Last Edit: 24-Jul-09

Further Inside

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Std: XII Sub: IT Year: 2004_2005

At This Level

Note: The following material is only for the students to remember what has been taught in class.

Data Communication

Data Communication means exchange of data or information and understanding it.

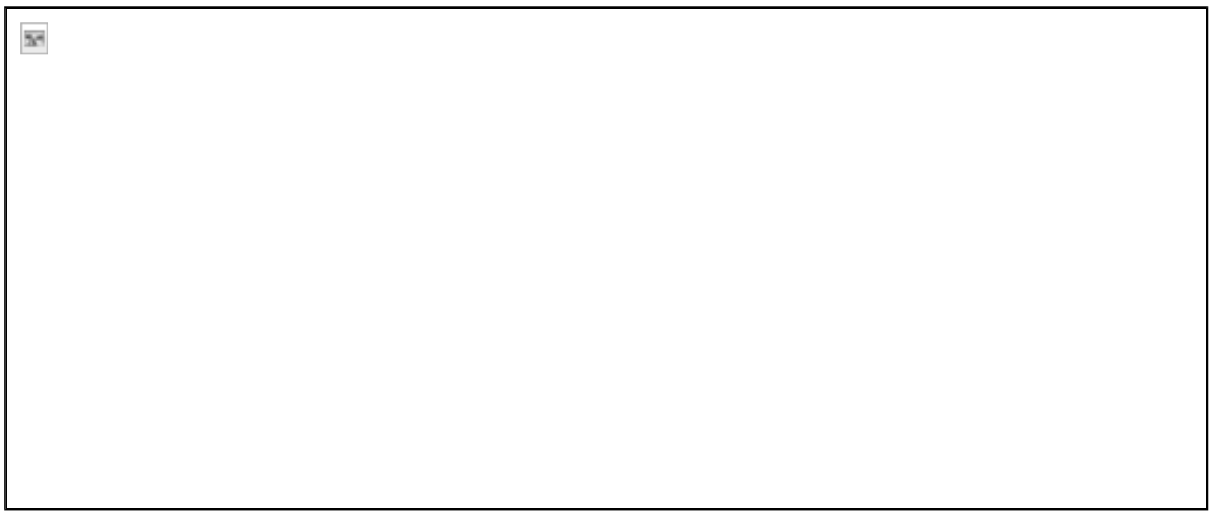
How Data is Transmitted

It is important to know how data is transmitted on a communication system. Data is stored inside th computer and moved in the form of binary digits. These digits are 0 and 1.These binar digits are represented in the form of electrical signals. High level signals represent a 1 an low level signals represent a 0.

Data communication is normally done in the form electrical signals. In rare instances data representatio may in the form of light signals.

Data Transmission

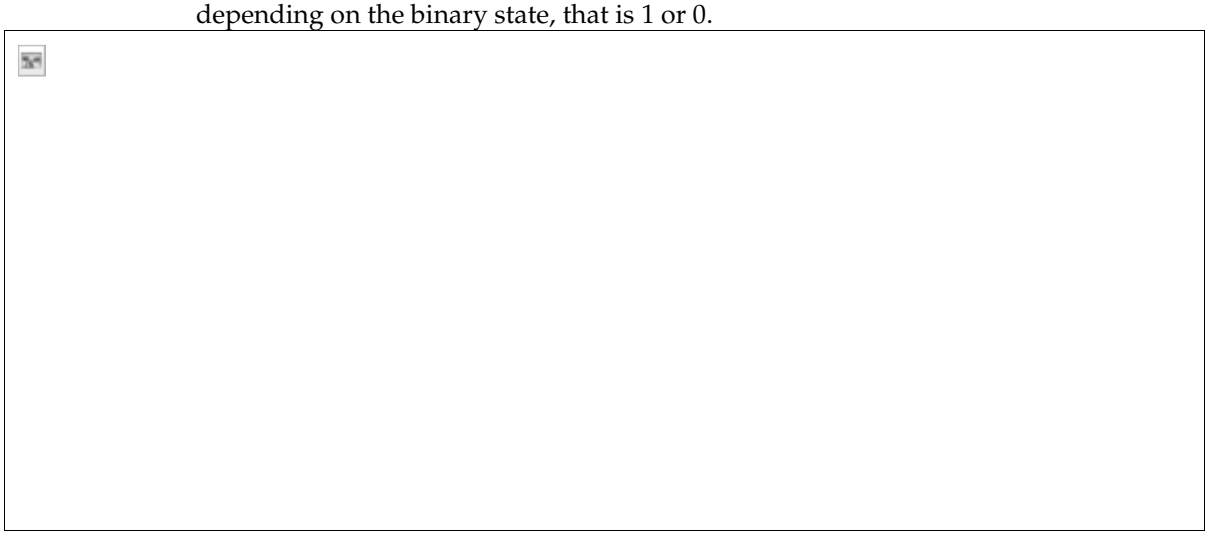
The movement of data over the path in the form signals is called signal propagation. On a path flow o signal is nothing but an electrical current. Radio transmission without the use of wires i done by emitting an electrical signal that propagates as electromagnetic wave.



