

Chapter 7

Computer Networks

Introduction

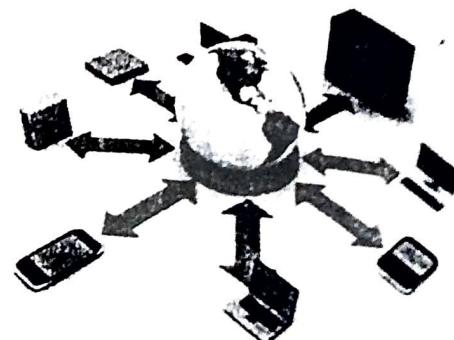
Computer communications means telecommunications in which data is sent from one device to another using communication media such as telephone lines, private cables and airwaves. Communications occur over a private network (such as home or business), the internet, or a telephone network.

This chapter aims to introduce the concepts and terminologies associated with computer networks. After defining a computer network, the chapter identifies the applications of networking. The chapter discusses some technical issues related to networks such as data transmission and the types of transmission media. The communication protocols and networking standards are explained. At the end of this chapter, an idea about various types of hardware used with a computer network is given.

The ILOs of this chapter are:

After completing this chapter, you will be able to:

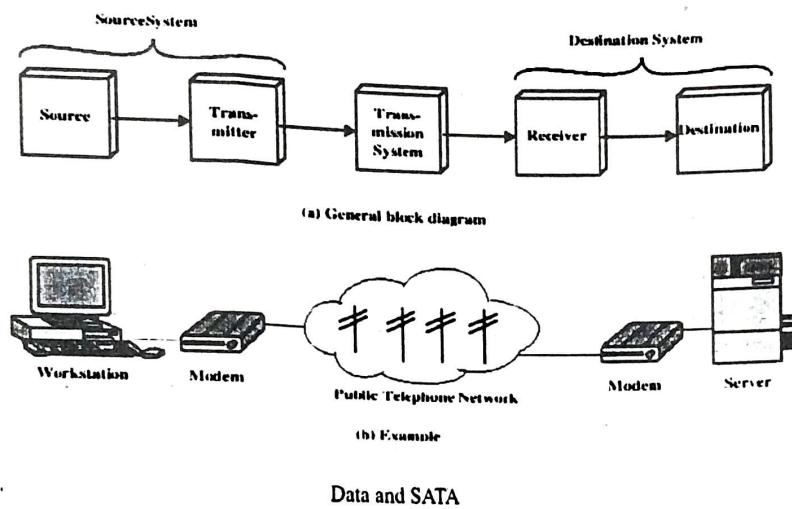
- Define a network and its purpose.
- Describe several uses for networks.
- Understand the various characteristics of a network, such as topology, architecture, and size.
- Understand characteristics about data and how it travels over a network.
- Name specific types of wired and wireless networking media and explain how they transmit data.
- Identify the most common communications protocols and networking standards used with networks today.
- List several types of networking hardware and explain the purpose of each.



Definition of a network

A network, in general, is a connected system of objects or people. A computer network is a collection of computers and other hardware devices connected together so that network users can share hardware, software, and data as well as communicate with each other electronically. Computer network ranges from small private networks to the internet.

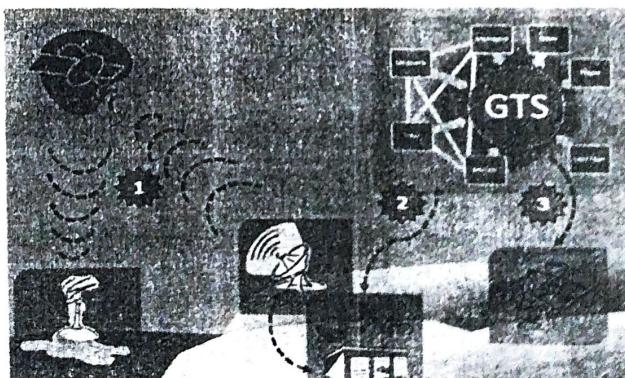
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Data and SATA

The telecommunications system

- **Telecommunications system:** Combination of hardware and software that transmits information (text, data, graphics, and voice) from one location to another.
- **Analog signal:** Continuous waves that transmit information by altering the amplitude and frequency of the waves.
- **Digital signal:**
A discrete pulse, either on or off, that conveys information in a binary form.

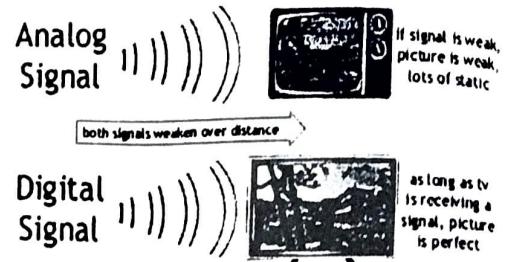


Telecommunication data

Note:

Analog vs Digital Transmission Terminology

- Analog data take on continuous values in a given interval, e.g. audio (human speech) or video.
- Digital data take on discrete values, e.g. text or integers.
- Signals are electromagnetic representations of data.
- Signaling is the physical propagation of the signal along a suitable medium.
- Transmission is the communication of data by the propagation and processing of signals.



Analog Data - Digital Signals

- **Analog signals** had the drawback that they attenuate (weaken) over long distances. Needed amplifiers to boost the signals. However, amplifiers distort the signal and introduce noise. Used in early telephone systems.
- **A digital signal** is a sequence of binary voltage pulses (0's and 1's).
- Digital transmission avoids the noise problem by encoding the analog signal into digital form. The digitized version is then sent across the network.
- The transmission of data across a long distance requires a modulator at one end to modulate the signal, i.e. modify the carrier wave. A demodulator is required at the other end to demodulate or reproduce the original signal.
- A modem is a device which performs modulation and demodulation functions.
- A codec (coder -decoder) converts analog signals to digital data - used mainly for voice data.

Note:

Why Digital?

- Ease with which digital signals are generated compared to analog.
- Digital signals are subject to less distortion and interference than are analog signals.
- Easier to detect and correct errors in digital data.
- Digital circuits are :
 - more reliable.
 - more flexible.
 - cheaper.

Communication Modes

Three modes are used to send data over a transmission line as shown in the following Figure. They are:

- **Simplex mode:**

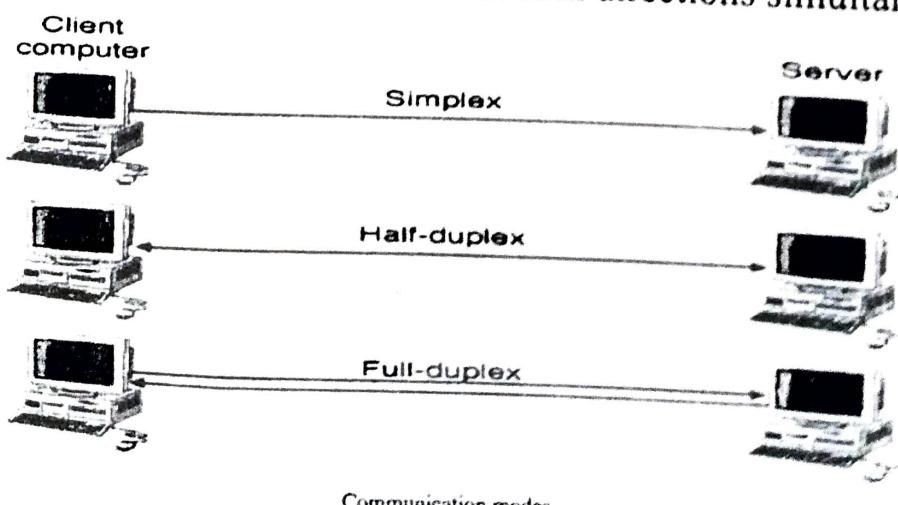
In this mode, data is transmitted in one direction only.

- **Half-Duplex mode:**

In this mode, data is transmitted in either direction, but not simultaneously. Used when devices wish to exchange data alternately.

- **Full-Duplex mode:**

In this mode, data is transmitted in both directions simultaneously.



Communication modes

Uses for computer networks:

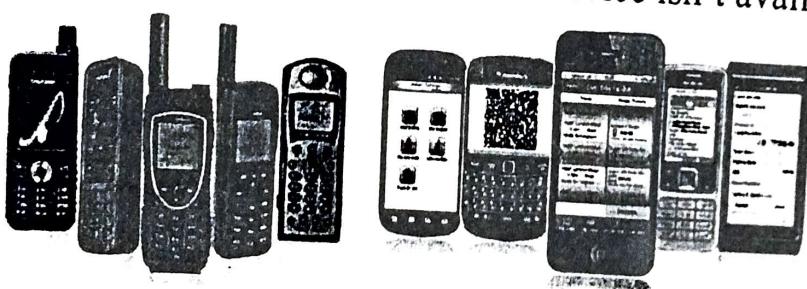
1. Sharing an internet connection among several users.
2. Sharing application software, printers, and other resources.
3. Facilitating voice over IP (VOIP), e-mail, video conferencing and other communication applications.
4. Working collaboratively, such as sharing a company database or using collaboration tools to create or review documents.
5. Exchanging files among network users and over the internet.
6. Connecting the computers and the entertainment devices, such as TVs, gaming consoles, and stereo systems located within a home.

