusting intelligent computers and robots so much they become personal safety hazards
 - Allowing medical technology to enable people to be controlled by others
 - Spending on research rather than other areas
 - Some say that technology is advancing too quickly, and we won't be able to see the repercussions until it's too late

Summary

- The Computer of the Future
- Emerging Networking Technologies
- Artificial Intelligence (AI)
- Technological Advances in Medicine
- Technological Advances in the Military
- Societal Implications of Emerging Technology