ITC 201: Computer Systems and Information Technology Applications

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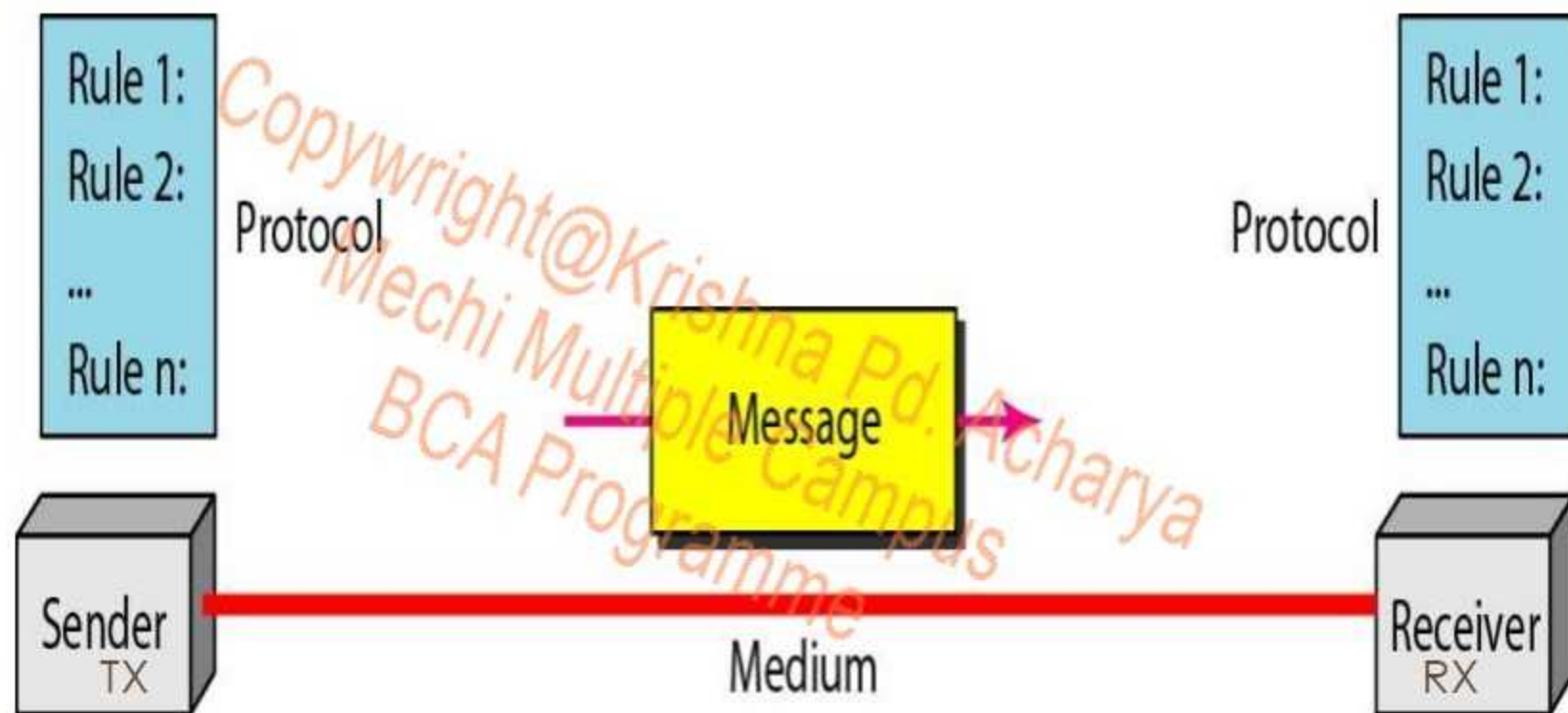# Data communication and computer Network LH 10

- Introduction to communication system
- Mode of communication,
- Introduction of computer network
- Types of computer network
- LAN Topology

- Transmission Media.
- Network Device.
- OSI Reference Model
- Communication protocols
- Centralized vs distributed system

Introduction to Communication system:

➢ Data communications are the exchange of data between two or more devices via some form of transmission medium such as a wire cable or wireless.

Computer Network

Components of communication system
1. **Message**. The message is the information 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, telephone handset, video camera, and so on.
3. **Receiver**. The receiver is the device that receives the message. It can be a computer, 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. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating.
-just as a person speaking Nepali cannot be understood by a person who speaks only Japanese.
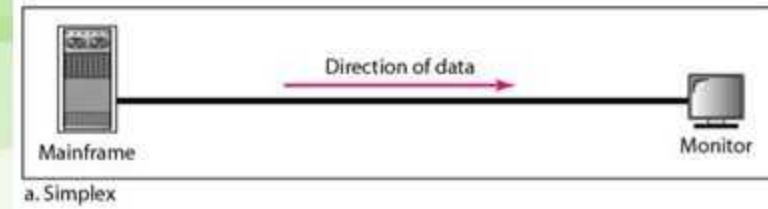
a. Simplex

b. Half-duplex

c. Full-duplex

Mode of communication:

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.

Examples:- 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. TV,Radio.
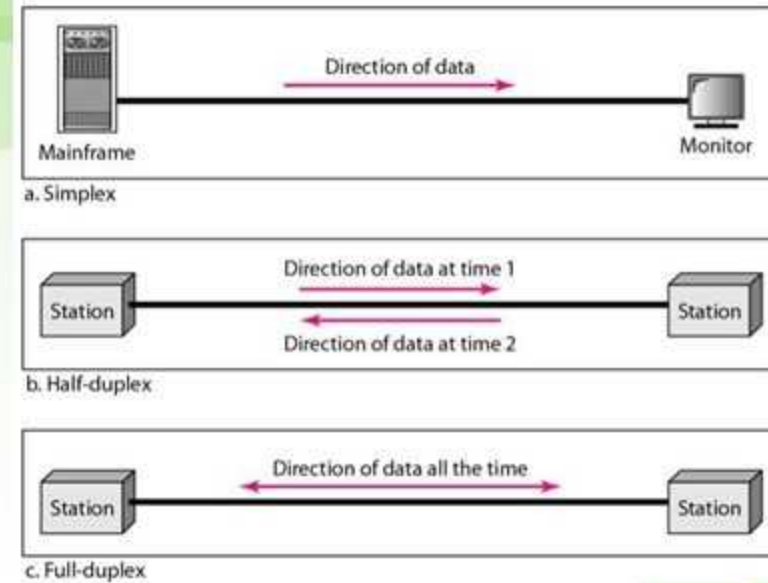
Mode of communication:

a. Simplex

b. Half-duplex

c. Full-duplex
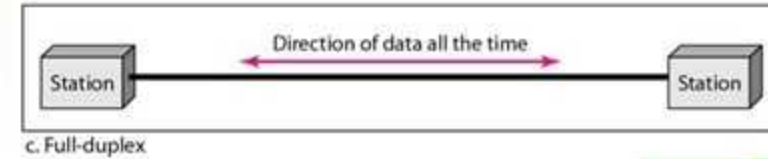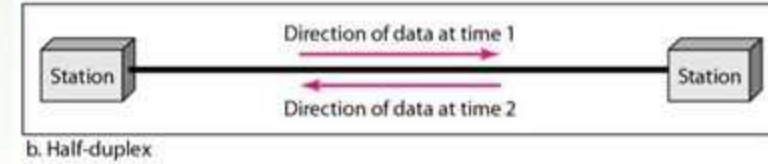
b. Half-Duplex:

➤ 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.