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Note:

Networking and Communications Applications

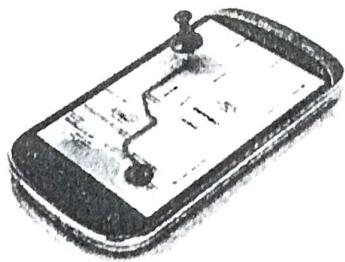
- Mobile phones (wireless phones).
 - Cellular (cell) phones (most common).
 - Satellite phones (used where cell service isn't available).



Types of mobile phones

- **Paging:** sending short numeric or text messages to a person's pager.
 - Most often used for onsite paging applications.
- **Messaging:** two-way paging.
 - Most often takes place today via a mobile phone.

- **Global positioning system (GPS):** Uses satellites and a receiver to determine the exact geographic location of the receiver.
 - Commonly found in cars today.
 - Available as handheld units.
 - Used by the military, hikers, travelers, and others who need to know their precise location.



Global positioning system

- **Monitoring systems:** which are used to monitor status or location of individuals, vehicles, assets, etc.
 - Electronic medical monitors.
 - GPS-based monitoring systems.
 - RFID short-range monitoring systems.
 - Monitoring via the Internet.
- **Satellite radio:** which delivers digital radio content to satellite receivers, which can be.
 - Car-mounted.
 - Placed in the home.
 - Carried around.
- **Video conferencing:** which use communications technology for real-time, face-to-face meetings between individuals located in different places.
 - Online conferencing (via the Internet).
 - Dedicated videoconferencing room.
 - Video phone calls.

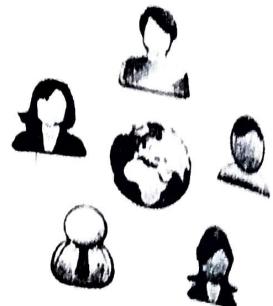


Satellite radio

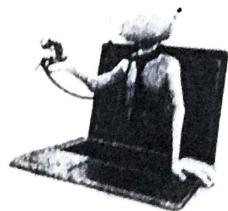


Video conferencing

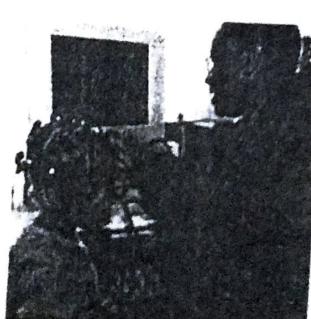
- **Collaborative computing (workgroup computing):** using a computer and communications technology to work together on documents and other project components.
- **Telecommunicating:** individuals work at home and communicate with their place of business and clients via communications technologies.
- **Digital data distribution:** transferring digital data (digital photos, music, movies, TV broadcasts, medical imaging files, etc.) electronically from one place to another.
 - Home use.
 - Business use.
 - Digital movie distribution.



- **Telemedicine:** use of communications technology to provide medical information and services.
 - Remote monitoring and consultations.
 - Remote diagnosis.
 - Telesurgery.



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



REMOTE DIAGNOSIS
At remote locations, such as the New York child-care center shown here, trained employees provide physicians with the real-time data (sent via the Internet) they need for 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.

Types of Networks

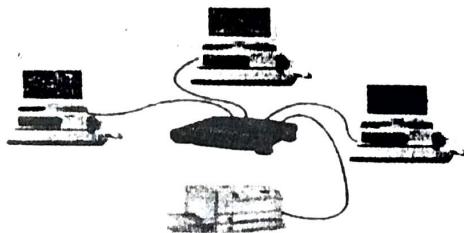
Networks can be identified by their

- Topology (physical arrangement).
- Architecture (the way they are designed to communicate).
- Size (how large of an area the network services).

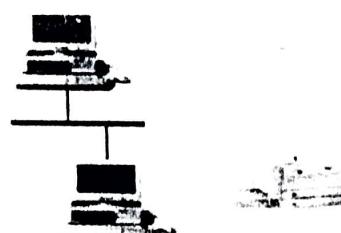
➤ Network Topologies:

Network topology means the way by which the devices are connected to form the network. There are different types of network topologies as shown in the following Figure. From these topologies:

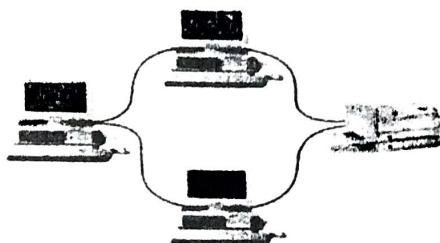
- **Star networks** (all devices connect to a central device or hub).
- ~~Bus~~ networks (all devices connect to a central cable).
- Ring networks (devices connect to one another in a ring).
- Mesh networks (multiple connections between devices).
- Some networks use a combination of topologies.



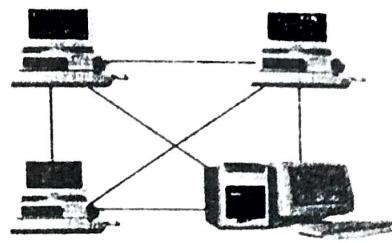
STAR NETWORK
Uses a central hub to connect each device directly to the network.



BUS NETWORK
Uses a single central cable to connect each device in a linear fashion.



RING NETWORK
Connects computers and other devices one to the next in a loop; there is no central hub or cable.



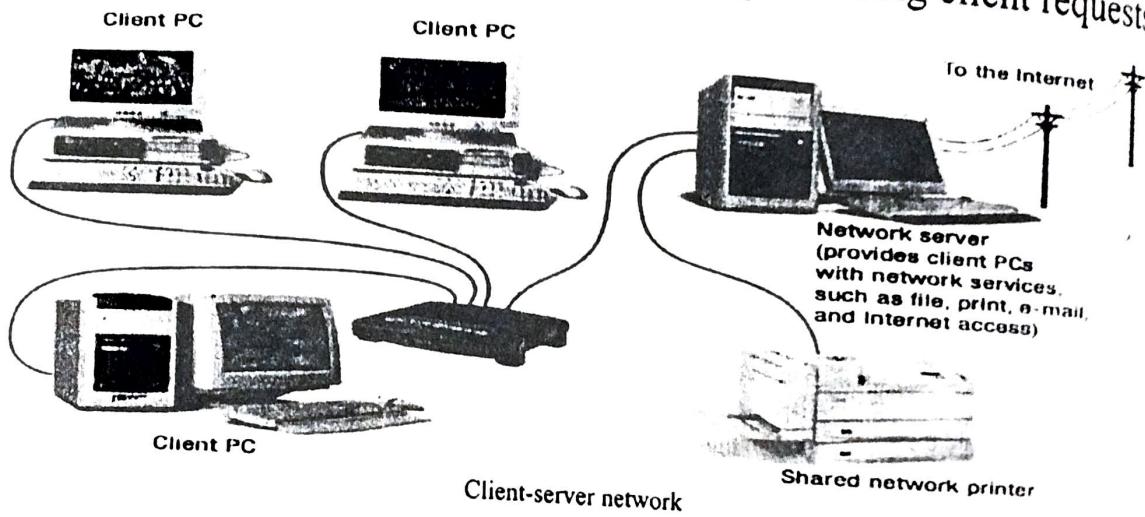
MESH NETWORK
Each computer or device is connected to all other devices.

Computer topologies

➤ Network Architectures

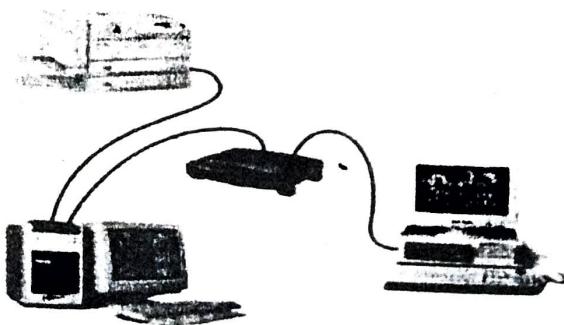
Network architecture is concerned with how the data are exchanged between the devices. From the types of computer architectures are:

- Client-server networks.
 - **Client:** PC or other device on the network that requests and utilizes network resources.
 - **Server:** computer dedicated to processing client requests.

