MEDIUM ACCESS SUB LAYER

Multiple Choice Type Questions

1. What is maximum data capacity for optical fiber cable? [WBUT 2017]
a) 10 mbps b) 100 mbps c) 1000 mbps d) 10000 mbps

Answer: (c)

2. Which one of the following routing algorithm can be used for network layer design? [WBUT 2018]
a) Shortest path algorithm b) Distance vector routing
c) Link state routing d) All of these

Answer: (d)

3. The Hamming Distance for the codes generated using either even or odd parity will be ________. [WBUT 2018]
a) 2 b) 4 c) 1 d) 0

Answer: (c)

4. PPP is a .... oriented protocol. [MODEL QUESTION]
a) phase b) bit c) byte d) none of these

Answer: (c)

5. Which of the following network architectures does not use the token passing access method? [MODEL QUESTION]
a) IEEE 802.4 b) FDDI c) CSMA/CD d) IEEE802.5

Answer: (c)

6. In the .... Random-access method there is no collision. [MODEL QUESTION]
a) ALOHA b) CSMA / CD c) CSMA / CA d) Token-passing

Answer: (d)

7. IEEE 802.5 standard is [MODEL QUESTION]
a) Token Ring b) Token Bus c) LLC d) FDDQ

Answer: (a)

8. How much channel throughput of slotted ALOHA will be in comparison to pure Aloha? [MODEL QUESTION]
a) Same b) Double c) Three times d) None of these

Answer: (b)

Short Answer Type Questions

1. Explain about ALOHA. **[WBUT 2013]**

OR,

Find the expressions for average delay and throughput for both pure ALOHA and slotted ALOHA. Compare their performances as well. **[WBUT 2015]**

Answer:

Suppose the stations generate frames following a Poisson distribution of mean S frames per second. Also, the probability of k transmissions attempts per time frame is a Poisson distribution with mean G per frame time, i.e. $\mathbf{P(k) = Gk\ e^{-G}/k!}$

Thus, **P(No frames generated in frame duration) = $\mathbf{e^{-G}}$**

Now, throughput = G * P(transmission is successful)

Hence, **S = GP(0)**

Collision happens if another frame is generated during twice the time duration of a frame. This is $\mathbf{P(0) = e^{-2G}}$

Solving for S we get:

$\mathbf{S = Ge^{-2G}}$

Maximum throughput occurs at G = 0.5, where **S = 1/2e = 0.184**

In slotted ALOHA, we need to check for collision only within duration of frame because no new frame can start within that time (collision can happen at the beginning only). This gives us:

$\mathbf{S = Ge^{-2G}}$

Where maximum **S = 1/e = 0.368**

Comparison:

a) Pure Aloha is a Continuous time system whereas Slotted ALOHA is discrete time system.

b) Pure ALOHA doesn't check whether the channel is busy before transmission. Slotted ALOHA send the data at the beginning of timeslot.

c) Pure ALOHA not divided in to time. Slotted ALOHA divided in to time

2. Why do you require a limit on the minimum size of Ethernet frame? **[WBUT 2014, 2015]**

Answer:

To detect collision, it is essential that a sender continue sending a frame and at the same time receives another frame sent by another station. Considering maximum delay with five Ethernet segments in cascade, the size of frame has been found to be 64 bytes such that the above condition is satisfied.

3. What is vulnerable period? How it affects the performance in MAC Protocols. **[WBUT 2014]**

Answer:

The total period of time when collision may occur for a packet is called vulnerable period. Let, all packets have a fixed duration λ. Then vulnerable period is 2λ in pure

ALOHA scheme and λ in slotted ALOHA scheme. If vulnerable period is long, probability of the occurrence collision increases leading to reduction in throughput.

4. Explain how the CSMA/CA protocol answers this question: "What should be done if the medium is busy?" **[WBUT 2014, 2015]**

Answer:

In CSMA/CA the medium is sensed busy, a station keeps monitoring the medium until it becomes idle again. At this point, it generates a random back-off period, which is chosen to be a multiple number of DIFS. The station then re-attempts the transmission after the back-off period ends. If a transmission is successful, the receiver responds with an acknowledgement packet.

