BUDDHA SERIES

(Unit Wise Solved Question & Answers)

Course – B.Tech. (CSE Allied-AIML/DS)

College – Buddha Institute of Technology

(AKTU CODE-525)

Department: Computer Science & Allied-PROGRAM: AIML-DS

Subject: Computer Networks (BCS 603)

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Unit - 1

Q.1 What are the number of cable links required for n devices connected in mesh, ring, bus and star topology? **(AKTU 2014-15)**

Solution: The number of cables for each type of network is:

a. Mesh: n (n – 1) / 2

b. Star: n

c. Ring: n – 1

d. Bus: one backbone and n drop lines

Q2. Differentiate between bit rate and baud rate. State two reason for using layered protocols. **(AKTU 2014-15)**

Solution: Bit rate and Baud rate, these two terms are often used in data communication. Bit rate is simply the number of bits (i.e., 0's and 1's) transmitted in per unit time. While Baud rate is the number of signal units transmitted per unit time that is needed to represent those bits. There are two main reasons for using the layered protocols and these are:

1. Specialization and

2. Abstraction

- A neutral standard is created by a protocol which can be used by the rival companies for creating programs that are compatible.
- So many protocols are required in the field and that should also be organized properly and these protocols have to be directed to the specialists that can work up on these protocols.
- A network program can be created using the layered protocols by a software house if the guidelines of one layer are known.
- The services of the lower level protocols can be provided by the companies.
- This helps them to specialize.
- In abstraction, it is assumed that another protocol will provide the lower services.
- A conceptual framework is provided by the layered protocol architecture that divides the complex task of information exchange into much simpler tasks between the hosts.
- The responsibility for each of the protocols is narrowly defined.
- A protocol provides an interface for the successive higher layer protocol.
- As a result of this, it goes in to hiding the details of the higher protocol layers that underlies.
- **The advantage of using the layered protocols** is that the same application i.e., the user level program can be used by a number of diverse communication networks.
- For example, when you are connected to a dial up line or internet via LAN you can use the same browser.
- For simplifying the networking designs, one of the most common techniques used is the protocol layering.
- The networking designs are divided in to various functional layers and the protocols are assigned for carrying out the tasks of each layer.
- It is quite common to keep the functions of the data delivery separate from each other and separate layers for the connection management too.
- Therefore, we have one protocol for performing the data delivery tasks and second one for performing connection management.
- The second one is layered up on the first one.

- Since the connection management protocol is not concerned with the data delivery, it is also quite simple.
- The OSI seven layer model and the DoD model are one of the most important layered protocols ever designed.
- A fusion of both the models is represented by the modern internet.
- Simple protocols are produced by the protocol layering with some well defined tasks.
- These protocols then can be put together to be used as a new whole protocol.
- As required for some particular applications, the individual protocols can be either replaced or removed.
- Networking is such a field involving programmers, electricians, mathematicians, designers, electricians and so on.
- People from these various fields have very less in common and it is because of the layering that people with such varying skills to make an assumption or feel like others are carrying out their duty.
- This is what we call abstraction.
- Protocols at a level can be followed by an application programmer via abstraction assuming that network exists and similarly electricians assume and do their work.
- One layer can provide services to the succeeding layer and can get services in return too.
- Abstraction is thus the fundamental foundation for layering.
- Stack has been used for representing the networking protocols since the start of network engineering.
- Without stack, it would be unmanageable as well as overwhelming.
- Representing the layers of specialization for the first protocols derived from TCP/ IP.

Q3. Calculate the required bandwidth, if in a communication channel the signal power is 100 W and noise power is 10 W and the information transmission rate is 10kbps.

(AKTU 2014-15)

Solution:

Signal power is 100 W

Noise power is 10 W

Data rate of 10 kbps

Bandwidth?

Data rate = bandwidth * log (1 + (Signal power / Noise power))

10 = bandwidth * log (1 + (100 / 10)) {log (1 + (100 / 10)) = 3.4594 approx. equal to 4 is taken here}

10 = bandwidth * 4

Bandwidth = 2.5 KHz

Q4. It is required to transmit a data at a rate of 64kbps over a 3 kHz telephone channel. What is the minimum SNR required to accomplish this? **(AKTU 2014-15)**

Solution:

Given: Bit Rate = 64Kbps
$W = 3KHz$
$C = W \log_2 (1 + SNR), C \geq C_{min} = 64$ kbps

$C_{min} = W \log_2 (1 + SNR_{min}) \Rightarrow$
$\log_2 (1 + SNR_{min}) = \boldsymbol{C_{min} / W = 64K / 3} \Rightarrow$
$1 + SNR_{min} = 2^{64K/3} \Rightarrow$
$SNR_{min} = 2.64 \times 10^6$
In dB: $SNR_{min} = 10 \log_{10} (2.64 \times 10^6) = 64.2$ dB

Q5. Discuss the devices of each layer of OSI reference model. **(AKTU 2014-15)**

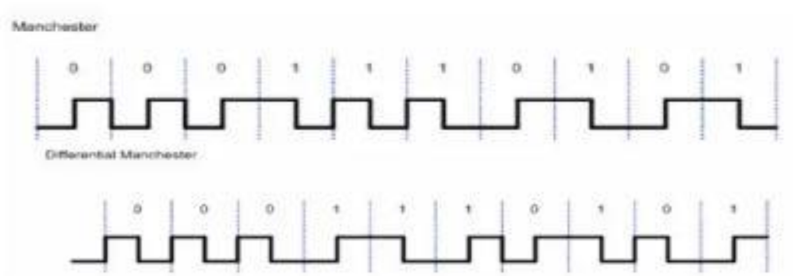
Solution: Devices used in each layer are:

1. Physical layer or below: Hubs, Repeaters, Cables, Fibers, Wireless.
2. Data-link layer: Bridges, Modems, Network cards, 2-layer switches.
3. Network layer: Routers, Brouters, 3-layer switches.
4. Transport layer: Gateways, Firewalls.
5. Session layer:Gateways, Firewalls, PC's.
6. Presentation layer: Gateways, Firewalls, PC's.
7. Application layer: Gateways, Firewalls, all end devices like PC's, Phones, Servers.

Q6. Sketch the Manchester and differential Manchester encoding for the bit stream: 0001110101.
(AKTU 2014-15)

Solution:

The Manchester and differential Manchester encoding for the bit stream 0001110101:



Q7. What is OSI model? Explain the functions and protocols and services of each layer.
(AKTU 2015-16, 2017-18, 2018-19, 2021-22)

or

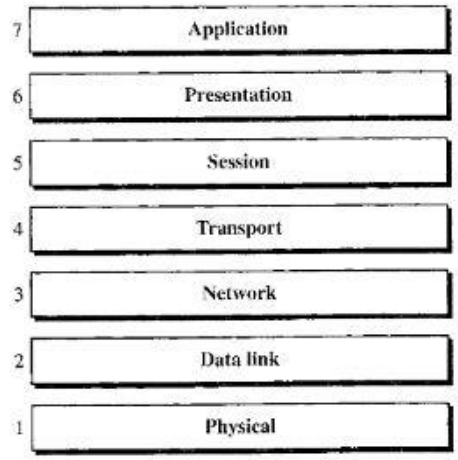
Explain functionalities of every layer in OSI model with neat block diagram.
(AKTU 2016-17, 2022-23, 2024-25)

Solution:

THE OSI MODEL:

The purpose of the OSI model is to show how to facilitate communication between different systems without requiring changes to the logic of the underlying hardware and software. The OSI model is not a protocol; it is a model for understanding and designing a network architecture that is flexible, robust, and interoperable.

The OSI model is a layered framework for the design of network systems that allows communication between all types of computer systems. It consists of seven separate but related layers, each of which defines a part of the process of moving information across a network.



1) Physical Layer:

- Physical characteristics of interfaces and medium.
- Representation of bits.
- Data rate.
- Synchronization of bits.
- Line configuration.
- Physical topology.
- Transmission mode.

2) Data Link Layer:

- Framing.
- Physical addressing.
- Flow control.
- Error control.
- Access control.

3) Network Layer:

- Logical addressing.
- Routing.

4) Transport Layer:

- Service-point addressing
- Segmentation and reassembly.
- Connection control.
- Flow control.
- Error control.

5) Session Layer:

- Dialog control
- Synchronization

6) Presentation Layer:

- Translation.
- Encryption.
- Compression.

