Computer Communication & Network

Chapter 1: Introduction to Communication

❖ Data Communication

The term telecommunication means communication at a distance. The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data. Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.

❖ Effectiveness of Data Communication

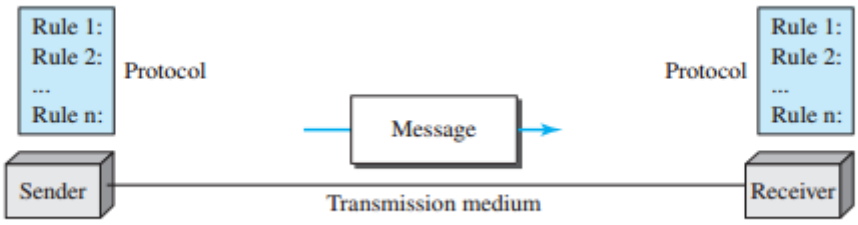
The effectiveness of data communication depends upon four fundamental characteristics; delivery, accuracy, timeline and jitter.

- **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, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called real-time transmission.
- **Jitter:** Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets. For example, let us assume that video packets are sent every 30 ms. If some of the packets arrive with 30-ms delay and others with40-ms delay, an uneven quality in the video is the result.

❖ Components of Data Communication

A data communications system has five components; Message, Sender, Receiver, Transmission Medium and Protocols. Their details are as follows:

- **Message:** The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
- **Sender:** The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
- **Receiver:** The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
- **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.
- **Protocol:** A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices maybe connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.



❖ Data Representation

Information today comes in different forms such as text, numbers, images, audio, and video.

- **Text**

In data communications, text is represented as a bit pattern, a sequence of bits (0s or1s). Different sets of bit patterns have been designed to represent text symbols. Each set is called a **code**, and the process of representing symbols is called **coding**. Today, the prevalent coding system is called **Unicode**, which uses 32 bits to represent a symbol or character used in any language in the world. The American Standard Code for Information Interchange (**ASCII**), developed some decades ago in the United States, now constitutes the first 127 characters in Unicode and is also referred to as **Basic Latin**.

- **Numbers**
  Numbers are also represented by bit patterns. However, a code such as ASCII is not used to represent numbers; the number is directly converted to a binary number to simplify mathematical operations.

- **Images**
  Images are also represented by bit patterns. In its simplest form, an image is composed of a matrix of pixels (picture elements), where each pixel is a small dot. The size of the pixel depends on the resolution. For example, an image can be divided into 1000 pixels or 10,000 pixels. In the second case, there is a better representation of the image (better resolution), but more memory is needed to store the image. There are several methods to represent color images. One method is called **RGB**, so called because each color is made of a combination of three primary colors: red, green, and blue. The intensity of each color is measured, and a bit pattern is assigned to it. Another method is called **YCM**, in which a color is made of a combination of three other primary colors: yellow, cyan, and magenta.
- **Audio**
  Audio refers to the recording or broadcasting of sound or music. Audio is by nature different from text, numbers, or images. It is continuous, not discrete. Even when we use a microphone to change voice or music to an electric signal, we create a continuous signal.

- **Video**
  Video refers to the recording or broadcasting of a picture or movie. Video can either be produced as a continuous entity (e.g., by a TV camera), or it can be a combination of images, each a discrete entity, arranged to convey the idea of motion.

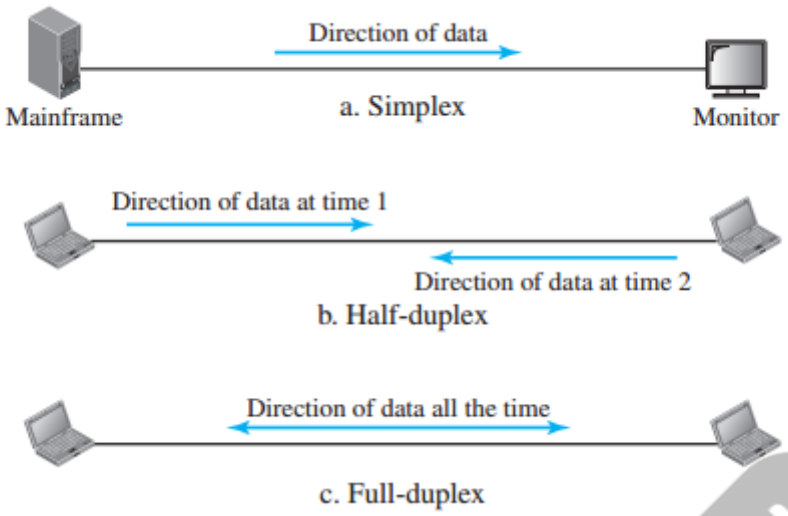
❖ Data Flow (Transmission Modes)

There is three modes of data flow/transmission; simplex, half-duplex and full duplex modes. Their details are as follows:

- **Simplex Modes**
  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. Keyboards and traditional monitors are examples of simplex devices. The keyboard can only introduce input; the monitor can only accept output. The simplex mode can use the entire capacity of the channel to send data in one direction.

