Questions & Answers

Q.1 Explain the architecture of 802.11

Answer:-

IEEE 802.11 standard, popularly known as WiFi, lays down the architecture and specifications of wireless LANs (WLANs). WiFi or WLAN uses high-frequency radio waves instead of cables for connecting the devices in LAN. Users connected by WLANs can move around within the area of network coverage.

IEEE 802.11 Architecture

The components of IEEE 802.11 architecture are as follows −

1) **Stations (STA) −** Stations comprises of all devices and equipment that are connected to the wireless LAN. A station can be of two types−

a) **Wireless Access Point (WAP) −** WAPs or simply access points (AP) are generally wireless routers that form the base stations or access.

b) **Client.** Clients are workstations, computers, laptops, printers, smartphones, etc.

- Each station has a wireless network interface controller.

2) **Basic Service Set (BSS)** − A basic service set is a group of stations communicating at the physical layer level. BSS can be of two categories depending upon the mode of operation−
    a. Infrastructure BSS − Here, the devices communicate with other devices through access points.
    b. Independent BSS − Here, the devices communicate in a peer-to-peer basis in an ad hoc manner.

3) **Extended Service Set (ESS) −** It is a set of all connected BSS.

4) **Distribution System (DS) −** It connects access points in ESS.

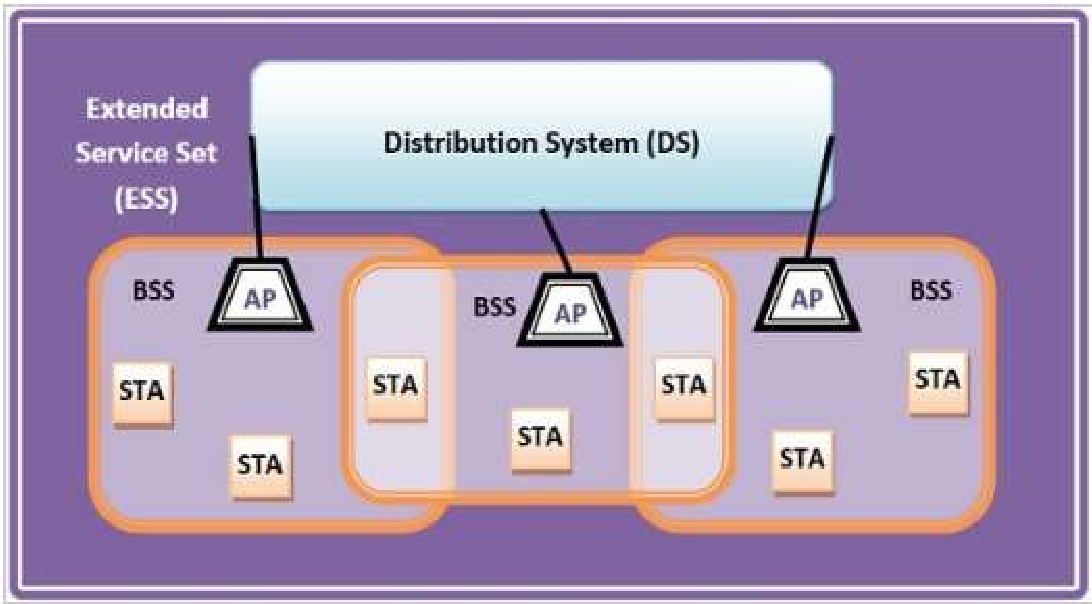
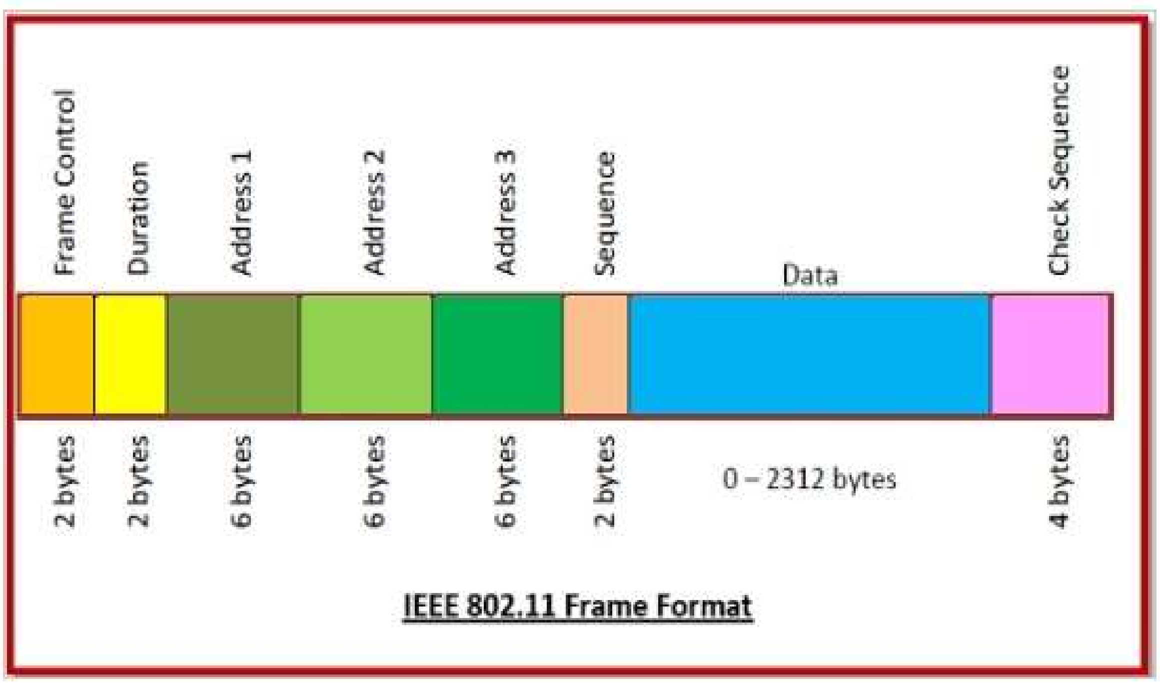


Fig. Architecture of 802.11

Q.2 Explain the frame format of 802.11

Answer: - The following fig. shows the frame format of 802.11



The main fields of a frame of wireless LANs as laid down by IEEE 802.11 are –

1) **Frame Control –** It is a 2 bytes starting field composed of 11 subfields. It contains control information of the frame.

2) **Duration –** It is a 2-byte field that specifies the time period for which the frame and its acknowledgment occupy the channel.
3) **Address fields –** There are three 6-byte address fields containing addresses of source, immediate destination, and final endpoint respectively.
4) **Sequence –** It a 2 bytes field that stores the frame numbers.
5) **Data –** This is a variable-sized field that carries the data from the upper layers. The maximum size of the data field is 2312 bytes.
6) **Check Sequence –** It is a 4-byte field containing error detection information.