7) Application Layer:

- Network virtual terminal.
- File transfer, access, and management.
- Mail services.
- Directory services.

Q8. List the advantages and disadvantages of star topology. **(AKTU 2016-17, 2021-22)**

Solution:

Advantages of Star Topology:

1) As compared to Bus topology it gives far much better performance, signals don't necessarily get transmitted to all the workstations.

2) Easy to connect new nodes or devices. In star topology new nodes can be added easily without affecting rest of the network. Similarly components can also be removed easily.

3) Centralized management. It helps in monitoring the network.

4) Failure of one node or link doesn't affect the rest of network. At the same time it's easy to detect the failure and troubleshoot it.

Disadvantages of Star Topology:

1) Too much dependency on central device has its own drawbacks. If it fails whole network goes down.

2) The use of hub, a router or a switch as central device increases the overall cost of the network.

3) Performance and as well number of nodes which can be added in such topology is depended on capacity of central device

Q9. List the advantages and disadvantages of ring topology. **(AKTU 2017-18, 2021-22)**

Solution: Advantages of ring topology:

1) Data can transfer between workstations at high speeds.

2) All data flows in one direction, reducing the chance of packet collisions.

Disadvantages of ring topology:

1) This topology is not very reliable, because when a link fails the entire ring connection is broken.

2) The entire network will be impacted if one workstation shuts down.

Q10. If a binary signal is sent over a 3 kHz channel whose signal to noise ratio is 20dB. What is the maximum achievable data rate? **(AKTU 2017-18)**

Solution:

According to Shannon theorem which specifies the maximum data rate in a noisy channel as B*log_2^(1+S/N) where B is the bandwidth, S/N is the signal-to-noise ratio. Usually, S/N is given in "decibel", not just a ratio. Decibel is calculated by dB=10log_10^(S/N)
Therefore, we get S/N first by 20dB=10log_10^(S/N) ==> S/N=10^2=100

Substitute S/N into Shannon's theorem, we get the maximum bps as
3k*log2^(1+S/N)=3log2^101kbps=19.97kbps.

However, the maximum data rate, assuming the channel is noise free, is only 6kbps, according to Nyquist rate. Therefore, the final answer should be 6kbps.

Q11. Explain network topological design with necessary diagram and brief the advantages and disadvantages of various topologies. **(AKTU 2017-18, 2022-23)**

or

Define topology and explain the advantage and disadvantage of Bus, Star and Ring topologies.

(AKTU 2018-19, 2021-22)

Solution:

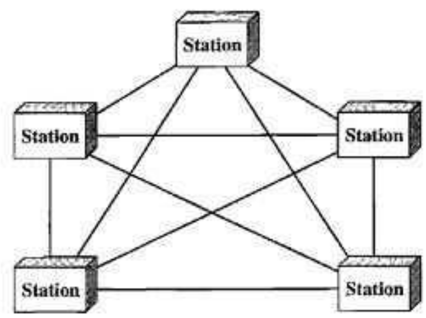
The term physical topology refers to the way in which a network is laid out physically. Two or more devices connect to a link; two or more links form a topology. The topology of a network is the geometric representation of the relationship of all the links and linking devices (usually called nodes) to one another.

Mesh Topology:

In a mesh topology, every device has a dedicated point-to-point link to every other device. The term dedicated means that the link carries traffic only between the two devices it connects.

To find the number of physical links in a fully connected mesh network with n nodes, we first consider that each node must be connected to every other node. Node 1 must be connected to n-1 nodes, node 2 must be connected to n-1nodes, and finally node n must be connected to n-1 nodes. We need n (n-1) physical links.

However, if each physical link allows communication in both directions (duplex mode), we can divide the number of links by 2. In other words, we can say that in a mesh topology, we need n*(n-1)/2 duplex-mode links. In this, connection is point-to-point.



Advantages:

(i) First, the use of dedicated links guarantees that each connection can carry its own data load, thus eliminating the traffic problems that can occur when links must be shared by multiple devices.

(ii) Second, a mesh topology is robust. If one link becomes unusable, it does not incapacitate the entire system.

(iii) Third, there is the advantage of privacy or security.

Disadvantages:

(i) The main disadvantages of a mesh are related to the amount of cabling and the number of I/O ports required.

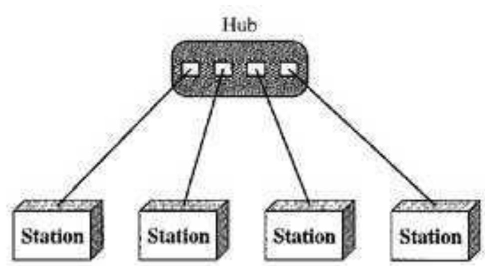
(ii) Every device must be connected to every other device, installation and reconnection are difficult.

Star Topology:

In a star topology, each device has a dedicated point-to-point link only to a central controller, usually called a hub. The devices are not directly linked to one another.

Unlike a mesh topology, a star topology does not allow direct traffic between devices. The controller acts as an exchange: If one device wants to send data to another, it sends the data to the controller, which then relays the data to the other connected device.

The star topology is used in local-area networks.



Advantages:

(i) A star topology is less expensive than a mesh topology. In a star, each device needs only one link and one I/O port to connect it to any number of others. This factor also makes it easy to install and reconfigure.

(ii) It is robustness. If one link fails, only that link is affected. All other links remain active.

Disadvantages:

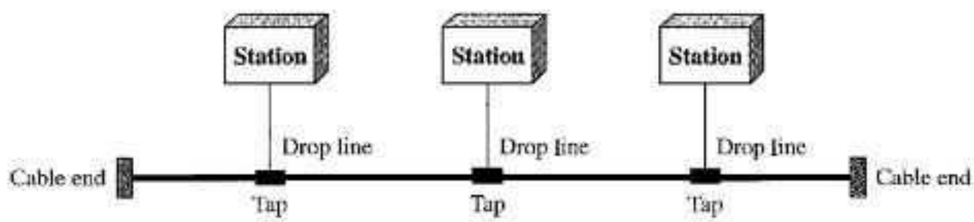
(i) The dependency of the whole topology on one single point, the hub. If the hub goes down, the whole system is dead.

Bus Topology:

A bus topology has multipoint connection. One long cable acts as a backbone to link all the devices in a network.

Nodes are connected to the bus cable by drop lines and taps. A drop line is a connection running between the device and the main cable. A tap is a connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core.

Bus topology was the one of the first topologies used in the design of early local- area networks. Ethernet LANs can use a bus topology, but they are less popular.



Advantages:

(i) Advantages of a bus topology include ease of installation.

Disadvantages:

(i) Disadvantages include difficult reconnection and fault isolation.

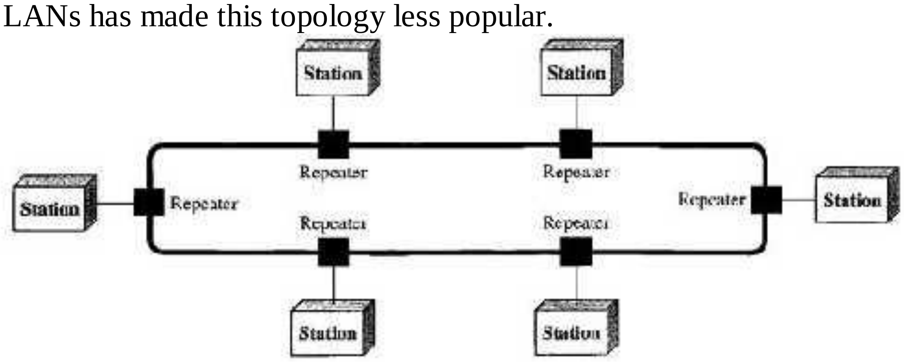
(ii) Difficult to add new devices.

(iii) A fault or break in the bus cable stops all transmission.

Ring Topology:

In a ring topology, each device has a dedicated point-to-point connection with only the two devices on either side of it. A signal is passed along the ring in one direction, from device to device, until it reaches its destination. Each device in the ring incorporates a repeater. When a device receives a signal intended for another device, its repeater regenerates the bits and passes them along.

Ring topology was prevalent when IBM introduced its local-area network Token Ring. Today, the need for higher-speed LANs has made this topology less popular.



Advantages:

(i) A ring is relatively easy to install and reconfigure. To add or delete a device requires changing only two connections.