- **Half-Duplex Mode**
  In half-duplex mode, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa. The half-duplex mode is like a one-lane road with traffic allowed in both directions. When cars are traveling in one direction, cars going the other way must wait. In a half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time. Walkie-talkies and CB (citizens band) radios are both half-duplex systems.

- **Full Duplex Mode**
  In full-duplex mode (also called duplex), both stations can transmit and receive simultaneously. The full-duplex mode is like a two-way street with traffic flowing in both directions at the same time. In full-duplex mode, signals going in one direction share the capacity of the link with signals going in the other direction. One common example of full-duplex communication is the telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time. The full-duplex mode is used when communication in both directions is required all the time. The capacity of the channel, however, must be divided between the two directions.



❖ Networks

A network is the interconnection of a set of devices capable of communication. In this definition, a device can be a host (or an end system as it is sometimes called) such as a large computer, desktop, laptop, workstation, cellular phone, or security system. A device in this definition can also be a connecting device such as a router, which connects the network to other networks, a switch, which connects devices together, a modem (modulator-demodulator), which changes the form of data, and so on. These devices in a network are connected using wired or wireless transmission media such as cable or air.

❖Network Criteria

A network must be able to meet a certain number of criteria. The most important of these are performance, reliability, and security.

- **Performance**

  Performance can be measured in many ways, including transit time and response time. **Transit time** is the amount of time required for a message to travel from one device to another. **Response time** is the elapsed time between an inquiry and a response. The performance of a network depends on a number of factors, including the number of users, the type of transmission medium, the capabilities of the connected hardware, and the efficiency of the software. Performance is often evaluated by two networking metrics: throughput and delay.

- **Reliability**

  In addition to accuracy of delivery, network reliability is measured by the frequency of failure, the time it takes a link to recover from a failure, and the network's robustness in a catastrophe.

- **Security**

  Network security issues include protecting data from unauthorized access, protecting data from damage and development, and implementing policies and procedures for recovery from breaches and data losses.

❖Physical Structures

- ### Types of connections

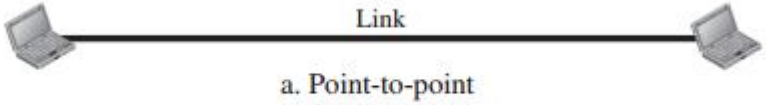
  There are two possible types of connections, point-to-point and multipoint. Their Details are as follows:

1) Point-to-Point Connection

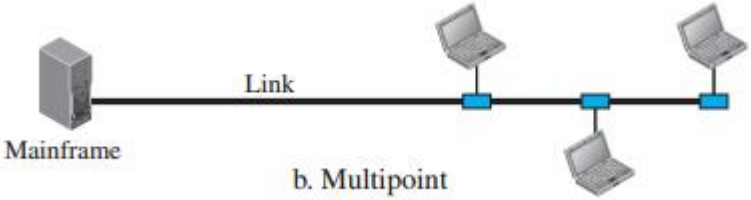
A point-to-point connection provides a dedicated link between two devices. The entire capacity of the link is reserved for transmission between those two devices. Most point-to-point connections use an actual length of wire or cable to connect the two ends, but other options, such as microwave or satellite links, are also possible. When we change television channels by infrared remote control, we are establishing a point-to-point connection between the remote control and the television's control system.

2) Multipoint

A multipoint (also called multidrop) connection is one in which more than two specific devices share a single link. 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 time shared connection.



a. Point-to-point



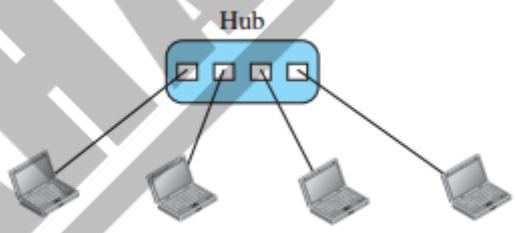
b. Multipoint

❖ Physical Topologies

The term physical topology refers to the way in which a network is laid out physically. Two or more devices connect to a link; two or more links form a topology. The topology of a network is the geometric representation of the relationship of all the links and linking devices (usually called nodes) to one another. There are four basic topologies possible: mesh, star, bus, and ring.

