Data Communications and Computer Networks

Learning Objectives

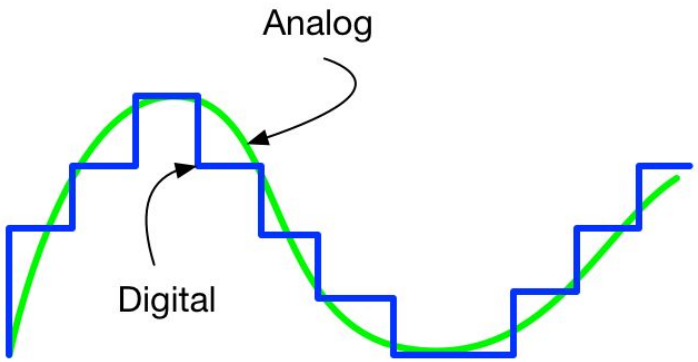
- Data Communications
- Basic elements of a communication system
- Computer Networks
- Types of computer networks
- Network Topologies
- Communication protocols and their use in computer networks

Data Communication

- Communication means the exchange of information or messages
- The process of transferring data from one location to another is called data communication
- Data is transmitted electronically from one location to another by using standard methods
- Computer networks are commonly used for data communication

Types of data transmission

- Data transmission is divided into two types
  - Analog data transmission.
  - Digital data transmission.



Analog Data Transmission

- The transfer of data from one place to another in the from of analog signals or in the from of continuous waves is called analog data transmission.
- The analog signal consists of a continuous electrical waves. This waves is called a carrier waves.
- The light waves, sound waves or radio waves are examples of analog signals.
- The transmission through telephone line, microwave system or satellite is the example of analog data transmission.

Analog Data Transmission

Characteristics

- **Frequency**
  - The number of times a wave repeats during a specific time interval is called frequency.
- **Amplitude**
  - The height of a wave within a given period of time is called amplitude.

Digital Data Transmission

- The transfer of data from one place to another in the form of digital signals is called digital data transmission.
- A digital signal consists of individual electrical pluses that represent bits grouped together into bytes.
- In digital technology, the data are generated and processed in two states: High (represented as 1) and Low (represented as 0).
- Computer accepts and processes data in the from of digital signals.
- Date is also transmitted from one computer to another through telephone line, microwave system and satellite.
- In this system, a modem is used on both sides.

Digital Data Transmission

- **Characteristics**
- **Delivery**
  - The data must be delivered from source device to the correct destination device.
- **Accuracy**
  - The data must be delivered accurately. If there is any error occurred during transmission, the data must be re-transmitted.
- **Timeliness**
  - Data must be delivered within time. It is very important in real time system because data becomes useless if it is delivered late.
  - For example, in television transmission, the video signals must be delivered within time as they are produced without any significant delay.
  - This kind of delivery is called real-time transmission.

Basic Elements of a Communication System

Basic Elements of a Communication System

- **Sender:**
  - A device that is used to send or transmit messages to another device
  - Also called transmitter or source
  - A sender may be a computer, telephone handset, workstation, video camera & mobile phone

- **Message:**
  - It is the information or data that is to be communicated
  - It may be in any format
- **Medium:**
  - The path through which data is transmitted
  - Also called communication channel
  - May be a wired or wireless

Basic Elements of a Communication System

- **Receiver:**
  - A device that is used to receive messages from another device
  - Also called Sink
  - A receiver can be of any device

- **Protocol:**
  - A set of rules that guides data communication
  - It represents an agreement between communicating devices
  - Without protocol, the devices may be connected but not communicate with each other

Data Transmission Modes

- The way in which data is transmitted from one place to another is called data transmission mode.
- It is also called as data communication mode.
- It indicates the direction of flow of information.
- Sometimes, data transmission mode are also called directional modes
- **Types of Transmission Modes**
  - Simple mode
  - Half-duplex mode
  - Full-duplex mode

Simplex Mode

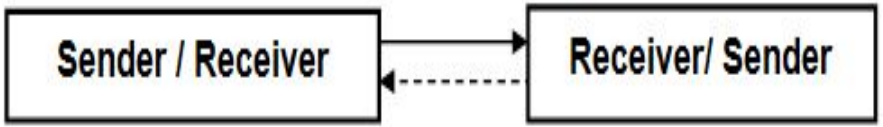
- Data can flow only in one direction
- A sender can only send data, not receive data
- Receiver can only receive data but cannot send
- Successful transmission is not confirmed
- Not possible to request sender to re transmit information
- Not widely used
- **E.g.**
- Example
  - data sent from computer to printer
  - Radio & T.V transmissions