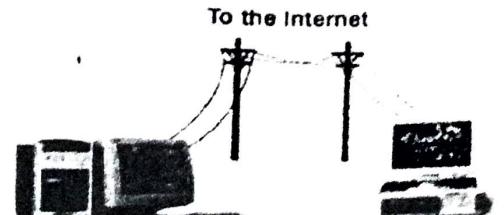


Note:

- **Peer-to-peer networks** (all computers at the same level).
 - Internet peer-to-peer (P2P) computing: performed via the Internet.



P2P HOME NETWORK
(PCs connect and communicate via network cabling and other networking hardware.)

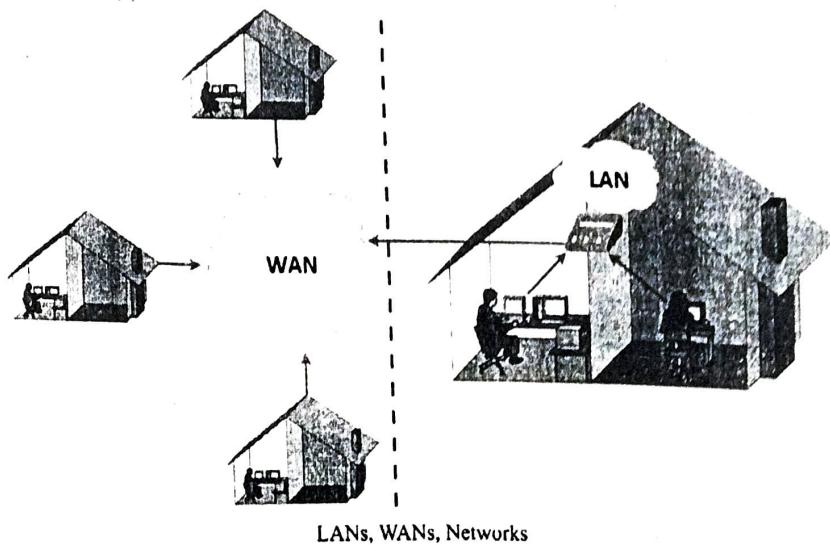


INTERNET P2P NETWORK
(PCs connect and communicate via the Internet.)

➤ Classification of computer networks from size point of view:

LANs, WANs, and Other Types of Networks

- **Local area network (LAN):** covers a relatively small geographical area, such as a home, office building, or school.
- **Wide area network (WAN):** covers a large geographical area; may consist of two or more LANs, which could be relatively close to one another (such as in the same city) or far apart.
- **Metropolitan area network (MAN):** designed for a metropolitan area, typically a city or county.
- **Personal area network (PAN):** connects personal devices for one individual, such as his or her portable PC, cell phone, and portable printer.
- **Intranet:** private network, such as a company LAN, set up by an organization for use by its employees.
- **Extranet:** intranet that is at least partially accessible to authorized outsiders.
- **Virtual private network (VPN):** group of secure paths over the Internet that provide authorized users a secure means of accessing a private network via the Internet.



Note:

Note:

How Does Data Travel Over a Network?

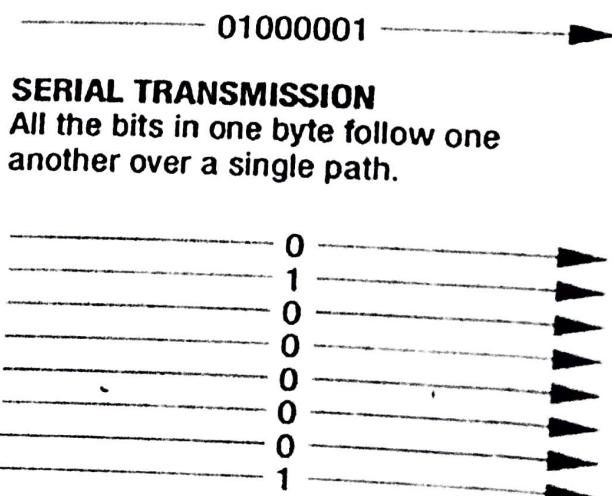
- Data transmitted over a network has specific characteristics.
- Data can travel over a network in various ways.
- Network devices can communicate through a.
 - **Wired connection:** via physical cables.
 - **Wireless connection:** typically through radio signals.

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Data Transmission Characteristics

- **Analog vs. digital:** continuous wave vs. discrete 0s and 1s.
- **Bandwidth (throughput):** amount of data that can be transmitted over a communications medium at one time (higher bandwidth will deliver data faster).
- **Serial vs. parallel transmission.**
 - **Serial:** one bit a time.
 - **Parallel:** at least one byte at a time.

Note: _____



PARALLEL TRANSMISSION
The eight bits in each byte are transmitted over separate paths at the same time.

Serial versus parallel transmission

- **Transmission timing:**

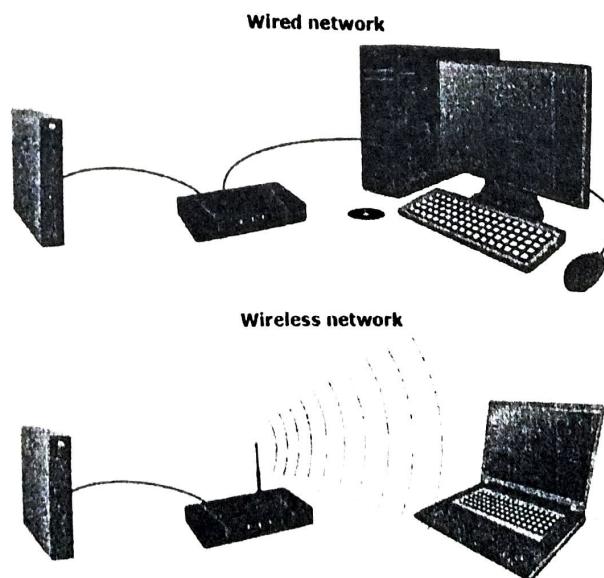
- Synchronous transmission (at regular, specified intervals).
- Asynchronous transmission (sent when ready).
- Isochronous transmission (sent at the same time as other, related, data).

- **Transmission directions:**

- Simplex transmission (one way only).
- Half-duplex transmission (one way at a time).
- Full-duplex transmission (both ways at the same time).

Wired vs. Wireless Connections

- **Wired network:** connection: the PC is physically cabled to the network.
 - Common in schools, business, and government facilities.
- **Wireless networks:** typically use radio waves to send data through the air.
 - Rapidly becoming more popular in homes and businesses; wireless hotspots are commonly available in public locations.



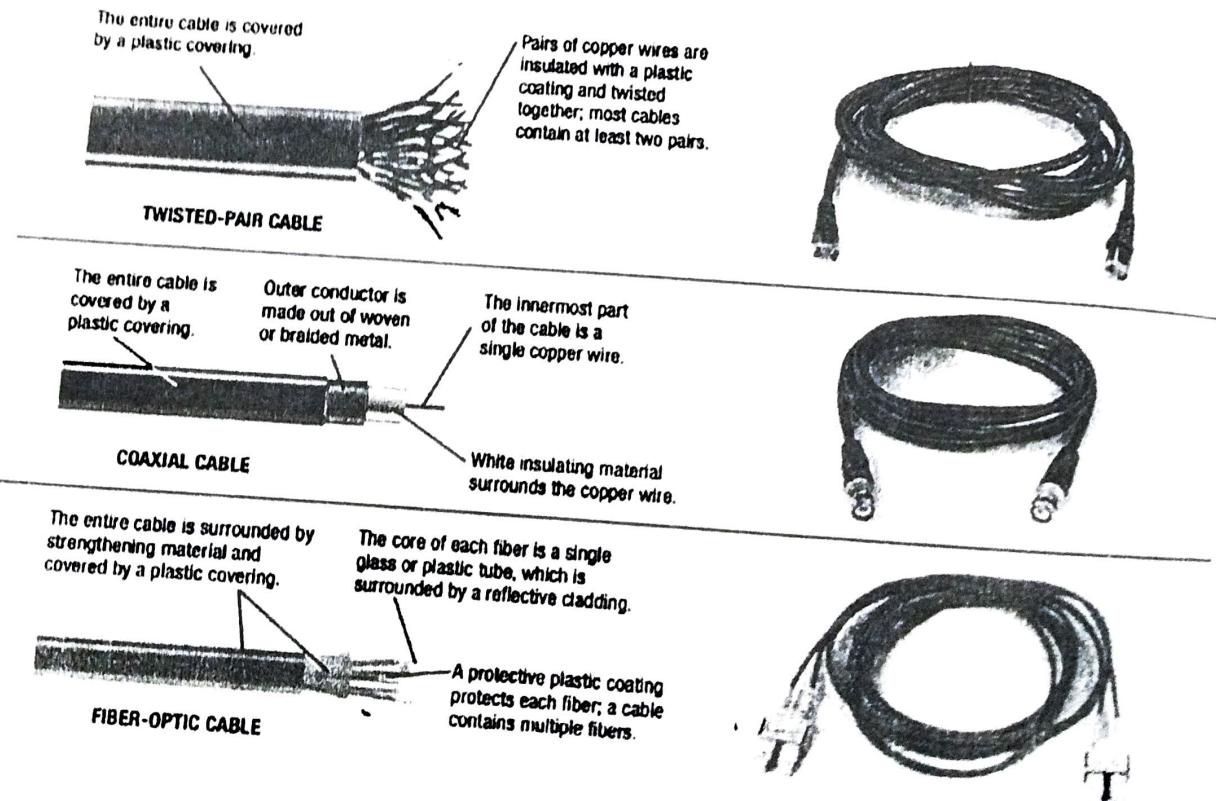
Note:

➤ Wired Network Transmission Media

- **Twisted-pair cable:**
 - Pairs of wires twisted together.
 - Used for telephone and network connections.
- **Coaxial cable:**
 - Thick center wire.
 - Used for computer networks, short-run telephone transmissions, cable television delivery.
- **Fiber-optic cable:**
 - Glass or fiber strands through which light can pass.
 - Used for high-speed communications.