1) 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. Unlike a mesh topology, a star topology does not allow direct traffic between devices. The controller acts as an exchange: 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.



Advantages:

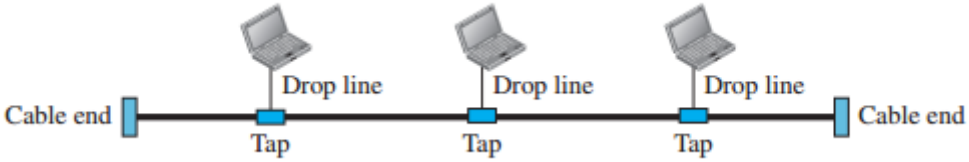
- ✓ It is easy to maintain and modify network.
- ✓ Adding and removing computers can be done without disturbing the network.
- ✓ Finding faults become very simple.
- ✓ Single computer failure does not bring down the whole network.
- ✓ It is more flexible than other topologies.

Disadvantages:

- ✓ If central hub fails, the entire network break downs.
- ✓ It requires a large length of cable to connect computers/devices.
- ✓ It is more expensive

2) Bus Topology

A bus topology is multipoint in which one long cable acts as a backbone to link all the devices in a network. Nodes are connected to the bus cable by drop lines and taps. A drop line is a connection running between the device and the main cable. A tap is a connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core. As a signal travels along the backbone, some of its energy is transformed into heat. Therefore, it becomes weaker and weaker as it travels farther and farther. For this reason there is a limit on the number of taps a bus can support and on the distance between those taps.



Advantages:

- ✓ It is simple and easy to use.
- ✓ It requires small length of cables to connect computers/devices.
- ✓ It is less expensive.
- ✓ It is easy to extend a bus. It allows more computers to join network.
- ✓ If one node fails, it does not affect the rest of network.

Disadvantages:

- ✓ It is difficult to troubleshoot.
- ✓ It only supports small number of computers.
- ✓ The network speed slows down as the number of computer increases.

3) Tree Topology

A tree topology combines the characteristics of bus and star topologies. It consists of different groups of computers attached in star topology. The groups are then connected to a bus backbone cable. Tree topology is used for expansion of an existing network.

Advantages:

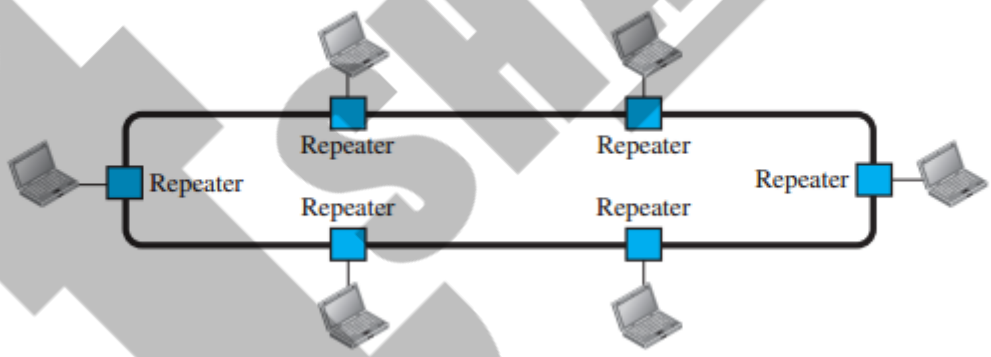
- ✓ It provides point-to-point wiring for individual segments.
- ✓ It is supported by several hardware and software vendors.

Disadvantages:

- ✓ Overall length of each segment is limited by the type of cabling used.
- ✓ The entire network goes down if the backbone line breaks.
- ✓ It is more difficult to configure and wire than other topologies.

4) 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.



Advantages:

- It is less expensive than star topology.
- Every computer has equal access to the network.