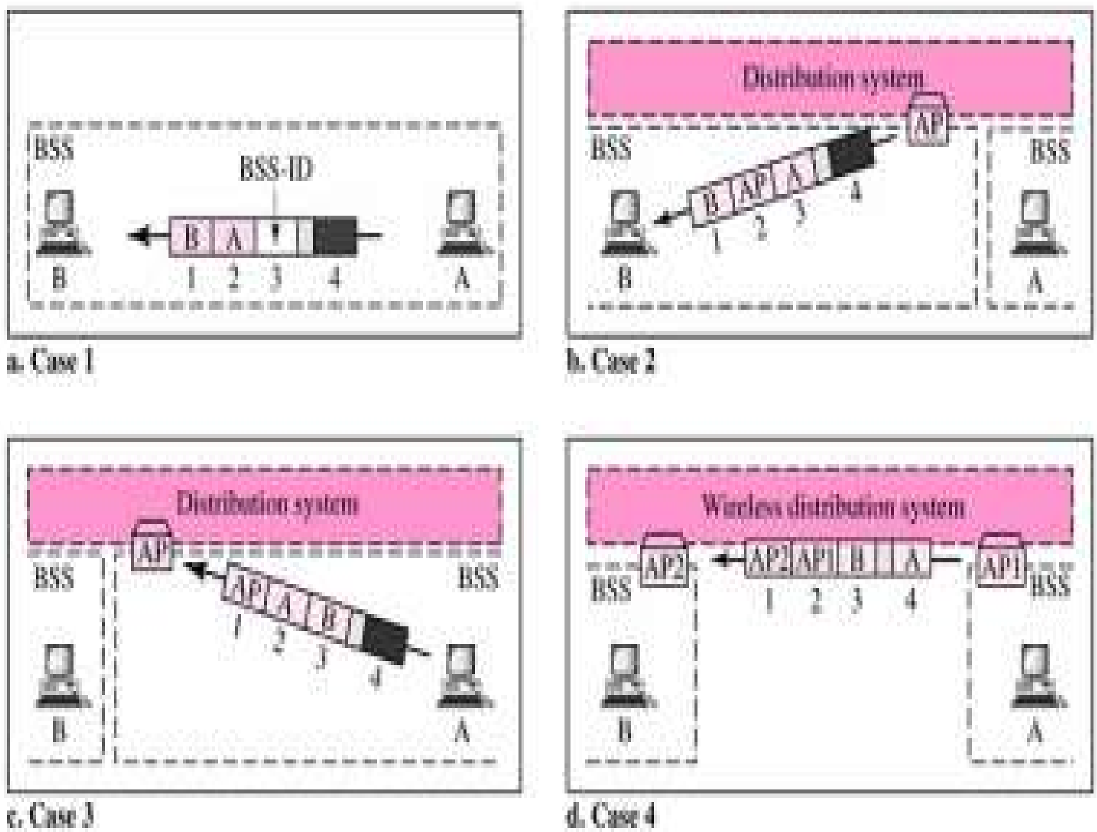
Q.3 Explain IEEE 802.11 addressing mechanism.
Answers:-
- There are 4 main cases by which the addressing mechanism operates with the help of To DS and From DS fields in the Frame Control.
- Each flag can either be a 0 or 1, resulting in the 4 cases which is interpreted in the 4 address fields as shown in the diagram.

TO DS	From DS	Address 1	Address 2	Address 3	Address 4
0	0	Destination	Source	BSS ID	N/A
0	1	Destination	Sending AP	Source	N/A
1	0	Receiving AP	Source	Destination	N/A
1	1	Receiving AP	Sending AP	Destination	Source

Fig. Addresses

- Note that address 1 is always the address of next device. Address 2 is always the address of the previous device. Address 3 is the address of the final destination station if it is not defined by address 1. Address 4 is the address of the original source station if it is not the same address 2.

- Following fig. shows the addressing mechanism of 802.11



- **Case 1: 00** If *To* DS = 0 and *From* DS = 0, it indicates that frame is not going to distribution system and is not coming from a distribution system. The frame is going from one station in a BSS to another.

- **Case 2: 01** If *To* DS = 0 and *From* DS = 1, it indicates that the frame is coming from a distribution system. The frame is coming from an AP and is going to a station. The address 3 contains original sender of the frame (in another BSS).

- **Case 3:10**. If *To* DS = 1 and *From* DS = 0, it indicates that the frame is going to a distribution system. The frame is going from a station to an AP. The address 3 field contains the final destination of the frame.

- **Case 4:11**. If *To* DS = 1 and *From* DS = 1,it indicates that frame is going from one AP to another AP in a wireless distributed system.

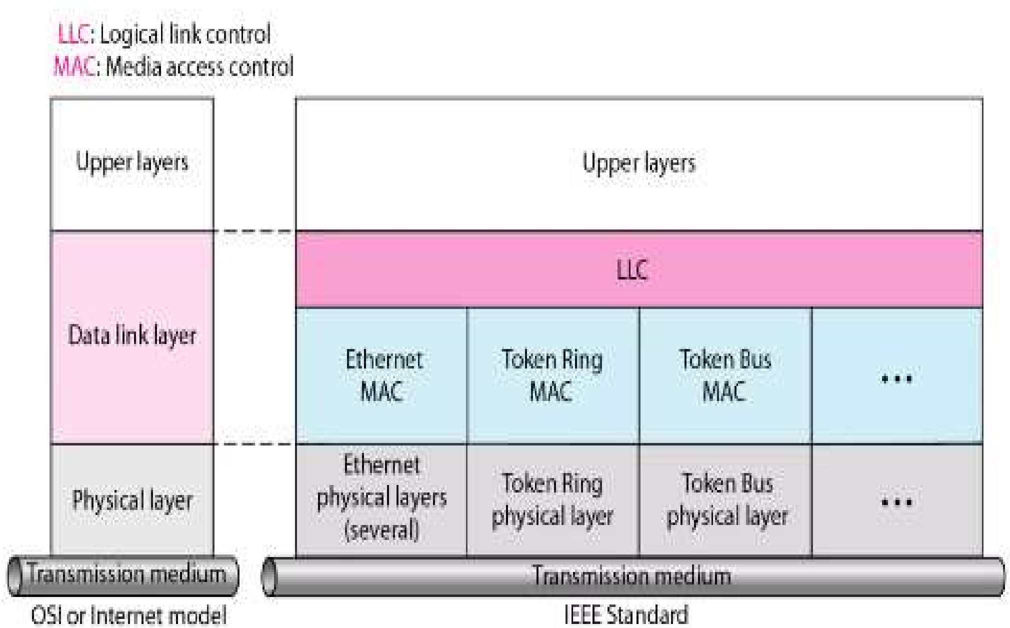
Q.4 Explain the concept of wired LAN's (Ethernet)
Answers:-

- The relationship of the 802 standard to the traditional OSI model is shown in Fig. 13.1 The IEEE has subdivided the data link layer into two sublayers: logical link control(LLC) and media access control(MAC). IEEE has also created several physical layers standards for different LAN protocols.

1. Data Link Layer:-

The data link layer in the IEEE standard is divided into two sublayers: LLC and MAC.

Figure 13.1 ***IEEE standard for LANs***



1.1 Logical Link Control Layer:-

- The logical link control (LLC) is the upper sublayer of the data link layer of the open system interconnections (OSI) reference model for data transmission.

- It acts act an interface between the network layer and the medium access control (MAC) sublayer of the data link layer.
- The LLC sublayer is mainly used for its multiplexing property. It allows several network protocols to operate simultaneously within a multipoint network over the same network medium.
- Data link control handles framing, flow control, and error control. In IEEE Project 802, flow control, error control, and rt of the framing duties are collected into one sublayer called the logical link control. Framing is handled in both the LLC sublayer and the MAC sublayer.
- The LLC provides one single data link control protocol for all IEEE LANs.In this way , the LLC is different from the media access control sub layer, which provides different protocols for different LANs.
- A single LLC protocol can provide interconnectivity between LANs because it makes the MAC sublayer transparent. Fig shows one single LLC protocol serving MAC protocols.

1.1.1 Framing

Framing LLC defines a protocol data unit (PDU) that is somewhat similar to that of HDLC. The header contains a control field like the one in HDLC; this field is used for flow and error control. The two other header fields define the upper-layer protocol at the source and destination that uses LLC. These fields are called the destination service access point (DSAP) and the source service access point (SSAP). The other fields defined in a typical data link control protocol such as HDLC are moved to the MAC sub layer. In other words, a frame defined in HDLC is divided into a PDU at the LLC sub layer and a frame at the MAC sub layer, as shown in Figure 2.