➤ Examples:-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 is half-duplex systems.
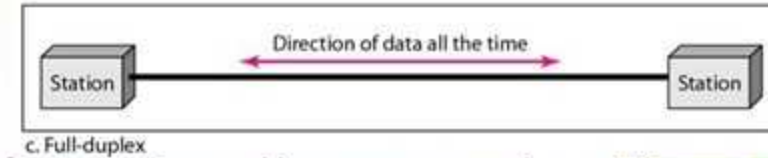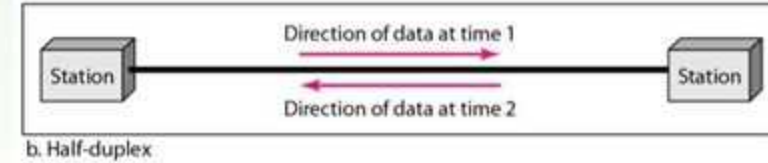
Mode of communication:

a. Simplex

b. Half-duplex

c. Full-duplex

C.

Full-Duplex:

> In full-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.

> Example:- 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.

Computer Network

Introduction to computer network

A computer network is an arrangement where two or more computer are connected to share the data as well as resources such hardware and software using communications media. The ability to exchange data and communicate efficiently is the main purpose of networking computers.
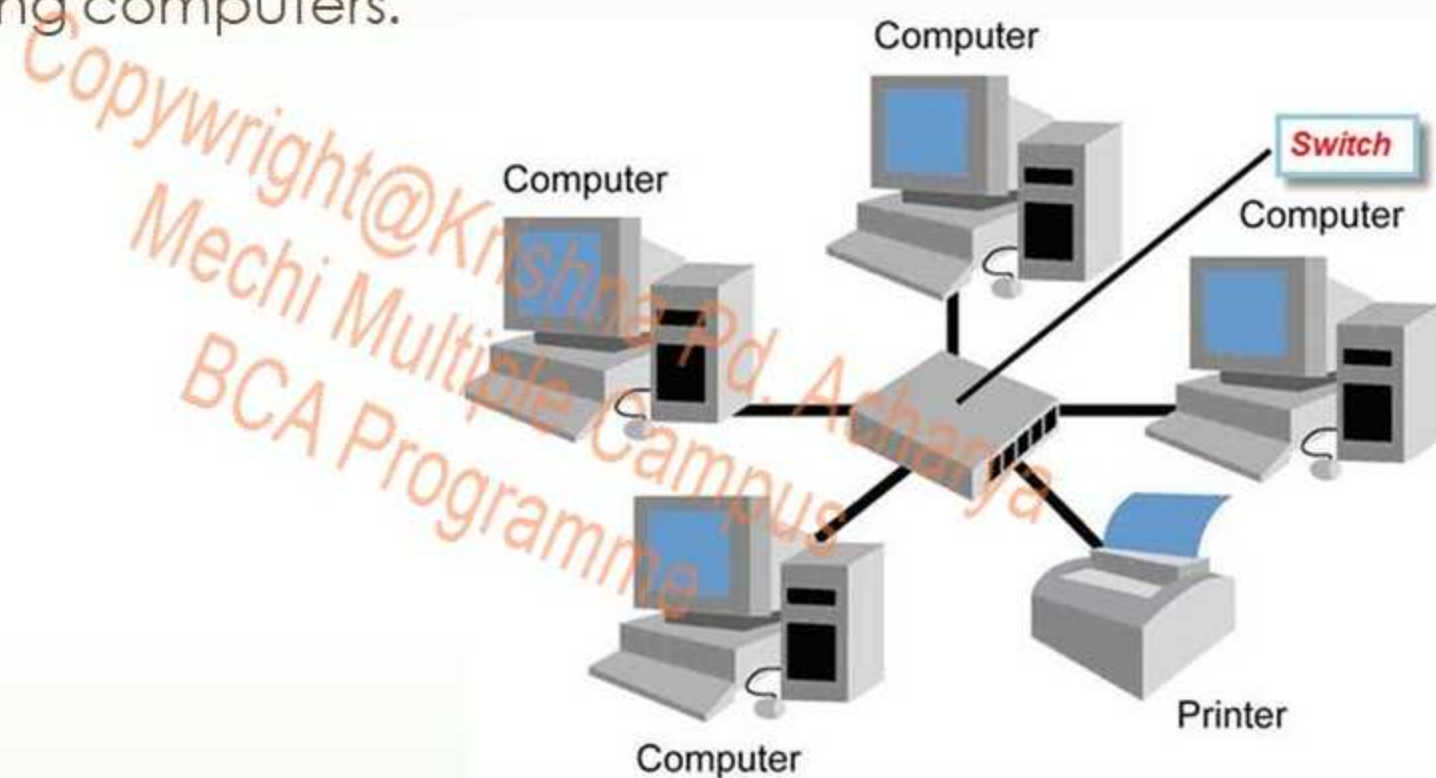
Advantage(Pros) of computer network

o **Sharing of resources**

In a network we can share our resources. That can be hardware or software like printer, scanner, camera and software, programs, video, audio, documents.

o **Communications**

It is very easy to communicate through a network. People can communicate efficiently using a network with a group of people. They can enjoy the benefit of emails, instant messaging, telephony, video conferencing, chat rooms, etc.

o **Security**

Sensitive files and programs on a network can be password protected. Then those files can only be accessed by the authorized users. every user has their own set of privileges to prevent them accessing restricted files and programs.

o **Increased Storage Capacity**

Since 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.

o **Backup and Recovery**

We can able to store essential date or resources in server, so if there is any problem with a single machine we can get the data from server in the network.