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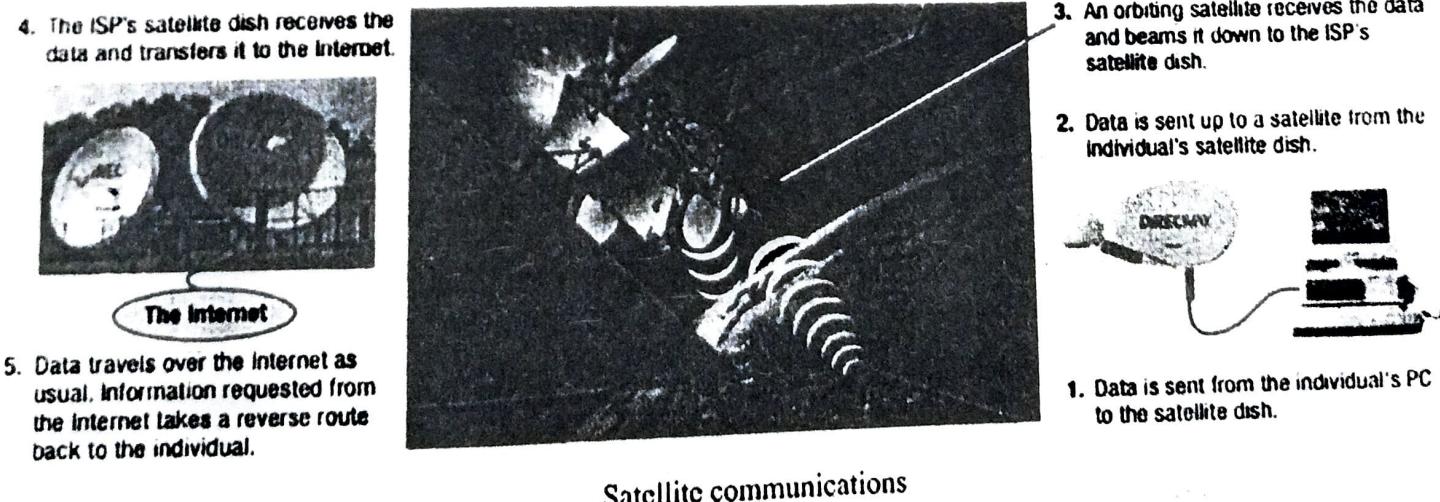
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Wired network transmission media

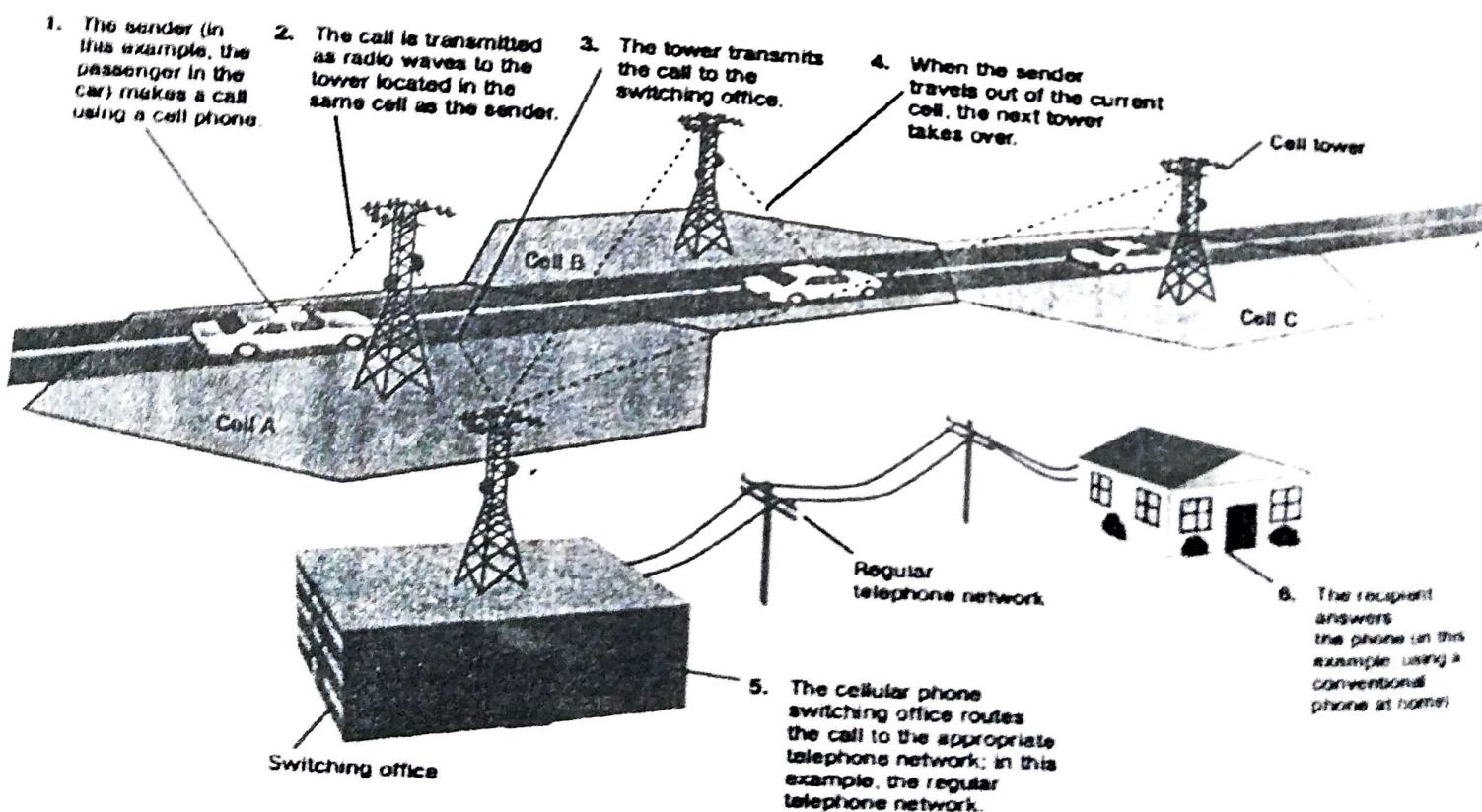
➤ Wireless Network Transmission Media

- **Broadcast radio transmissions:**
 - Short-range (such as Bluetooth): can connect a wireless keyboard or mouse to a PC.
 - Medium-range (such as Wi-Fi): used for wireless LANs and to connect portable PC users to the Internet at public hotspots.
- **Microwave and satellite transmissions:**
 - **Microwave stations** (earth based).
 - **Communications satellites** (placed in orbit).



- **Cellular radio transmissions:**

- Use cellular towers within cells.
- Calls are transferred from cell tower to cell tower as the individual moves.
- Different transmission frequencies are used to avoid interference and allow multiple conversations to take place via a single tower at one time.
- Widely used, but cell service not available everywhere.



How cellular phones work

Communications Protocols

- **Communications protocol:**

It is an agreed-upon standard for transmitting data between two devices on a network.