5. What are the drawbacks of token ring topology? **[WBUT 2014, 2018]**

Answer:

Drawbacks of Token Ring topology

i) Necessity of having a monitor function
ii) Under conditions of low load, substantial delay waiting for token to come around, even though network is idle
iii) Can require significantly more wire to be run than a bus architecture

6. Explain S-Frame of HDLC frame in Data Link layer. **[WBUT 2014]**

Answer:

HDLC defines three types of frames:

Each type of frame serves as an envelope for the transmission of a different type of message.

I-frames (information) are used to transport user data and control information relating to user data (piggybacking).

S-frames (Supervisory) are used only to transport control information.

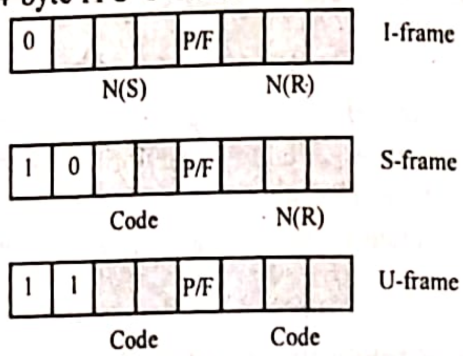
U-frames (Unnumbered) are reserved for system management. Information carried by U-frames is intended for managing the link itself.

Fields

Let us now discuss the fields and their use in different frame types.

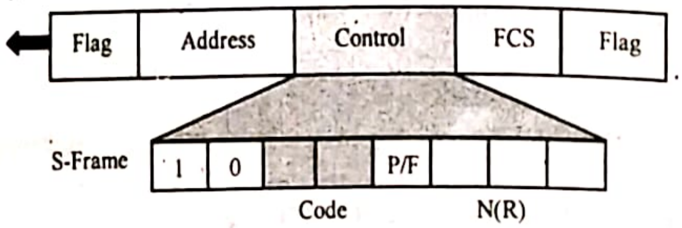
- **Flog field:** The flag field of an HDLC frame is an 8-bit sequence with the bit pattern 01111110 that identifies both the beginning and the end of a frame and serves as asynchronization pattern for the receiver.
- **Address field:** The second field of an HDLC frame contains the address of the secondary station. If a primary station created the frame, it contains a to address. If a secondary creates the frame, it contains from address. An address field field can be 1 byte or several bytes long, depending on the needs of the network.
- **Control field:** The control field is a 1- or 2-byte segment of the frame used for flow and error control. The interpretation of bits in this field depends on the frame type. The control field determines the type of frame and defines its functionality.

- **Information field:** The information field contains the user's data from the network layer or management information. Its length can vary from one network to another.
- **FCS field:** The frame check sequence (FCS) is the HDLC error detection field. It can contain either a 2- or 4-byte ITU-T CRC.



Control field for S-frame

Receive ready (RR), Receive not ready (RNR), Reject (REJ) Selective reject (SREJ)



Code		Command
00	RR	Receive ready
01	REJ	Reject
10	RNR	Receive not ready
11	SREJ	Selective -reject