Disadvantage(Cons) of computer network:

o **Security Threats**

If a computer is on a network, a hacker can get unauthorized access by using different tools.

o **Virus and Malware**

viruses can spread on a network easily, because of the interconnectivity of computers. all clients in the network that are connected to that server will get affected automatically.

o **Bandwidth Issues**

Internet Bandwidth will be shared among the various users in the network so that they have bandwidth related problems.

o **Dependency on the server**

All the computer in network is relay on the server when a server is down the services that provide by server can not be available to other client.

o **Expensive to setup**

To setup the network additional net work equipment is required like switch, router, cable and network experts so they increases the cost for organization.
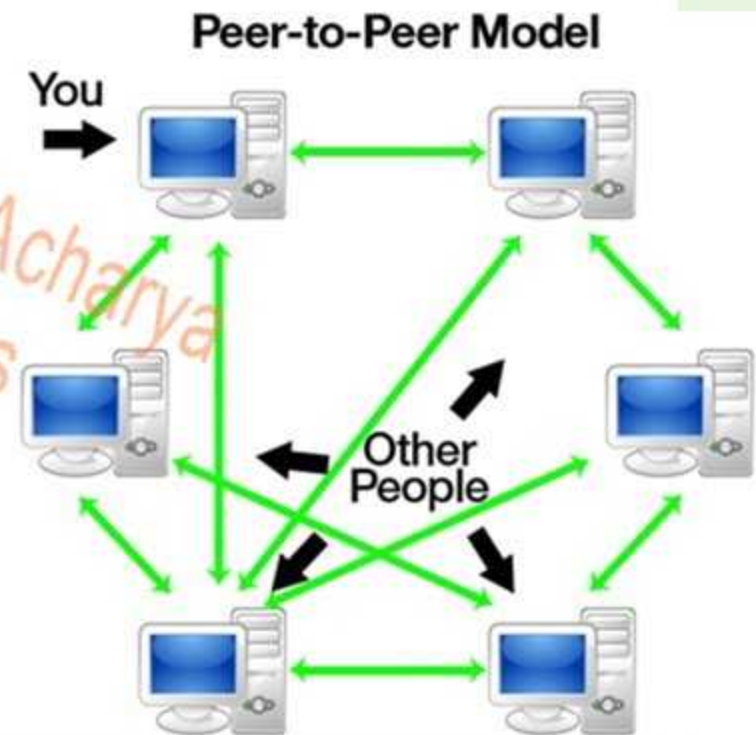
o **Required Technical person**

To monitor, maintenance, upgrade, it is important to have a expert such as Network Administrator, It add extra burden to organization.

1.Peer to Peer Architecture

All the computer have equal authority to access data so it is known as peers. Each computer function as both a client and a server. Client task is to request to server to get the resources and Server task is to verify and provide the services based on request places by the client. There is no any dedicated server. This network architecture is a good choice for environment where there are few (less then 10) computers and users, security is not an issue, centralized control is not needed.

Peer-to-Peer Model

You →

Other People

2.Client/Server Architecture

Client-server architecture is a network architecture in which each computer on the network is either a client or a server. Servers are powerful computers, dedicated to managing disk drives (file servers), printers (print servers), or network traffic (network servers). Clients are PCs on which users run applications. Clients rely on servers for resources, such as files, devices, and even processing power.

Client Server Network
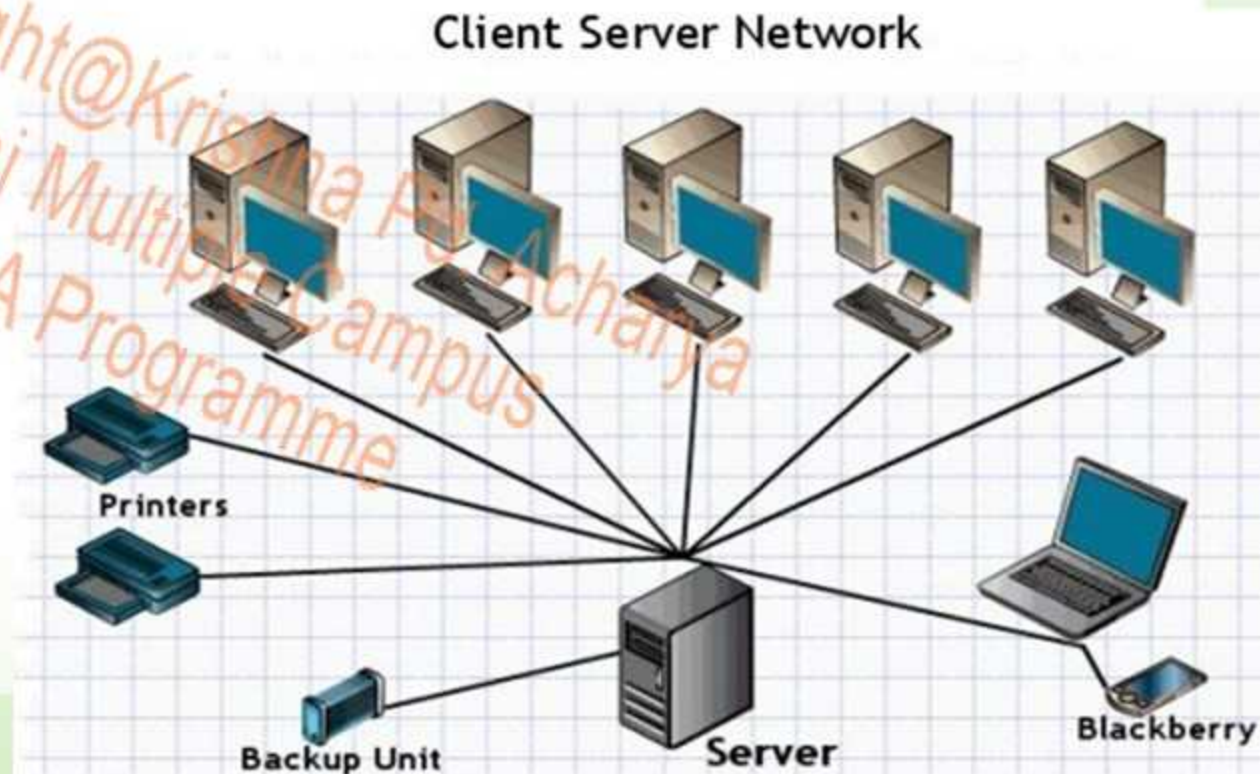
Advantage and Disadvantage

Advantages (Peer-to-Peer Networks)
- No dedicated server.
- Less expensive.
- Easy to install and maintain.
- Good file, printer, and CD-ROM sharing.

Disadvantages(Peer-to-Peer Networks)
- Slow.
- No good for database applications.
- Less reliable (server is workstation).
- Limited expandability.

Client/Server Networks(Advantage)
- Fast.
- Expandable.
- Will work with any application.
- Handles shared database applications.
- More reliable (dedicated server).
- Highest level of security.

Client/Server Networks(Disadvantage)
- Needs dedicated server.
- More expensive to buy.
- More expensive to maintain.

Classification computer on the basis of Size.

1. LAN(Local Area Network)

It is a network that is restricted to smaller physical areas(few hundred meter) e.g. a local office, school, or house. On a 'Local Area Network' data transfer speeds are higher than WAN and MAN that can extend to a 10.0 Mbps and 10 Gbps. it requires little wiring, typically a single cable connecting to each device and it has as lower cost compared to MAN's or WAN's.