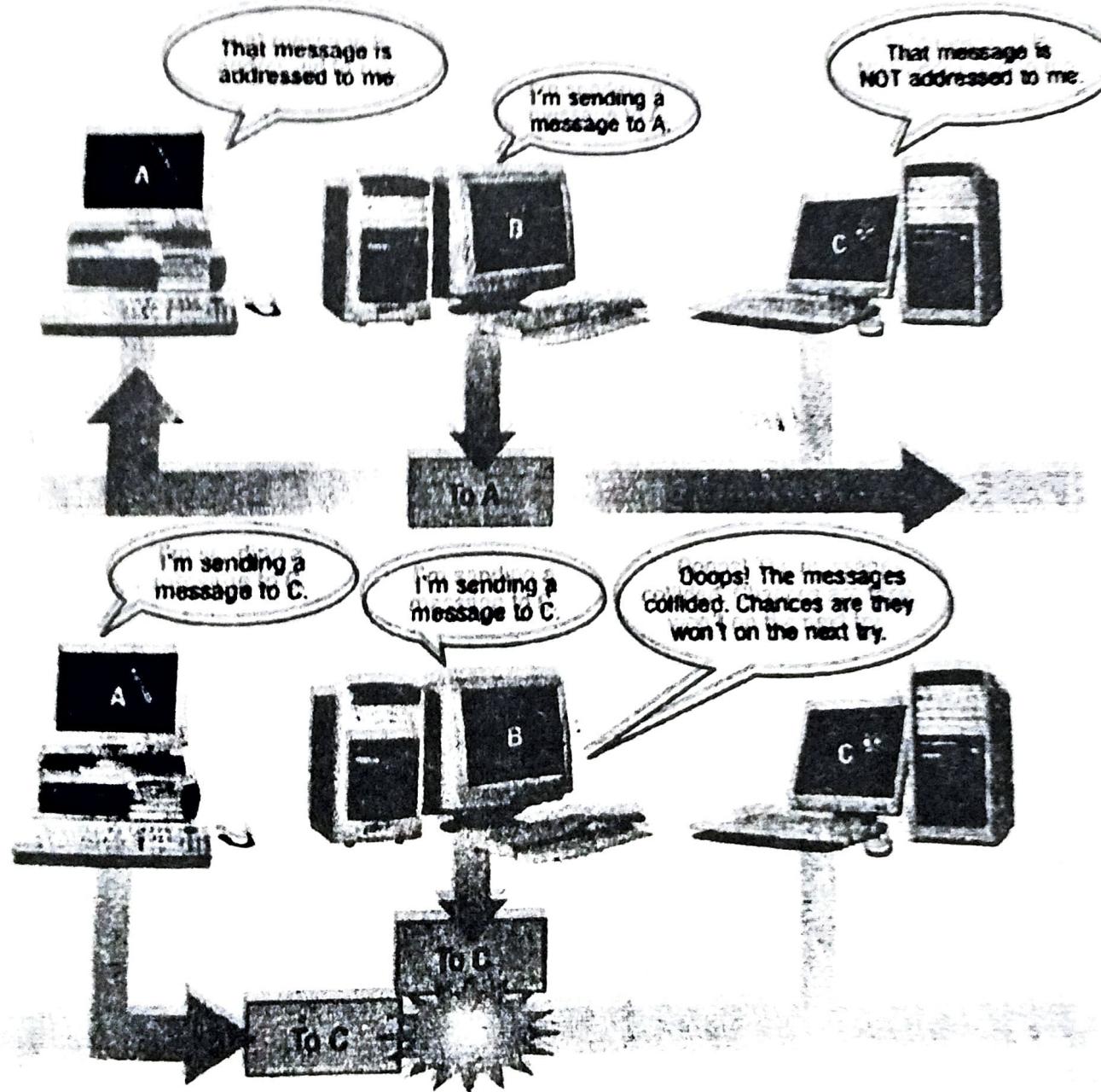
- **Protocols specify how:**

- Devices physically connect to a network.
- Data is packaged for transmission.
- Receiving devices acknowledge signals (handshaking).
- Errors are handled.

Ethernet

A widely used communications protocol for LANs.

- Typically used with LANs that have a bus or star topology and use twisted-pair or coaxial cables.
- Original (10Base-T) Ethernet networks run at 10 Mbps; newer 100 Mbps and 1 Gbps versions are now available.
- Utilizes a set of procedures (CSMA/CD) to send data and make sure it arrives.



SENDING MESSAGES

Computer B checks to see if the network is free and sends a message if it thinks it is. The message is broadcast across the network to all computers, but only the one it is addressed to, A, can pick it up.

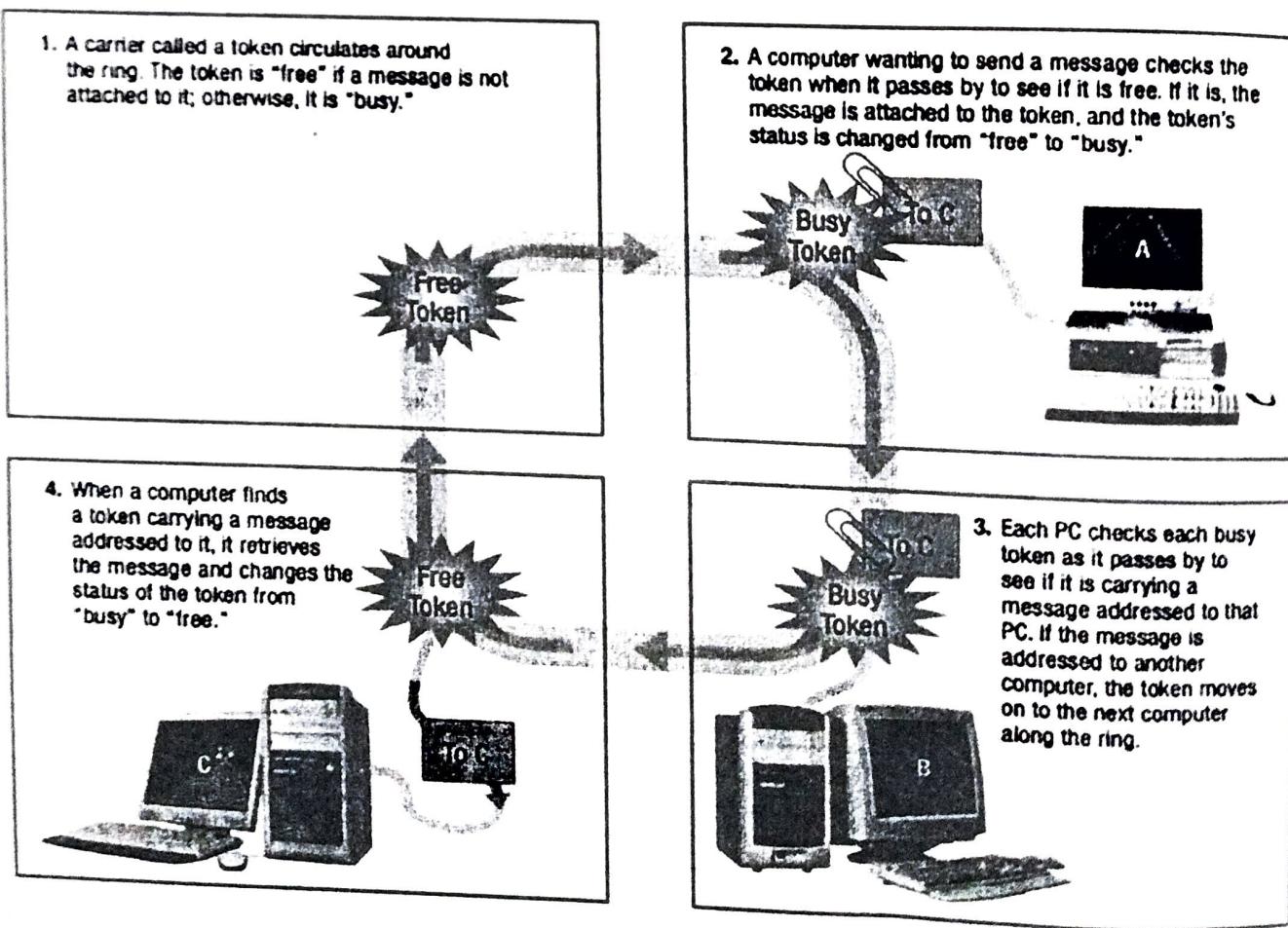
COLLISIONS

Collisions occur when two computers send messages at precisely the same time, both thinking the network is free. When a collision occurs, the computers can sense it, and each waits a random fraction of a second before transmitting its message again. Collisions and retransmissions are not noticeable to the user.

Token Ring

Communications protocol usually used with a ring network topology

- Utilizes a token to send and retrieve data.
- Token circulates in one direction.
- Token is either free or carries a message to be delivered to a device.
- Each device checks to see if the message is addressed to it.
- Devices can grab a free token and add a message.



Token Ring

Wi-Fi

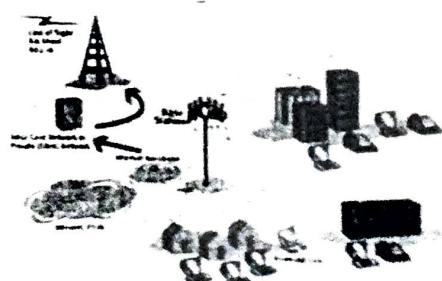
Wi-Fi (802.11): family of wireless networking standards:

- **802.11b:** original standard (11 Mbps).
- **802.11a (Wi-Fi5):** about five times faster than 802.11b; more expensive, uses a different radio frequency (5 GHz) than 802.11b (2.4 GHz), making the two standards incompatible.
- **802.11g:** current Wi-Fi standard; supports data transfer rates of 54 Mbps; it uses the same 2.4 GHz frequency as 802.11b, so their products are compatible.
- **802.11n (Fast Wi-Fi):** in development.