Sender

Receiver

Half-Duplex Mode

- Data flow in both directions but only in one direction at a time
- At a time only one end transmits data while the other end receives
  - i.e. data is sent and received alternatively
  - Like one lane bridge where two way traffic must give way in order to cross the other.
- Example: Internet browsing (or surfing)
  - User sends request to a Web server for a webpage
    - Information flows from user's computer to Web server
  - Web server receives request and sends data
    - Data flows from Web server to user's computer
  - At a time, user can send a request OR receive data from web page.



Sender **OR** Receiver

Sender **OR** Receiver

Full-Duplex Mode

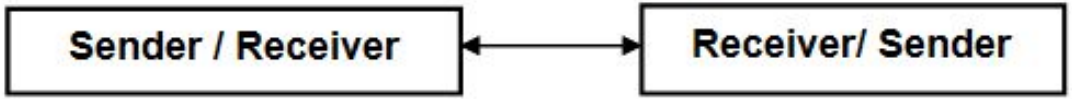
- The data can flow in both directions at the same time
- Fastest means of communication
- E.g.
  - Telephone communication system

Sender **AND** Receiver

Sender **AND** Receiver

Full-Duplex Mode

- Data flow in both directions at the same time
- Both sender & receiver can send & receive data at the same time.
- Fastest directional mode of data communication
- Example
  - Telephone communication system
    - Two persons can talk at the same time
  - Daily life: Automobile traffic on a two lane road
    - Traffic can move in both directions at the same time.



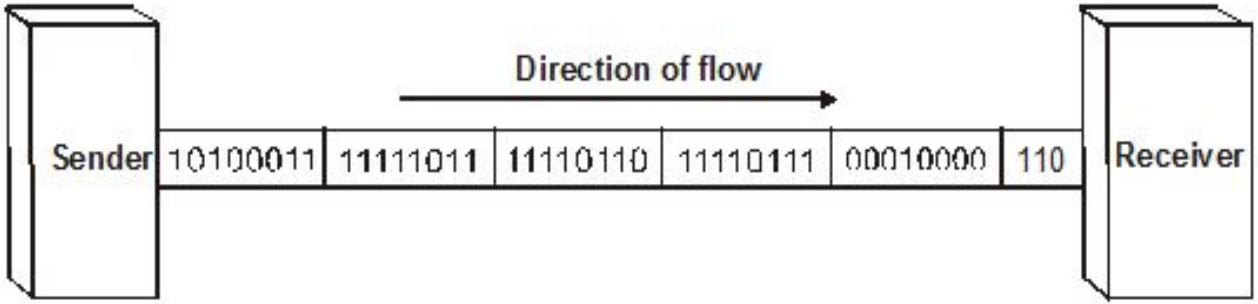
Types of Transmission

- There are two broad types of data transmission:
  - Synchronous Transmission
  - Asynchronous Transmission

Synchronous Transmission

- Data is transmitted block by block OR word by word
- Each block may contain several bytes of data
- Data is saved before transmission
- No start and stop bits
- Uses synchronized clock to schedule or control the transmission of information
  - synchronized clock is a special communication device
- Large volume of data can be transmitted at a time
- No gaps between the characters being transmitted
- Fast transmission method
- Suited for the remote communication between a computer and related devices like printers etc.