2. MAN(Metropolitan Area Network)

A metropolitan area network (MAN) is a large computer network that usually spans a city. A MAN is spread in a larger geographical area than a LAN, ranging from several blocks of buildings to entire cities. A MAN might be owned and operated by a single organization, but it usually will be used by many individuals and organizations. A MAN typically covers an area of between 5 and 50 km diameter. Examples of MAN: Telephone company network that provides a high speed DSL to customers and cable TV network.

3.WAN(Wide Area Network)

WAN covers a large geographic area such as country, continent or even whole of the world. A WAN is two or more LANs connected together. The LANs can be many miles apart. To cover great distances, WANs may transmit data over leased high-speed phone lines or wireless links such as satellites. Multiple LANs can be connected together using devices such as bridges, routers, or gateways, which enable them to share data. The world's most popular WAN is the Internet.

4. Personal Area Network(PAN)

➢ A personal area network is a computer network organized around an individual person.

➢ It generally consists of a mobile computer, a cell phone or personal digital assistant. PAN enables the communication among these devices.

➢ It can also be used for communication among personal devices themselves for connecting to a digital level network and internet.

➢ The PANs can be constructed using wireless or cables.

Comparison between PAN/LAN,MAN,WAN

Networks / Parameters	PAN	LAN	MAN	WAN
Area covered	Small area around 10 M radius	Few meters to KM(1-5)	City and its vicinity Up to 100KM	Entire countries, continents or global
Error Rate	Lowest	Lowest	Moderate	Highest
Transmission speed	Higher	Higher	Moderate	Low
Setup Cost	negligible	Inexpensive	Moderately expensive	Expensive
Example/Location	Home/Individual network	Within Building/School/Business	Cable TV/ISP Within metropolitan/City	Internet
Acronyms	Personal Area Network	Local Area Network	Metropolitan Area Network	Wide Area Network
Ownership	Individual	Private	Private/public	Public

LAN Topologies

➢ The term LAN topology refers to the way in which a network is laid out physically. One 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.
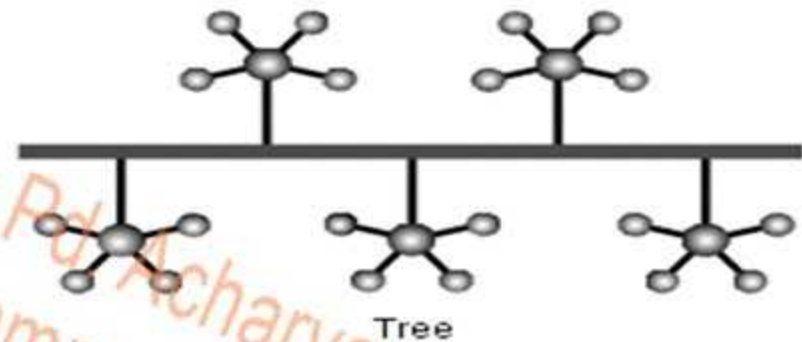
Topology depends on:

➢ **Cost.** For a network to be cost effective, one would try to minimize installation cost.

➢ **Flexibility.** the topology should allow for easy reconfiguration of the network. This involves moving existing nodes and adding new ones.

➢ **Reliability.** The topology chosen for the network can help by allowing the location of the fault to be detected and to provide some means of isolating it.

➢ Network topology is used initially for planning the best way to design your network to get maximum performance.

LAN Topologies

Different Types of Topologies

- o Bus Topology
- o Star Topology
- o Ring Topology
- o Mesh Topology
- o Tree Topology
- o Hybrid Topology

Bus

Star

Token ring

Ring

Mesh

Tree
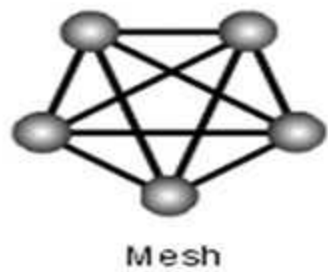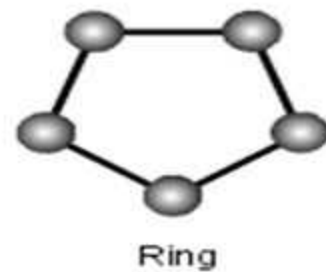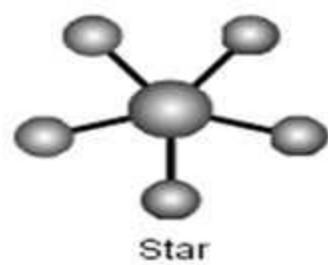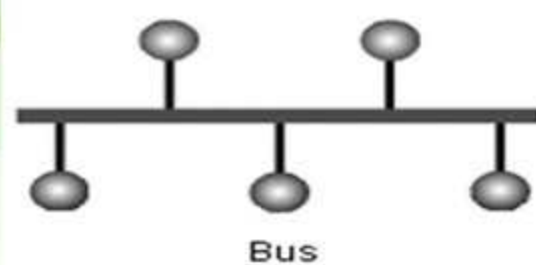
Bus Topology

- o All the nodes (PCs) on a bus topology are connected by one single/ linear cable.
- o A bus topology consists of a main run of cable with a terminator at each end.
- o   Bus Topology because they are inexpensive and easy to install.
- o A bus topology is normally implemented with coaxial cable

Advantages of Bus Topology

- o Easy to implement and extend
- o Well suited for temporary networks that must be set up in a hurry
- o Typically the cheapest topology to implement
- o Failure of one station does not affect others
- o Require less cable

Disadvantages of Bus Topology

- o This network topology can perform well only for a limited number of nodes.
- o Difficult to administer/troubleshoot
- o Limited cable length and number of stations.
- o A cable break can disable the entire network.
- o Maintenance costs may be higher in the long run.
- o Performance degrades as additional computers are added.
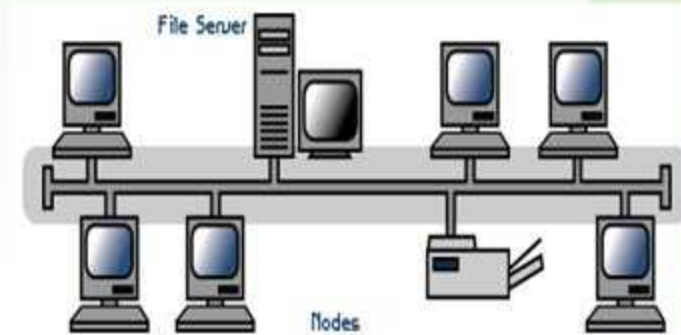
Ring Topology

o In a ring network, every device has exactly two neighbours for communication purposes.

o All messages travel through a ring in the same direction.