Signals are represented like oscillating wave forms .An Oscillating wave has got three characteristics tha can vary in order to carry computer generated data. They are

1.Amplitude 2.Frequency and 3.Phase.

Amplitude or voltage is the amount of electrical charge inserted on the wire. It can be set high or lov depending on the binary state, that is 1 or 0.



The signal is also distinguished by its frequency. Frequency is the number of complete oscillations of th wave. Frequency is measured in oscillations per second. 1 hertz(Hz) means 1 oscillatio per second. Another way to refer Frequency is cycles per second (cps). There is n relation between Amplitude and Frequency. Amplitude represents the magnitude or th amount of negative or positive voltage while frequency refers to rate of the signa

oscillation.

Phase of the signal indicates the point to which the signal has advanced in its cycle. The phases of th signal are identified by 1/4 of the cycle ,1/2 of the cycle 3/4 of the cycle and complet cycle. The wave can also be labeled like degree markings .1/4 represents 90 degrees,1/4 stands for 180 degrees and so on. The complete wave represents 360 degrees

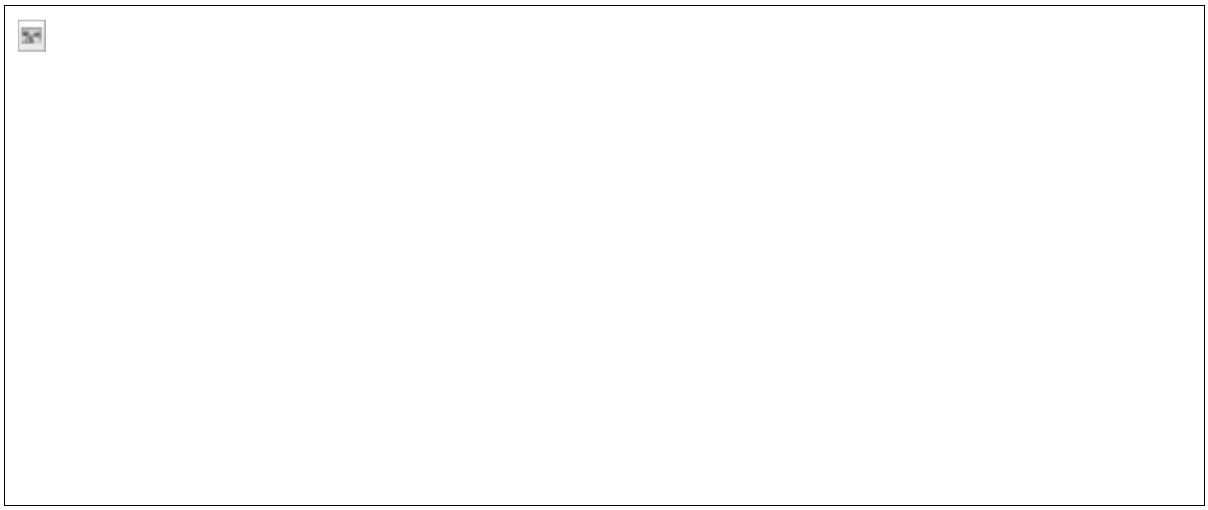
Analog Transmission

The alternating nature of the signal voltage the direction of the current flow on a transmission mediun The negative voltage at the transmitting end repels the negative particles of the conducto wire towards the receiving end while positive voltage will attracts them back to th transmitter thus creating the direction of flow. This is called as alternating current and thi describes an analog signal because of the continuous non discrete nature. It is widely use because analog facilities like telephone lines are readily available.

BUT the data is stored in a discrete digital form in the computer. So when digital data has to b transmitted the analog signal is modified , that is the amplitude ,frequency or phase of th signal is modulated in order to transmit the information.

Digital Transmission

Another way for transmission of computer oriented binary data is by using digital signal which ar symmetrical square waves. In digital signal voltage is switched instantaneously fron positive to negative. Digital signal are more suitable to represent binary states of 0 and with its positive and negative value.



Comparison

Digital transmission is superior to analog transmission . In both these cases, since the signal weakens as i travels the media regenerators have to be used to restore the weakened signal. Th regenerators (amplifiers) used in analog circuits attempt to compensate for the loss, bu never compensates exactly for it and error gets cumulated. The signal gets distorted. Bu in digital circuits the regenerators can restore the weakened signal to its original valu exactly, because the only possible values are 0 and 1.

Networking Essentials

The Network

A group of computers and other devices connected together is called a *network,* and the concept of connected computers sharing resources is called *networking.*

Basic Network Architecture:

The basic building blocks of a network are nodes, hubs, and backbones.

- A node is any piece of hardware on the system that can be addressed by a message from another node, that is, a computer, printer, fax, modem, or CD-ROM drive.
- Nodes are connected to a hub, also known as a concentrator, whose purpose is to simplify the

wiring of the nodes to each other and to route signals between the nodes.

§ A backbone is a high capacity link to which many nodes or hubs can be connected. It's designed to carry lots of traffic.