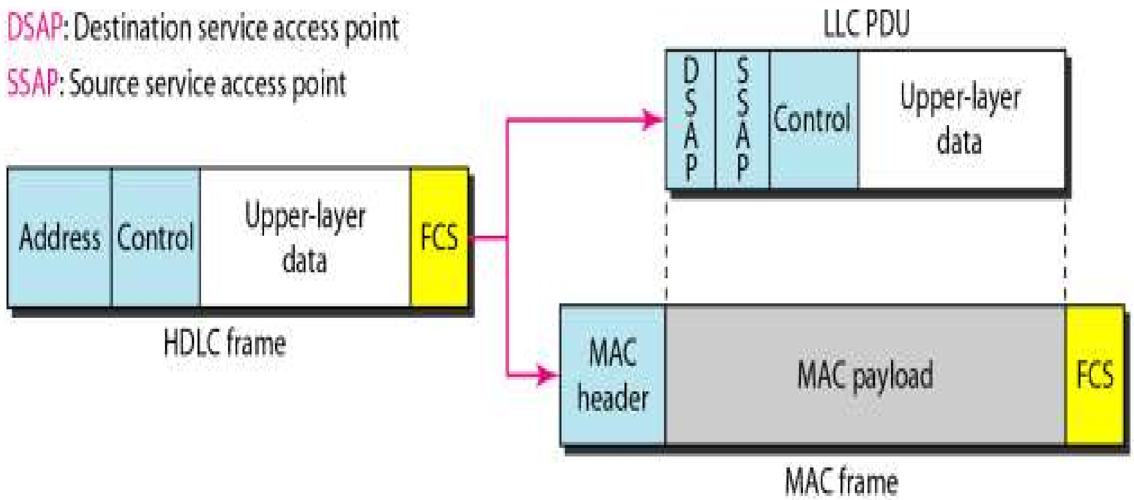


Figure: *HDLC frame compared with LLC and MAC frames*

1.1.2 Need for LLC

Need for LLC: The purpose of the LLC is to provide flow and error control for the upper-layer protocols that actually demand these services. For example, if a LAN or several LANs are used in an isolated system, LLC may be needed to provide flow and error control for the application layer protocols. However, most upper-layer protocols such as IP, do not use the services of LLC.

2. Medium Access Control Layer

- IEEE Project 802 has created a sublayer called media access control that defines the specific access method for each LAN.
- For example, it defines CSMA/CD as the media access method for Ethernet LANs and the token passing method for Token Ring and Token Bus LANs.
- In contrast to the LLC sublayer, the MAC sublayer contains a number of distinct modules; each defines the access method and the framing format specific to the corresponding LAN protocol.

- MAC address is defined as the Media Access Control address. It is a unique address that is allocated to the NIC of the device. It is used as an address to transmit data within ethernet or Wi-Fi.
- This layer acts as an interface between the physical layer and the LLC layer in the OSI model. The main responsibility of the MAC layer is that it encapsulates the frames during transmission so that, whether they are suitable.
- The MAC layer identifies and verifies the address of source stations and destinations. MAC layer performs multiple access resolution when there are more data frames.
- MAC layer coordinates with the physical layer to seize a shared channel by using multiple MAC entities to avoid collisions.
- Ethernet is an example of a medium that is defined through the MAC sublayer.

2. Physical Layer

Physical Layer:

- The physical layer is dependent on the implementation and type of physical media used.
- IEEE defines detailed specifications for each LAN implementation.
- For example, although there is only one MAC sublayer for Standard Ethernet, there is a different physical layer specification for each Ethernet implementations.

Q.5 Explain frame format for Standard Ethernet(802.3)

Answer:-

Frame Format:-

- The Ethernet frame contains seven fields: preamble, SFD, DA, SA, length or type of protocol data unit (PDU), upper-layer data, and the CRC.
- Ethernet does not provide any mechanism for acknowledging received frames, making it what is known as an unreliable medium. Acknowledgments must be implemented at the higher layers.

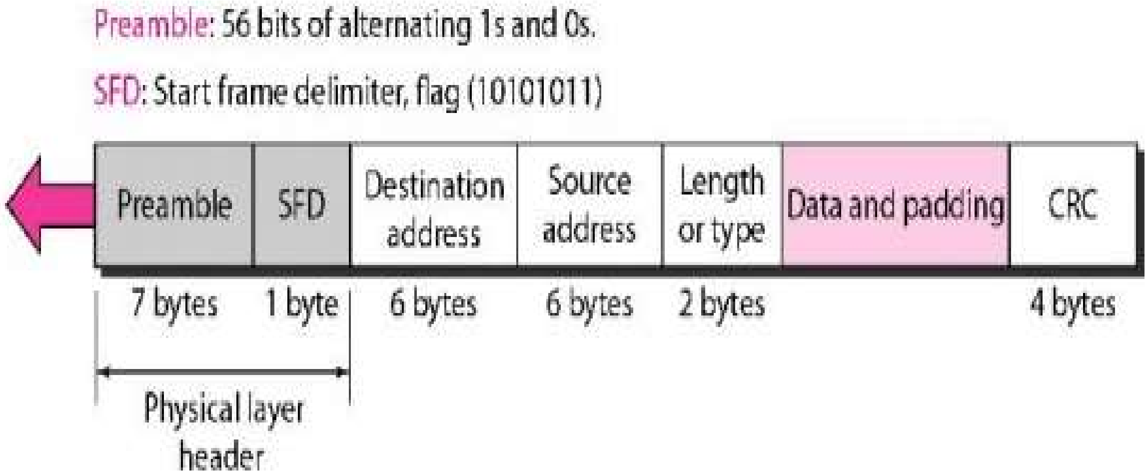


Fig: 802.3 MAC frame

1) **Preamble:** The first field of the 802.3 frame contains 7 bytes (56 bits) of alternating 0s and 1s that alerts the receiving system to the coming frame and enables it to synchronize its input timing. The pattern provides only an alert and a timing pulse.
2) **Start frame delimiter (SFD).** The second field (l byte: 10101011) signals the beginning of the frame. The SFD warns the station or stations that this is the last chance for synchronization. The last 2 bits is 11 and alerts the receiver that the next field is the destination address.
3) **Destination address (DA).** The DA field is 6 bytes and contains the physical address of the destination station or stations to receive the packet.
4) **Source address (SA).** The SA field is sender of the packet.
5) **Length or type**. This field is defined as a type field or length field. The original Ethernet used this field as the type field to define the upper-layer protocol using the MAC frame.
6) **Data.** This field carries data encapsulated from the upper-layer protocols. It is a minimum of 46 and a maximum of 1500 bytes.
7) **CRC**. The last field contains error detection information, in this case a CRC-32.

Q.6 Describe the concept of frame length in Standard Ethernet (802.3)

Answer:-

- Ethernet has imposed restrictions on both the minimum and maximum lengths of a frame. An Ethernet frame needs to have a minimum length of 512 bits or 64 bytes.
- Part of this length is the header and the trailer. If we count 18 bytes of header and trailer, then the minimum length of data from the upper layer is 64 - 18 = 46 bytes.
- If the upper-layer packet is less than 46 bytes, padding is added to make up the difference.
- The standard defines the maximum length of a frame as 1518 bytes. If we subtract the 18 bytes of header and trailer, the maximum length of the payload is 1500 bytes.

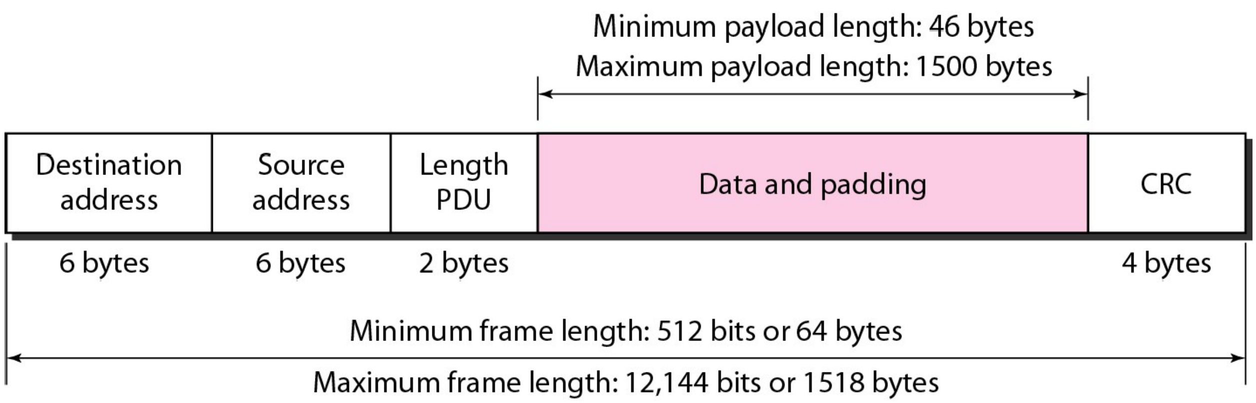


Fig. Minimum and maximum lengths

Q.7 Explain address mechanism in Standard Ethernet (802.3)

Answer:-

- Each station on an Ethernet network has its own network interface card (NIC). The NIC fits inside the station and provides the station with a 6-byte physical address.
- The Ethernet address is 6 bytes (48 bits), nominally written in hexadecimal notation, with a colon between the bytes.

