UNIT I - FUNDAMENTALS AND LINK LAYER

1.1 OVERVIEW OF DATA COMMUNICATIONS

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 characteristics: delivery,accuracy, timeliness, and jitter.

1.Delivery. The system must deliver data to the correct destination. Data must be received by the Receiver device .

2.Accuracy. The system must deliver the data accurately. Data that have been altered (changed during transmission) in transmission and left uncorrected are unusable.

3.Timeliness. The system must deliver data in exact time. 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 (any delay) significant delay. This kind of delivery is called real-time transmission.

4.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 with 40-ms delay, an uneven quality in the video occurs.

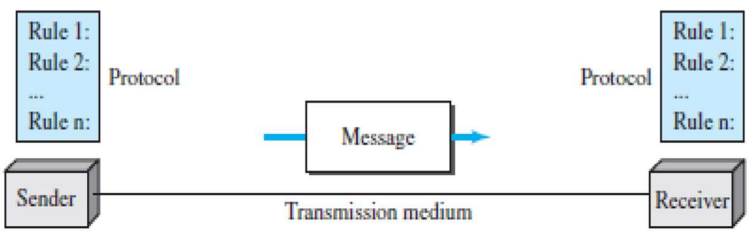

Fig1.1.1: Five Components of Data Communication.
[Source : "Data Communications and Networking" by Behrouz A. Forouzan,Page-4]

1.Message. The message is the information (data) to be communicated as shown in figure 1.1.1. 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.

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 (Between sender and Receiver).

Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

Data Representation

Information today (available) comes in different forms such as text, numbers, images, audio, and Video.

a. Text:

Text is represented as a bit pattern, a sequence of bits (Os or 1s).

What is bit pattern? All data inside a computer is transmitted as a series of electrical signals that are either on or off. Therefore, in order for a computer to be able to process any kind of data, including text, images and sound, they must be converted into binary form.

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.

b. Numbers:

Numbers are also represented by bit patterns. The number is directly converted to a binary number to simplify mathematical operations.

ie: Conversion of decimal to binary

c. Images: Images are also represented by bit patterns.

Representing image by bit pattern: Images also need to be converted into binary in order for a computer to process them so that they can be seen on our screen.

Digital images are made up of pixels. Each pixel in an image is made up of binary numbers.

If we say that 1 is black (or on) and 0 is white (or off), then a simple black and white picture can be created using binary.

d. Audio:

Audio refers to the recording or broadcasting of sound or music. It is continuous, not discrete.

e. Video:

Video refers to the 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

Communication between two devices can be simplex, half-duplex, or full-duplex.

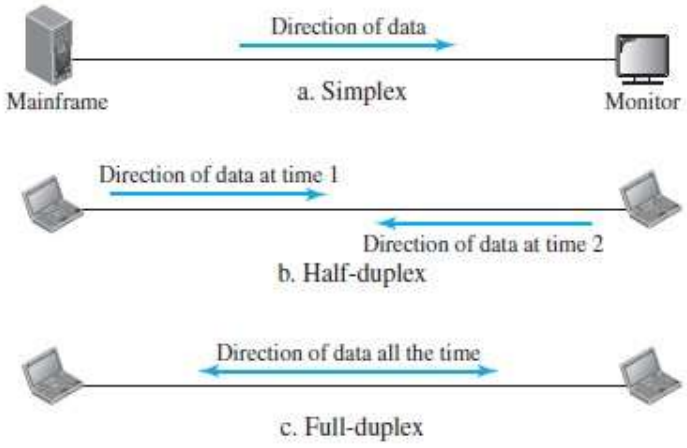

Fig 1.1.2: Mode of Communication.

[Source : "Data Communications and Networking" by Behrouz A. Forouzan,Page-6]

a. 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 (see Figure 1.1.2a).

Keyboards and traditional monitors are examples of simplex devices.

b. Half-Duplex:

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 (see Figure 1.1.2b).

Walkie-talkies are both half-duplex systems.

c. Full-Duplex:

In full-duplex mode (also called duplex), both stations can transmit and receive simultaneously (at the same time), (see Figure 1.1.2c).

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.

NETWORKS

A network is the interconnection of a set of devices capable of communication.

Here , a device can be a host (called as end system) such as a large computer, desktop, laptop, workstation, cellular phone, or security system.

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.

1.the number of users 2.the type of transmission medium 3.the capabilities of the connected hardware 4.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 data losses.

Physical Structures

Type of Connection

A network is two or more devices connected through links. A link is a communications pathway that transfers data from one device to another.

Point-to-Point: 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 .

Multipoint: A multipoint (also called multidrop) connection is one in which more than two specific devices share a single link (see Figure1.1.3 below).

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.

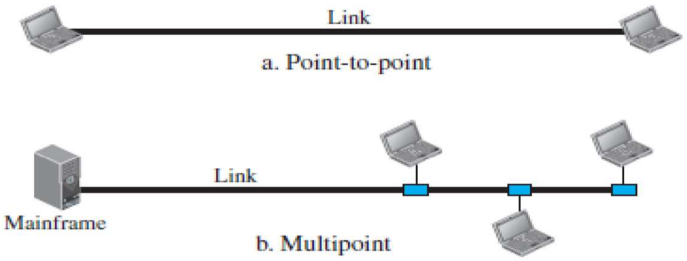

Fig1.1.3: Types of Connections.