- Clients, Servers, and Peers

There are three roles for computers in a local area network:

- Clients, which use but do not provide network resources
- Peers, which both use and provide network resources
- Servers, which provide network resources

Servers:

A server on a LAN is any computer that can be shared by other computers working on the LAN. In many cases, the server has to be the most powerful computer on the network, because it is shared among so many users, or clients, so called because these computers depend on the server for programs and data, or connections to other computers and devices**.**

Types of Servers:

§ **File Server:** A file server stores data files and some application programs. It has large amounts of secondary storage in the form of hard disks, CD-ROM drives, tape drives, and other storage devices

§ **Print Server:** A print server stores print jobs on a hard disk until the printer is ready to handle them.

§ **Communication Server:** A communication server can be a fax or modem over which data from any other node can be sent. It can also be used as a gateway to the Internet.

Types of Networks

Local area network(Lan)

Metropolitan area network(Man)

Wide area network(Wan)

very wide area network(vWan)

Types of Networking

1.Peer-to-peer Networking

Peer-to-peer Networking Advantages

- A peer-to-peer network is easy to install and configure.
- Individual machines do not depend on the presence of a dedicated server.
- Individual users control their own shared resources.
- Peer-to-peer networking is inexpensive to purchase and operate.
- Peer-to-peer networks need to additional equipment or software beyond a suitable operating system.
- No dedicated administrators are needed to run the network.

- It works best for networks with 10 or fewer users.

Peer-to-peer Networking Disadvantages

- Network security applies only to a single resource at a time.
- Users may be forced to use as many passwords as there are shared resources.
- Each machine must be backed up individually to protect all shared data.
- Every time a user access a shared resource, the user at the machine where the resource resides suffers reduced performance.
- There is no centralized organizational scheme to locate or control access to data.
- **A peer-to-peer network does not usually work well with more than 10 users.**

2.Server-based Networking

Server-based Networking Advantages

- Centralized user accounts, security, and access controls simplify network administration.
- More powerful equipment means more efficient access to network resources.
- A single password for network logon delivers access to all resources.
- Networks resources, such as files and printers, are more accessible because they are located on specific servers, not spread around individual users machines across the network.
- Concentration of resources on a similar number of servers also makes data resources easier to backup and maintain.
- Server-based networking makes the most sense for networks with 10 or more users or any networks where resources are used heavily.

Server-based Networking Disadvantages

- · At worst, server failure renders a network unusable; at best, it results in loss of network resources.
- · Complex, special-purpose server software requires allocation of expert staff, which increases expenses.
- · Dedicated hardware and specialized software add to the cost.

3 .Storage-area Networks (SANs)

It is for the largest-scale networks especially those with many thousands of users, or with particularly large collections of data to manage. The **storage-area network (SAN)** uses high-speed network links between servers that may be located anywhere in an enterprise and centralized storage systems where data and applications reside. The link that connects a server to a SAN storage device users a high-speed network technology such as Gigabit Ethernet solely for the purpose of connecting servers to an extremely fast and highly reliable storage cluster somewhere else on an organization's premises. Because the network link that connects SAN components completely separate from the network that links clients and servers, this type of connections is a **sideband link.**

SANs provide centralized control over network storage, primarily by consolidating in a single local at the site level. Such systems are considerably more expensive than conventional storage, but they offer considerably more expensive than conventional storage, but they offer considerable advantages as well:

- · Use of high-speed network links makes access to SAN storage as fast as, if not faster than, conventional storage.

- · Consolidation of all server storage permits all backup to occur in a single location and often involves large enough data collections that backup occurs continuously in real time.

- · Consolidation of all server storage permits organizations to buy the fastest, most reliable storage subsystems. Most of these systems include **hot-swappable** power supplies and disk drives that can be removed and replaced with the system stays operational, so that no down time need ever occur. Such capability is not always practical (or affordable) on a per-server basis.

- · Consolidation of storage can add an extra level of security and access controls where needed, or can behave "just like local storage", as far as servers are concerned.

- · Its much easier to increase the storage capacity of a SAN storage system than it is to increase storage on a per-server basis, making it easier for organizations to keep up with rapidly growing storage needs.

Implementing a SAN means adding a second, high-speed network for SAN use to the servers that access any SAN storage devices. This includes an additional high-speed NIC for each such server, the cabling needed to link those servers to the SAN storage device (also known as a SAN storages cluster), and a high-speed switch to connect the network links from the servers to the storage cluster. The storage cluster usually consists of a bank of high-speed, high-reliability disk arrays, with associated back-up subsystems.

4.Hybrid Networks

Networks in which workstations function simultaneously as peer on peer-to-peer networks and as clients on server-based networks. Such **hybrid networks,** sometimes called **combination networks,** partake of the advantages and disadvantages of **Network** Types. Network fall into two major types: peer-to-peer and client/server(sometimes also called **server-based.**

Network Devices:

When signals are sent through a network, they must be sent in the right direction, and they must also sometimes be amplified so they travel farther or converted so they can be transferred to a different network. These are the roles of a series of hardware devices called Repeaters, bridges, routers, and gateways.

§ **Repeaters:** connect segments of a network, and since signals get weaker and less distinct with distance, these small devices refresh and enhance them before sending them along. Their job is to extend the network as far as Possible, perhaps to another building.