Synchronous Transmission



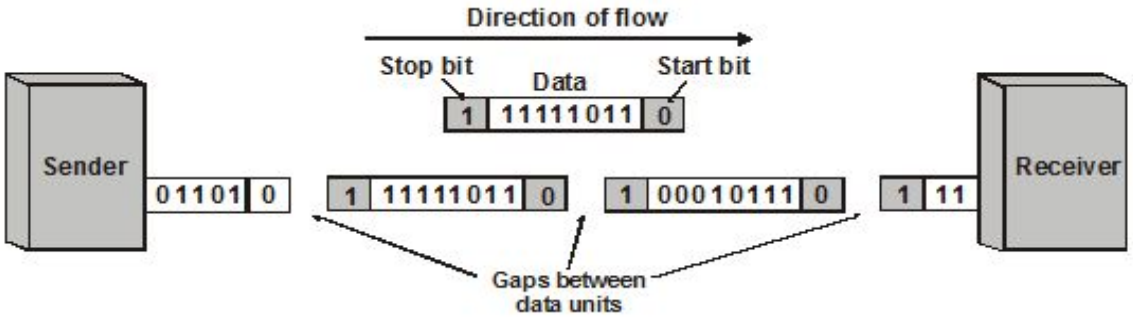
Asynchronous Transmission

- Data is transmitted one byte at time.
  - i.e. data is transmitted character by character
- Data not saved before transmission
- Commonly used in teletype communications
  - User types character on keyboard , immediately transmitted
- Time interval between two characters is not fixed
  - because user cannot type at uniform speed
- Gaps between transmission
- Slow method of transmission
- Tra

Start Bit (0)	Character	Stop Bit (1)

Asynchronous Transmission

- **Start bit 0:** tells receiver that a character is coming, space state
- **Stop bit 1** indicates that transmission has finished, transmitted at the end of each character.
- **Mark State** When gaps appear between character transmissions
  - indicated by binary value 1
  - indicates idle line
- When character is transmitted, the line switched from 1 <mark state> to 0 <start bit>
  - Receiver is alerted for receiving the message



Computer Networks/Types

Group of computer systems that are linked together through communication channels to facilitate communication and resource-sharing among a wide range of users.

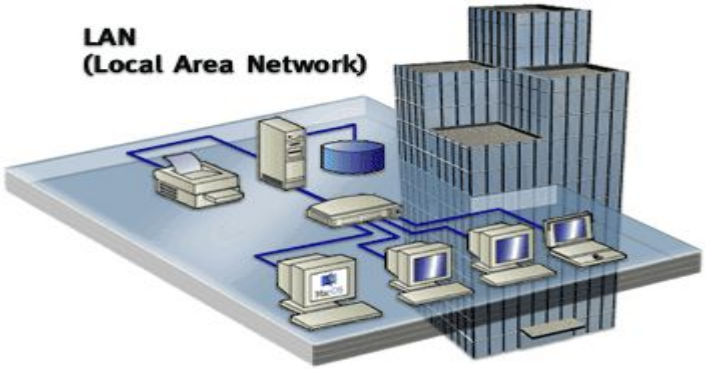
Computer Networks/Types

Networks are broadly classified into three types:

- Local Area Network (LAN)
- Metropolitan Area Network (MAN)
- Wide Area Network (WAN)

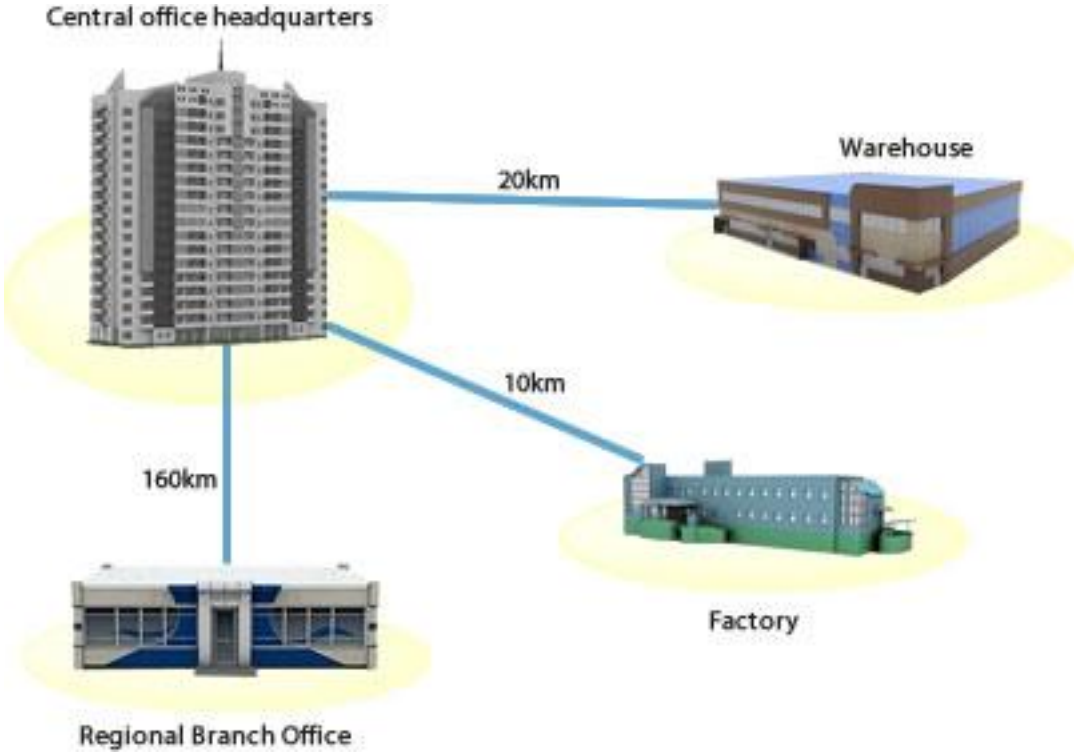
Local Area Network (LAN)