o A failure in any cable or device breaks the loop and can take down the entire network.

o To implement a ring network we use the Token Ring technology

o A token, or small data packet, is continuously passed around the network. When a device needs to transmit, it reserves the token for the next trip around, then attaches its data packet to it.
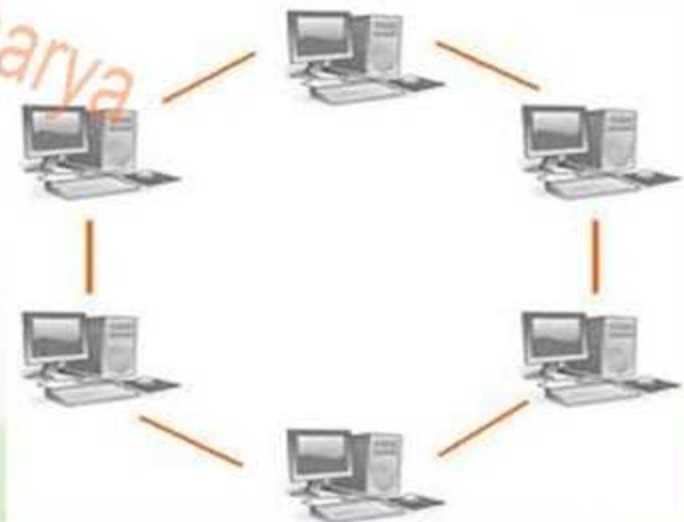
Ring Topology

Advantages of Ring Topology

o No one computer monopolies the network because every computer is given equal access to the token.

o Rings are used in high-performance networks where large bandwidth is necessary.

o Good Communication over long distances

o Handles high volume of traffic

o Require less cabling so less expensive.

o Fault isolation is simplified.

Disadvantages of Ring Topology

o Adding or removing node made to network affects the performance of the entire network.

o Traffic is unidirectional.

o If one node goes down, it takes down the whole network.

o Slow in speed due to the token to receive.

o Adding or removing the computers disturbs the network activity.

Star Topology

o In a star network, each node (PC) is connected to a central device called a hub.

o The hub takes a signal that comes from any node and passes it along to all the other nodes in the network.

o Data on a star network passes through the hub, switch before continuing to its destination.

o The hub, switch manages and controls all functions of the network.

o The star topology reduces the chance of network failure by connecting all of the systems to a central node.

Concentrator/Hub

Nodes
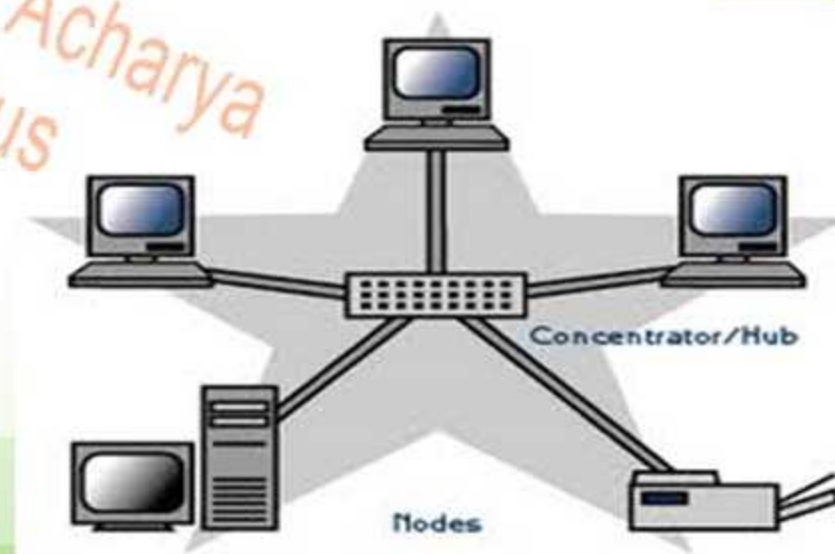
Star Topology

Advantages of Star Topology

o   Easy to modify and add new computers without disturbing the rest of the network.

o   Single computer failures do not bring down the whole network.

o   Easy to locate problems (cable/workstations)

o   Easy to install and wire and detect faults.

o   Fast as compare to ring topology.

Disadvantages of Star Topology

o   Requires more cable length than a Bus topology.

o   If the main hub or switch fails, all the nodes attached are unable to get services.

o   More expensive because of the cost of the main switch/hub/router.

o   Slow in speed due to high data traffic and collision.

Tree Topology

o A tree topology (hierarchical topology) can be viewed as a collection of star networks arranged in a hierarchy.

o In this network, main cable is divided into branches and each branch is further divided into smaller branches and so on.

o The tree topology arranges links and nodes into distinct hierarchies in order to allow greater control and easier troubleshooting.

o This is particularly helpful for colleges, universities and schools so that each of the connect to the big network in some way.
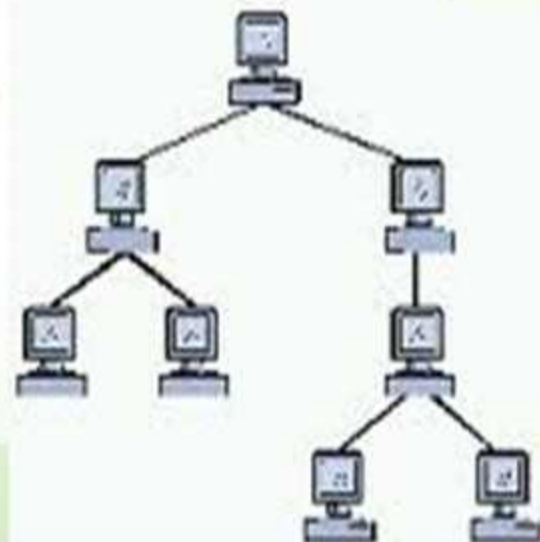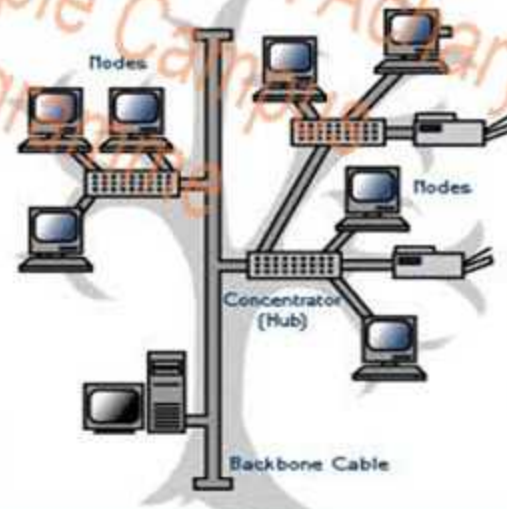
Tree Topology

Advantages of a Tree Topology

o Expansion of Network is possible and easy.

o Networks divided into segments, that can be easily maintained.

o Each segment is provided with dedicated point-to-point wiring to the central hub.

o If one segment is damaged, other segments are not affected.

o Error detection and correction is easy

Disadvantages of a Tree Topology

o If the backbone line breaks, the entire segment goes down.

o More difficult to configure and wire than other topologies.

o As more and more nodes and segments are added, the maintenance becomes difficult.

o Scalability of the network depends on the type of cable used.