§ **Bridges:** connect networks which use different physical links. For example, a network running on twisted-pair wires is connected to one using coaxial cable with a bridge.

§ **Routers:** control where messages are sent on networks. The router keeps the addresses of other nodes in a table. If the address of a message sent through the router is on the network, the message is forwarded. If the address is not on the network, the router forwards the message to another network by sending it to a gateway.

§ **Gateways:** are used to connect different types of networks. Since two networks may not share a common protocol these devices translate each network's protocol so the other network can understand the data.

Network Interface Cards:

A network interface card (NIC), or LAN Adapter serves a number of purposes:

- It makes the physical connection or bridge between the computer and the network.
- It converts the parallel data on the computer's bus into serial data for the network.
- It boosts or amplifies the signal's strength so it can flow through the cables.

Analog Phone Modems:

There are two main types of analog modems. One is an adapter card or PC card that plugs into an expansion slot in the computer. The other is an external modem that connects to the computer's serial port with a cable. Both types are then connected to the telephone's wall jack with a standard phone cable.

How Analog Modems Work:

Analog modems are needed to connect computers to phone lines because the computer generates digital signals but telephone lines carry analog signals. A modem at the sending end converts the computer's digital signals into analog signals (modulation). The modem at the receiving end then converts the analog signals back into digital signals (demodulation) so that the computer can use them. The name modem derives from these two procedures: modulate & demodulate.

Cable Modems:

The coaxial cable that comes into your home from the cable company can carry data much faster than a telephone line and analog modem. However, when these cable systems were built, they were designed to send video to your home (down stream). No one anticipated that you would want to send anything back called (up stream). These one-way systems are slowly being converted to two-way systems. To connect to an upgraded cable line, you use a two-way cable modem.

Topology

The way in which the connections are made is called the *topology* of the network. Network topology specially refers to the physical layout of the network, especially the locations of the computers and how the cable is run between them. The four most common topologies are the bus, the star, the ring, and the mesh.

Bus Topology

The bus topology is often used when a network installation is small, simple, or temporary.

Advantages of the bus

There are several advantages to a bus topology :

- The bus is simple, reliable in very small networks, easy to use, and easy to understand.
- The bus requires the least amount of cable to connect the computers together and is therefore less expensive than other cabling arrangements.
- It is easy to extend a bus. Two cables can be joined into one longer cable with a BNC barrel connector, making a longer cable and allowing more computers to join the network.
- A repeater can also be used to extend a bus; a repeater boosts the signal and allows it to travel a longer distance.

Disadvantages of the Bus

A bus topology is commonly subject to the following disadvantages:

- Heavy network traffic can slow a bus considerably.
- Each barrel connector weakens the electrical signal.
- It is difficult to troubleshoot a bus.
- A cable break or loose connector will bring down the whole network.

Star Topology

In a *star* topology, all the cables run from the computers to a central location, where they are all connected by a device called a *hub*.

Advantages of the Star

There are several advantages to a star topology:

- It is easy to modify and add new computers to a star network without disturbing the rest of the network.
- You can use several cable types in the same network with a hub that can accommodate multiple cable types.

Of the four network types, the star is the most flexible and the easiest to diagnose when there is a network fault

Disadvantages of the Star

The star topology has a few disadvantages:

- If the central hub fails, the whole network fails to operate.
- It costs more to cable a star network because all network cables must be pulled to one central point, requiring more cable than other networking topologies.

Ring Topology

In a ring topology, each computer is connected to the next computer, with the last one connected to the first.

Advantages of the Ring

The ring topology offers the following advantages:

- Because every computer is given equal access to the token, no one computer can monopolize the network.

Disadvantages of the Ring

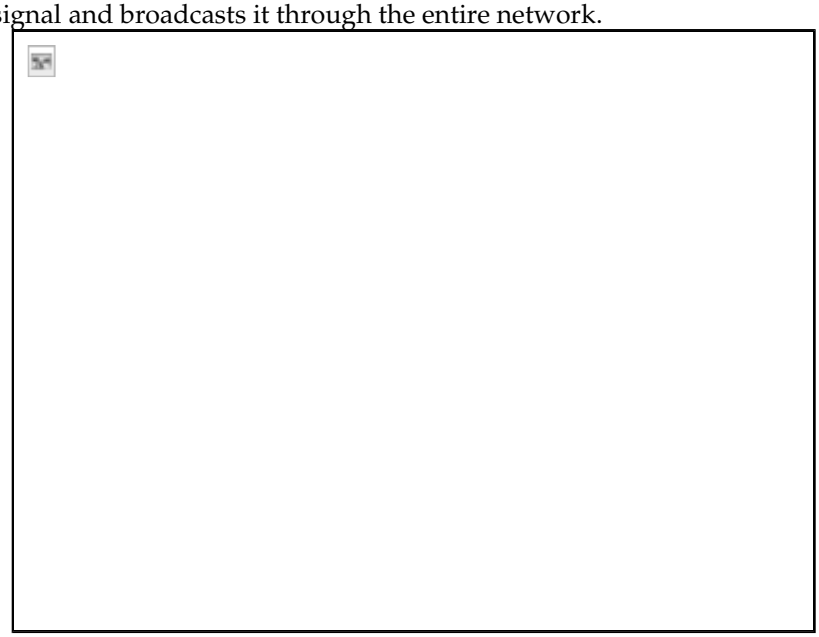
The ring topology has the following disadvantages:

- Failure of one computer on the ring can affect the whole network.
- It is difficult to troubleshoot a ring network.
- Adding or removing computers disrupts the network.