Disadvantages:

(i) Unidirectional traffic can be a disadvantage.

Q12. Use the network architecture knowledge to compare TCP/IP and OSI model.

(AKTU 2018-19, 2023-24)

Solution:

TCP/IP is a hierarchical protocol made up of interactive modules, each of which provides a specific functionality; however, the modules are not necessarily inter dependent. Whereas the OSI model specifies which functions belong to each of its layers, the layers of the TCP/IP protocol suite contain relatively independent protocols that can be mixed and matched depending on the needs of the system.

i) Physical and Data Link Layers:

At the physical and data link layers, TCP/IP does not define any specific protocol. It supports all the standard and proprietary protocols. A network in a TCP/IP internet work can be a local-area network or a wide-area network.

ii) Network Layer:

At the network layer (or, more accurately, the internetwork layer), TCP/IP supports the Internetworking Protocol. IP, in turn, uses four supporting protocols: ARP, RARP, ICMP, and IGMP.

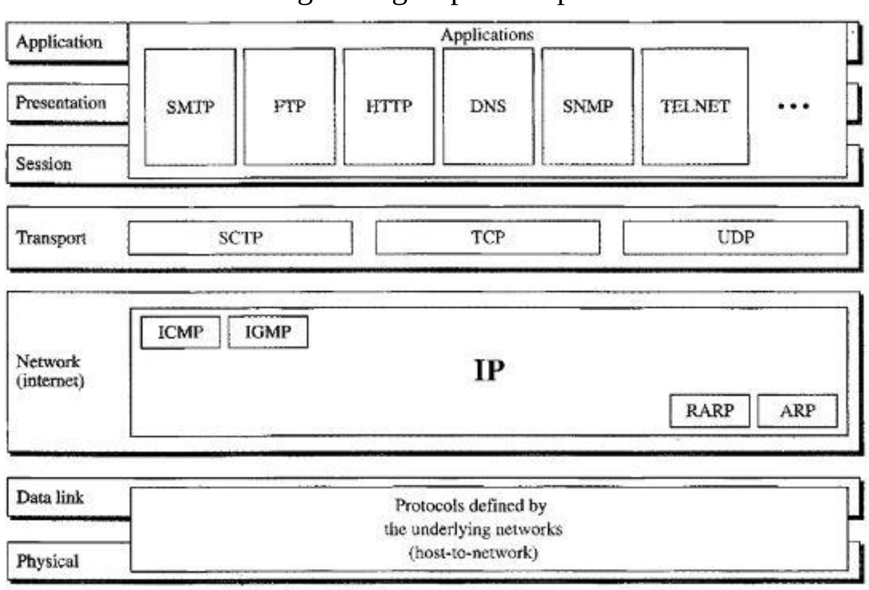
Internetworking Protocol (IP): The Internetworking Protocol (IP) is the transmission mechanism used by the TCP/IP protocols. It is an unreliable and connectionless protocol. IP transports data in packets called datagrams, each of which is transported separately. Datagrams can travel along different routes and can arrive out of sequence or be duplicated. IP does not keep track of the routes and has no facility for reordering datagrams once they arrive at their destination.

Address Resolution Protocol: The Address Resolution Protocol (ARP) is used to associate a logical address with a physical address. ARP is used to find the physical address of the node when its Internet address is known.

Reverse Address Resolution Protocol: The Reverse Address Resolution Protocol (RARP) allows a host to discover its Internet address when it knows only its physical address. It is used when a computer is connected to a network for the first time or when a diskless computer is booted.

Internet Control Message Protocol: The Internet Control Message Protocol (ICMP) is a mechanism used by hosts and gateways to send notification of datagram problems back to the sender. ICMP sends query and error reporting messages.

Internet Group Message Protocol: The Internet Group Message Protocol (IGMP) is used to facilitate the simultaneous transmission of a message to a group of recipients.



iii) Transport Layer:

The transport layer was represented in TCP/IP by two protocols: TCP and UDP. IP is a host-to-host protocol, meaning that it can deliver a packet from one physical device to another. UDP and TCP are transport level protocols responsible for delivery of a message from a process (running program) to another process. A new transport layer protocol, SCTP, has been devised to meet the needs of some newer applications.

User Datagram Protocol: It is a process-to-process protocol that adds only port addresses, check sum error control, and length information to the data from the upper layer.

Transmission Control Protocol: TCP is a reliable stream transport protocol. The term stream, in this context, means connection-oriented: A connection must be established between both ends of a transmission before either can transmit data. At the sending end of each transmission, TCP divides a stream of data into smaller units called segments. Each segment includes a sequence number for reordering after receipt, together with an acknowledgment number for the segments received. Segments are carried across the internet inside of IP datagrams. At the receiving end, TCP collects each datagram as it comes in and reorders the transmission based on sequence numbers.

Stream Control Transmission Protocol: The Stream Control Transmission Protocol (SCTP) provides support for newer applications such as voice over the Internet. It is a transport layer protocol that combines the best features of UDP and TCP.

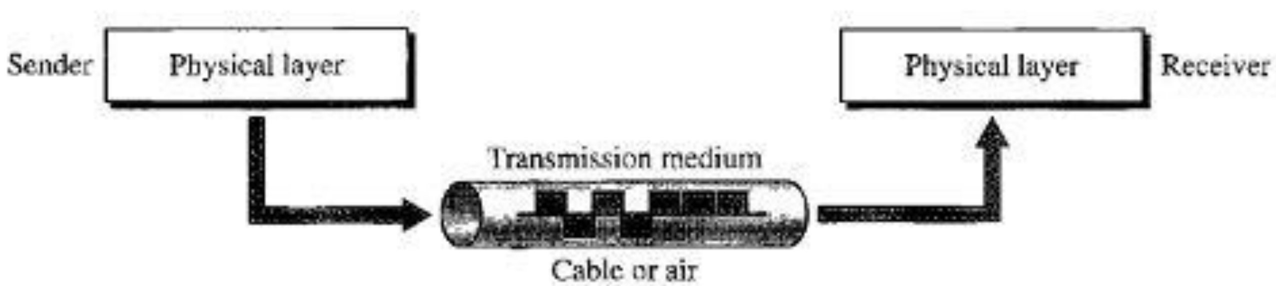
iv) Application Layer:

The application layer in TCP/IP is equivalent to the combined session, presentation, and application layers in the OSI model.

Q 13. Define transmission media. Explain fibre optic cable in brief. Also explain the advantages of optical fibre over twisted pair and coaxial cable. **(AKTU 2017-18)**

Solution:

Transmission media are actually located below the physical layer and are directly controlled by the physical layer. A transmission medium can be broadly defined as anything that can carry information from a source to a destination. The transmission medium is usually free space, metallic cable,or fiber-optic cable.



For example, the transmission medium for two people having a dinner conversation is the air. For a written message, the transmission medium might be a mail carrier, a truck, or an airplane.

A fiber-optic cable is made of glass or plastic and transmits signals in the form of light. Following figure shows how a ray of light changes direction when going from a more dense to a less dense substance.

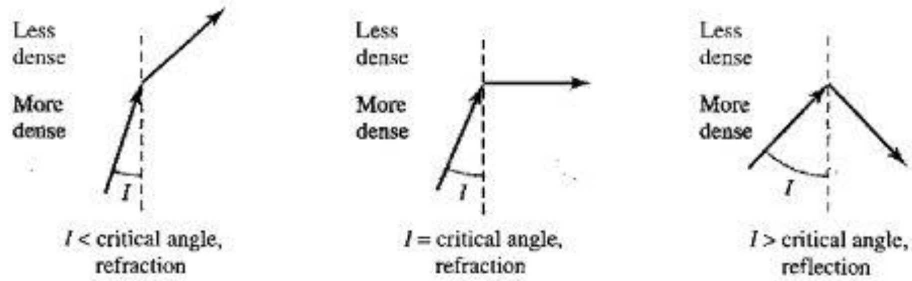


Figure: Bending of light ray

Optical fibers use reflection to guide light through a channel. A glass or plastic core is surrounded by a cladding of less dense glass or plastic. The difference in density of the two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted into it.

