Chapter One: Introduction

Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable. For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware (physical equipment) and software (programs). The effectiveness of a data communications system depends on four fundamental characteristics:

- Delivery: The system must deliver data to the correct destination. Data must be received by the intended device or user and only by that device or user.
- Accuracy: The system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.
- Timeliness: The system must deliver data in a timely manner. Data delivered late are useless. In the case of video and audio.
- Jitter: Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets.

A data communications system has five components (see Figure (1.1)).

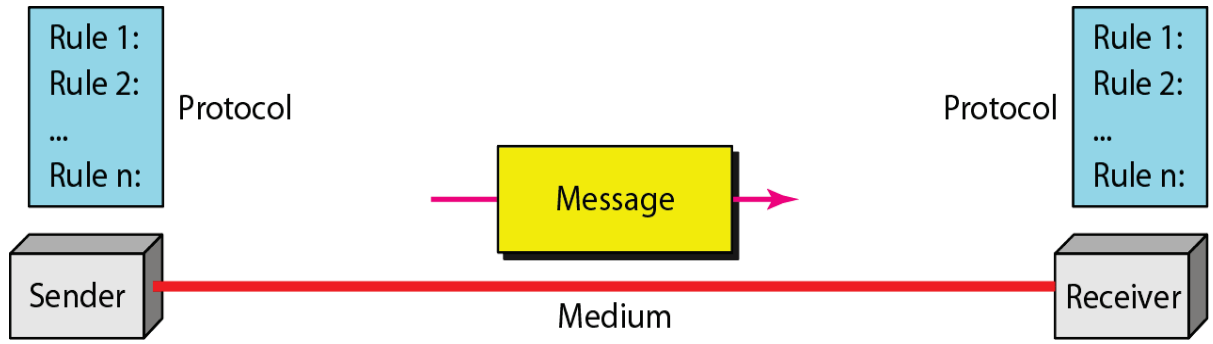

Fig. (1.1): Five components of data communication system.

1. **Message**. The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
2. **Sender**. The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
3. **Receiver**. The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
4. **Transmission medium**. The transmission medium is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.

5. **Protocol**. A protocol is a set of rules that govern data communications.

Data Flow

Communication between two devices can be simplex, half-duplex, or full-duplex as shown in Figure (1.2).