[Source : "Data Communications and Networking" by Behrouz A. Forouzan,Page-9]

Physical Topology

The physical layout of a network is called Topology. 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 (called nodes) to one another.

There are four basic Topologies: mesh, star, bus, and ring.

Mesh: In a mesh topology, every device has a dedicated point-to-point link as in figure 1.1.4,to every other device. A fully connected mesh network with n nodes has n(n -1) /2 physical channels.

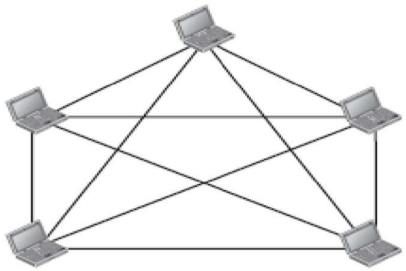

Fig1.1.4: Mesh topology.

[Source : "Data Communications and Networking" by Behrouz A. Forouzan,Page-10]

Advantages:

The 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.

A mesh topology is robust. If one link becomes unusable, it does not incapacitate the entire system.

Point-to-point links make fault identification and fault isolation easy.

Disadvantages:

Every device must be connected to every other device, installation and reconnection are difficult.

More number of wire connections make it greater than the available space (in walls, ceilings, or floors) which can accommodate.

The hardware required to connect each link (I/O ports and cable) can be 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 connected 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 (see Figure 1.1.5).

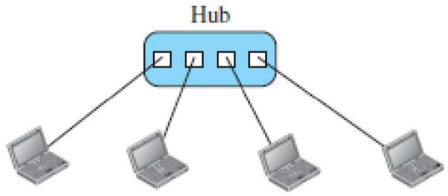

Fig1.1.5: Star topology.

[Source : "Data Communications and Networking" by Behrouz A. Forouzan,Page-10]

Advantages:

Less expensive than a mesh topology.

Easy to install and reconfigure. Less cables are required, and additions, and deletions involve only one connection: between that device and the hub.

It is Robust. If one link fails, only that link is affected. All other links remain active.

Disadvantages:

The topology depends on one single point, the hub. If the hub goes down, the whole system is dead. A star requires far less cable than a mesh; each node must be linked to a central hub. The star topology is used in local-area networks (LANs). High-speed LANs also use a star topology with a central hub.

c. Bus Topology: A bus topology is multipoint. One long cable acts as a backbone to link allthe devices in a network (see Figure 1.1.6).

Nodes are connected to the bus cable by drop lines and taps.A drop line is a connection 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, the signal becomes weaker and weaker as it travels farther and farther. For this reason there is a limit on the number of taps used in this topology.

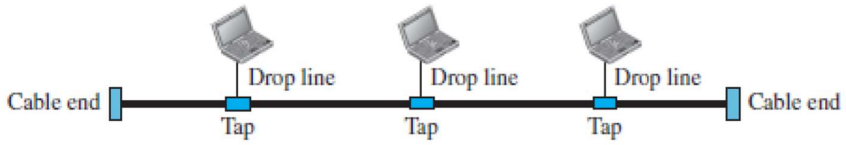

Fig1.1.6: Bus Topology.

[Source : "Data Communications and Networking" by Behrouz A. Forouzan,Page-11]

Advantages:

Ease of installation.

Less cabling

Disadvantages:

Difficult reconfiguration and fault isolation, Difficult to add new devices, Signal reflection at top can cause degradation in quality. If any fault in backbone occurs ,then it can stop all transmission. Ethernet LANs can use a bus topology, but they are less popular now.

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. When a device receives a signal intended for another device, its repeater regenerates the bits and passes along them (see Figure 1.1.7).

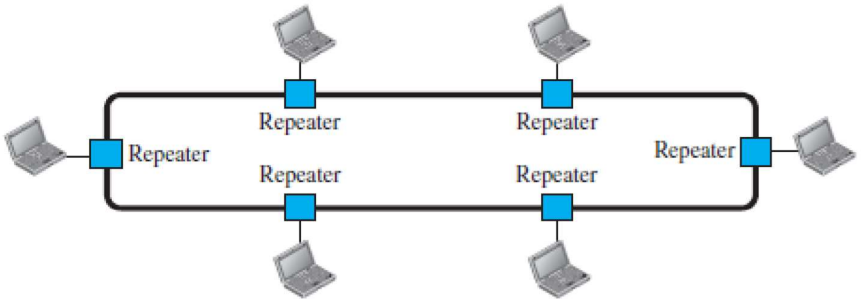

Fig1.1.7: Ring Topology.

[Source : "Data Communications and Networking" by Behrouz A. Forouzan,Page-12]

Advantages:

Easy to install.

Easy to reconfigure.

Fault identification is easy.

Disadvantages:

Unidirectional traffic.

Break in a single ring can break entire network.