Hybrid Topology :
From the above discussed topologies such as star, bus and ring, it is observed that, each topology has some advantages and disadvantages. So to get a useful result, it is possible to combine or to modify some of the characteristics of the above mentioned 'pure' topologies. These combinations are called as **hybrid topologies.**
There are two types of hybrid topologies.
1. Tree topologies
2. Star-ring topology

1. **Tree topology :** In tree topology, shape of the network is like an inverted tree0. Tree topology contains central root branching and sub-branching and sub-branching to the extremities of the network. In tree topology, star topology and bus topology are combined together. Tree topology is normally implemented by using coaxial cable as a transmission medium. Technically tree is a bus network which connects individual workstation in a very limited area. Hence, network is divided into different

segments. This topology is also referred to as rooted tree. In tree topology, when any node transmits, the root receives the signal and broadcasts it through the entire network.



Advantages of Tree Topology

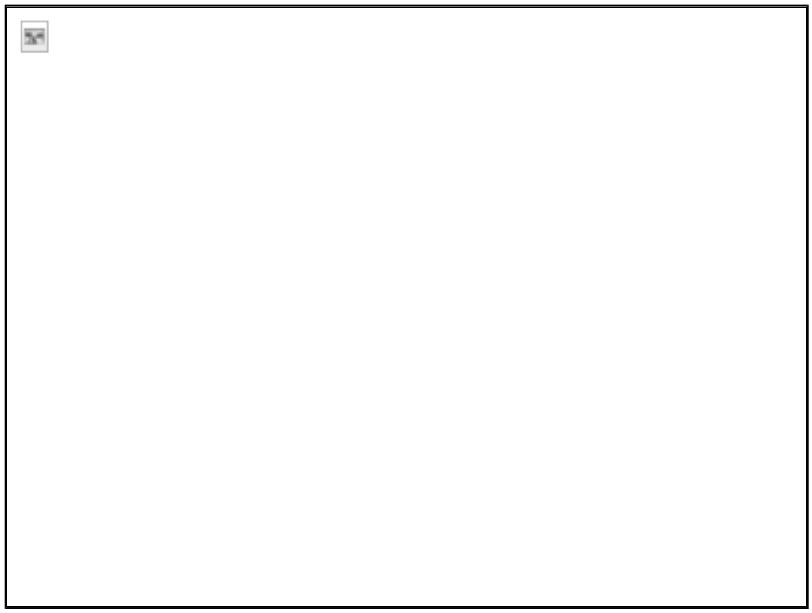
a. Easy to extend : Tree can be further divided into subunits. It is easy to add new nodes or branches to it.

b. Fault isolation : To isolate a defective node, it is possible to disconnect whole branches of the network from the main structure.

Disadvantages of Tree Topology

Depend on the root : In tree topology, root is very important. If root fails, the operation of entire network will stop. In this respect, the tree suffers from the same reliability problem as the star topology.

2. **Star-ring Topology** : In star- ring topology, two topologies such as star and ring is combined to achieve the best of both topology. In star ring topology, number of concentration points are connected together in a ring. These concentration points consists of writing closets located on each floor of a building. Then from each closet, nodes are connected in a star configuration. In star-ring topology physical wiring is arranged as a series of interconnected stars. Because of this, star-ring topology is more descriptively called as the **star-shaped ring**. In star-ring topology cable between workstations passes through a central wire centre. It gets the advantage to operate the ring when cable fails. Automatic bypass relays are used to configure network operations. If a failure, occurs, the "dead" section of the ring is effectively eliminated and effective workstations can keep operating.



Advantages of star-ring topology :
a. Easy fault diagnosis : The presence of concentration points in the network makes easy to diagnose a fault. If a fault is detected on the network, then related concentration point is blamed. The offending concentration point can be easily isolated.
b. Ease of expansion : The modular construction of a star-ring network means that new sections may be easily added. While designing the network, each concentration has extra, unused lobes which can be used for expansion.
c. Cabling : The concentration points in a star-ring are connected via a single cable. This simplifies between
installation areas and cuts down the congestion of cable ducts.

Disadvantages of star-ring topology :
a. Requires intelligent concentration points : Star-ring topology requires need of intelligence or processing ability to the concentration points. This requires to assist the fault diagnosis in the network and node isolation.
b. Cabling : The inter closet cabling in a star-ring topology is critical to its operation. It requires redundant cabling in the form of one or more back up rings. Considerable amount of cable is required for star network which is the major portion of star-ring topology.