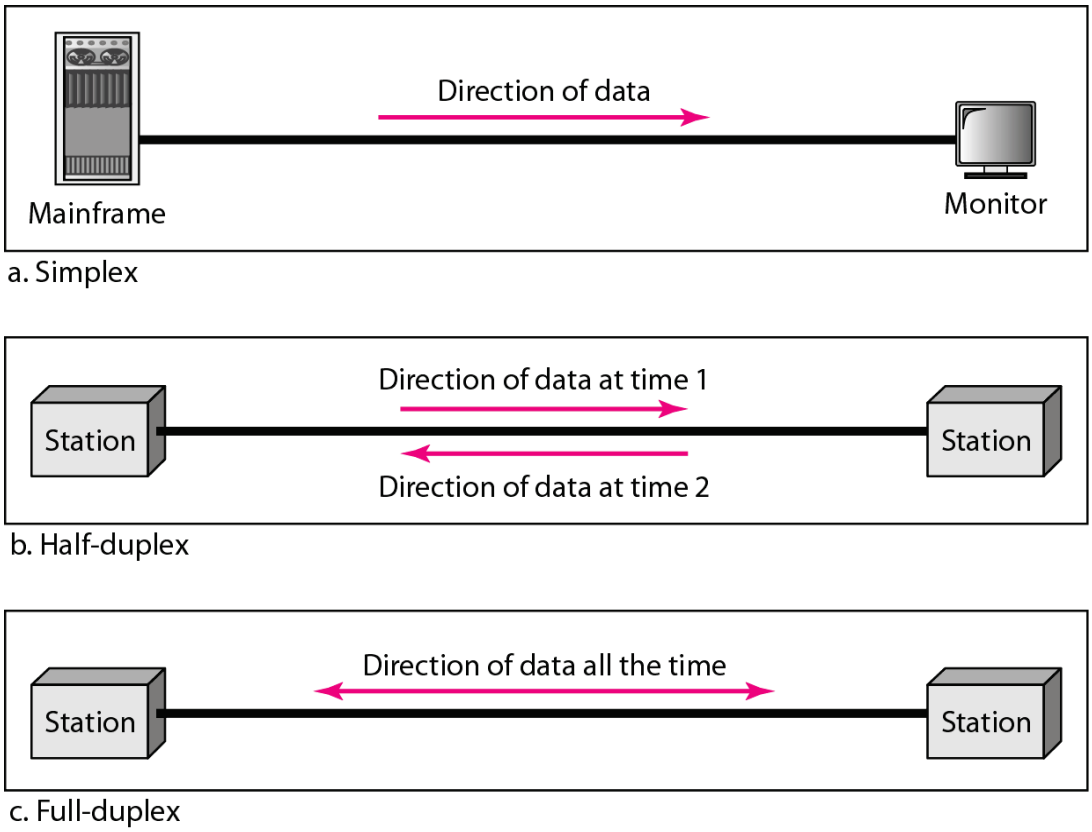

Fig. (1.2): Data flow (simplex, half-duplex and full-duplex).

Simplex

In simplex mode, the communication is unidirectional, as on a one-way street. Only one of the two devices on a link can transmit; the other can only receive.

Half-Duplex

In half-duplex mode, each station can both transmit and receive, but not at the same time.

Full-Duplex

In full-duplex (called duplex), both stations can transmit and receive simultaneously.

NETWORKS

A network is a set of devices (often referred to as *nodes)* connected by communication links. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.

Network Criteria:

- **Performance**
    - Depends on Network Elements.
    - Measured in terms of Delay and Throughput.
- **Reliability**
    - Failure rate of network components.
    - Measured in terms of availability/robustness.
- **Security**
    - Data protection against corruption/loss of data due to:
        - Errors.
        - Malicious users.

Networks Advantages:

- **File Sharing**: The major advantage of a computer network is that is allows file sharing and remote file access.
- **Resource Sharing**: Files, modems, printers…
- **Increased Storage Capacity**: As there is more than one computer on a network which can easily share files, the issue of storage capacity gets resolved to a great extent.
- **Increased Cost Efficiency**: There are many software available in the market which are costly and take time for installation. Computer networks resolve this issue as the software can be stored or installed on a system or a server and can be used by the different workstations.

Networks Disadvantages:

- **Security Issues**: Physical access, computer hacker can get unauthorized access by using different tools.
- **Rapid Spread of Computer Viruses**: If any computer system in a network gets affected by computer virus, there is a possible threat of other systems getting affected too.

- **Expensive Set Up**: The initial set up cost of a computer network can be high depending on the number of computers to be connected. Costly devices like routers, switches, hubs, etc., can add up to the bills of a person trying to install a computer network. He will also have to buy NICs (Network Interface Cards) for each of the workstations, in case they are not inbuilt.
- **Dependency on the Main File Server**: In case the main File Server of a computer network breaks down, the system becomes useless. In case of big networks, the File Server should be a powerful computer, which often makes it expensive.

Physical Structures

- **Type of Connection**
    - **Point-to-Point** A point-to-point connection provides a dedicated link between two devices.
    - **Multipoint** A multipoint (also called multidrop) connection is one in which more than two specific devices share a single link (see Figure (1.3)).

In a multipoint environment, the capacity of the channel is shared, either spatially or temporally. If several devices can use the link simultaneously, it is **a *spatially shared*** connection. If users must take turns, it is a ***timeshared*** connection.