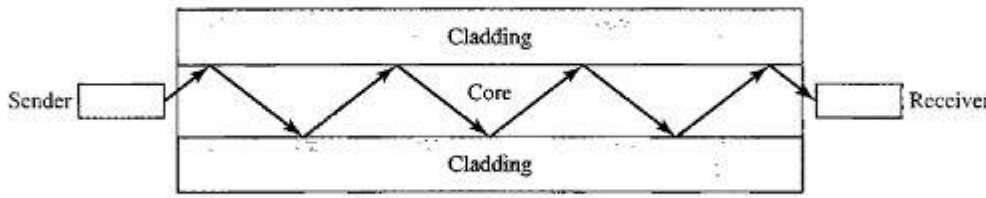


Figure: Optical fiber

Propagation Modes: It supports two modes (multimode and single mode) for propagating light along optical channels, each requiring fiber with different physical characteristics. Multimode can be implemented in two forms: step-index or graded-index.

Multimode: Multimode is so named because multiple beams from a light source move through the core in different paths. Multimode are two types:

i) **In multi mode step-index fiber**, the density of the core remains constant from the center to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding.

ii) A second type of fiber, called **multimode graded-index fiber**, decreases this distortion of the signal through the cable. A graded-index fiber, therefore, is one with varying densities. Density is highest at the center of the core and decreases gradually to its lowest at the edge.

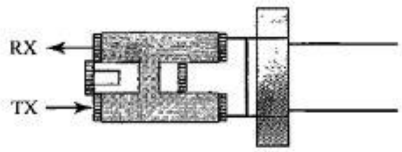
Single-Mode: Single-mode uses step-index fiber and a highly focused source of light that limits beams to a small range of angles, all close to the horizontal. The single-mode fiber itself is manufactured with a much smaller diameter than that of multimode fiber, and with substantially lower density.

Fiber Sizes: Optical fibers are defined by the ratio of the diameter of their core to the diameter of their cladding, both expressed in micrometers.

Type	*Core (μm)*	*Cladding (μm)*	*Mode*
50/125	50.0	125	Multimode, graded index
62.5/125	62.5	125	Multimode, graded index
100/125	100.0	125	Multimode, graded index
7/125	7.0	125	Single mode

Fiber-Optic Cable Connectors: There are three types of connectors for fiber-optic cables.

SC connector ST connector



MT-RJ connector

The subscriber channel (SC) connector is used for cable TV. It uses a push/pull locking system. The straight-tip (ST) connector is used for connecting cable to networking devices. It uses a bayonet locking system and is more reliable than SC.MT-RJ is a connector that is the same size as RJ45.

Performance: Attenuation is flatter than in the case of twisted-pair cable and coaxial cable. The performance is such that we need fewer (actually 10 times less) repeaters when we use fiber-optic cable.

Applications: Fiber-optic cable is often found in backbone networks because its wide bandwidth is cost-effective. Today, with wavelength-division multiplexing (WDM), we can transfer at a rate of 1600 Gbps. Some cable TV companies use a combination of optical fiber and coaxial cable, thus creating a hybrid network. Local-area networks such as 100Base-FX network (Fast Ethernet) and l000Base-Xalso use fiber-optic cable.

Advantages and Disadvantages of Optical Fiber:

Advantages: Fiber-optic cable has several advantages over metallic cable (twisted pair or coaxial)-

- ❖ Higher bandwidth.
- ❖ Less signal attenuation.
- ❖ Electromagnetic noise cannot affect fiber-optic cables.
- ❖ Glass is more resistant to corrosive materials than copper.
- ❖ Light weight.

Disadvantages: There are some disadvantages in the use of optical fiber-

- ❖ Installation and maintenance.
- ❖ Unidirectional light propagation.
- ❖ Cost.

Q 14. What is transmission impairment? Explain the three causes of transmission impairment.

(AKTU 2022-23)

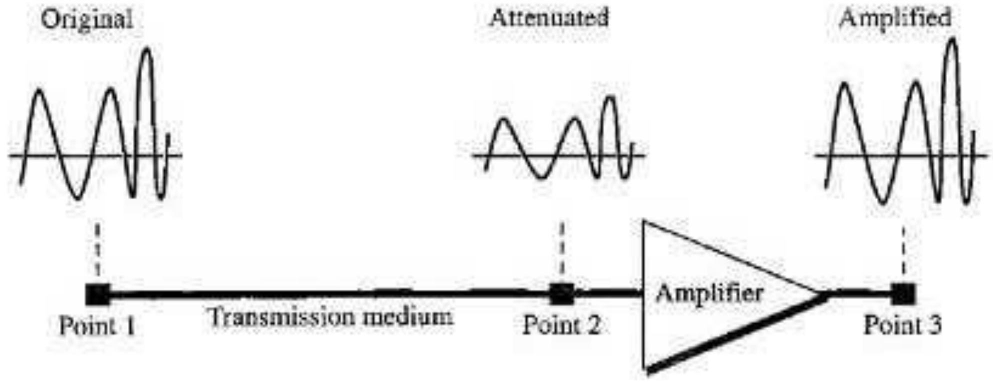
Solution:

Transmission Impairment:

Signals travel through transmission media, which are not perfect. The imperfection causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. What is sent is not what is received. Three causes of impairment are attenuation, distortion, and noise.

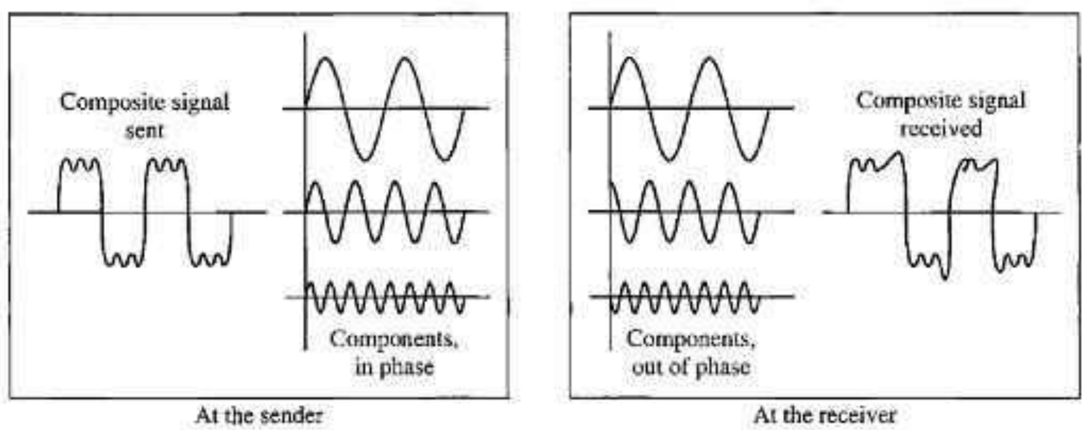
i) Attenuation:

Attenuation means a loss of energy. When a signal, simple or composite, travels through a medium, it loses some of its energy.



ii) Distortion:

Distortion means that the signal changes its form or shape. Distortion can occur in a composite signal made of different frequencies. Each signal component has its own propagation speed through a medium and, therefore, its own delay in arriving at the final destination. Differences in delay may create a difference in phase if the delay is not exactly the same as the period duration.



iii) Noise:

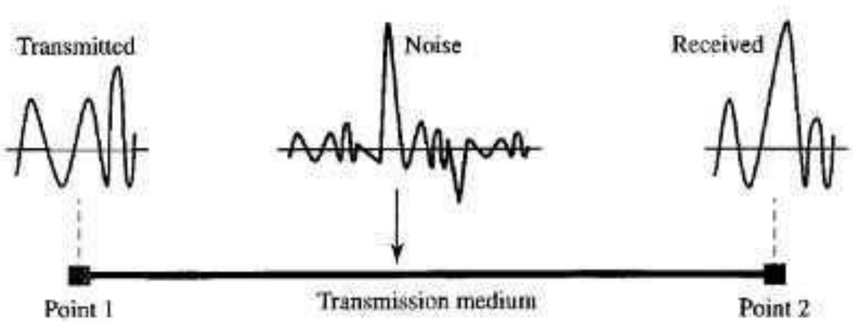
Noise is another cause of impairment. Several types of noise, such as thermal noise, induced noise, crosstalk, and impulse noise, may corrupt the signal.

Thermal noise is the random motion of electrons in a wire which creates an extra signal not originally sent by the transmitter.

Induced noise comes from sources such as motors and appliances. These devices act as a sending antenna, and the transmission medium acts as the receiving antenna.