Mesh Topology

o In this topology, each node is connected to every other node in the network.

o Implementing the mesh topology is expensive and difficult.

o In this type of network, each node may send message to destination through multiple paths.

o While the data is travelling on the Mesh Network it is automatically configured to reach the destination by taking the shortest route which means the least number of hops.
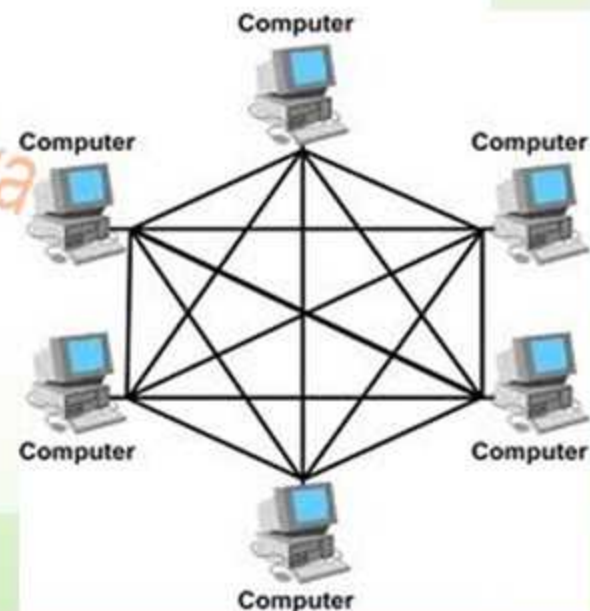
Mesh Topology

Advantage of Mesh Topology

o No traffic problem as there are dedicated links.

o It has multiple links, so if one route is blocked then other routes can be used for data communication.

o Points to point links make fault identification easy.

o It ensures the data privacy or security, because every message travels along a dedicated link.

o It performance is not affected with heavy load of data transmission.

Disadvantage of Mesh Topology

o There is mesh of wiring which can be difficult to manage.

o Installation is complex as each node is connected to every node.

o Cabling cost is high.

o Error detection and correction is default task.

Hybrid Topology

o   A combination of any two or more network topologies.

o   A hybrid topology always accrues when two different basic network topologies are connected.

o   It is a mixture of above mentioned topologies. Usually, a central computer is attached with sub-controllers which in turn participate in a variety of topologies

Advantages of a Hybrid Topology

o   Reliable : Unlike other networks, fault detection and troubleshooting is easy in this type of topology.

o   Scalable: Its easy to increase the size of network by adding new components, without disturbing existing architecture.

o   Flexible: Hybrid Network can be designed according to the requirements of the organization and by optimizing the available resources

o   Effective: Hybrid topology is the combination of two or more topolo

Disadvantages of a Hybrid Topology

o   Expensive for network equipment.

o   Complexity of Design, a tough job for designers.

o   Maintenance and monitor and configure is difficult task.

o   Costly Infrastructure(require a lot of cables, cooling systems, sophisticate network devices)
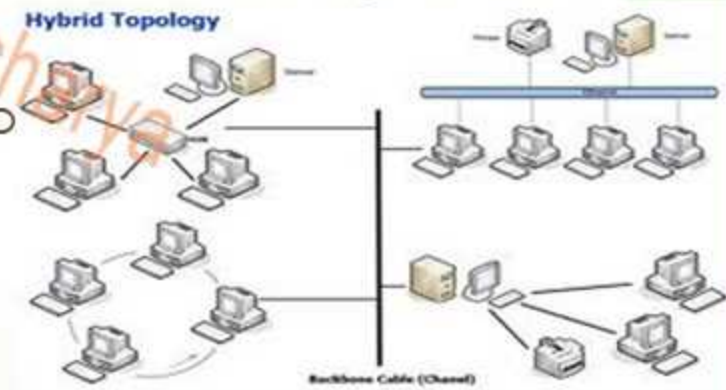
Communication channel (media)

Communication media is the pathway or channel along which the signals or data can be transmitted from one point to another. The signal transmitted from one device to another is through electromagnetic signals. It includes voice, radio waves, infrared light etc.

Guided Media:

➤ Guided media uses a transmission carrier to send data signals through a contained conductor.

➤ This conductor can be a metal wire through which electricity flows or a glass strand through which pulses of light flows.

a) Twisted Pair:

Twisted pair cable is the oldest and common medium of transmission. Twisted pair cable consists of two insulated strands of copper wire twisted around each other. There are two types of twisted pair cable. There are:

i). Unshielded Twisted Pair (UTP):

➤ UTP cable consists of a number of twisted pairs of wires with a simple plastic casing.

➤ UTP is commonly used in telephone system which is suitable for both data and voice transmission.

➤ It comes in different categories (cat 1 to cat 7).

➤ The bandwidth of the cables depends upon the category of the cable.

➤ UTP is good for noise rejection and it covers a maximum distance of 100m.

Communication channel (media)

- ➤ **ii). Shielded Twisted Pair (STP)**
- ➤ The STP cable is similar in construction to UTP except that the twisted pairs are enclosed in a woven copper and foil wrap shield for providing extra protection from external interference.
- ➤ STP is more difficult to install than UTP and Coaxial cable.
- ➤ It covers shorter distance than UTP, but it has better noise rejection capacity.
- ➤ The STP is more costlier than UTP cables.

b). Coaxial cable:

Coaxial cable (commonly called "coax") is made of two conductors that share a common axis, hence the same ("co", "axis"). Typically, the center of the cable is a relatively stiff solid copper wire or stranded wire encased in insulating plastic foam. The foam is surrounded by the second conductor, a wire mesh tube, which serves as a shield from electromagnetic interference (EMI). The coaxial cables are used in communication networks with single ended single reference where the central conductor carries the data signals. The Connectors used in Coaxial cable are BNC, T-connector and terminals.

c). Fiber Optics:

Fiber-optic cable is made of a light conducting glass or plastic core surrounded by more glass called cladding and a tough (hard) outer cover. A fiber optic consists of a bundle of glass threads, each of which is capable of transmitting message modulated onto light waves. Fiber optics uses light signals rather than electricity, so it offers high bandwidth and greatest distance of any transmission system. The main disadvantage of fiber optics are; it is costlier to produce, maintain and install. The connectors used in fiber optics are Screw Mounted Adaptors (SMA), Spring-loaded Twist (ST).
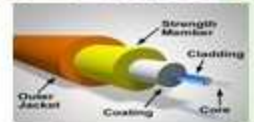
Communication channel (media)

➢ **2) Unguided Media:**
  In unguided media, the data signals flows through the air instead of cables. It includes wireless transmission methods such as radio frequency, infrared transmission, microwaves and others.