- A **local area network** (**LAN**) is a computer **network** that interconnects computers within a limited **area**
- such as a home, school, computer laboratory, or office building, using **network** media.
- A LAN is composed of inter-connected computers which are each capable of accessing and sharing data and devices



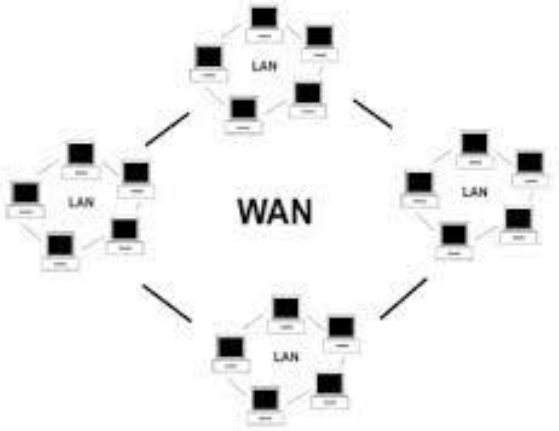
Metropolitan Area Network (MAN)

- A **metropolitan area network** (**MAN**) is a large computer network that usually spans a city or a large campus.
- A MAN usually interconnects a number of local area networks (LANs)
- MANs are larger than local-area networks (LANs), but smaller than wide-area networks (WANs).
- MANs are usually characterized by very high-speed connections using fiber optical cable or other digital media.


Central office headquarters
Warehouse
20km
10km
160km
Factory
Regional Branch Office

Wide Area Network (WAN)

- A computer network that spans a relatively large geographical area such as a state, province or country.
- WANs often connect multiple smaller networks, such as local area networks(LANs) or metro area networks (MANs).
- The largest WAN in existence is the Internet.

