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Lecture Material

22IT502 – COMPUTER NETWORKS

UNIT I & DATA COMMUNICATIONS

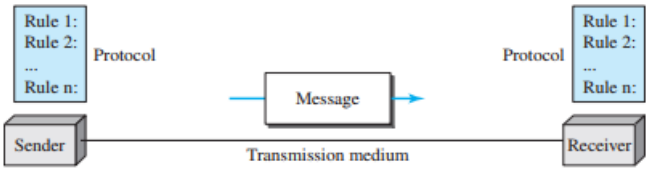
1. DATA COMMUNICATIONS

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 fundamental characteristics: delivery, accuracy, timeliness, and jitter.

a) **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.
b) **Accuracy.** The system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.
c) **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.
d) **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 is the result.

1.1 COMPONENTS

Figure 1.1 *Five components of data communication*



- **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 may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

1.2 DATA REPRESENTATION

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

a) **Text:**

In data communications, text is represented as a bit pattern, a sequence of bits (0s or 1s). 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.***

b) **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.***

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: ***r***ed,***g***reen, and ***b***lue.

Another method is called ***YCM,*** in which a color is made of a combination of three other primary colors: ***y***ellow, ***c***yan, and ***m***agenta.

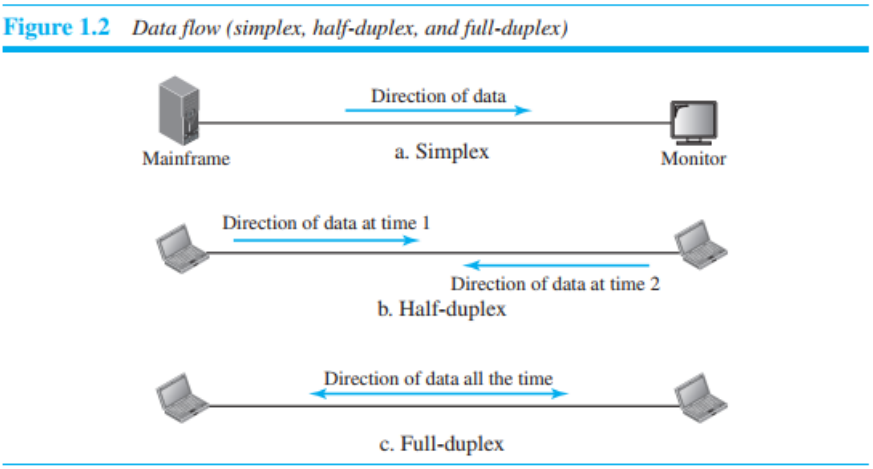
c) **Audio:**

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.

d) **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.

1.3 DATA FLOW



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 . 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

The half-duplex mode is like a one-lane road with traffic allowed in both directions. Walkie-talkies and CB (citizens band) radios are both half-duplex systems.

c) **Full-Duplex**
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.
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.

2. NETWORKS

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

In thisdefinition, 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. When we connect two computers at home using a plug-and-play router, we have created a network, although very small.

2.1 NETWORK CRITERIA

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

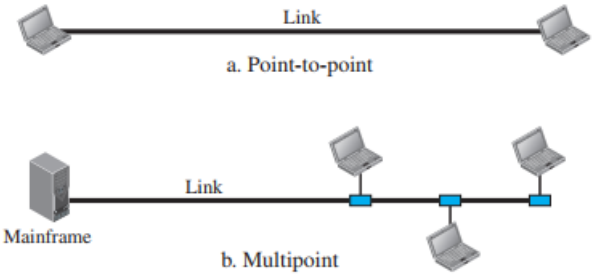
- **Performance**
  Performance can be measured in many ways, including transit time and response time.
  Transit time is the amount of time required for a message to travel from one device to another.
  Response time is the elapsed time between an inquiry and a response.
  The performance of a network 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.*
  We often need more throughput and less delay. However, these two criteria are often contradictory. If we try to send more data to the network, we may increase throughput but we increase the delay because of traffic congestion in the network.
- **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.

2.2 PHYSICAL STRUCTURES

2.2.1 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.
There are two possible types of connections: point-to-point and multipoint.

Figure 1.3 *Types of connections: point-to-point and multipoint*



- ***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. 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.
- **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 *timeshared* connection.

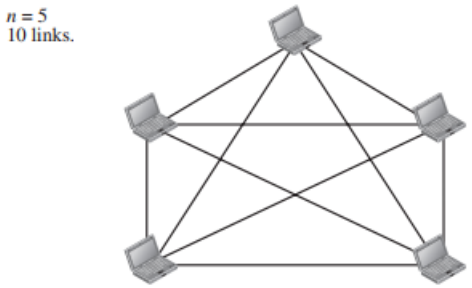
2.2.2 Physical Topology

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.

- ***Mesh Topology***
  - ✔ **Number of Physical Links:**
    - o Each node must be connected to every other node.
    - o Node 1 connects to n−1n - 1n−1 nodes, Node 2 connects to n−1n - 1n−1 nodes, ..., Node nnn connects to n−1n - 1n−1 nodes.
    - o Total physical links required: n×(n−1)n \times (n - 1)n×(n−1).
    - o In duplex mode (communication in both directions), total links = n×(n−1)2\frac{n \times (n - 1)}{2}2n×(n−1).

Figure 1.4 *A fully connected mesh topology (five devices)*



✔ **I/O Ports Requirement:**
- Each device needs n−1n - 1n−1 input/output (I/O) ports to connect to the other n−1n - 1n−1 devices.