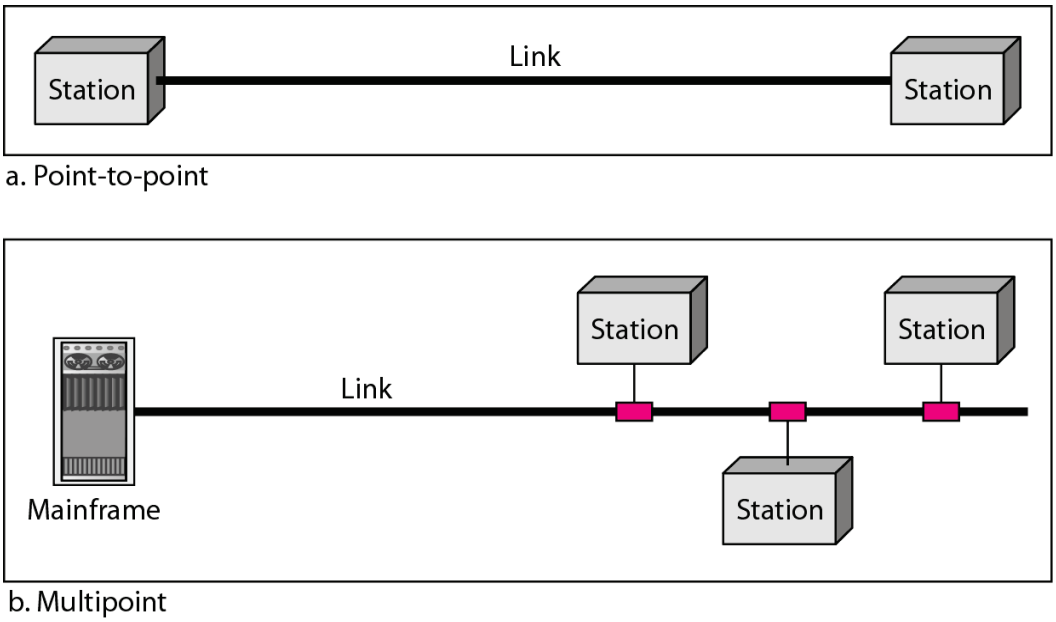

Fig. (1.3): Types of connections: (Point-to-Point and Multipoint).

Physical topology

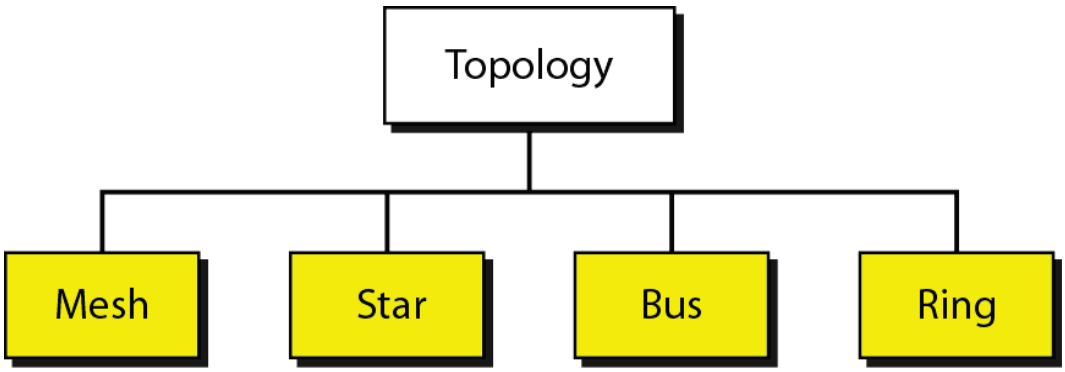

Fig. (1.4): Categories of topology.

Mesh topology

Every device has a dedicated point-to-point link to every other device. The term *dedicated* means that the link carries traffic only between the two devices it connects. To find the number of physical links in a fully connected mesh network with *n* nodes, we first consider that each node must be connected to every other node. Node 1 must be connected to *n* - I nodes, node 2 must be connected to *n* – 1 nodes, and finally node *n* must be connected to *n* - 1 nodes. We need *n(n* - 1) physical links. However, if each physical link allows communication in both directions (duplex mode), we can divide the number of links by 2. In other words, we can say that in a mesh topology, we need *n(n* -1) /2.

Duplex-mode links: To accommodate that many links, every device on the network must have *n* – 1 input/output *(VO)* ports (see Figure (1.5)) to be connected to the other *n* - 1 stations.