Crosstalk is the effect of one wire on the other. One wire acts as a sending antenna and the other as the receiving antenna.

Impulse noise is a spike (a signal with high energy in a very short time) that comes from power lines, lightning, and so on.



Q 15. How do guided media differ from unguided media? Explain co-axial cable in brief.

(AKTU 2018-19)

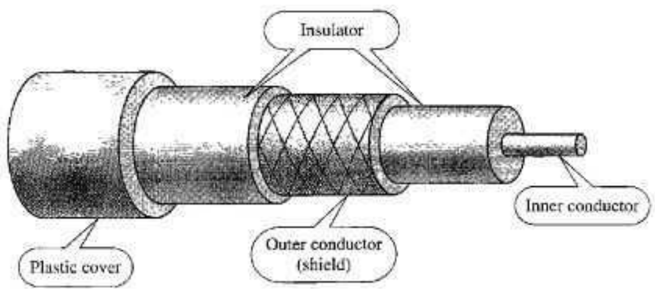
Solution:

In guided media, Twisted-pair and coaxial cable use metallic (copper) conductors that accept and transport signals in the form of electric current. Optical fiber is a cable that accepts and transports signals in the form of light.

Unguided media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication. Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.

Coaxial Cable:

Coaxial cable (or coax) carries signals of higher frequency ranges than those in twisted pair cable. Coax has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two. The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit. This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.



Coaxial Cable Standards: Coaxial cables are categorized by their radio government (RG) ratings. Each RG number denotes a unique set of physical specifications, including the wire gauge of the inner conductor, the thickness and type of the inner insulator, the construction of the shield, and the size and type of the outer casing.

Coaxial Cable Connectors: To connect coaxial cable to devices, we need coaxial connectors. The most common type of connector used today is the Bayone-Neill-Concelman (BNC), connector. Three popular types of these connectors: the BNC connector, the BNC T connector, and the BNC terminator.

Performance: the attenuation is much higher in coaxial cables than in twisted-pair cable. In other words, although coaxial cable has a much higher bandwidth.

Applications: Coaxial cable was widely used in analog telephone networks where a single coaxial network could carry 10,000 voice signals. Later it was used in digital telephone networks where a single coaxial cable could carry digital data up to 600 Mbps. However, coaxial cable in telephone networks has largely been replaced today with fiber -optic cable. Cable TV networks also use coaxial cables.

Q 16. What is line coding? Explain different types of line coding scheme. **(AKTU 2018-19)**

Solution:

Line Coding: Line coding is the process of converting digital data to digital signals. We assume that data, in the form of text, numbers, graphical images, audio, or video, are stored in computer memory as sequences of bits. Line coding converts a sequence of bits to a digital signal. At the sender, digital data are encoded into a digital signal; at the receiver, the digital data are recreated by decoding the digital signal.

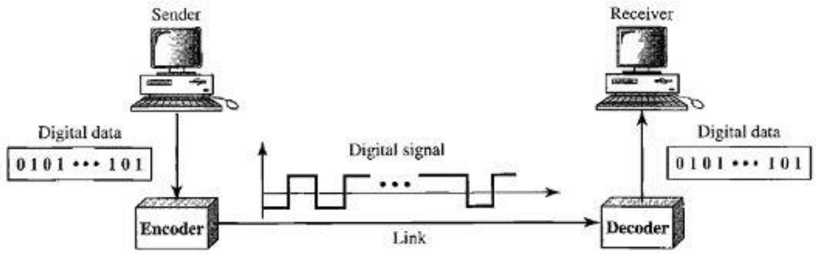


Figure: Line coding and decoding

Line Coding Schemes: We can roughly divide line coding schemes into five broad categories, as shown in Figure 1.54.

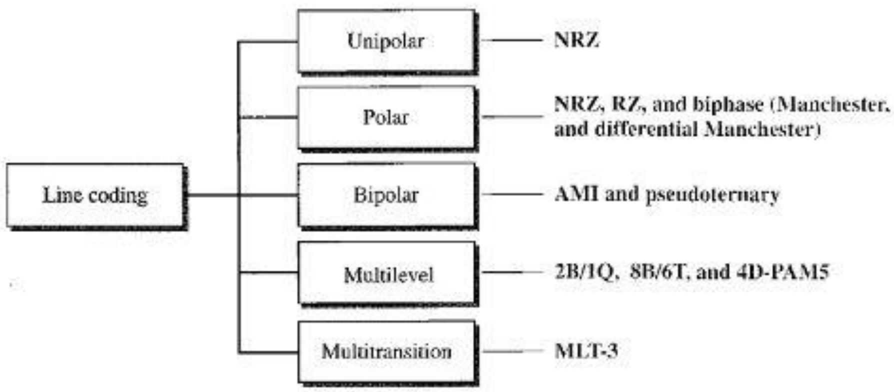


Figure: Line coding schemes

i) Unipolar Scheme: In a unipolar scheme, all the signal levels are on one side of the time axis, either above or below.

NRZ (Non-Return-to-Zero): Traditionally, a unipolar scheme was designed as a non-return-to-zero (NRZ) scheme in which the positive voltage defines bit 1 and the zero voltage defines bit 0. It is called NRZ because the signal does not return to zero at the middle of the bit.

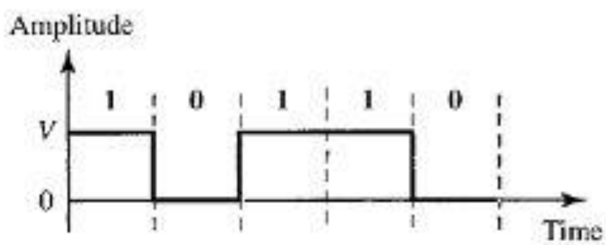


Figure: Unipolar NRZ scheme

ii) Polar Schemes: In polar schemes, the voltages are on the both sides of the time axis. For example, the voltage level for 0 can be positive and the voltage level for 1 can be negative.

Non-Return-to-Zero (NRZ): In polar NRZ encoding, we use two levels of voltage amplitude. We can have two versions of polar NRZ: NRZ-L and NRZ-I.

In the first variation, NRZ-L (NRZ-Level), the level of the voltage determines the value of the bit. In the second variation, NRZ-I (NRZ-Invert), the change or lack of change in the level of the voltage determines the value of the bit. If there is no change, the bit is 0; if there is a change, the bit is 1.

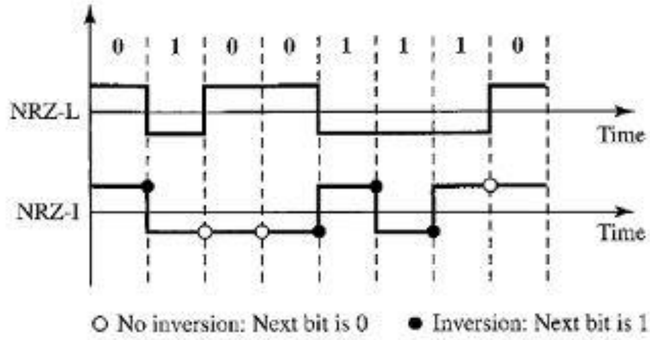


Figure: Polar NRZ-L and NRZ-I schemes

Return to Zero (RZ): The main problem with NRZ encoding occurs when the sender and receiver clocks are not synchronized. The receiver does not know when one bit has ended and the next bit is starting. One solution is the return-to-zero (RZ) scheme, which uses three values: positive, negative, and zero. In RZ, the signal changes not between bits but during the bit.

In Figure 1.57 we see that the signal goes to 0 in the middle of each bit. It remains there until the beginning of the next bit.

The main disadvantage of RZ encoding is that it requires two signal changes to encode a bit and therefore occupies greater bandwidth. Another problem is the complexity: RZ uses three levels of voltage, which is more complex.

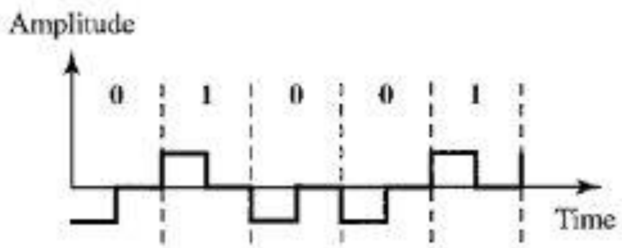


Figure: Polar RZ scheme

Biphase: Manchester and Differential Manchester The idea of RZ (transition at the middle of the bit) and the idea of NRZ-L are combined into the Manchester scheme.