Fig. Example of an Ethernet address in hexadecimal notation

Unicast, Multicast, and Broadcast Addresses:-

- A source address is always a unicast address-the frame comes from only one station. The destination address, however, can be unicast, multicast, or broadcast.
- Figure shows how to distinguish a unicast address from a multicast address.
- If the least significant bit of the first byte in a destinanation address is 0, the address is unicast; otherwise, it is multicast.

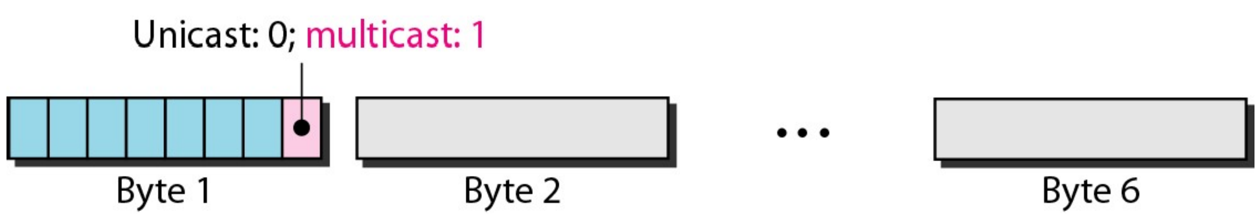


Fig. Unicast and multicast addresses

- A unicast destination address defines only one recipient; the relationship between the sender and the receiver is **one-to-one**. A multicast destination address defines a group of addresses; the relationship between the sender and the receivers is **one-to-many**. The broadcast address is a special case of the multicast address; the recipients are all the stations on the LAN. A broadcast destination address is **forty-eight 1's.**

Q.8 Define the type of the following destination addresses:

a. 4A:30:10:21:1O:1A

b. 47:20:1B:2E:08:EE

c. FF:FF:FF:FF:FF:FF

Solution:

To find the type of the address, we need to look at the second hexadecimal digit from the left. If it is even, the address is unicast. If it is odd, the address is multicast. If all digits are F's, the address is broadcast. Therefore, we have the following:

a. This is a unicast address because A in binary is 1010 (even).
b. This is a multicast address because 7 in binary is 0111 (odd).
c. This is a broadcast address because all digits are F's.

Q.9 Explain access method in CSMA/CD in Standard Ethernet (802.3) OR Explain the relationship between slot time and collision

Answer:-

- Standard Ethernet uses 1-persistent CSMA/CD.
- **Slot Time** :- In an Ethernet network, the round-trip time required for a frame to travel from one end of a maximum-length network to the other plus the time needed to send the jam sequence is called the slot time.

Slot time =round-trip time + time required to send the jam sequence

- The slot time in Ethernet is defined in bits. It is the time required for a station to send 512 bits. This means that the actual slot time depends on the data rate; for traditional 10-Mbps Ethernet it is 51.2 μs.

Slot Time and Collision:-

- The choice of a 512-bit slot time was not accidental. It was chosen to allow the proper functioning of CSMA/CD.
- To understand the situation, let us consider two cases. In the first case, we assume that the sender sends a minimum-size packet of 512 bits. Before the sender can send the entire packet out, the signal travels through the network and reaches the end of the network.
- If there is another signal at the end of the network (worst case), a collision occurs. The sender has the opportunity to abort the sending of the frame and to send a jam sequence to inform other stations of the collision.
- The round-trip time plus the time required to send the jam sequence should be less than the time needed for the sender to send the minimum

frame, 512 bits. The sender needs to be aware of the collision before it is too late, that is, before it has sent the entire frame.

- In the second case, the sender sends a frame larger than the minimum size (between 512 and 1518 bits). In this case, if the station has sent out the first 512 bits and has not heard a collision, it is guaranteed that collision will never occur during the transmission of this frame.
- The reason is that the signal will reach the end of the network in less than one-half the slot time. If all stations follow the CSMA/CD protocol, they have already sensed the existence of the signal (carrier) on the line and have refrained from sending.
- If they sent a signal on the line before one-half of the slot time expired, a collision has occurred and the sender has sensed the collision.
- In other words, collision can only occur during the first half of the slot time, and if it does, it can be sensed by the sender during the slot time.
- This means that after the sender sends the first 512 bits, it is guaranteed that collision will not occur during the transmission of this frame.
- The medium belongs to the sender, and no other station will use it. In other words, the sender needs to listen for a collision only during the time the first 512 bits are sent.

Q.10 Explain the relationship between slot time and Maximum Network Length.

Answer:-

- There is a relationship between the slot time and the maximum length of the network (collision domain). It is dependent on the propagation speed of the signal in the particular medium.
- In most transmission media, the signal propagates at 2 x 108 m/s (two-thirds of the rate for propagation in air). For traditional Ethernet, we calculate

$$MaxLength = PropagationSpeed \times \frac{SlotTime}{2}$$

- Assume the propagation speed is 2×108 m/s, the maximum length can be 5120m or 4096m. However, the allowed length is much shorter due to delays caused by network devices/connectors, signal attenuation, EMI, etc.

- Of course, we need to consider the delay times in repeaters and interfaces, and the time required to send the jam sequence. These reduce the maximum-length of a traditional Ethernet network to 2500 m, just 48 percent of the theoretical calculation.

$$MaxLength = 2500 \text{m}$$

Q.11 Explain following categories of Standard Ethernet.
A) 10Base5: Thick Ethernet
B) 10Base2: Thin Ethernet
C) 10Base-T: Twisted-Pair Ethernet
D) 10Base-F
Answer:-
A) 10Base5: Thick Ethernet

- The first implementation is called 10Base5, thick Ethernet, or Thicknet. The nickname derives from the size of the cable, which is roughly the size of a garden hose and too stiff to bend with your hands.
- 10Base5 was the first Ethernet specification to use a bus topology with an external transceiver (transmitter/receiver) connected via a tap to a thick coaxial cable. Figure shows a schematic diagram of a 10Base5 implementation.

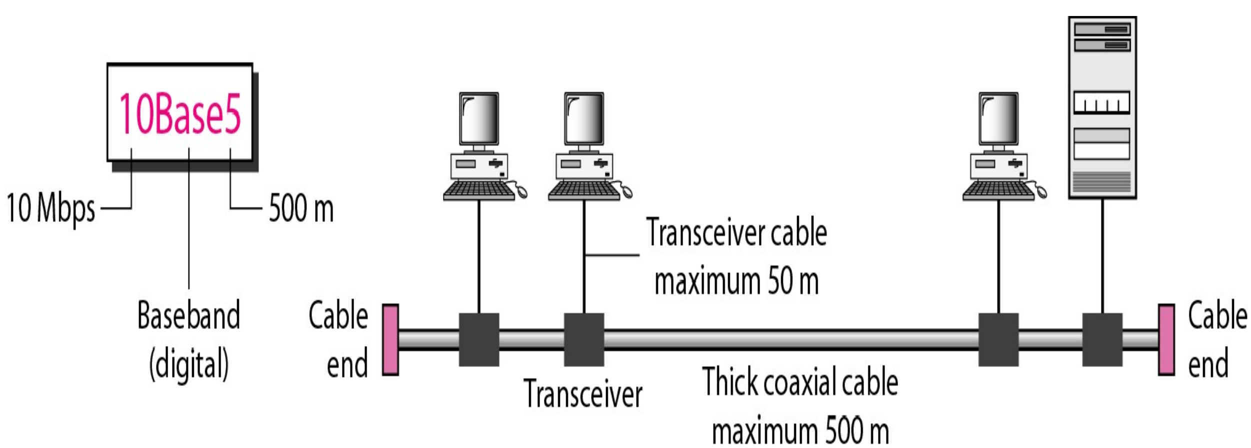


Fig.10Base5 implementation

- The transceiver is responsible for transmitting, receiving, and detecting collisions. The transceiver is connected to the station via a transceiver cable that provides separate paths for sending and receiving.
- This means that collision can only happen in the coaxial cable. The maximum length of the coaxial cable must not exceed 500 m; otherwise, there is excessive degradation of the signal.
- If a length of more than 500 m is needed, up to five segments, each a maximum of 5OO-meter, can be connected using repeaters.