Mesh Networks, WiMAX, Mobile-Fi, and xMax

- **Mesh networks:** use a mesh topology, so messages can take any of several possible paths from source to destination.
 - Used to connect wireless networks.
 - Can be used to enlarge hotspot areas.
 - Can be used to allow emergency workers to communicate with one another.
 - Most often used to create MANs.
- **WiMAX (802.16):** emerging wireless networking standard that is faster and has a greater range than Wi-Fi.
 - Expected to provide fast wireless Internet access over a distance of up to 30 miles.
 - Mobile WiMAX is under development.



WiMAX (802.16)

- **Mobile-Fi (802.20):** high-speed mobile Internet technology currently in development.
 - Expected to be used while moving, such as in cars and trains.
- **xMax:** recently developed, for longer range wireless connections; uses unused portions of radio channels.

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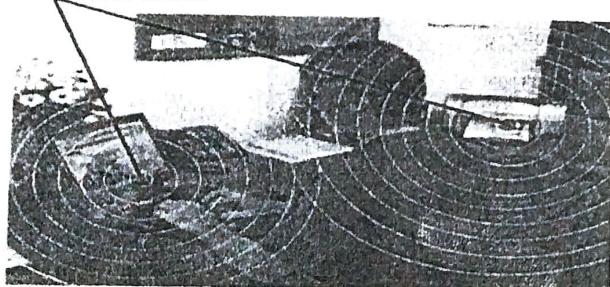
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Bluetooth

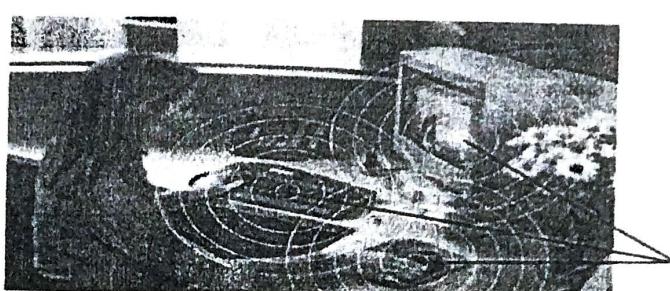
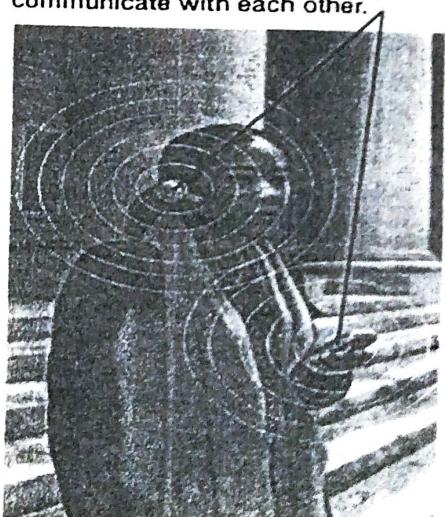
Communications standard for very short-range wireless connections.

- The devices are automatically connected once they get within the allowable range.
- Designed for communications between personal devices (within 10 meters or 33 feet), such as keyboards and PCs, cell phones and earpieces, PCs and printers, etc.
- Devices form piconets of up to 8 devices each.

The notebook PC and printer form a piconet when they are within range to communicate with each other.



The headset and cell phone form a piconet when they are within range to communicate with each other.



The desktop PC, keyboard, and mouse form a piconet to communicate with each other.

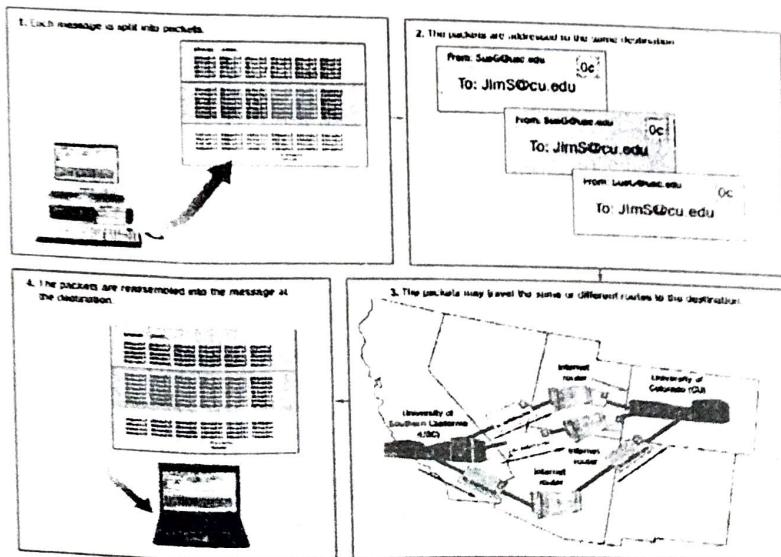
Ultra Wideband (UWB)

Another short-range wireless technology.

- Faster and has a greater range than Bluetooth.
- Originally developed for the military in the 1960s.
- Beginning to be used to wirelessly network consumer multimedia devices to wireless deliver digital data (video, music, photos, etc.).
- Emerging Bluetooth standards may use UWB to speed up connections between devices.

TCP/IP and Wireless Application Protocol (WAP)

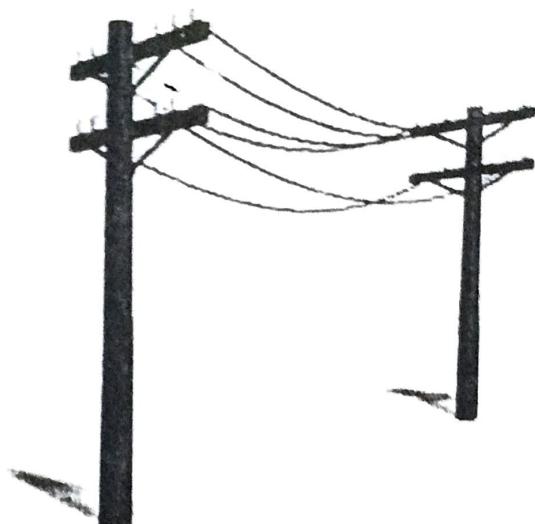
- **TCP/IP:** Protocol used for transferring data over the Internet.
 - Uses packet switching to facilitate the transmission of messages.
 - Packets are sent separately and reassembled at the final destination.
 - Also used with home networking.
- **Wireless Application Protocol (WAP):** Standard for delivering content, such as Web pages, to mobile devices.



Phone line and Power line Networks

- **Phone line or Home PNA standard:**

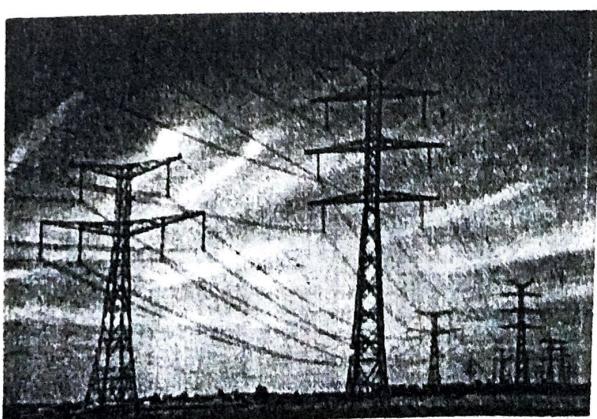
- Allows computers to be networked through ordinary phone wiring and phone jacks, without interfering with voice telephone calls.
- Geared toward setting up quick and easy home networks.



Phone line or Home PNA standard

- **Power line standard:**

- Allows PCs to be networked over existing power lines using conventional electrical outlets.
- Emerging standard will also connect home entertainment devices.



Power line standard

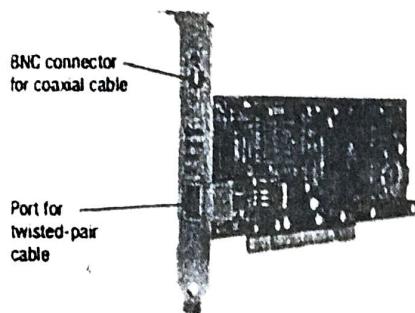
Networking Hardware

Used to connect a PC to a network.

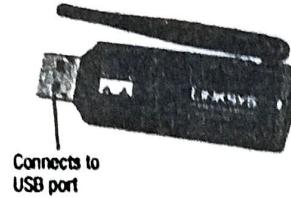
- Also called **network interface card (NIC)** when in the form of an expansion card.
- Come in a variety of formats.
 - PCI.
 - USB.
 - PC Card.
- Adapter must match the type of network being used (Ethernet, WiFi, Bluetooth, etc.).