In Manchester encoding, the duration of the bit is divided into two halves. The voltage remains at one level during the first half and moves to the other level in the second half. The transition at the middle of the bit provides synchronization.

Differential Manchester, on the other hand, combines the ideas of RZ and NRZ-I. There is always a transition at the middle of the bit, but the bit values are determined at the beginning of the bit. If the next bit is 0, there is a transition; if the next bit is 1, there is none.

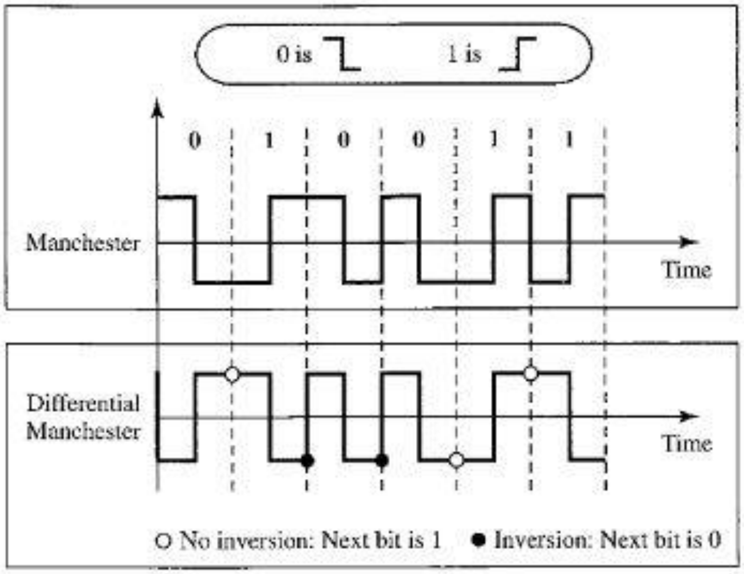


Figure: Polar biphase: Manchester and differential Manchester schemes

Q 17. What are transmission media? Explain Twisted-Pair Cable in brief. **(AKTU 2018-19)**

Solution:

A transmission medium can be broadly defined as anything that can carry information from a source to a destination. The transmission medium is usually free space, metallic cable, or fiber-optic cable.

A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together. One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference. The receiver uses the difference between the two. In addition to the signal sent by the sender on one of the wires, interference (noise)and crosstalk may affect both wires and create unwanted signals.

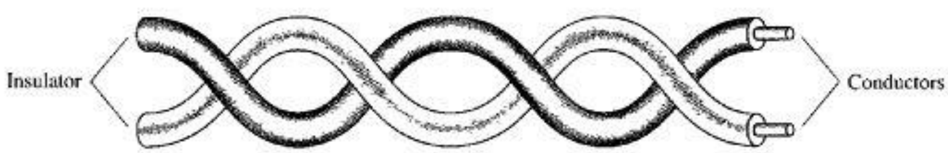


Figure: Twisted-pair cable

If the two wires are parallel, the effect of these unwanted signals is not the same in both wires because they are at different locations relative to the noise or crosstalk sources (e.g., one is closer and the other is farther). This results in a difference at the receiver. By twisting the pairs, a balance is maintained. It is clear that the number of twists per unit of length (e.g., inch) has some effect on the quality of the cable.

Unshielded Versus Shielded Twisted-Pair Cable: The most common twisted-pair cable used in communications is referred to as unshielded twisted-pair (UTP). IBM has also produced a version of twisted-pair cable for its use called shielded twisted-pair (STP). STP cable has a metal foil or braided-mesh covering that encases each pair of insulated conductors. Although metal casing improves the quality of cable by preventing the penetration of noise or crosstalk, it is bulkier and more expensive.

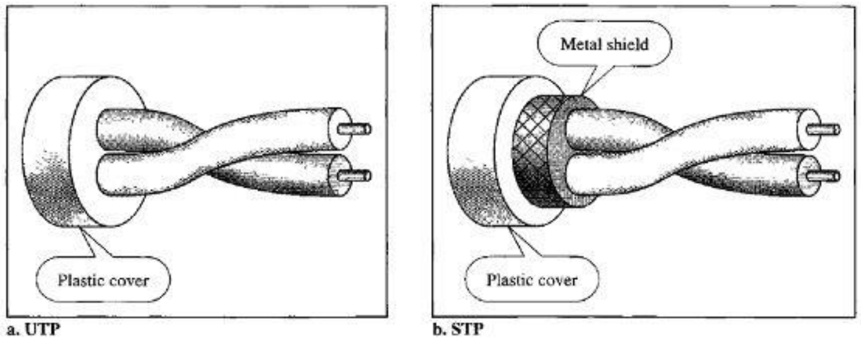


Figure: UTP and STP cables

Categories: The Electronic Industries Association (EIA) has developed standards to classify unshielded twisted-pair cable into seven categories, as shown in below Table 1.1. Categories are determined by cable quality, with 1 as the lowest and 7 as the highest.

Table 1.1: Categories of unshielded twisted-pair cables

Category	*Specification*	*Data Rate (Mbps)*	*Use*
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T-lines	2	T-1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANs
5E	An extension to category 5 that includes extra features to minimize the crosstalk and electromagnetic interference	125	LANs
6	A new category with matched components coming from the same manufacturer. The cable must be tested at a 200-Mbps data rate.	200	LANs
7	Sometimes called SSTP (shielded screen twisted-pair). Each pair is individually wrapped in a helical metallic foil followed by a metallic foil shield in addition to the outside sheath. The shield decreases the effect of crosstalk and increases the data rate.	600	LANs

Connectors: The most common UTP connector is RJ45 (RJ stands for registered jack). The RJ45 is a keyed connector, meaning the connector can be inserted in only one way.

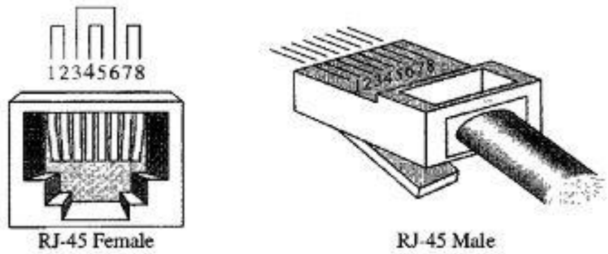


Figure: UTP connector

Performance: One way to measure the performance of twisted-pair cable is to compare attenuation versus frequency and distance. A twisted-pair cable can pass a wide range of frequencies.

Application: Twisted-pair cables are used in telephone lines to provide voice and data channels. The local loop-the line that connects subscribers to the central telephone office commonly consists of unshielded twisted-pair cables. The DSL lines that are used by the telephone companies to provide high-data-rate connections also use the high-bandwidth capability of unshielded twisted-pair cables.
Local-area networks, such as l0Base-T and l00Base-T, also use twisted-pair cables.

Q 18. What is switching? Explain circuit switched network in brief. **(AKTU 2021-22)**

Solution:

A switched network consists of a series of interlinked nodes, called switches. Switches are devices capable of creating temporary connections between two or more devices linked to the switch. In a switched network, some of these nodes are connected to the end systems (computers or telephones, for example) and others are used only for routing.

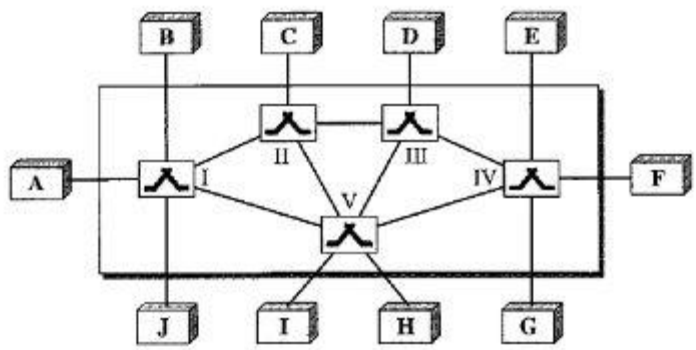


Figure: Switched network

The end systems (communicating devices) are labeled A, E, C, D, and so on, and the switches are labeled I, II, III, IV, and V. Each switch is connected to multiple links.
Three methods of switching: circuit switching, packet switching, and message switching. The first two are commonly used today. The third has been phased out in general communications but still has networking applications.