➢ **A) radio wave:**
A low range electromagnetic wave is called radio frequency. Frequencies between 3 kHz and 1 GHz are normally are called radio frequencies and between 1 and 300 GHz are called microwaves. It is suitable for transmitting radio signal around the earth surface. Radio waves, particularly those of low and medium frequencies, can penetrate walls.

➢ **B) Microwave**
Microwave signals are used to transmit data without the use of cables, similar to that of radio and television signals but at different frequency range . It is line-of-sight transmission , which means the signal travels in straight line free of material obstacles.

➢ **C) Infrared**
This type of transmission uses infrared light to send data. You can see the use of this type of transmission in everyday life - TV remotes, Presentator, wireless speakers etc., all make use of infrared as transmission media. The infrared light transmits data through the air and can propagate throughout a room(bouncing off surfaces), but will not penetrate walls.
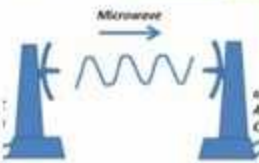
Communication channel (media)

D) Satellite

Satellite communications is the use of satellite technology in the field of communications. The services provided by satellite communications are voice and video calling, internet, fax, television and radio channels.

Satellite communications can provide communication capabilities spanning long distances and can operate under circumstances or conditions which are inoperable for other forms of communication.

OSI reference model

It is based on a proposal developed by the international organization for standardization (ISO). The model is called ISO OSI(**Open System Interconnection**) reference model, because it deals with connecting open system i.e. the system that are open for communication with other system.

1. **Physical Layer**: This layer concerned with transmission of bit it determines voltage level for 0 & 1. It also determines the data rate of the system. This layer involves standardized protocol dealing with electrical & signaling interface.

2. **Data Link Layer**: It handles error in physical layer. This layer ensures the correct delivery of frame to the destination address. It consists of 2 parts or 2 sub-layers. i.e. Logic Link Control Media Access Control(MAC). The **Logical Link Control** layer **controls** frame synchronization, flow **control** and error checking

OSI reference model

3. **Network Layer:** This layer is concerned with transmission of packet. Network layer protocol chooses the best path to send a package called routing. Two protocols are widely used in n/w layer. X.25 Protocol, Internet Protocol

4. **Transport Layer:** It provides the mechanism for the exchange of data between end systems. It ensures that the data received is in fact in order. Following jobs are performed by this layer. Port Addressing, Segmentation & Reassemble, Connection Control.

5. **Session Layer:** It is responsible for requesting logical connection to be established for communication process. This logical connection is termed as session. It also provides data synchronization between two communication terminals.

6. **Presentation layer:** This layer translates format data to adapt to the needs of the application layer & nodes at both receiving & sending end of communication process. It handles data communication, formatting, encryption, decryption, etc.

7. **Application Layer:** It is the top-most layer of OSI model & provides user access to the n/w. It provides services that support user application, such as database access, email & file transfer, etc.

Communication Protocol

Protocol

A protocol is a set of rules for the exchange of data between a terminal and computer or between two computers. Think of protocol as a sort of pre-communication agreement about the form in which a message or data is to be sent and receipt is to be acknowledge.

Types of Protocols

1. Hypertext Transfer Protocol (HTTP) – This protocol is used to access, send and receive Hypertext Markup Language (HTML) files on the Internet.

2. Simple Mail Transfer Protocol (SMTP) – This protocol is used for transferring email between computers

3. File Transfer Protocol (FTP) – FTP is responsible for allowing file to be transferred between devices using internet.

4. Transmission Control Protocol (TCP) – This protocol ensures the delivery of information packets across network.

5. Internet Protocol (IP) – This important protocol is responsible for providing logical addressing called IP address to route information between networks.

6. Hyper Text Transfer Protocol Secure (**HTTPS**) is the secure version of **HTTP**, the protocol over which data is sent between your browser and the website that you are connected to. The 'S' at the end of **HTTPS** stands for 'Secure'. It means all communications between your browser and the website are encrypted.

OSI Model
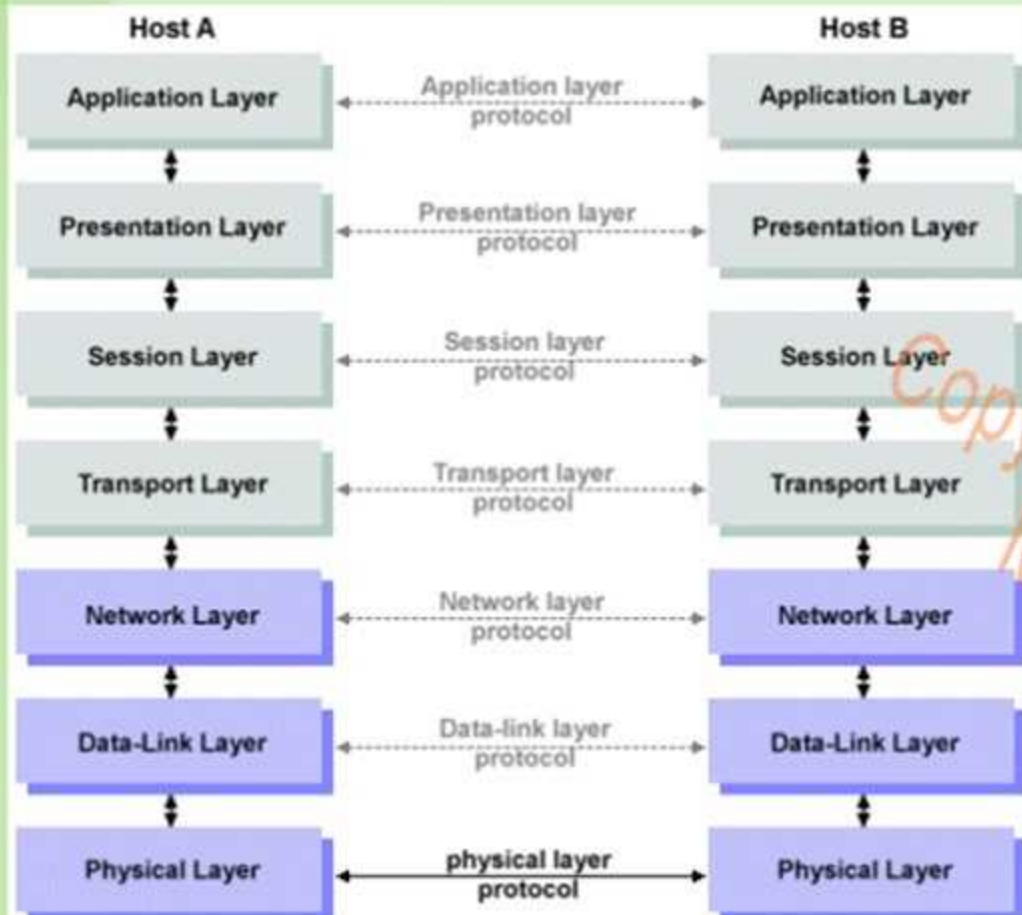
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Application Layer	Interface to application program with application-oriented commands (read, write)
Presentation Layer	Representation (coding) of data for analysis and interpretation in the next layer
Session Layer	Establishing and clearing temporary station connections; synchronization of communicating processes
Transport Layer	Controlling data transmission for layer 5 (transport errors, break down into packets)
Network Layer	Establishing and clearing connections, avoiding network congestion
Data Link Layer	Description of bus access protocol (Medium Access Control, MAC) including data security
Physical Layer	Definition of the medium (hardware), coding and speed of the data transmission