B) 10Base2: Thin Ethernet

- The second implementation is called lOBase2, thin Ethernet, or Cheapernet. 10Base2 also uses a bus topology, but the cable is much thinner and more flexible.
- The cable can be bent to pass very close to the stations. In this case, the transceiver is normally part of the network interface card (NIC), which is installed inside the station. Figure 13.11 shows the schematic diagram of a 10Base2 implementation

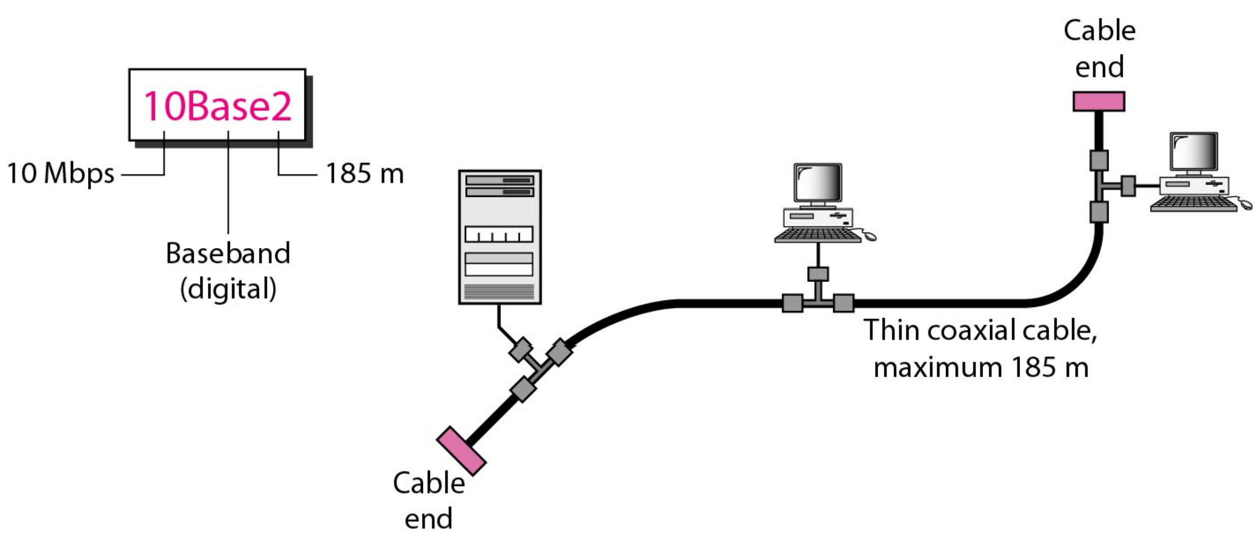


Fig.10Base2 implementation

- Note that the collision here occurs in the thin coaxial cable. This implementation is more cost effective than 10BaseS because thin coaxial cable is less expensive than thick coaxial and the tee connections are much cheaper than taps.
- Installation is simpler because the thin coaxial cable is very flexible. However, the length of each segment cannot exceed 185 m (close to 200 m) due to the high level of attenuation in thin coaxial cable.

c) 10Base-T: Twisted-Pair Ethernet

- The third implementation is called 10Base-T or twisted-pair Ethernet. 10Base-T uses a physical star topology.
- The stations are connected to a hub via two pairs of twisted cable, as shown in Figure.
- Note that two pairs of twisted cable create two paths (one for sending and one for receiving) between the station and the hub.

- Any collision here happens in the hub. Compared to 10Base5 or 10Base2, we can see that the hub actually replaces the coaxial cable as far as a collision is concerned.
- The maximum length of the twisted cable here is defined as 100 m, to minimize the effect of attenuation in the twisted cable.

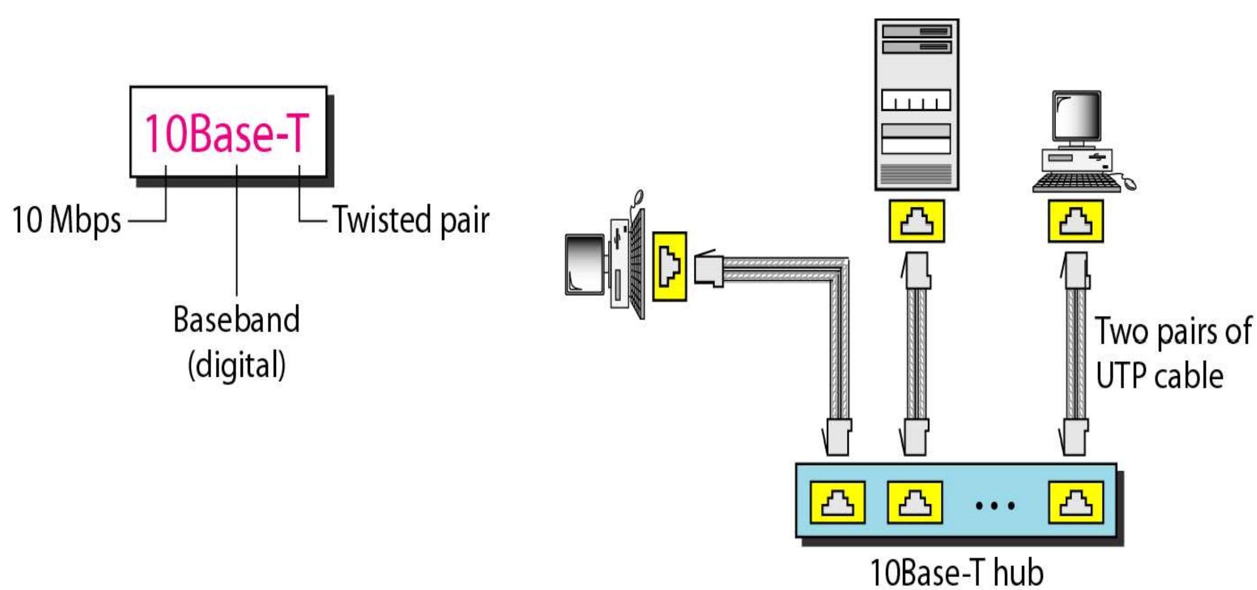
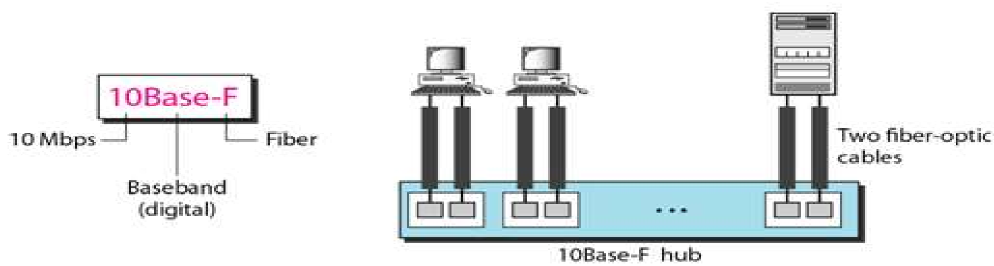


Fig.10Base-T implementation

D) 10Base-F:

- Fiber Ethernet Although there are several types of optical fiber 10-Mbps Ethernet, the most common is called 10Base-F. 10Base-F uses a star topology to connect stations to a hub. The stations are connected to the hub using two fiber-optic cables, as shown in Figure.

Figure 13.13 *10Base-F implementation*

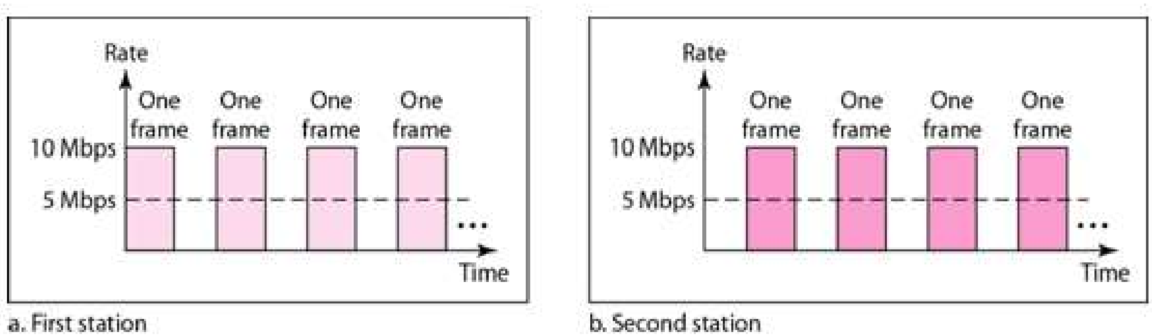


Q.12 Explain the concept of bridged Ethernet.
Answer:-
Bridged Ethernet
The first step in the Ethernet evolution was the division of a LAN by bridges. Bridges have two effects on an Ethernet LAN: They raise the bandwidth and they separate collision domains.