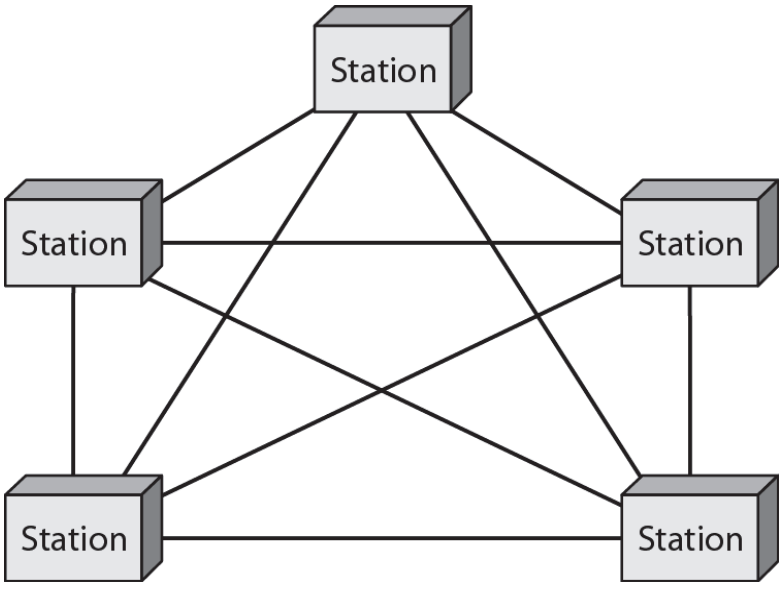

Fig. (1.5): ***A fully connected mesh topology (five devices)***

The advantages of mesh topology:

1. Use of dedicated links guarantees that each connection can carry its own data load, thus eliminating the traffic problems that can occur when links must be shared by multiple devices.
2. a mesh topology is robust
3. the advantage of privacy or security
4. Point-to-point links make fault identification and fault isolation easy.

The disadvantages of this topology related to the amount of cabling and the number of I/O ports required:

1. Every device must be connected to every other device, installation and reconnection are difficult.
2. The sheer bulk of the wiring can be greater than the available space (in walls, ceilings, or floors) can accommodate.
3. The hardware required to connect each link (I/O ports and cable) can be prohibitively expensive.

One practical example of a mesh topology is the connection of telephone regional offices in which each regional office needs to be connected to every other regional office

Star Topology

In a star topology, each device has a dedicated point-to-point link only to a central controller, usually called a hub. The devices are not directly linked to one another. If one device wants to send data to another, it sends the data to the controller, which then relays the data to the other connected device (see Figure (1.6)).

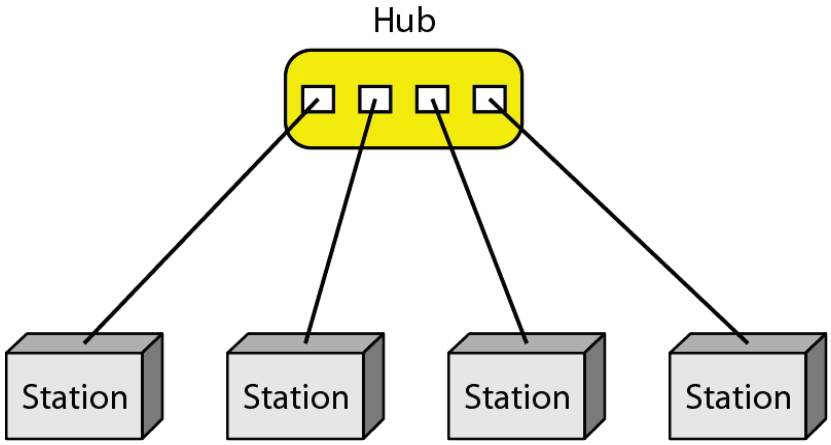

Fig. (1.6): A star topology connecting four stations

The advantages of this topology:

1. A star topology is less expensive than a mesh topology
2. It easy to install and reconfigure
3. Include robustness. If one link fails, only that link is affected. All other links remain active.
4. Easy fault identification and fault isolation.

The disadvantages of this topology

1. One big disadvantage of a star topology is the dependency of the whole topology on one single point, the hub. If the hub goes down, the whole system is dead.
2. Each node must be linked to a central hub. For this reason, often more cabling is required in a star than in some other topologies (such as ring or bus).

The star topology is used in local-area networks (LANs).