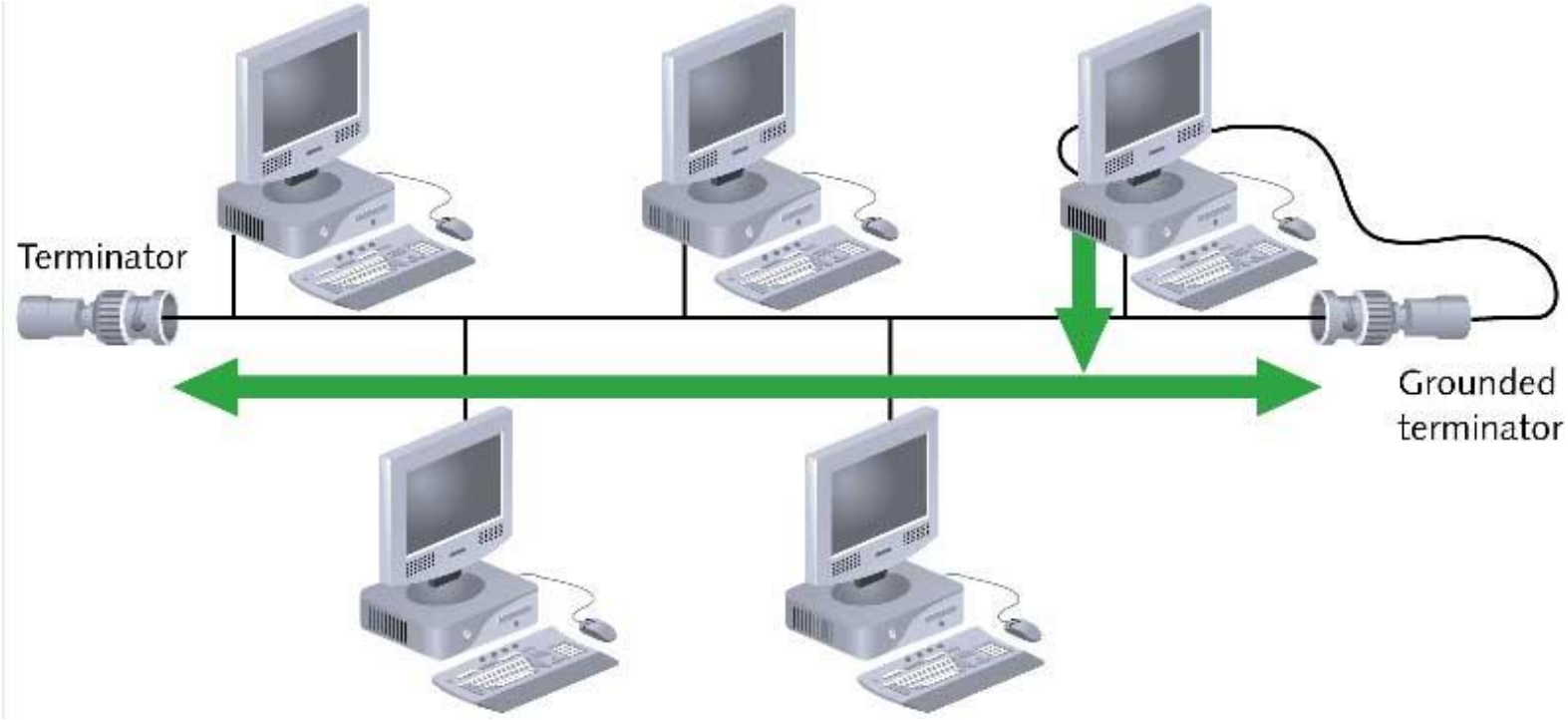

LAN
LAN
WAN
LAN
LAN

Network Topologies/Types

- Term network topology refers to the way in which the nodes of a network are linked together
- The three topologies that are commonly used
  - **Bus** Topology
  - Ring topology
  - Star topology
  - MeshTopology
  - Tree Topology
  - Hybrid Topology

Bus Topology

- All devices on the network are connected through a central cable called a **Bus.**
- The data signal is available to all computers.
- The data signal carries address of destination computer.
- As the data arrives at each computer system, it checks the destination address to see if it matches.
- If the address does not match, the node ignores the **packet**.
- If the address of the node matches that contained in the data, it processes the data.