- Raising the Bandwidth in an unbridged Ethernet network, the total capacity (10 Mbps) is shared among all stations with a frame to send; the stations share the bandwidth of the network. If only one station has frames to send, it benefits from the total capacity (10 Mbps).
- But if more than one station needs to use the network, the capacity is shared. For example, if two stations have a lot of frames to send, they probably alternate in usage.

- When one station is sending, the other one refrains from sending. We can say that, in this case, each station on average sends at a rate of 5 Mbps. Figure shows the situation.

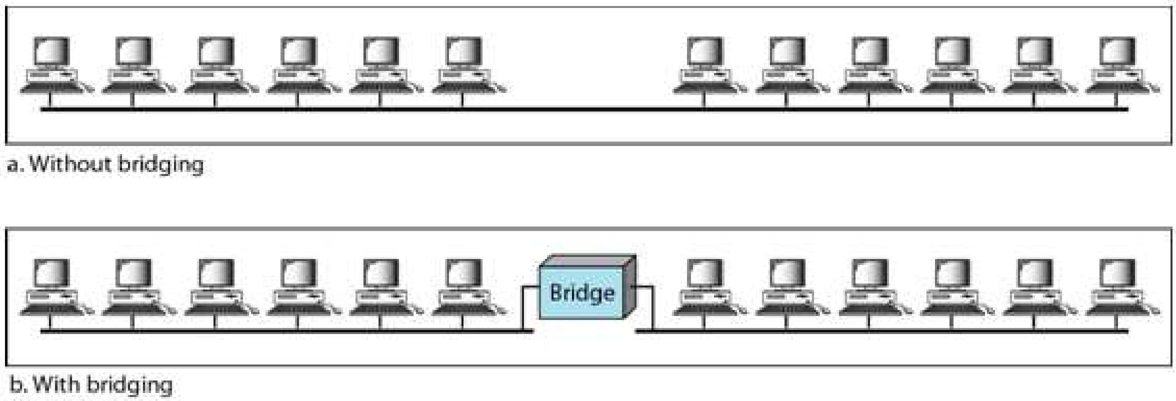
Figure 13.14 ***Sharing bandwidth***



- A bridge divides the network into two or more networks. Bandwidth-wise, each network is independent.
- For example, in Figure 13.15, a network with 12 stations is divided into two networks, each with 6 stations. Now each network has a capacity of 10 Mbps.

- The 10Mbps capacity in each segment is now shared between 6 stations (actually 7 because the bridge acts as a station in each segment), not 12 stations.

Figure 13.15 *A network with and without a bridge*



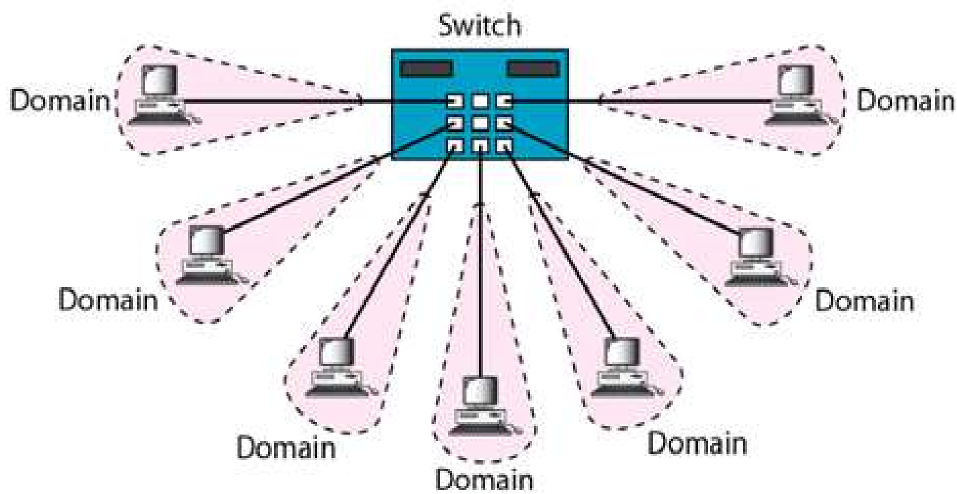
Q.13 Explain the concept of Switched Ethernet.

Answer:-

Switched Ethernet

- The idea of a bridged LAN can be extended to a switched LAN. Instead of having two to four networks, why not have N networks, where N is the number of stations on the LAN? In other words, if we can have a multiple-port bridge, why not have an N-port switch? In this way, the bandwidth is shared only between the station and the switch (5 Mbps each).
- In addition, the collision domain is divided into N domains. A layer 2 switch is an N-port bridge with additional sophistication that allows faster handling of the packets. Evolution from a bridged Ethernet to a switched Ethernet was a big step that opened the way to an even faster Ethernet, as we will see. Figure shows a switched LAN.

Figure 13.17 *Switched Ethernet*

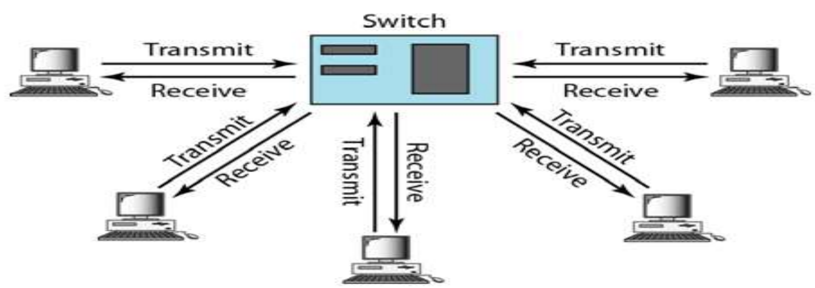


Q.14 Explain the concept of full duplex Ethernet.

Answer:-

- One of the limitations of 10Base5 and 10Base2 is that communication is half-duplex (10Base-T is always full-duplex); a station can either send or receive, but may not do both at the same time.
- The next step in the evolution was to move from switched Ethernet to full-duplex switched Ethernet. The full-duplex mode increases the capacity of each domain from 10 to 20 Mbps.
- Figure shows a switched Ethernet in full-duplex mode. Note that instead of using one link between the station and the switch, the configuration uses two links: one to transmit and one to receive

Figure 13.18 *Full-duplex switched Ethernet*



No Need for CSMAICD

- In full-duplex switched Ethernet, there is no need for the CSMAICD method. In a full duplex switched Ethernet, each station is connected to the switch via two separate links.
- Each station or switch can send and receive independently without worrying about collision. Each link is a point-to-point dedicated path between the station and the switch.
- There is no longer a need for carrier sensing; there is no longer a need for collision detection. The job of the MAC layer becomes much easier. The carrier sensing and collision detection functionalities of the MAC sublayer can be turned off.

MAC Control Layer

Standard Ethernet was designed as a connectionless protocol at the MAC sublayer. There is no explicit flow control or error control to inform the sender that the frame has arrived at the destination without error. When the receiver receives the frame, it does not send any positive or negative acknowledgment. To provide for flow and error control in full-duplex switched Ethernet, a new sublayer, called the MAC control, is added between the LLC sublayer and the MAC sublayer.

Q.15 Explain the concept of Fast Ethernet.

Answer:-

- Fast Ethernet was designed to compete with LAN protocols such as FDDI or Fiber Channel (or Fibre Channel, as it is sometimes spelled). IEEE created Fast Ethernet under the name 802.3u.
- Fast Ethernet is backward-compatible with Standard Ethernet, but it can transmit data 10 times faster at a rate of 100 Mbps.
- The goals of Fast Ethernet can be summarized as follows:

1. Upgrade the data rate to 100 Mbps.
2. Make it compatible with Standard Ethernet.
3. Keep the same 48-bit address.
4. Keep the same frame format.
5. Keep the same minimum and maximum frame lengths.