Bus Topology The preceding examples all describe point-to-point connections. A **bus topology,** on the other hand, is multipoint. One long cable acts as a **backbone** to link all the devices in a network (see Figure (1.7)). Nodes are connected to the bus cable by drop lines and taps.

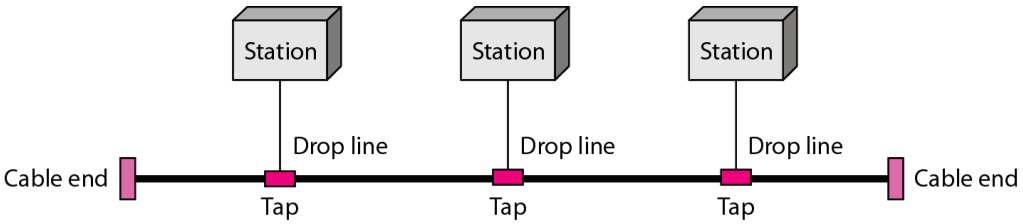

Fig. (1.7): A bus topology connecting three stations.

The advantages of this topology:

1. Ease of installation. Backbone cable can be laid along the most efficient path, then connected to the nodes by drop lines of various lengths.
2. In this way, a bus uses less cabling than mesh or star topologies.

The disadvantages of this topology:

1. Include difficult reconnection and fault isolation.
2. Direction of origin, creating noise in both directions.
3. Signal reflection at the taps can cause degradation in quality. This degradation can be controlled by limiting the number and spacing of devices connected to a given length of cable

4. Fault or break in the bus cable stops all transmission, even between devices on the same side of the problem. The damaged area reflects signals back in the direction of origin, creating noise in both directions Bus topology was the one of the first topologies used in the design of early local area networks.

Ring Topology

In a ring topology, each device has a dedicated point-to-point connection with only the two devices on either side of it. A signal is passed along the ring in one direction, from device to device, until it reaches its destination. Each device in the ring incorporates a repeater. When a device receives a signal intended for another device, its repeater regenerates the bits and passes them along (see Figure (1.8)).

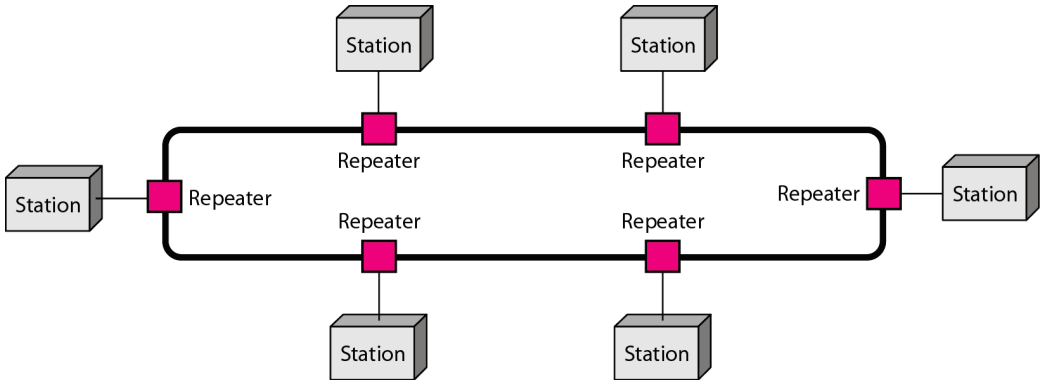

Fig. (1.8): A ring topology connecting six stations.

The advantages of this topology:

1. Easy to install and reconfigure.
2. To add or delete a device requires changing only two connections.
3. Fault isolation is simplified.

The disadvantages of this topology

1. Unidirectional traffic can be a disadvantage in a simple ring, a break in the ring (such as a disabled station) can disable the entire network.

Hybrid Topology

A network can be hybrid. For example, we can have a main star topology with each branch connecting several stations in a bus topology as shown in Figure (1.9).