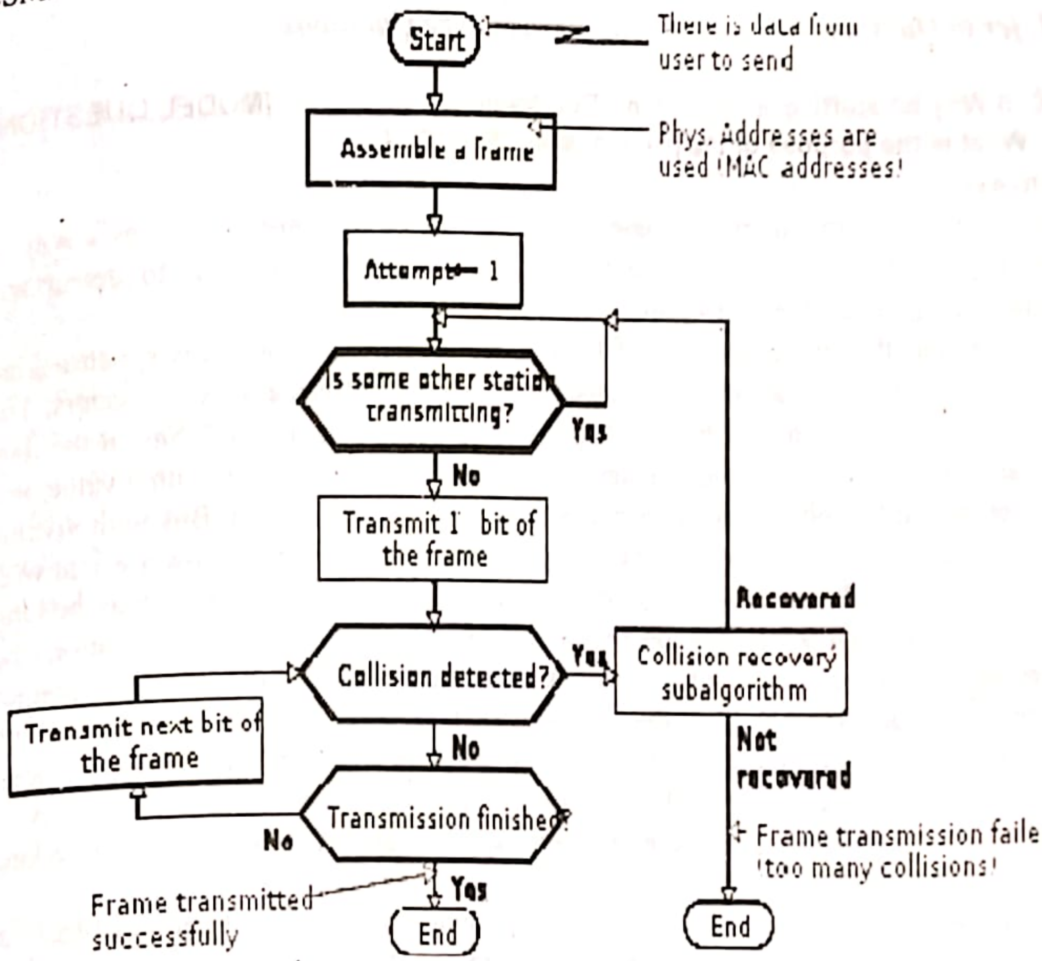
7. Explain about CDMA and CSMA/CD technology. **[WBUT 2016]**

Answer:

CDMA: In cellular service there are two main competing network technologies: Global System for Mobile Communications (GSM) and Code Division Multiple Access (CDMA).

One of the basic concepts in data communication is the idea of allowing several transmitters to send information simultaneously over a single communication channel. This allows several users to share a band of frequencies (see bandwidth). This concept is called multiplexing. CDMA employs spread-spectrum technology and a special coding scheme (where each transmitter is assigned a code) to allow multiple users to be multiplexed over the same physical channel. By contrast, time division multiple access (TDMA) divides access by time, while frequency-division multiple access (FDMA) divides it by frequency. CDMA is a form of spread-spectrum signaling, since the modulated coded signal has a much higher data bandwidth than the data being communicated.

CSMA/CD: CSMA/CD is a modification of pure Carrier sense multiple access (CSMA). CSMA/CD is used to improve CSMA performance by terminating transmission as soon as a collision is detected, thus reducing the probability of a second collision on retry.
A jam signal is sent which will cause all transmitters to back off by random intervals, reducing the probability of a collision when the first retry is attempted.
CSMA/CD is a layer 2 access method, not a protocol of the OSI model.