Comparative study of network topologies

Particulars	Bus	Star	Ring
1. Complexity	Not very complex hardware	Relatively complex hardware	Quite complex hardware
2. Performance	Excellent under light load, degrade rapidly as load increases.	Good for moderate load.	Good for heavy load and remains stable with less delay and degradation of service.
3. System overload	Network overload is comparatively low since hardware is fully developed and readily available.	Network overload is high, since server cannot be used for any other purpose while acting as a network server.	If equipment fails, method of bypassing failure point is needed.
4. Vulnerability	Vulnerable to a failure from danger tot he main link and other problems affecting the bus.	Reliability depends on central server. If server fails, all activity of the network stops.	Failure in a single workstation can cause system failure because of the independence of the failure.
5. Expandability	Expansion and reconfiguration is easy.	Expandability is strictly restricted since server supports limited no. of network interfaces.	Easy to add and delete workstations, hence system modification cost is relatively low.
6. Application	Good choice for small networks.	Best way to integrate voice and data services.	Used where a small number of workstations operate at high speeds over short distances.

Choosing a topology : To choose a 'best' topology for network, it is necessary to consider complexity of topology. Topology must be easy to install. Once installed, it must be able to cope with growth requirements. If required it should be possible to carry out extensive changes to the network. Also system should be able to detect the faults quickly. It requires to check vulnerability of topology. The choice of topology can affect the range of possible media and the access method used to share it. The choice of topology can affect the range of possible media and the access method used to share it.
From the above, star topology is the most interest point of view. It is more appropriate for terminal-host configurations. The remaining two (bus and ring) 'pure' topologies have both good and bad points These can be improved by combining them with other topologies.

Cable Connectors : Connectors are used to provide connections for cable. Most connectors require two types of connector to complete a connection. There are two types of connector i.e. male and female. The male connector is a connector with pins and the female connector has sockets into which the pins are inserted. Commonly used alternative for 'male' and 'female' is pins and sockets'.

Cable connectors are as follows :
i. British Naval Connector (BNC) T-connector
ii. N-connectors
iii. DB-9 connector

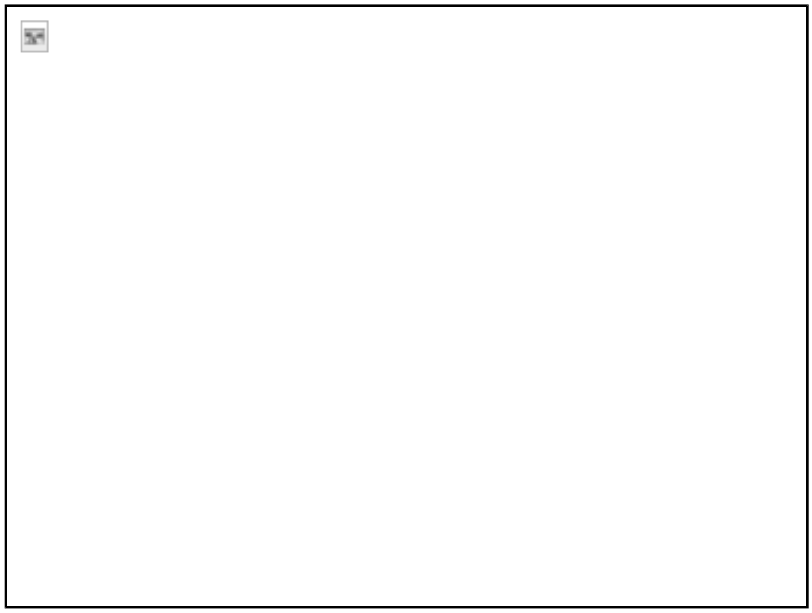
i. BNC T-connector : BNC T-connector are the most commonly used connectors in coaxial cable.

- A BNC T-connector connects the network board in the PC to the network. The T-connector attaches directly to the network board.
- BNC cable connectors attach cable segments to the T-connectors.
- A BNC barrel connector connects to Thinnet cables
- A BNC terminator is a special connector that includes a resistor that is carefully matched to the characteristics of the cable system.
- One of the terminators must be grounded.

i. N-connectors : Thicknet uses N-connectors. With thinnet both ends of the cable must be terminated. N-connector uses a connecting device called a **Transceiver** which is attached tot eh thicknet cable. Transceiver has a port for AUI connector. There are two ways to connect Transceiver to thicknet cable.

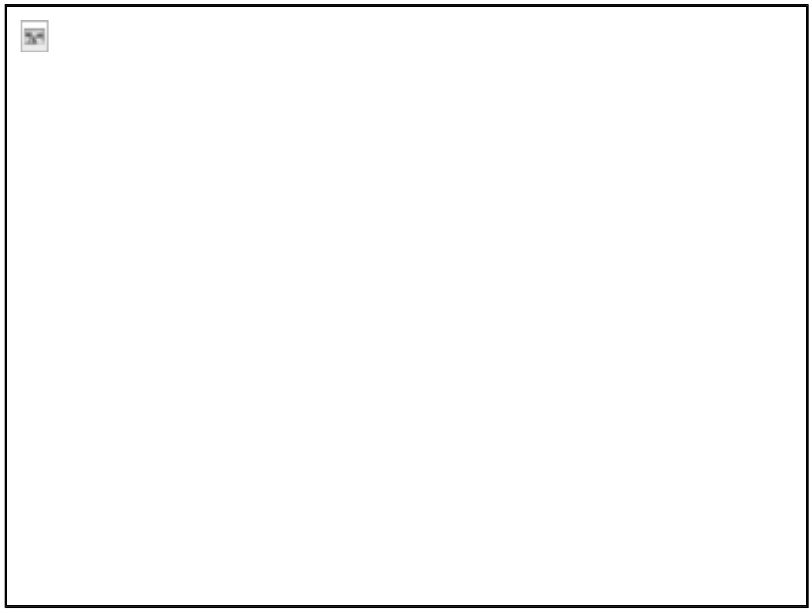
- Transceivers can connect by cutting the cable and using N-connectors and a T-connector on the transceiver.
- Another way is to use a clamp-on transceiver, which has pins that penetrate the cable without the need for cutting.