Terminator
Grounded
terminator

Advantages of Bus Topology

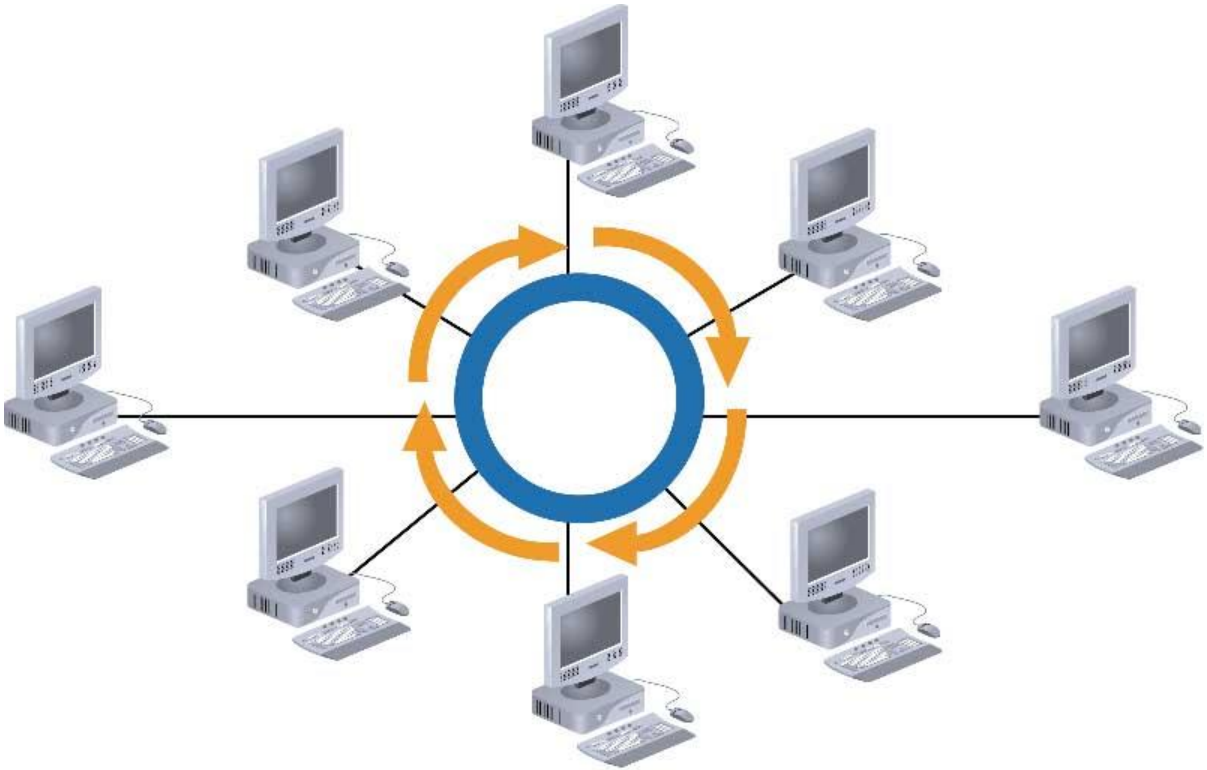
- It is cost effective.
- It is one of the simple forms of networking where a failure of a device does not affect the other devices.
- Cable required is least compared to other network topology.
- Used in small networks.
- Easy to expand joining two cables together.

Disadvantages of Bus Topology

- But failure of the shared communication line can make all other devices stop functioning.
- If network traffic is heavy or nodes are more the performance of the network decreases.
- Cable has a limited length.
- It is slower than the ring topology.

Ring topology

- In Ring topology each node is connected to the two nearest nodes creating a circular network structure. .
- When one host tries to communicate or send message to a host which is not adjacent to it, the data travels through all intermediate hosts.
- To connect one more host in the existing structure, the administrator may need only one more extra cable.
- Data only travels in one direction on a Ring network.



Advantages of Ring Topology

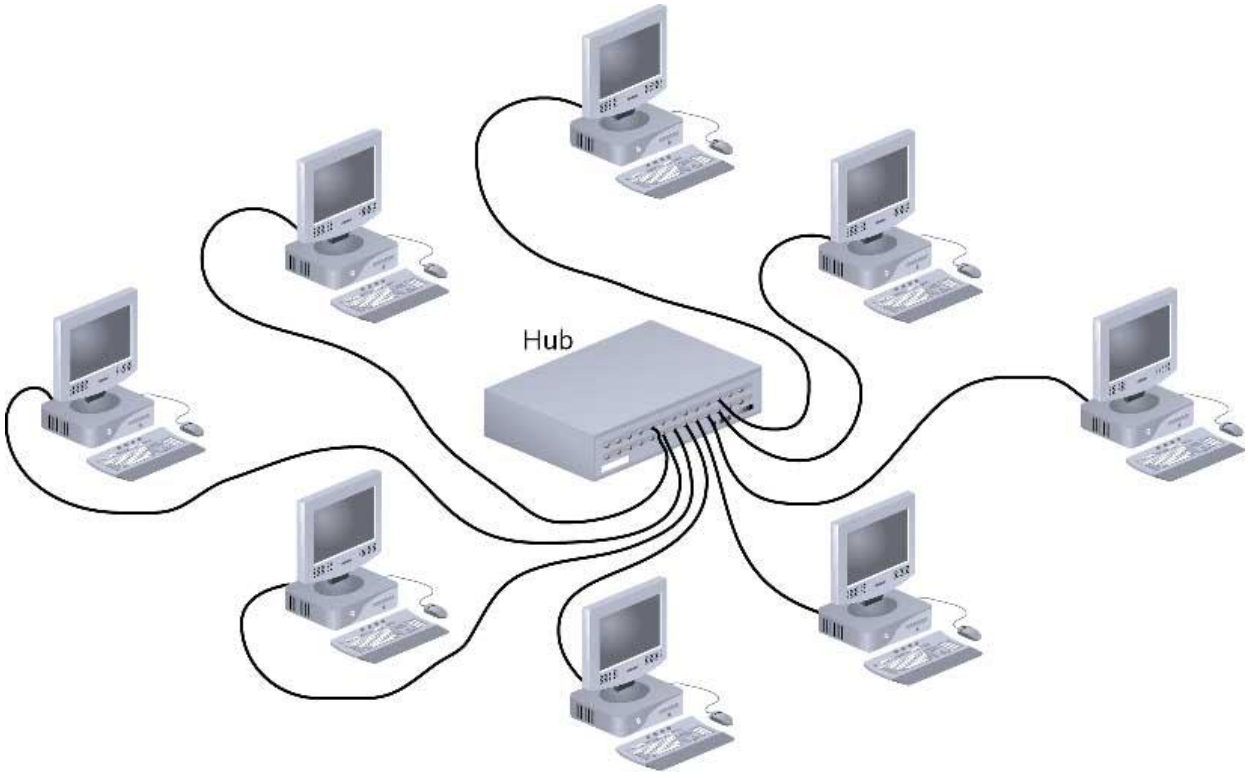
- Transmitting network is not affected by high traffic or by adding more nodes, as only the nodes having tokens can transmit data.