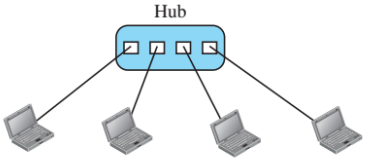
✔ **Advantages of Mesh Topology:**
- **Dedicated Links:**
  - Each connection can carry its own data load.
  - Eliminates traffic problems that occur with shared links.
- **Robustness:**
  - If one link fails, the system remains functional.
- **Privacy/Security:**
  - Only the intended recipient sees the message.
  - Physical boundaries prevent unauthorized access.
- **Fault Identification and Isolation:**
  - Easy to identify and isolate faults.
  - Traffic can be rerouted to avoid problematic links.
  - Helps in discovering the fault location and aids in troubleshooting.

- ***Star Topology***

✔ **Structure:**

- Each device has a dedicated point-to-point link to a central controller (hub).
- Devices are not directly linked to each other.
- The controller acts as an exchange, relaying data between devices.

Figure 1.5 *A star topology connecting four stations*



✔ **Cost and Installation:**
- Less expensive than a mesh topology.
- Each device needs only one link and one I/O port.

- Easier to install and reconfigure.
- Requires less cabling, facilitating easier additions, moves, and deletions.

✔ **Advantages:**

- **Robustness:**
  - If one link fails, only that link is affected; other links remain active.
- **Fault Identification and Isolation:**
  - Easy to identify and isolate faults.
  - The hub can monitor link problems and bypass defective links.
- **Disadvantages:**
- **Dependency on Hub:**
  - The entire system depends on the hub.
  - If the hub fails, the entire network goes down.
- **Cabling Requirements:**
  - Requires more cabling compared to some other topologies (e.g., ring or bus) since each node must be linked to the hub.

✔ **Usage:**

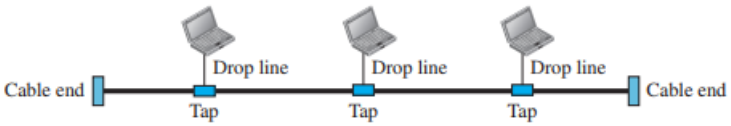
- Commonly used in local-area networks (LANs).
- High-speed LANs often use a star topology with a central hub.

- ***Bus Topology***

✔ **Structure:**

- **Multipoint Connection:**
  - One long cable acts as a backbone to link all devices.
- **Connection Components:**
  - **Drop Line:** Connects each device to the main cable.
  - **Tap:** Connects to the main cable, either by splicing into it or puncturing the sheathing to make contact with the metallic core.

Figure 1.6 *A bus topology connecting three stations*



✔ **Signal Transmission:**

- Signal weakens as it travels due to energy loss.
- Limits on the number of taps and distance between taps to maintain signal quality.

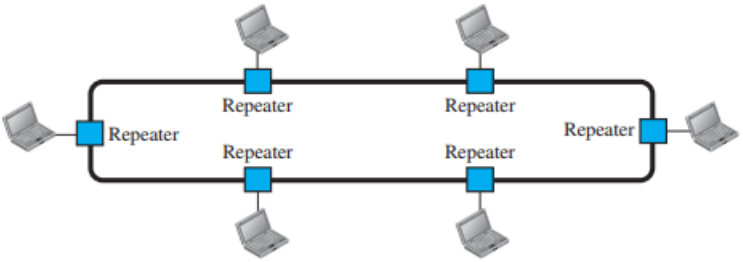
✔ **Advantages:**

- **Ease of Installation:**
  - Backbone cable can be efficiently laid out.
  - Devices connect via short drop lines, reducing overall cabling.

        - Uses less cabling compared to mesh or star topologies.
    - **Efficient Cabling:**
        - Eliminates redundancy by using a single backbone cable.
- ✔ **Disadvantages:**
    - **Difficult Reconnection and Fault Isolation:**
        - Challenging to add new devices.
        - Signal degradation due to reflection at the taps.
        - Adding devices may require modifying or replacing the backbone.
    - **Vulnerability to Faults:**
        - A fault or break in the bus cable stops all transmissions.
        - Damaged area reflects signals back, causing noise in both directions.

- ***Ring Topology***
    - ✔ **Structure:**
        - **Point-to-Point Connection:**
            - Each device connects only to the two adjacent devices.
    - ✔ **Signal Transmission:**
        - Signal passes in one direction from device to device until it reaches its destination.
    - ✔ **Repeater:**
        - Each device includes a repeater that regenerates and passes along signals.

Figure 1.7 *A ring topology connecting six stations*



    - ✔ **Installation and Reconfiguration:**
        - Easy to install and reconfigure.
        - Each device is linked to its immediate neighbors.
        - Adding or deleting a device requires changing only two connections.
        - Constraints include media and traffic considerations (maximum ring length and number of devices).
    - ✔ **Fault Isolation:**
        - Simplified fault isolation due to circulating signals.
        - Devices can issue an alarm if they do not receive a signal within a specified period, alerting the network operator to the problem and its location.
    - ✔ **Disadvantages:**
        - **Unidirectional Traffic:**
            - Traffic flows in only one direction.

        - A break in the ring can disable the entire network.
        - This issue can be mitigated by using a dual ring or a switch to close off the break.
    - **Historical Context:**
    - Ring topology was popularized by IBM's Token Ring LAN.
    - The demand for higher-speed LANs has made ring topology less popular today.

DISCUSSION QUESTIONS:

1. How networks helps in day to day life?
2. Identify the basic component which are used in network system?
3. On what basis the topology are designed and how they are identified