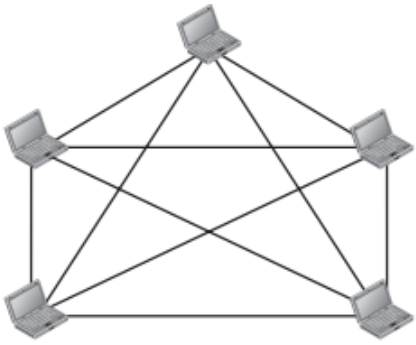
Disadvantages:

- Failure of one computer in the ring can affect the whole network.
- It is difficult to troubleshoot.
- Adding and removing computers affects the whole network.

5) Mesh Topology

In a 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 – 1 nodes, node 2 must be connected to n – 1nodes, 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.

$n = 5$
10 links.



Advantages:

1) It has multiple links so if one route is blocked, the other routes can be used for data communication.
2) Its performance is not affected with heavy load of data transmission.
3) It is easy to troubleshoot.

Disadvantages:

- A full mesh network can be very expensive.
- It is difficult to install and reconfigure.

❖ Network Types

1) LAN

A local area network (LAN) is usually privately owned and connects some hosts in a single office, building, or campus. Depending on the needs of an organization, 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 devices. Each host in a LAN has an identifier, an address that uniquely defines the host in the LAN.

- ✓ The scope of LAN is small, typically a building or cluster of buildings.
- ✓ LAN is usually owned by same organization.
- ✓ Data rates of LAN are typically greater than WAN.

2) WAN

A wide area network (WAN) is also an interconnection of devices capable of communication. However, there are some differences between a LAN and a WAN. A LAN is normally limited in size, spanning an office, a building, or a campus; a WAN has a wider geographical span, spanning a town, a state, a country, or even the world. A LAN interconnects hosts; a WAN interconnects connecting devices such as switches, routers, or modems. A LAN is normally privately owned by the organization that uses it; a WAN is normally created and run by communication companies and leased by an organization that uses it. We see two distinct examples of WANs today: point-to-point WANs and switched WANs**.** A **point-to-point WAN** is a network that connects two communicating devices through a transmission media (cable or air).A **switched WAN** is a network with more than two ends. We can say that a switched WAN is a combination of several point-to-point WANs that are connected by switches.
Traditionally, WANs have been implemented using one of two technologies: circuit switching and packet switching. Subsequently, frame relay and ATM networks assumed major roles.

- ➢ **Circuit Switching**

Circuit switching is a method of implementing a telecommunications network in which two network nodes establish a dedicated communications channel (circuit) through the network before the nodes may communicate. The circuit guarantees the full bandwidth of the channel and remains connected for the duration of the communication session. The circuit functions as if the nodes were physically connected as with an electrical circuit. Data generated by the source station are transmitted along the dedicated path as rapidly as possible. At each node, incoming data are routed or switched to the appropriate outgoing channel without delay. The most common example of circuit switching is the telephone network.

- ➢ **Packet Switching**

In a packet-switching network, it is not necessary to dedicate transmission capacity along a path through the network. Rather, data are sent out in a sequence of small chunks, called packets. Each packet is passed through the network from node to node along some path leading from source to destination. At each node, the entire packet is received, stored briefly, and then transmitted to the next node. Packet-switching networks are commonly used for terminal-to-computer and computer-to-computer communications.

- ➢ **Frame Relay**

In frame relay data packets are sent to the frame relay network or cloud, which is networks of different devices, and service provider sends the data to the receiver. This is cheaper connection than point to point leased line connection. Frame relay networks are designed to operate efficiently at user data rates of up to 2 Mbps.

- ➢ **ATM**

Asynchronous transfer mode, sometimes referred to as cell relay, is a culmination of developments in circuit switching and packet 1switching. ATM can be viewed as an evolution from frame relay. The most obvious

difference between frame relay and ATM is that frame relay uses variable-length packets, called frames, and ATM uses fixed-length packets, called cells. By using a fixed packet length, the processing overhead is reduced even further for ATM compared to frame relay. The result is that ATM is designed to work in the range of 10s and 100s of Mbps, and in the Gbps range.

3) Internetwork

Today, it is very rare to see a LAN or a WAN in isolation; they are connected to one another. When two or more networks are connected, they make an internetwork, or internet. As an example, assume that an organization has two offices, one on the east coast and the other on the west coast. Each office has a LAN that allows all employees in the office to communicate with each other. To make the communication between employees at different offices possible, the management lease a point-to-point dedicated WAN from a service provider, such as a telephone company, and connects the two LANs. Now the company has an internetwork, or a private internet (with lowercase i). Communication between offices is now possible.