iii. DB-9connector : Twisted pair cable uses DB-9 connector and IBM data connector.



IBM connector is connector is connected to a network card having a DB-9 connector, by using twisted pair cable.

Network cards : A network card or network adapter card is a hardware device that is installed in a computer which provides an interface from a computer to the transmission medium. Most PC networks such as Ethernet and Token Ring networks use networks use network adapter card. The network adapter card fits into one of the PC's expansion slots. The card has on e or more user accessible ports to which the network cabling medium is connected. The network adapter card has a driver that manages the device. ODI standards (Open Data-Link Interface) provide a uniform interface for the adapter card driver which enables one adapter to support multiple protocols.



The network adapter card performs the following functions :

i. Preparing data for transmission media : Data travels in a serial form on the network (one bit at a time). However, inside the PC, data moves along the bus in parallel form (8, 16 or 32 bits at a time). Network adapter card converts the parallel data from the bus into the serial form required for network transmission.

ii. Sending data : The network adapter card places the data on the network and receives data from the network. To perform this 'Token Passing Method'. (discussed in ring topology) is used to transfer the data. Network card receives packets from the network. It checks the destination address of all packets. It interrupts the CPU if packet is addressed to the local system.

iii. Controlling the flow of data : When two computers need to exchange data, the network adapter cards must decide the agreement for transmission of certain parameters. Before sending data, the cards exchange messages and agrees on transmission speed and a time interval between packets. Installing a network adapter card depends on the card, the operating system and the hardware platform.

Network Medium

In computer networking, the medium affects nearly every aspect of communication. Most important, it determines how quickly and to whom a computer can talk and how expensive the process is.

Copper

The most common network medium is copper.

Glass

Photons are the basic particles of light. Light can travel for several miles in the less expensive multi-mode fiber optic cable without signal loss.

Air

Both fiber optics and copper cabling have the drawback that you need a cable to connect the computers.

Air—no cabling required!

Network Media Types

- Cables

- Wireless

Refer the Textbook

Media Characteristics

Each media type has certain characteristics that make it suitable for particular networks. To choose the best type of media for your network, you should know how each medium's characteristics relate to the following factors:

- Cost
- Installation
- Capacity
- Attenuation
- Immunity from electromagnetic interference (EMI) (Details read from the text book)

The Electromagnetic Spectrum

<table>
<tr><td rowspan="2">____ 1
____ 3
____10
____30
____ 100
____ 300 Hertz</td><td rowspan="3">Power & Telephone</td><td></td></tr>
<tr><td>Extremely Low Frequency (ELF)</td></tr>
<tr><td rowspan="3">____ 1
____ 3
____10
____30
____ 100
____ 300 Kilohertz</td><td>Voice Frequency</td></tr>
<tr><td rowspan="5">Radio Waves</td><td>Very Low Frequency (VLF)</td></tr>
<tr><td>Low Frequency (LF)</td></tr>
<tr><td rowspan="3">____ 1
____ 3
____10
____30
____ 100
____ 300 Megahertz</td><td>Medium Frequency (MF)</td></tr>
<tr><td>High Frequency (HF)</td></tr>
<tr><td>Very High Frequency (VHF)</td></tr>
<tr><td>____ 1</td><td></td><td></td></tr>
</table>

____ 3 ____10 ____30 ____ 100 ____ 300	Gigahertz	Microwave	Ultra High Frequency (UHF) Super High Frequency (SHF) Extremely High Frequency (EHF)
____ 1 ____ 3 ____10 ____30	Terahertz	Infra red	Submillimeter waves Far infrared Intermediate infrared
0v ____ 1 ____ 10 ____ 100	Photon Energy In Hertz Volts(ev)	Ultraviolet	Near infrared Near Ultraviolet
Kev ____ 1 ____ 10 ____ 100			Vaccum ultraviolet
Mev ____ 1 ____ 10 ____ 100		X-rays	Soft x-rays Hard x-rays
Gev ____ 1 ____ 10 ____ 100		Gamma rays	Soft gamma rays Hard gamma rays Secondary cosmic rays (gamma rays produced by cosmic rays)

Cable Media Cables have a central conductor that consists of a wire or fiber surrounded by a plastic jacket. Three types of cable media are twisted-pair, coaxial, and fiber-optic cable. Two types of twisted-pair cable are used in networks; unshielded (UTP) and shielded (STP).