Disadvantages of Ring Topology

- Adding or deleting the computers disturbs the network activity.
- Failure of any host results in failure of the whole ring.

Star topology

- In a Star topology every node is connected through a central device such as a Hub using a point-to-point connection.
- The hub acting as a server and the peripheral devices as clients.
- Every workstation is indirectly connected to every other through the central computer.
- Star topology is not expensive as to connect one more host, only one cable is required and configuration is simple.


Hub

Advantages of Star Topology

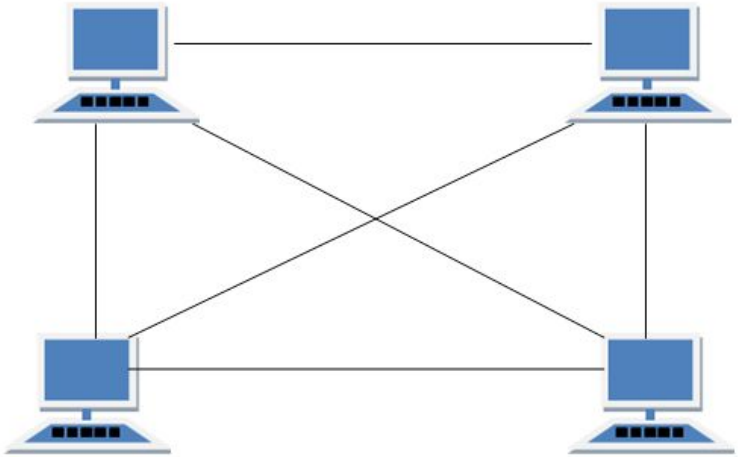
- Fast performance with few nodes and low network traffic.
- Hub can be upgraded easily.
- Easy to troubleshoot.
- Easy to setup and modify.
- Only that node is affected which has failed, rest of the nodes can work smoothly.

Disadvantages of Star Topology

If hub fails, connectivity of all hosts to all other hosts fails because communication between hosts, takes place through only the hub.

Mesh Topology

- In this type of topology, a host is connected to one or multiple hosts.
- This topology has hosts in point-to-point connection with every other host or may also have hosts which are in point-to-point connection to few hosts o



Data Communication Protocol

- The rules to send or receive data is called protocol
- These rules are defined in the network server
- A protocol defines:
  - *Which is communicated?*
  - *How it is communicated?*
  - *When it is communicated?*

Role of Communication Protocols

- Connection Establishment
- Data Sequencing
- Data Routing
- Data Flow
- Ordered Delivery
- Flow Control
- Error Control

Role of Communication Protocols

- Connection Establishment

- Data Sequencing

  It mainly refers to divide data into packets i.e. it divided the whole data into some packets.

- Data Routing

  It refers to select the best path for data transmission between a sender and a receiver because there can be many routes from sender to receiver and you should select the best possible route.

Role of Communication Protocols

- Data Flow:
  - It mainly deals with sending data to the correct destination i.e. the flow of the data is correct or not.