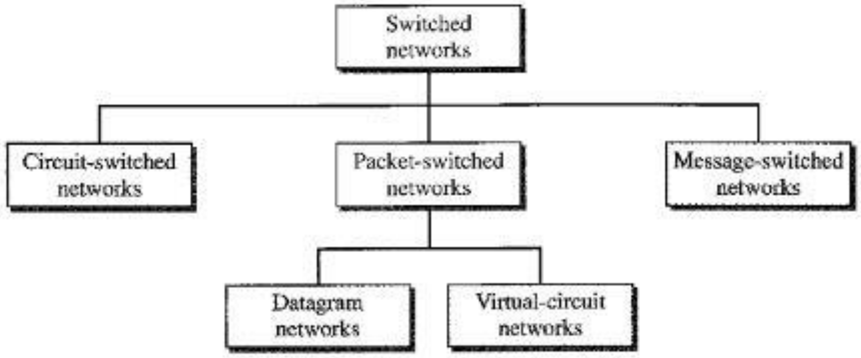


Figure: Taxonomy of switched networks

i) CIRCUIT-SWITCHED NETWORKS:
A circuit-switched network consists of a set of switches connected by physical links. A connection between two stations is a dedicated path made of one or more links. Each link is normally divided into n channels by using FDM or TDM.

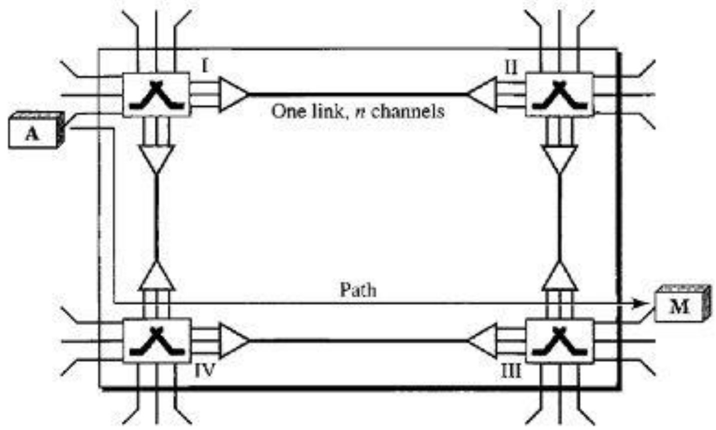


Figure: A circuit-switched network

The end systems, such as computers or telephones, are directly connected to a switch. When end system A needs to communicate with end system M, system A needs to request a connection to M that must be accepted by all switches as well as by M itself. This is called the setup phase; a circuit (channel) is reserved on each link, and the combination of circuits or channels defines the dedicated path. After the dedicated path made of connected circuits (channels)is established, data transfer can take place. After all data have been transferred, the circuits are tear down.

- ❖ Circuit switching takes place at the physical layer.
- ❖ Before starting communication, the stations must make a reservation for the resources to be used during the communication.
- ❖ Data transferred between the two stations are not packetized (physical layer transfer of the signal). The data are a continuous flow sent by the source station and received by the destination station.
- ❖ There is no addressing involved during data transfer.

In circuit switching, the resources need to be reserved during the setup phase; the resources remain dedicated for the entire duration of data transfer until the teardown phase.

Three Phases: The actual communication in a circuit-switched network requires three phases: connection setup (request and acknowledgement), data transfer, and connection teardown.

Efficiency: Resources are allocated during the entire duration of the connection. These resources are

unavailable to other connections. In a telephone network, people normally terminate the communication when they have finished their conversation.
Delay: A circuit-switched network normally has low efficiency; the delay in this type of network is minimal. During data transfer the data are not delayed at each switch; the resources are allocated for the duration of the connection.

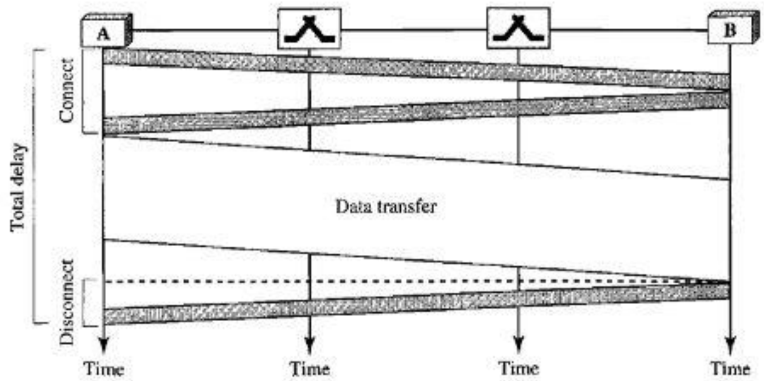


Figure: Delay in a circuit-switched network

Circuit switching today can use either of two technologies: the space-division switch or the time-division switch.
Space-Division Switch: In space-division switching, the paths in the circuit are separated from one another spatially. This technology was originally designed for use in analog networks but is used currently in both analog and digital networks. It is of two types: crossbar switch or matrix switch and multi-stage switch.
a) Crossbar Switch: A crossbar switch connects n inputs to m outputs in a grid, using electronic microswitches (transistors) at each crosspoint. The major limitation of this design is the number of crosspoints required. To connect n inputs tom outputs using a crossbar switch requires n x m crosspoints.

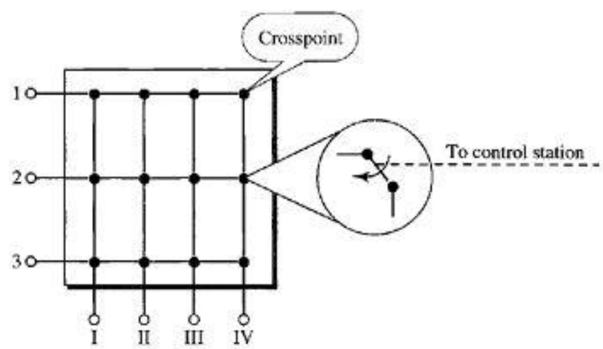


Figure: Crossbar switch with three inputs and four outputs

b) Multistage Switch: The solution to the limitations of the crossbar switch is the multistage switch, which combines crossbar switches in several (normally three) stages. The multistage switch has one drawback-blocking during periods of heavy traffic.
The advantage of space-division switching is that it is instantaneous. Its disadvantage is the number of crosspoints required to make space-division switching acceptable in terms of blocking.
Time-Division Switch: Time-division switching uses time-division multiplexing (TDM) inside a switch. The most popular technology is called the time-slot interchange (TSI).The advantage of time-division switching is that it needs no crosspoints. Its disadvantage, in the case of TSI, is that processing each connection creates delays. Each timeslot must be stored by the RAM, then retrieved and passed

on.

Virtual-circuit network:

A virtual-circuit network is a cross between a circuit-switched network and a datagram network. It has some characteristics of both.

- ❖ As in a circuit-switched network, there are setup and teardown phases in addition to the data transfer phase.
- ❖ Resources can be allocated during the setup phase, as in a circuit-switched network, or on demand, as in a datagram network.
- ❖ As in a datagram network, data are packetized and each packet carries an address in the header.
- ❖ As in a circuit-switched network, all packets follow the same path established during the connection.
- ❖ A virtual-circuit network is normally implemented in the data link layer, while a circuit-switched network is implemented in the physical layer and a datagram network in the network layer.

Three Phases: As in a circuit-switched network, a source and destination need to go through three phases in a virtual-circuit network: setup, data transfer, and teardown.