Factor	UTP	STP	Coaxial	Fiber-optic
Cost	Lowest	Moderate	Moderate	Highest

Installation	Easy	Fairly Easy	Fairly Easy	Difficult
Band-Width Capacity	1 to 155 Mbps (typically 10Mbps)	1 to 155Mbps (typically 16Mbps)	Typically 10 Mbps	2 Gbps (typically 100 Mbps)
Node capacity per segment	2	2	30 (10 base2) 100 (10 base5)	2
Attenuation	High (range of hundreds of meters)	High (range of Hundreds of meters)	Lower (range of a few kilometers)	Lowest (range of a few kilometers)
EMI	Most vulnerable to EMI & Eavesdropping	Less vulnerable than UTP but still vulnerable to EMI & eavesdropping	Less vulnerable than UTP but still vulnerable to EMI & eavesdropping	Not affected by EMI or eavesdropping

Twisted-Pair Cable

Twisted-pair cable uses one or more pairs of two twisted copper wires to transmit signals. It is commonly used as telecommunications cable.

- **Unshielded Twisted-Pair Cable**
- **Shielded Twisted-Pair Cable**

Coaxial Cable

Fiber-Optic Cable

Optical Technology have made it possible to transmit data by pulses of light. A light pulse can be used to represent a 1 bit and the absence of pulse indicates a 0 bit. Optical transmission system uses three components: *transmission medium*, the *light source* and the *detector.* The transmission medium is ultra thin fiber of glass or silica. The light source is a LED (Light emitting Diode) or laser Diode. These emits a light pulse when electrical signal falls on it. The detector is a photodiode which generates an electrical signal light pulse falls on it. By having a combination of LED at one end and photodiode at the other end of an optical fiber it is possible accepts an electrical signal converts and transmits like a light pulses, and reconverts the output to electrical signal at the receiving end.

Fiber-optic cable transmits light signals rather than electric signals. Each fiber has an inner core of glass or plastic that conducts light. The inner core is surrounded by cladding, a layer of glass that reflects the light back into the core. Each fiber is surrounded by a plastic sheath.

Optical fibers may be multimode or single-mode. Single-mode fibers allow a single light path and are typically used with laser signaling. Single-mode fiber can allow greater bandwidth and cable runs than multimode but is more expensive. Multimode fibers use multiple light paths. The physical characteristics of the multimode fiber make all parts of the signal (those from the various path) arrive at the same time, appearing to the receiver as though they were one pulse. If you want to save money, look into multimode, since it can be used with LED's (light-emitting diodes), which are a more affordable light source than lasers.

Optical interface devices convert computer signals into light for transmission through the fiber. Conversely, when light pulses come through the fiber, the optical interface converts them into computer signals. For single-mode fiber, light pulses are created by Injection Laser Diodes (ILD's) , which create a higher quality of light. For multimode fiber, LED's are used, when the light pulse is received, it is converted back into electric signals by Photodiodes.

Wireless Media

Wireless media do not use an electrical or optical conductor.

Radio Wave Transmission Systems

Radio waves have frequencies between Kilohertz (KHz) and gigahertz (GHz). The range of the electromagnetic spectrum between 10KHz and 1GHz is called radio frequency (RF).

Radio waves include the following types:

- Short-wave
- Very-high-frequency (VHF) television and FM radio
- Ultra-high-frequency (UHF) radio and television

Radio waves can be broadcast omni-directionally or directionally. Various kinds or antennas can be used to broadcast radio signals. Typical antennas includes the following

- Omni-directional towers
- Half-wave dipole
- Random length wire
- Beam (such as the Yagi)

The power of the RF signal is determined by the antenna and transceiver (a device that TRANSmits and reCEIVES a signal over a medium such as copper, radio waves, or fiber-optic cables).

Microwave Transmission System

Microwave communication makes use of the lower gigahertz frequencies of the electromagnetic spectrum. These frequencies, which are higher than radio frequencies, produce better throughput and performance. There are two types of microwave data communication systems: terrestrial and satellite.

Factors	Terrestrial Microwave	Satellite Microwave
Frequency range	Low gigahertz (typically between 4 to 6 or 21 to 23 GHz)	Low gigahertz (typically 11 to 14)
Cost	Moderate to high	High
Installation	Moderately difficult	Difficult
Bandwidth capacity	About 1 to 10 Mbps	About 1 to 10 Mbps
Node capacity	2(sender and receiver)	2(sender and receiver)
Attenuation	Depends on conditions (affected by atmospheric conditions)	Depends on conditions (affected by atmospheric conditions)
EMI	Poor	Poor

Terrestrial Microwave

Terrestrial Microwave systems typically use directional parabolic antennas to send and receive signals in the lower gigahertz range. The signals are highly focused, and the physical path must be line-of-sight.

Satellite Microwave

Here's how it usually works: a LAN sends a signal through cable media to an antenna (commonly known as a satellite dish), which beams the signal to the satellite in orbit above the earth. The orbiting antenna then transmits the signal to another location on the earth or, if the destination is on the opposite side of the earth, to another satellite, which then transmits to a location on earth.

Infrared Transmission Systems

Infrared signals do have a downside: the signals cannot penetrate walls or other objects, and they are diluted by strong light sources.