- Ordered Delivery:
  - Protocol facilitates ordered delivery of data, by providing a unique sequence number to each data packet.
  - It is the function of the sender to maintain ordered delivery. By doing so, the receiver will receive the data in the same order as sent by the sender.

Role of Communication Protocols

Flow Control

- Flow control tells the sender how much data should be sent to the receiver so that it is not lost.
- In this way, the sender sends an amount of data that can be handled by the receiver.
- This mechanism makes the sender wait for an acknowledgment before sending the next data.

Role of Communication Protocols

Error Control

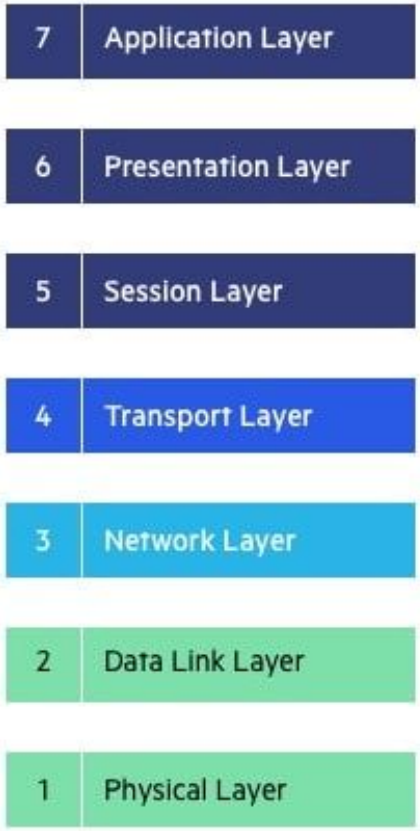
- It deals with error detection (using the checksum bits) and its control.
- If any error is detected during the transmission of the data, a request for retransmission of data is sent to the sender by the receiver, and the corrupt data packet is discarded.

Examples

- TCP/ IP
- UDP
- FTP
- HTTP

OSI Model

- The Open Systems Interconnection (OSI) model describes seven layers that computer systems use to communicate over a network.
- It was the first standard model for network communications, adopted by all major computer and telecommunication companies in the early 1980s.
- OSI was introduced in 1983 by representatives of the major computer and telecom companies, and was adopted by ISO as an international standard in 1984.


7
Application Layer
6
Presentation Layer
5
Session Layer
4
Transport Layer
3
Network Layer
2
Data Link Layer
1
Physical Layer

7. Application Layer

- The application layer is used by end-user software such as web browsers and email clients.
- It provides protocols that allow software to send and receive information and present meaningful data to users.
- A few examples of application layer protocols are the Hypertext Transfer Protocol (HTTP), File Transfer Protocol (FTP).

6. Presentation Layer

- The presentation layer prepares data for the application layer.
- It defines how two devices should encode, encrypt, and compress data so it is received correctly on the other end.
- The presentation layer takes any data transmitted by the application layer and prepares it for transmission over the session layer.

5. Session Layer

- The session layer creates communication channels, called sessions, between devices.
- It is responsible for opening sessions, ensuring they remain open and functional while data is being transferred, and closing them when communication ends.
- The session layer can also set checkpoints during a data transfer—if the session is interrupted, devices can resume data transfer from the last checkpoint.

4. Transport Layer

- The transport layer takes data transferred in the session layer and breaks it into “segments” on the transmitting end.
- It is responsible for reassembling the segments on the receiving end, turning it back into data that can be used by the session layer.
- The transport layer carries out flow control, sending data at a rate that matches the connection speed of the receiving device, and error control, checking if data was received incorrectly and if not, requesting it again.

3. Network Layer

The network layer has two main functions.

- One is breaking up segments into network packets, and reassembling the packets on the receiving end.
- The other is routing packets by discovering the best path across a physical network.
- The network layer uses network addresses to route packets to a destination node.

2. Data Link Layer

- The data link layer establishes and terminates a connection between two physically-connected nodes on a network.
- It breaks up packets into frames and sends them from source to destination.

1. Physical Layer

- The physical layer is responsible for the physical cable or wireless connection between network nodes.
- It defines the connector, the electrical cable or wireless technology connecting the devices, and is responsible for transmission of the raw data, which is simply a series of 0s and 1s, while taking care of bit rate control.