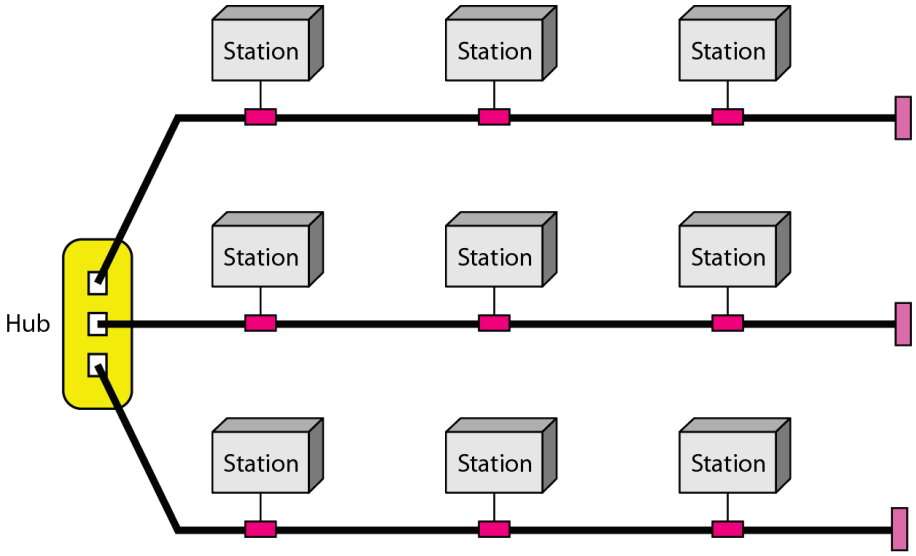

Fig. (1.9): A hybrid topology: a star backbone with three bus networks.

Network classification

1-Local Area Networks (LANs)

A local area network (LAN) is usually privately owned and links the devices in a single office, building, or campus (see Figure (1.10)). Depending on the needs of an organization and the type of technology used, a LAN can be as simple as two PCs and a printer in someone's home office; or it can extend throughout a company and include audio and video peripherals. Currently, LAN size is limited to a few kilometers.

In addition to size, LANs are distinguished from other types of networks by their transmission media and topology. In general, a given LAN will use only one type of transmission medium. The most common LAN topologies are bus, ring, and star. Early LANs had data rates in the 4 to 16 megabits per second (Mbps) range. Today, however, speeds are normally 100 or 1000 Mbps.

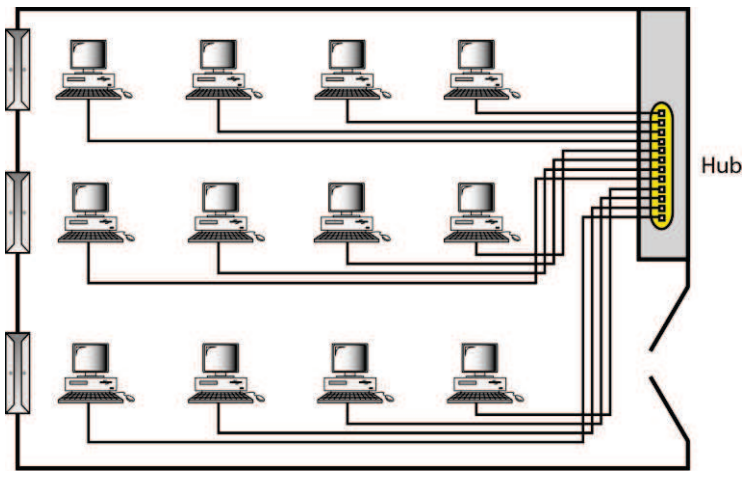

Fig. (1.10): An isolated LAN connecting 12 computers to a hub in a closet

2-Wide Area Networks (WANs)

A wide area network (WAN) provides long-distance transmission of data, image, audio, and video information over large geographic areas that may comprise a country, a continent, or even the whole world. A WAN can be as complex as the backbones that connect the Internet or as simple as a dial-up line that connects a home computer to the Internet. We normally refer to the first as a switched WAN and to the second as a point-to-point WAN (Figure (1.11)).The switched WAN connects the end systems, which usually comprise a router (internetworking connecting device) that connects to another LAN or WAN. The point-to-point WAN is normally a line leased from a telephone or cable TV provider that connects a home computer or a small LAN to an Internet service provider (ISP). This type of WAN is often used to provide Internet access.