1) MAC Sublayer

- A main consideration in the evolution of Ethernet from 10 to 100 Mbps was to keep the MAC sublayer untouched. However, a decision was made to drop the bus topologies and keep only the star topology.

- For the star topology, there are two choices, as we saw before: half duplex and full duplex. In the half-duplex approach, the stations are connected via a hub; in the full-duplex approach, the connection is made via a switch with buffers at each port. The access method is the same (CSMA/CD) for the half-duplex approach; for full duplex Fast Ethernet, there is no need for CSMA/CD.
- However, the implementations keep CSMA/CD for backward compatibility with Standard Ethernet.

1.1 Autonegotiation:-

A new feature added to Fast Ethernet is called autonegotiation. It allows a station or a hub a range of capabilities. Autonegotiation allows two devices to negotiate the mode or data rate of operation. It was designed particularly for the following purposes:

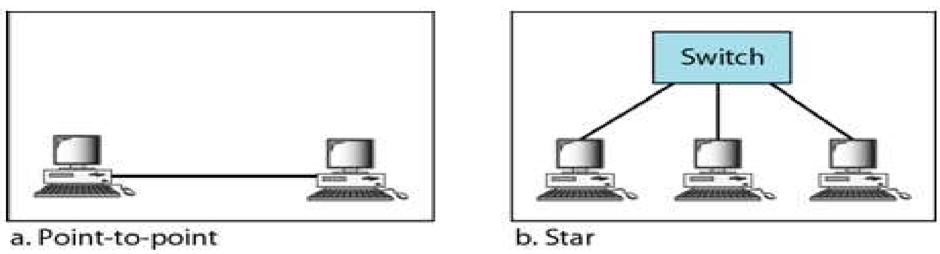
- To allow incompatible devices to connect to one another. For example, a device with a maximum capacity of 10 Mbps can communicate with a device with a 100 Mbps capacity (but can work at a lower rate).
- To allow one device to have multiple capabilities.
- To allow a station to check a hub's capabilities.

2) Physical Layer:-

The physical layer in Fast Ethernet is more complicated than the one in Standard Ethernet. We briefly discuss some features of this layer.

a) **Topology :-** Fast Ethernet is designed to connect two or more stations together. If there are only two stations, they can be connected point-to-point. Three or more stations need to be connected in a star topology with a hub or a switch at the center, as shown in Figure.

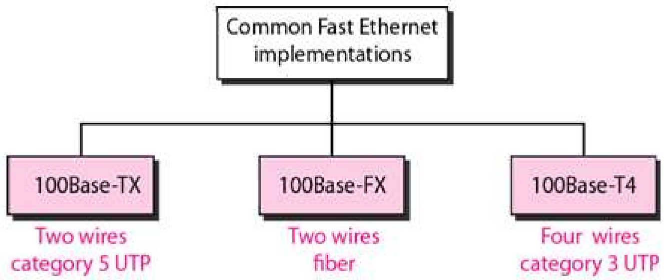
Figure 13.19 *Fast Ethernet topology*



b) Implementation :-

- Fast Ethernet implementation at the physical layer can be categorized as either two-wire or four-wire. The two-wire implementation can be either category 5 UTP (100Base-TX) or fiber-optic cable (100Base-FX). The four-wire implementation is designed only for category 3 UTP (100Base-T4). See Figure

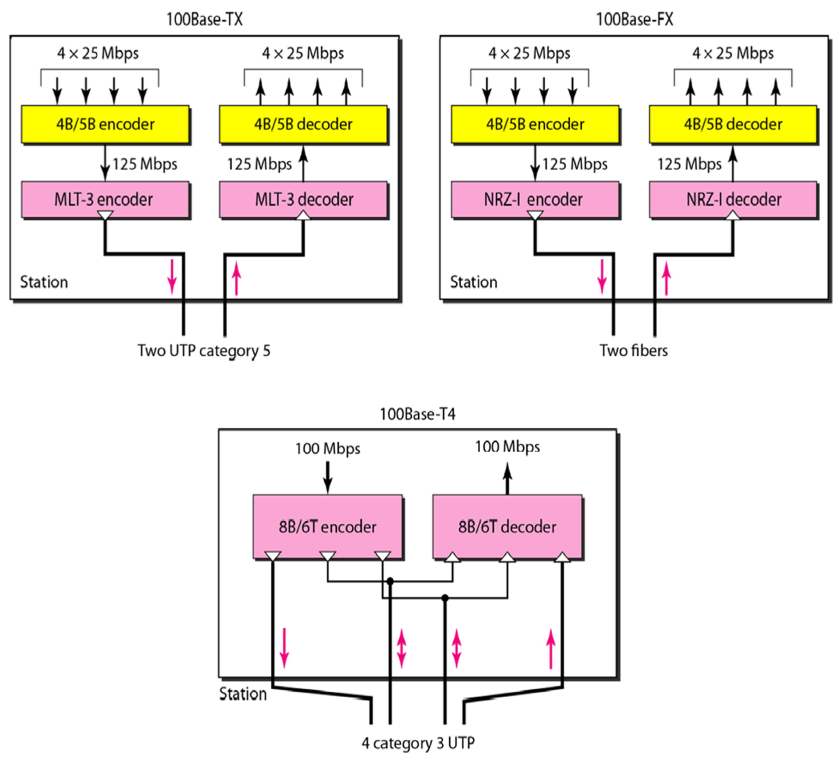
Figure 13.20 *Fast Ethernet implementations*



c) Encoding

- Manchester encoding needs a 200-Mbaud bandwidth for a data rate of 100 Mbps, which makes it unsuitable for a medium such as twisted-pair cable.
- For this reason, the Fast Ethernet designers sought some alternative encoding/decoding scheme.
- However, it was found that one scheme would not perform equally well for all three implementations.
- Therefore, three different encoding schemes were chosen.

Figure 13.21 *Encoding for Fast Ethernet implementation*



Q.16 Explain the following implementations of fast Ethernet.

1) 100Base-TX

2) 100Base-FX

3) A 100Base-TX

Answer:-

1) 100Base-TX

- It uses two pairs of twisted-pair cable (either category 5 UTP or STP). For this implementation, the MLT-3 scheme was selected since it has good bandwidth performance .
- However, since MLT-3 is not a self-synchronous line coding scheme, 4B/5B block coding is used to provide bit synchronization by preventing the occurrence of a long sequence of 0's and 1's. This creates a data rate of 125 Mbps, which is fed into MLT-3 for encoding

2) 100Base-FX

- It uses two pairs of fiber-optic cables. Optical fiber can easily handle high bandwidth requirements by using simple encoding schemes. The designers of 100Base-FX selected the NRZ-I encoding scheme for this implementation.

- However, NRZ-I has a bit synchronization problem for long sequences of 0’s (or 1’s, based on the encoding). To overcome this problem, the designers used 4B/5B block encoding as we described for 100Base-TX. The block encoding increases the bit rate from 100 to 125 Mbps, which can easily be handled by fiber-optic cable.

3) A 100Base-TX

- This network can provide a data rate of 100 Mbps, but it requires the use of category 5 UTP or STP cable. This is not cost-efficient for buildings that have already been wired for voice-grade twisted-pair (category 3)
- A new standard, called 100Base-T4, was designed to use category 3 or higher UTP. The implementation uses four pairs of UTP for transmitting 100 Mbps. Encoding/decoding in 100Base-T4 is more complicated.
- As this implementation uses category 3 UTP, each twisted-pair cannot easily handle more than 25 Mbaud. In this design, one pair switches between sending and receiving. Three pairs of UTP category 3, however, can handle only 75 Mbaud (25 Mbaud) each.

Q.17 Explain the concept of Gigabit Ethernet.

Answer:-

- The need for an even higher data rate resulted in the design of the Gigabit Ethernet protocol (1000 Mbps).
- The IEEE committee calls the Standard 802.3z. The goals of the Gigabit Ethernet design can be summarized as follows.