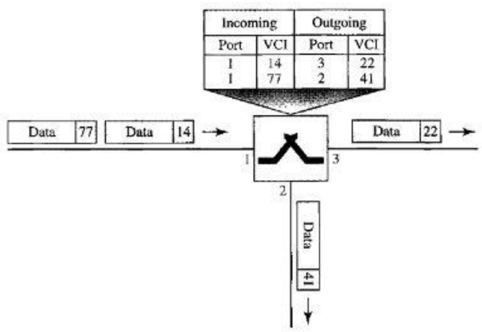


Figure: Switch and tables in a virtual-circuit network

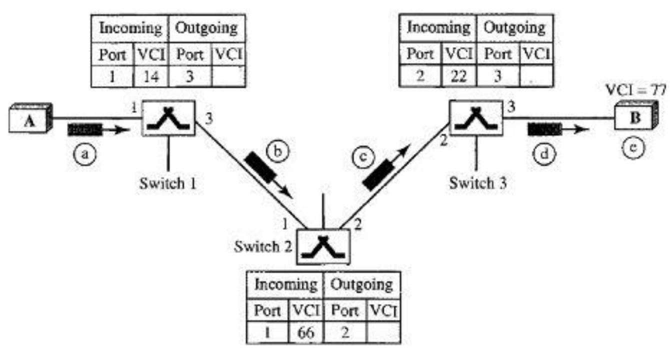


Figure: Setup request in a virtual-circuit network

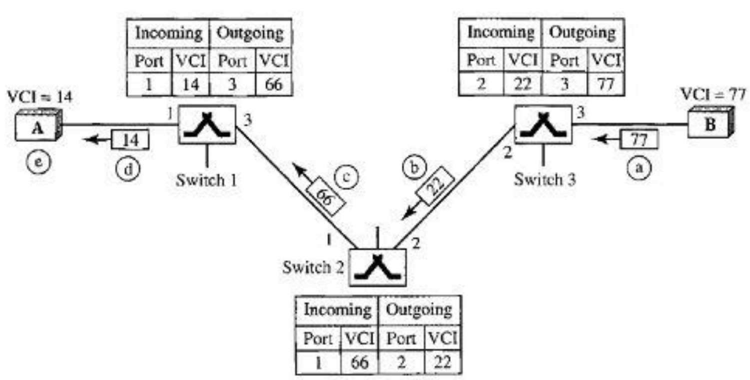


Figure: Setup acknowledgment in a virtual-circuit network

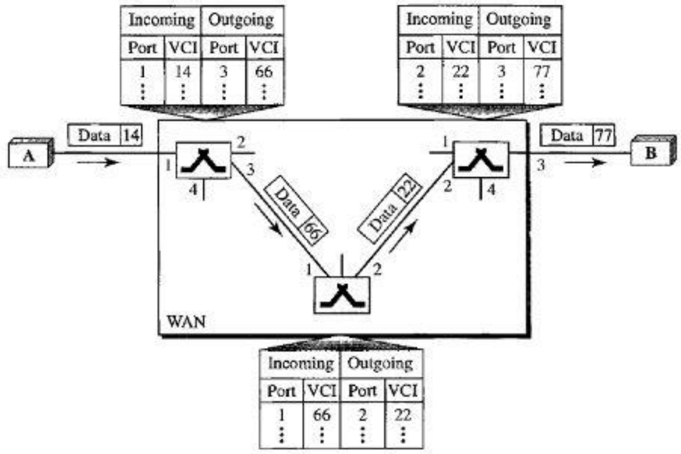


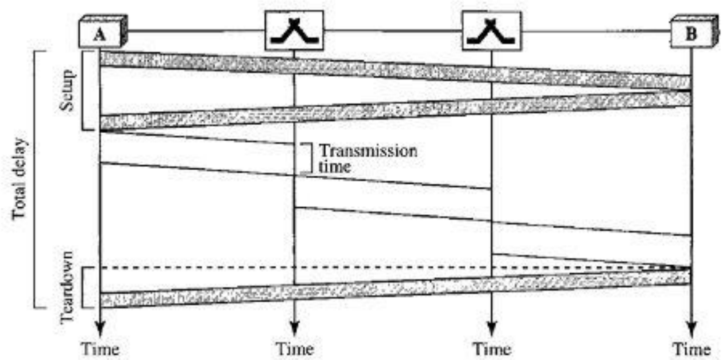
Figure: Source-to-destination data transfer in a virtual-circuit network

Teardown phase

In this, source A, after sending all frames to B, sends a special frame called a teardown request. Destination B responds with a teardown confirmation frame. All switches delete the corresponding entry from their tables.

Delay in Virtual-Circuit Networks: In a virtual-circuit network, there is a one-time delay for setup and a one-time delay for teardown. If resources are allocated during the setup phase, there is no wait time for individual packets.

Total delay = $3T + 3\tau +$ setup delay + teardown delay



Q 19. What are the design issues of network architecture? **(AKTU 2018-19)**

Solution:

Some design issues in computer network architecture include:

i) Security

The increasing number of internet-connected devices has made cyber-attacks more common and sophisticated.

ii) calability

The network should be able to accommodate future changes, such as more network traffic, new technologies, or business growth.

iii) Error control

Error control ensures that frames are delivered safely to their destination without being copied.

iv) Mal functioning hardware

Network issues can be caused by malfunctioning hardware, such as routers, switches, firewalls, and wireless access points.

v) Addressing, packing, routing, and inter-networking

These are key design issues in the network layer.

Q20. Determine the number of links needed for a fully connected mesh topology with 10 nodes. **(AKTU 2024-25)**

Solution:

A fully connected mesh topology with 10 nodes requires 45 links.

In a full mesh network, every node is directly connected to every other node, and the number of links (L) is calculated using the formula L=n(n-1)/2, where n is the number of nodes.

Formula: 10*(10-1)/2

=10*9/2

=90/2

=45

Q21. A signal is transmitted with an initial power of 2W and experiences an attenuation of - 3 dB. Calculate the received power. **(AKTU 2024-25)**

Solution:

➡️ Step 1: Identify the relationship between power and decibels

The relationship between the output power (P_{out}), input power (P_{in}), and the gain or attenuation in decibels (L_{dB}) is given by the formula:

$$P_{out} = P_{in} \cdot 10^{\frac{L_{dB}}{10}}$$

➡️ Step 2: Substitute the known values and calculate

Given that $P_{in} = 2\ \mathrm{W}$ and the attenuation/gain is $-3\ \mathrm{dB}$:

$$P_{out} = 2 \cdot 10^{\frac{-3}{10}}$$

$$P_{out} = 2 \cdot 10^{-0.3}$$

Using the property that a $-3\ \mathrm{dB}$ change represents a halving of power ($10^{-0.3} \approx 0.5$):

$$P_{out} = 2 \cdot 0.5 = 1\ \mathrm{W}$$

Q22. A 4 MB frame is transmitted over a 1000KM link with 2 Mbps bandwidth. Propagation speed is 2×10^8 m/s. Compute total delay (latency) if there are 5 routers, each with 1µs processing and 2µs Queuing delay. **(AKTU 2024-25)**

Solution:

Step 1: Calculate Transmission Delay (d_{trans})

The transmission delay is the time required to push all bits of the frame onto the link.
Assuming 1MB=10^6 bytes and 1 byte=8 bits:

$$L = 4 \times 10^6 \times 8 = 3.2 \times 10^7 \text{ bits}$$

$$R = 2 \text{ Mbps} = 2 \times 10^6 \text{ bps}$$

$$d_{trans\_per\_hop} = \frac{L}{R} = \frac{3.2 \times 10^7}{2 \times 10^6} = 16 \text{ seconds}$$

Since there are 5 routers, there are **6 hops** (Sender → R1 → R2 → R3 → R4 → R5 → Receiver). In a store-and-forward network, the frame is transmitted at each hop:

$$Total\ d_{trans} = 6 \times 16 = 96 \text{ seconds}$$

Step 2: Calculate Propagation Delay (d_{prop})

The propagation delay is the time for a bit to travel the physical distance of the link:

$$d = 1000 \text{ km} = 10^6 \text{ m}$$

$$s = 2 \times 10^8 \text{ m/s}$$

$$d_{prop} = \frac{d}{s} = \frac{10^6}{2 \times 10^8} = 0.005 \text{ seconds (or 5 ms)}$$

Step 3: Calculate Nodal Processing and Queuing Delays

These delays occur at each of the 5 routers:

$$d_{proc} = 1\ \mu\text{s} = 1 \times 10^{-6} \text{ s}$$

$$d_{queue} = 2\ \mu\text{s} = 2 \times 10^{-6} \text{ s}$$

$$Total\ d_{node} = 5 \times (d_{proc} + d_{queue}) = 5 \times 3 \times 10^{-6} = 15 \times 10^{-6} \text{ s (or 15 } \mu\text{s)}$$

Step 4: Compute Total Delay

The total latency is the sum of all components:

$$Latency = Total\ d_{trans} + d_{prop} + Total\ d_{node}$$

$$Latency = 96 + 0.005 + 0.000015 = 96.005015 \text{ seconds}$$