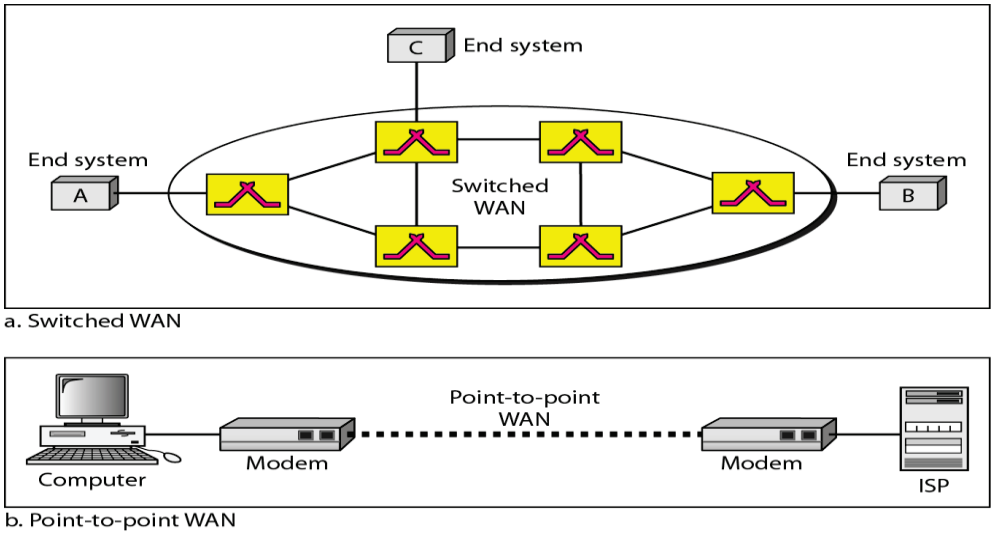

Fig. (1.11): WANs: a switched WAN and a point-to-point WAN

An early example of a switched WAN is X.25, a network designed to provide connectivity between end users. A good example of a switched WAN is the asynchronous transfer mode (ATM) network, which is a network with fixed-size data unit packets called cells.

3-Metropolitan Area Networks (MANs)

A metropolitan area network (MAN) is a network with a size between a LAN and a WAN. It normally covers the area inside a town or a city. It is designed for customers who need a high-speed connectivity, normally to the Internet, and have endpoints spread over a city or part of city. A good example of a MAN is the part of the telephone company network that can provide a high-speed DSL line to the customer. Another example is the cable TV network that originally

was designed for cable TV, but today can also be used for high-speed data connection to the Internet.

Interconnection of Networks: Internetwork

Today, it is very rare to see a LAN, a MAN, or a LAN in isolation; they are connected to one another. When two or more networks are connected, they become an internetwork, or internet as in Figure (1.12).

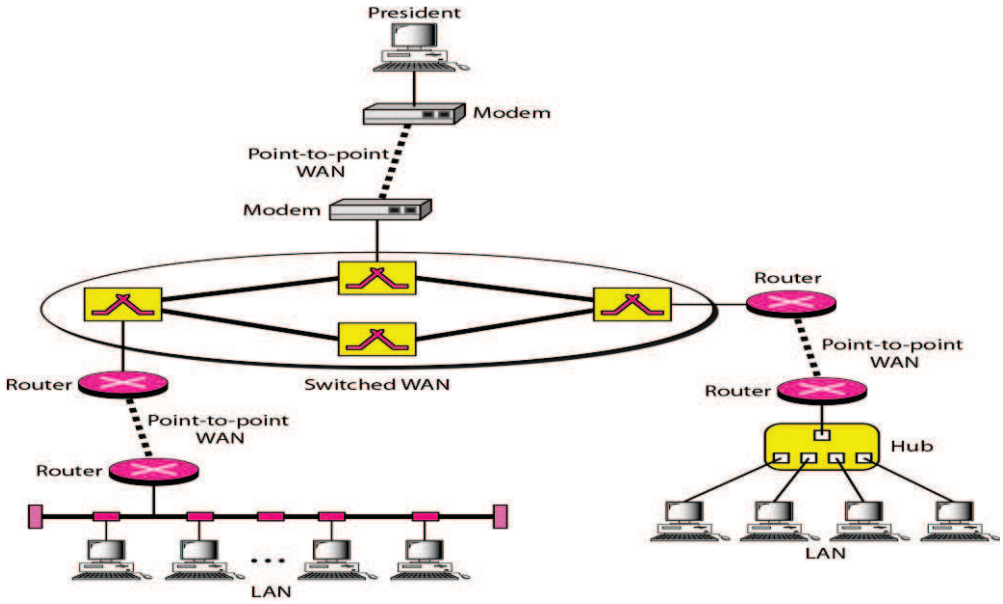

Fig. (1.12): A heterogeneous network made of four WANs and two LANs.