1. Upgrade the data rate to 1 Gbps.
2. Make it compatible with Standard or Fast Ethernet.
3. Use the same 48-bit address.
4. Use the same frame format.
5. Keep the same minimum and maximum frame lengths.
6. To support autonegotiation as defined in Fast Ethernet.

1) MAC Sublayer

- A main consideration in the evolution of Ethernet was to keep the MAC sublayer untouched.
- However, to achieve a data rate 1 Gbps, this was no longer possible. Gigabit Ethernet has two distinctive approaches for medium access:

half-duplex and full-duplex Almost all implementations of Gigabit Ethernet follow the full-duplex approach.

- However, we briefly discuss the half-duplex approach to show that Gigabit Ethernet can be compatible with the previous generations.

1.1 Full-Duplex Mode

- In full-duplex mode, there is a central switch connected to all computers or other switches. In this mode, each switch has buffers for each input port in which data are stored until they are transmitted.
- There is no collision in this mode, as we discussed before. This means that CSMA/CD is not used. Lack of collision implies that the maximum length of the cable is determined by the signal attenuation in the cable, not by the collision detection process.

1.2 Half-Duplex Mode

- Gigabit Ethernet can also be used in half-duplex mode, although it is rare. In this case, a switch can be replaced by a hub, which acts as the common cable in which a collision might occur.
- The half-duplex approach uses CSMA/CD. However, as we saw before, the maximum length of the network in this approach is totally dependent on the minimum frame size. Three methods have been defined: traditional, carrier extension, and frame bursting.

a)Traditional

- In the traditional approach, we keep the minimum length of the frame as in traditional Ethernet (512 bits).
- However, because the length of a bit is 1/100 shorter in Gigabit Ethernet than in 10-Mbps Ethernet, the slot time for Gigabit Ethernet is 512 bits x 1/1000 μs which is equal to 0.512 μs. The reduced slot time means that collision is detected 100 times earlier.
- This means that the maximum length of the network is 25 m. This length may be suitable if all the stations are in one room, but it may not even be long enough to connect the computers in one single office.

b)Carrier Extension

- To allow for a longer network, we increase the minimum frame length. The carrier extension approach defines the minimum length of a frame as 512 bytes (4096 bits).

- This means that the minimum length is 8 times longer. This method forces a station to add extension bits (padding) to any frame that is less than 4096 bits.
- In this way, the maximum length of the network can be increased 8 times to a length of 200 m. This allows a length of 100 m from the hub to the station.

c) Frame Bursting

- Carrier extension is very inefficient if we have a series of short frames to send; each frame carries redundant data. To improve efficiency, frame bursting was proposed.
- Instead of adding an extension to each frame, multiple frames are sent. However, to make these multiple frames look like one frame, padding is added between the frames (the same as that used for the carrier extension method) so that the channel is not idle.
- In other words, the method deceives other stations into thinking that a very large frame has been transmitted.

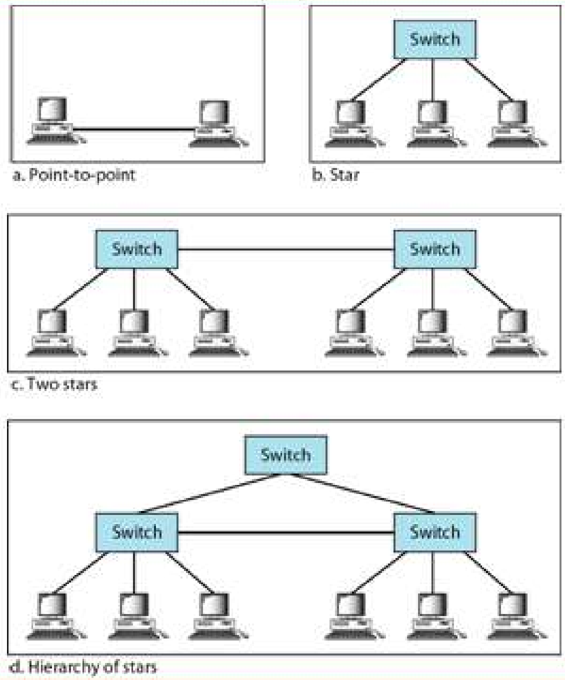
2) Physical Layer

- The physical layer in Gigabit Ethernet is more complicated than that in Standard or Fast Ethernet. We briefly discuss some features of this layer.

a) Topology

- Gigabit Ethernet is designed to connect two or more stations. If there are only two stations, they can be connected point-to-point. Three or more stations need to be connected in a star topology with a hub or a switch at the center.
- Another possible configuration is to connect several star topologies or let a star topology be part of another as shown in Figure

Figure 13.22 *Topologies of Gigabit Ethernet*



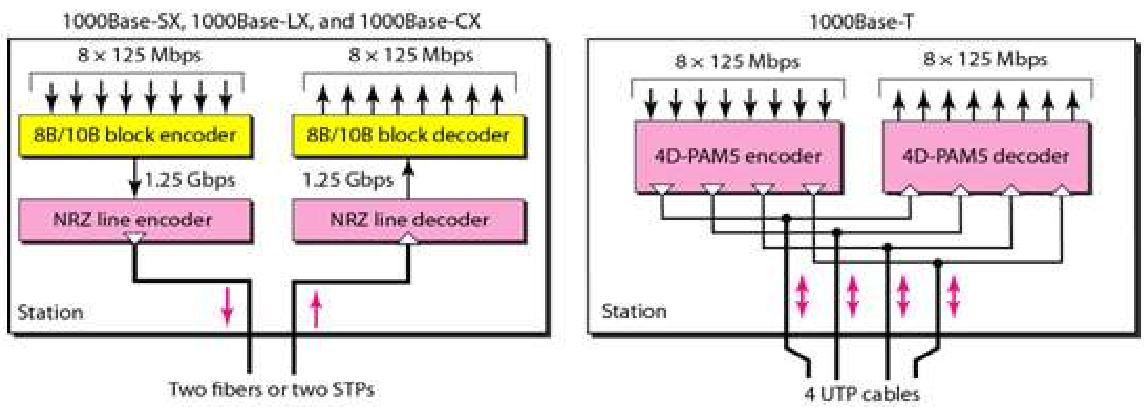
b) Implementation

- Gigabit Ethernet can be categorized as either a two-wire or a four-wire implementation.
- The two-wire implementations use fiber-optic cable (1000Base-SX, short-wave, or 1000Base-LX, long-wave), or STP (1000Base-CX).
- The four-wire version uses category 5 twisted-pair cable (1000Base-T). In other words, we have four implementations, as shown in Figure. 1000Base-T was designed in response to those users who had already installed this wiring for other purposes such as Fast Ethernet or telephone services.

c) Encoding

Figure shows the encoding/decoding schemes for the four implementations.

Figure 13.24 *Encoding in Gigabit Ethernet implementations*



Q.18 Explain the concept of Ten Gigabit Ethernet.

Answer:-

Ten-Gigabit Ethernet The IEEE committee created Ten-Gigabit Ethernet and called it Standard 802.3ae. The goals of the Ten-Gigabit Ethernet design can be summarized as follows:

1. Upgrade the data rate to 10 Gbps.
2. Make it compatible with Standard, Fast, and Gigabit Ethernet.
3. Use the same 48-bit address.
4. Use the same frame format.
5. Keep the same minimum and maximum frame lengths.
6. Allow the interconnection of existing LANs into a metropolitan area network (MAN) or a wide area network (WAN).
7. Make Ethernet compatible with technologies such as Frame Relay and ATM

1) MAC Sublayer:- Ten-Gigabit Ethernet operates only in full duplex mode which means there is no need for contention; CSMA/CD is not used in Ten-Gigabit Ethernet.

2) Physical Layer:- The physical layer in Ten-Gigabit Ethernet is designed for using fiber-optic cable over long distances. Three implementations are the most common: lOGBase-S, lOGBase-L, and lOGBase-E. Table shows a summary ofthe Ten-Gigabit Ethernet implementations.

Table 13.4 ***Summary of Ten-Gigabit Ethernet implementations***

Characteristics	*10GBase-S*	*10GBase-L*	*10GBase-E*
Media	Short-wave 850-nm multimode	Long-wave 1310-nm single mode	Extended 1550-mm single mode
Maximum length	300 m	10 km	40 km