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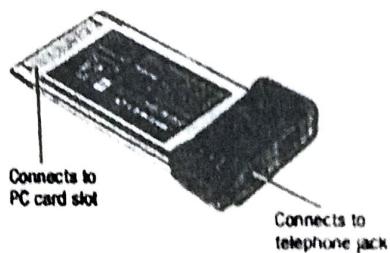
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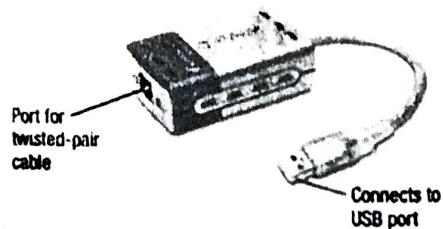
PCI ETHERNET ADAPTER FOR DESKTOP PC



USB BLUETOOTH ADAPTER FOR DESKTOP OR NOTEBOOK PC



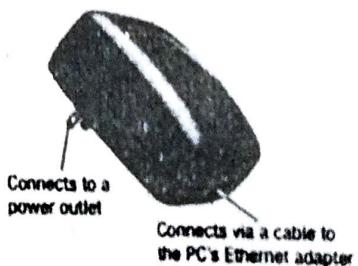
PHONELINE ADAPTER FOR NOTEBOOK PC



USB ETHERNET ADAPTER FOR DESKTOP OR NOTEBOOK PC



WI-FI ADAPTER FOR NOTEBOOK PC

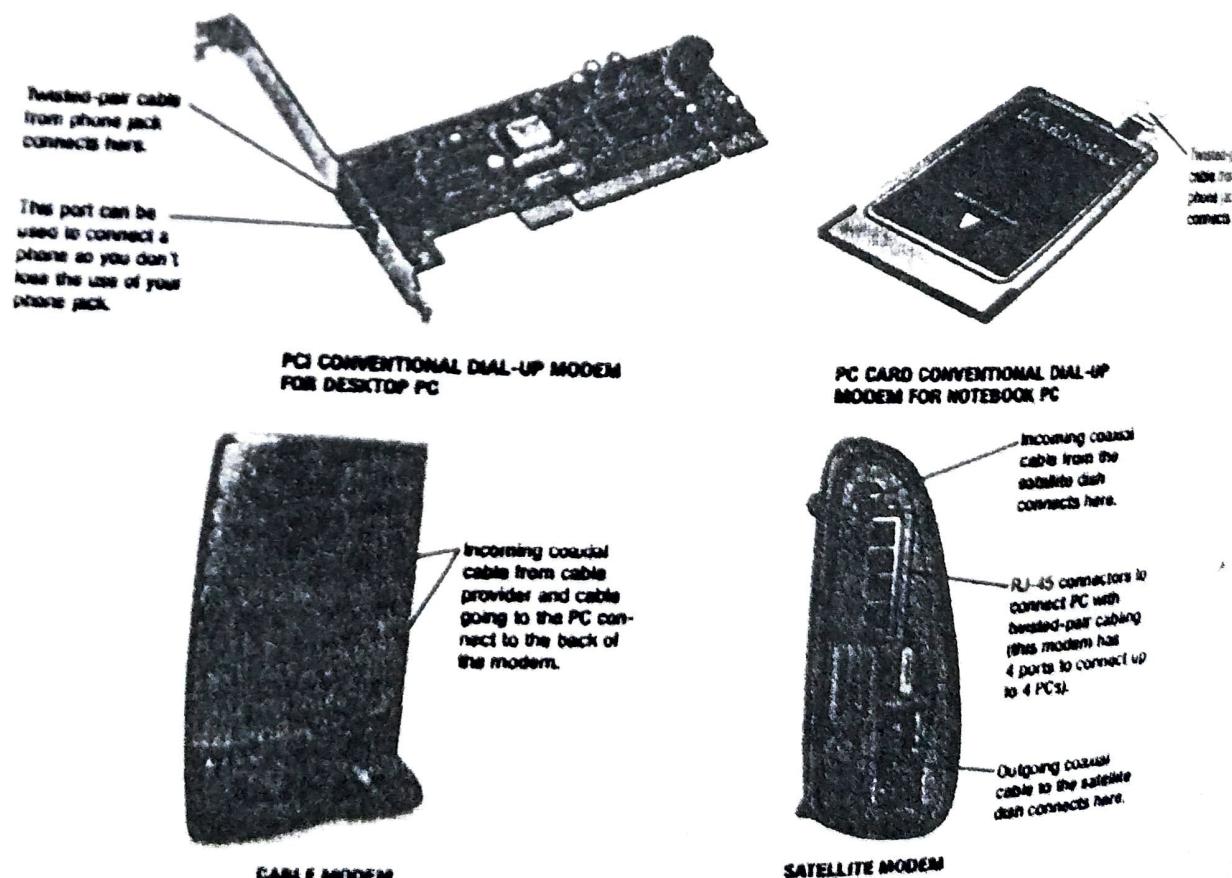


POWERLINE ETHERNET BRIDGE FOR DESKTOP OR NOTEBOOK PC

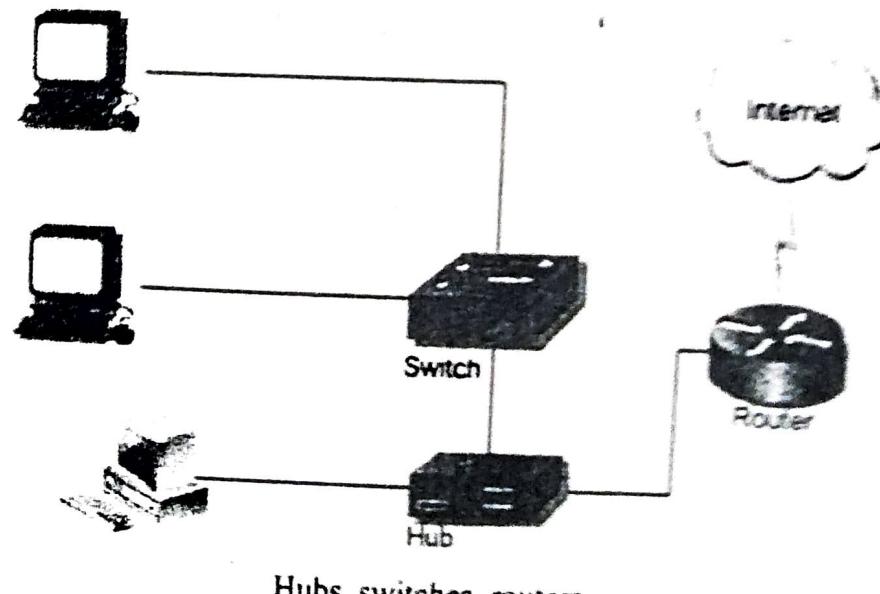
Network adapters and modems

- **Modem:** device that connects a computer to the Internet.
 - Term used even if not connecting via a phone line.
 - Type of modem needed depends on the type of Internet access being used.

- Conventional dial-up.
- ISDN.
- DSL.
- Cable.
- Satellite.