THE INTERNET

The Internet has revolutionized many aspects of our daily lives. It has affected the way we do business as well as the way we spend our leisure time. The Internet is a communication system that has brought a wealth of information to our fingertips and organized it for our use.

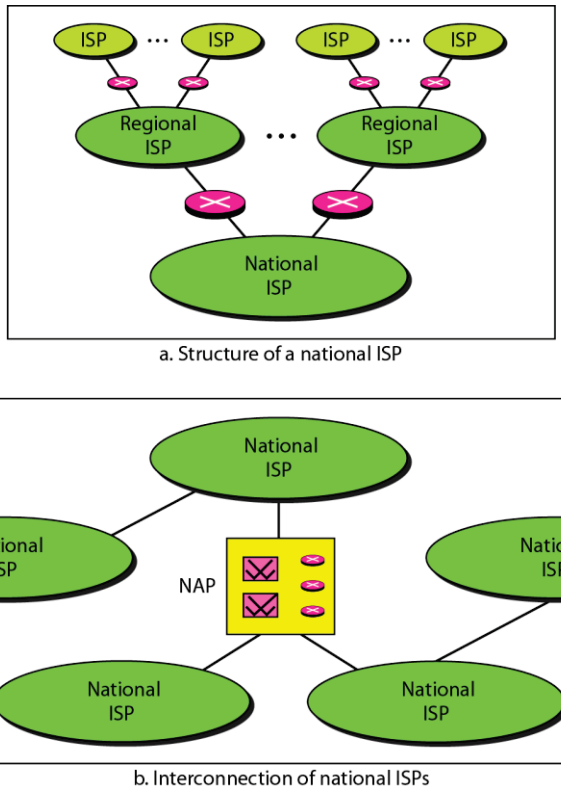

Fig. (1.13): Hierarchical organization of the Internet.

There are international service providers, national service providers, regional service providers, and local service providers. The Internet today is run by private companies, not the government.

PROTOCOLS AND STANDARDS

A protocol is a set of rules that govern data communications. A protocol defines what is communicated, how it is communicated, and when it is communicated. The key elements of a protocol are:

- **Syntax**
  - Structure or format of the data
  - Indicates how to read the bits - field delineation
- **Semantics**
  - Interprets the meaning of the bits

- Knows which fields define what action

- **Timing**
  - When data should be sent and what
  - Speed at which data should be sent or speed at which it is being received.

Communication Standards

The rules that are established to ensure compatibility among similar communications products and services. Communication standards specify how a particular communication product, service, or interface will operate.

- The way that a standard is developed is through consensus of the members of the standards organization.

Standards Organization	Main telecommunication focus	Internet web address
International:		
International Telecommunication Union-Telecommunication Standardization Section (ITU-T)	**Telephone And Data Communication**	**http://www.itu.ch**
International Organization for Standardization (ISO)	**Communications Standards Of All Types (Coordinate With The ITU-T)**	**http://www.iso.ch**
Internet Engineering Task Force (IETF)	**Sets Standards For How The Internet will operate**	**http://ietf.org**
United States:		
American National Standards Institute (ANSI)	**data communication in general**	**http://www.ansi.org**
Electronic Industries Association (EIA)	**Interfaces, connections, media. facsimile**	**http://eia.org**
Institute of Electrical and Electronics Engineers (IEEE)	**802 LAN standards**	**http://www.ieee.org**
National Institute of Standards and Technology (NIST)	**Standards of all types**	**http://nist.gov**
National Exchange Carriers Association (NECA)	**North American WAN standards**	**http://neca.org**