7 Layers of OSI

Centralized vs Distributed system

Centralized System vs. Distributed System

Criteria	Centralized system	Distributed System
Economics	Low	High
Availability	Low	High
Complexity	Low	High
Consistency	Simple	High
Scalability	Poor	Good
Technology	Homogeneous	Heterogeneous
Security	High	Low
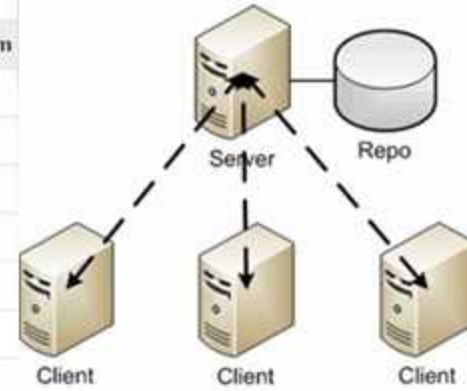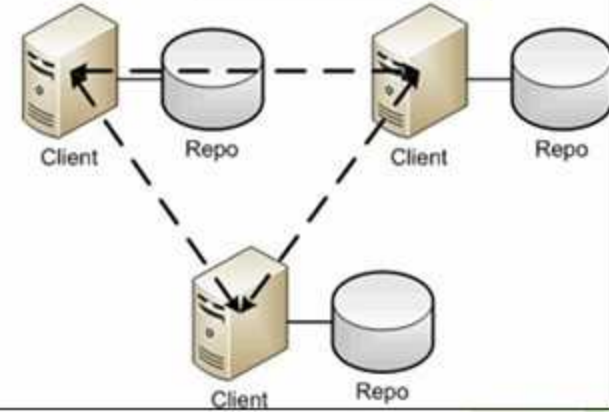
Centralized:

Collecting all information at one place allows better decision to be made but is less robust and can put a heavy load on central machine.

Distributed:

Opposite to Centralized (may also be termed as Decentralized). Here there is no central machine and algorithm is implemented on all the machine.

Despite the increased complexity and the difficulty of building distributed computing systems, the installation and the use of distributed computing systems are rapidly increasing. This is mainly because the advantages of distributed computing systems overcome their disadvantages.

Network Devices

Modem is a device that converts digital signal to analog signal as a modulator and analog signal to digital signal as a demodulator.

➢ Modem of computer A converts these digital signals it into analog signals and sends over the telephone line. This process is called as modulator.

➢ While at the other end, modem of computer B receives the analog signals and converts back into digital signals. This process is called as demodulator.

Hub is a connecting device in which various types of cables are connected to centralize network traffic through a single connecting point.

➢ Hub with multiple ports are used to connect topologies, segments of LAN and to monitor network traffic.

➢ It manages and controls the send and received data to and from the computers.

➢ Hub works on the physical layer of OSI or TCP/IP model.

Switch is a multiple LAN connecting device, which takes incoming data packet from any multiple input ports and passes the data packet to specific output port.

➢ It works same as hub but does its work very efficiently.

➢ It uses MAC address information to switch forward the data packets to a particular destination device.

➢ By monitoring the network traffic, it can learn where the particular addresses is located.

➢ Operates at one or more OSI model layers mainly the data link layer.

Network Devices

Network Interface Card (NIC) is circuit board or a card that allows computers to communicate over a network via cables or wirelessly.

➢ It is also called as LAN adaptor, network adaptor or network card.

➢ Enable clients, servers, printers and other devices to transmit and receive data over the network.

➢ Operates on physical and data link layer of OSI model.

Repeater is a electronic device that reshapes and amplifies the signal received from one LAN segment to another.

➢ Mostly used to boost the signals in the network.

➢ Operates at physical layer in the OSI layer model.

➢ Best suited for long distances network and bus topology.

➢ Main advantage is that they remove unwanted noise from the incoming signals.

➢ Requires separate power supply for functioning.

Bridge is a networking device that connects two or more LAN's together.

➢ Bridge is used when number of LANs starts increasing, the network traffic begins on overwhelming to available bandwidth.

➢ Reduces the network traffic of LAN by dividing it into segments.

➢ Operates at data link layer of OSI model.

Network Devices

Gateway is a network point that act as entry point to other network and translates one data format to another.

➢ Protocol translation : translates protocol format into required protocol format of the network, such as X.25 to TCP/IP.

➢ Network address translation : translates your public IP address to the private IP addresses on your network.

➢ DHCP service : automatically assigns IP address to a computer from a defined range of addresses for a given network.

Router is internetwork connecting device that determines most efficient path for sending a data packet to any given network.

➢ Used to connect two or more similar or dissimilar topological LANs or WLANs

➢ Shares available bandwidth with multiple computers in a network.

➢ Provides a better protection as a hardware firewall against hacking.

➢ Routers are intelligent enough to determine shortest and fastest path from source to destination in a network using algorithms.

➢ Operates at network layer of OSI model.

➢ Wireless routers are now widely used in home and offices as they allow a user to connect easily without installing any cables.

Questions

1. What is computer network? Explain advantage and disadvantage?

2. Define Communication system? Explain components of it.

3. Explain the mode of communication with example.

4. Explain the characteristics and applications of peer-to-peer network

5. Explain peer to peer network architecture? explain its application in real world.

6. Discuss strength and weakness of peer to peer and client/server architecture.

7. Explain types of network on basis of geographical area it covers in detail.

8. What is network topologies? Explain the important factors while designing topologies.

9. Explain ring and mesh topology along with pros and cons?

10. What is communication media? explain Guided and unguided communication media.

11. Write down the importance of OSI model? Explain all the layers of OSI.

12. Differentiate between Centralized and distributed system.

13. Explain major network devices.

14. Define protocol. Explain the role of protocols in communications.

15. What is router? explain the characters of router.