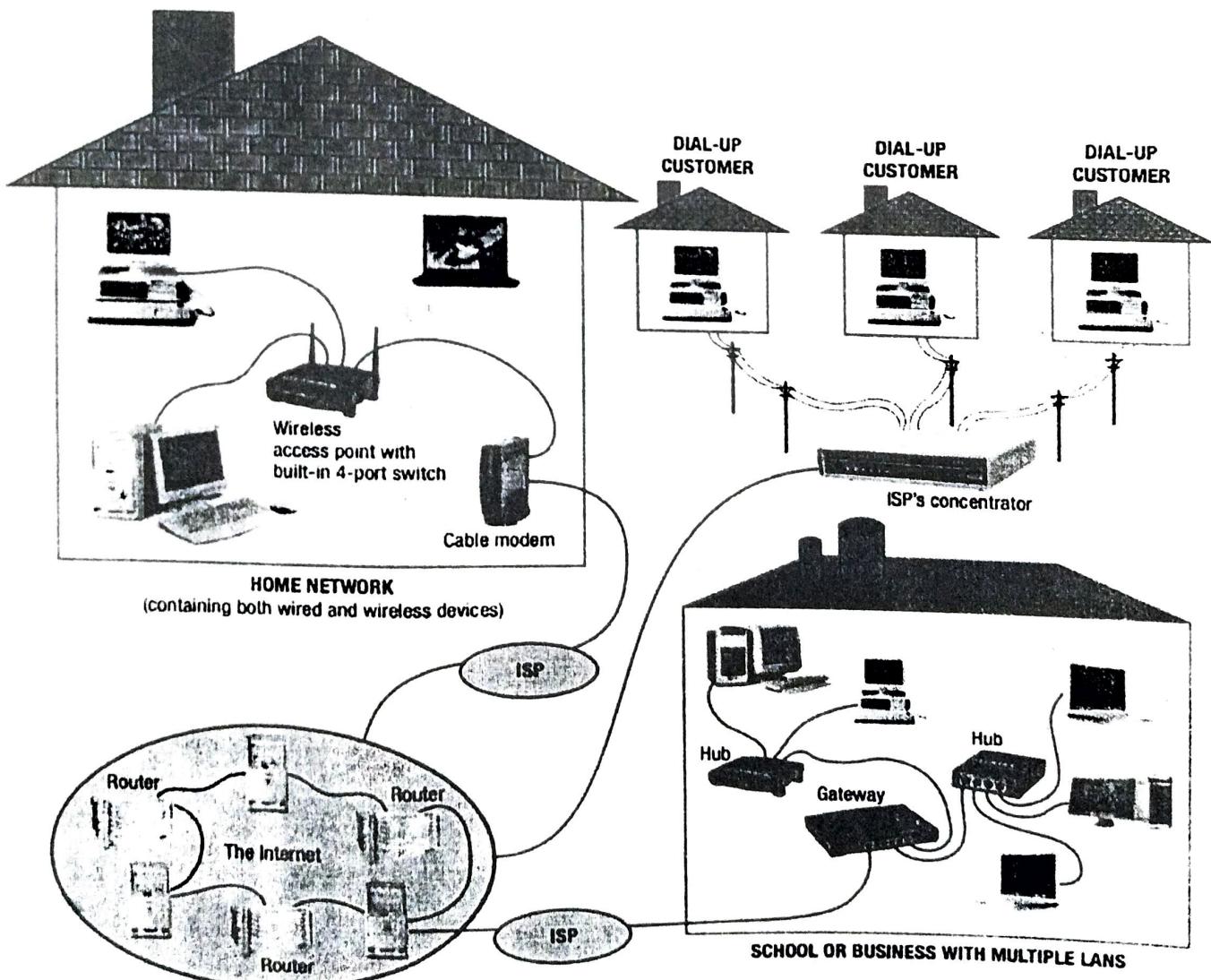


- Hubs, switches, routers, and wireless access points: used to connect devices and route data to the devices on a network.
 - Hub: all data goes to all devices.
 - Switch: data goes to just appropriate device.
 - Router: more efficiently delivers data.
 - Wireless access point: connects wireless devices to a wired network.
 - Some devices contain more than one of these capabilities.

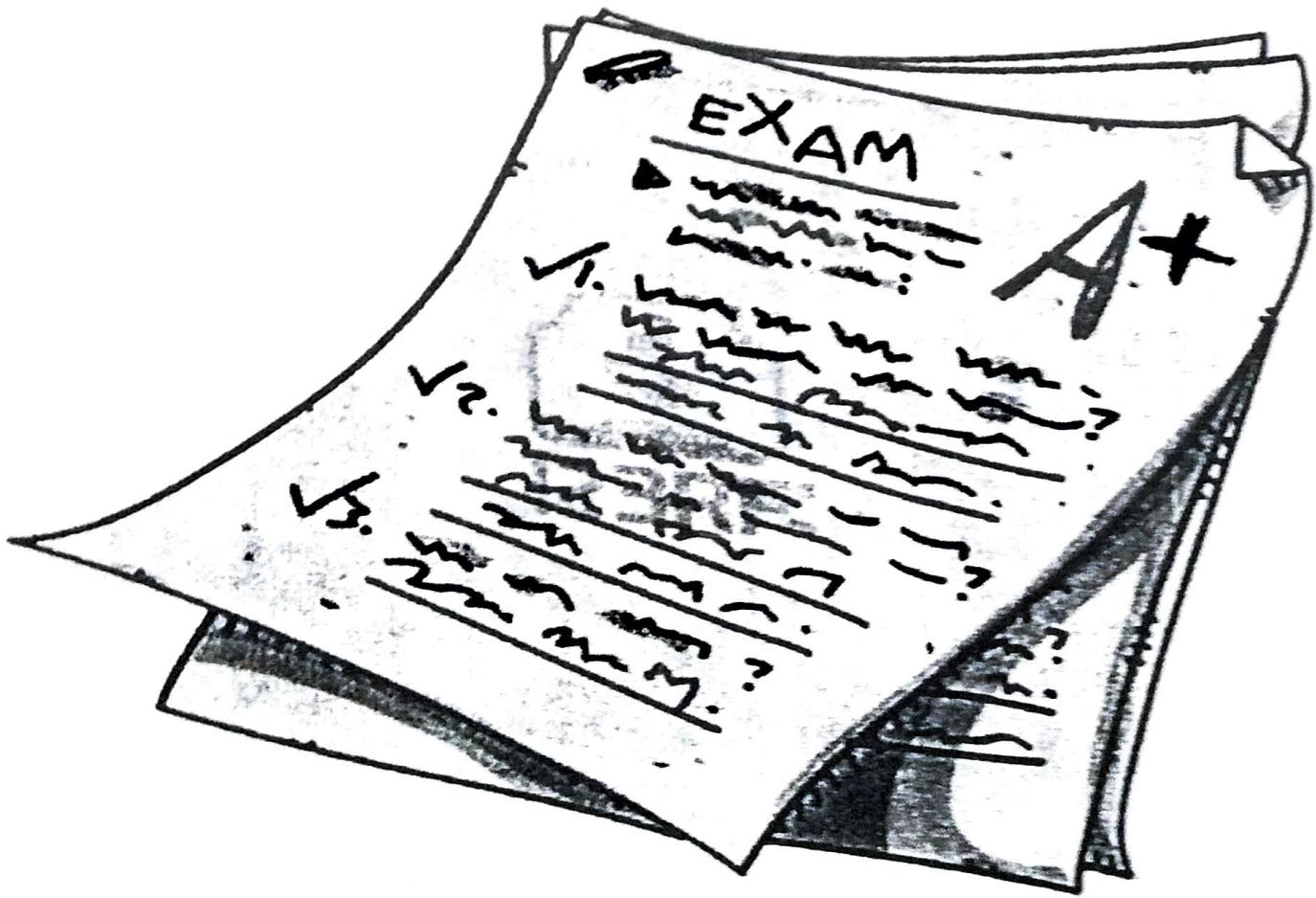


Hubs, switches, routers

- **Gateways and bridges:** connect one network to another.
 - **Gateway:** connects dissimilar networks.
 - **Bridge:** connects similar networks.
- **Repeaters:** amplify signals on a network so they can travel further.
- **Multiplexers and concentrators:** combine transmissions from multiple devices to send over a medium and then separates them again at the destination.



Exercises



1- Match each key term on the left with the definition on the right that best describes it.

Key term matching	Description
a. antenna	1- A collection of computers and other hardware devices that are connected together to share hardware, software, and data, as well as to communicate electronically with one another.
b. Bluetooth	2- A device used for receiving or sending radio signals; often used to increase the range of a network.
c. computer network	3- A device used to connect multiple devices on a single (typically wired) network; forwards packets to only the intended recipient.
d. digital transmission	4- A networking standard for very short-range wireless connections; the devices are automatically connected once they get within the allowable range.
e. Ethernet	5- A network in which there are multiple connections between the devices on the network so that messages can take any of several possible paths.
f. global positioning system (GPS)	6- An emerging wireless networking standard that is faster and has a greater range than Wi-Fi.
g. mesh network	7- A networking protocol that uses packet switching to facilitate the transmission of messages; the protocol used with the Internet.
h. switch	8- A system that uses satellites and a receiver to determine the exact geographic location of the receiver.
i. TCP/IP	9- A type of data transmission where the data is represented by 0s and 1s.
j. WiMAX	10- A widely used wired LAN networking standard.

2- Circle T if the statement is true and F if the statement is false.

- a). T F GPS systems are used only by the government.
- b). T F With serial transmissions, each bit of data is sent individually.
- c). T F The Internet is an example of a LAN.
- d). T F The type of cable used inside most homes for telephone service is twisted-pair wire.
- e). T F A router is a type of modem.

3- Write the best answer in the space provided.

- a). With a(n) network topology, all devices are connected in a line to a central cable.
- b). A(n) phone can be used with more than one communications network, such as with both a cellular and Wi-Fi network.
- c). A small network designed to connect the personal devices for an individual (such as via Bluetooth) is called a(n)
- d). A(n) is a network that transfers private information securely over the Internet or other public network.

4- Match each description to its networking application, and write the corresponding number in the blank to the left of the description.

a. To diagnose a patient from a distance.	1. Multimedia networking
b. To work for a company in New York when you live in California.	2. GPS
c. To watch a TV show in the living room that is recorded on your computer.	3. Telemedicine
d. To receive telephone calls while you are out shopping.	4. Telecommuting
e. To determine your physical location while hiking in the mountains.	5. Cellular phone