8. a) What do you mean by CSMA? **[WBUT 2017]**

Answer:

Carrier Sense Multiple Access (CSMA) is a network protocol that listens to or senses network signals on the carrier/medium before transmitting any data. CSMA is implemented in Ethernet networks with more than one computer or network device attached to it. CSMA is part of the Media Access Control (MAC) protocol.
A transmitter attempts to determine whether another transmission is in progress before initiating a transmission using a carrier-sense mechanism. That is, it tries to detect the presence of a carrier signal from another node before attempting to transmit. If a carrier is sensed, the node waits for the transmission in progress to end before initiating its own transmission. Using CSMA, multiple nodes may, in turn, send and receive on the same medium. Transmissions by one node are generally received by all other nodes connected to the medium.

b) How it differ from CSMA / CD? **[WBUT 2017]**

Answer:

CSMA/CD is a protocol that can detect collision where as CSMA is unable to detect it.

9. Why do we need to map IP address and MAC address? What are the protocols deal this mapping of IP address to MAC address and vice versa. **[WBUT 2018]**

Answer:

Refer to Question No. 1(a) of Long Answer Type Questions.

10. i) Why bit stuffing is needed in HDLC frame? **[MODEL QUESTION]**
ii) What is the purpose of the jam signal in CSMA/CD?

Answer:

i) Bit stuffing is the insertion of one or more bits into a transmission unit as a way to provide signaling information to a receiver. The receiver knows how to detect and remove or disregard the stuffed bits.

For example, the timing or bit rate of T-carrier system signals is constantly synchronized between any terminal device and an adjacent repeater or between any two repeaters. The synchronization is achieved by detecting the transition in polarity for 1 bits in the data stream. (T-1 signaling uses bipolar signaling, where each successive bit with a value of 1 is represented by voltage with a reverse polarity from the previous bit. Bits with a value of 0 are represented by a no-voltage time slot). If more than 15 bits in a row are sent with a 0 value, this "lull" in 1 bits that the system depends on for synchronization may be long enough for two end points to become out of synchronization. To handle this situation (the sequence of more than 150 bits), the signal is "stuffed" with a short, unique bit pattern (which includes some 1 bits) that is recognized as a synchronization pattern. The receiving end removes the stuffed bits and restores the bit stream to its original sequence. In another example of bit stuffing, a standard HDLC packet begins and ends with 01111110. To make sure this sequence doesn't appear again before the end of the packet, a 0 is inserted after every five consecutive 1s.

Bit stuffing is defined by some to include bit padding, which is the addition of bits to a transmission to make the transmission unit conform to a standard size, but is distinct from bit robbing, a type of in-band signaling.

ii) A network in which the medium access control protocol requires carrier sense and where a station always starts transmission by sending a jam signal; if there is no collision with jam signals from other stations, it begins sending data; otherwise, it stops transmission and then tries again later.

11. Discuss the principles of operation of a wireless LAN. **[MODEL QUESTION]**

Answer:

A wireless LAN (or WLAN, for wireless local area network, sometimes referred to as LAWN, for local area wireless network) is one in which a mobile user can connect to a local area network (LAN) through a wireless (radio) connection. The IEEE 802.11 group of standards specify the technologies for wireless LANs. 802.11 standards use the

Ethernet protocol and CSMA/CA (carrier sense multiple access with collision avoidance) for path sharing and include an encryption method, the Wired Equivalent Privacy algorithm.

High-bandwidth allocation for wireless will make possible a relatively low-cost wiring of classrooms in the United States. A similar frequency allocation has been made in Europe. Hospitals and businesses are also expected to install wireless LAN systems where existing LANs are not already in place.

Using technology from the Symbionics Networks, Ltd., a wireless LAN adapter can be made to fit on a Personal Computer Memory Card Industry Association (PCMCIA) card for a laptop or notebook computer.

Long Answer Type Questions

1. Write short notes on the following:
a) Ethernet MAC frame format **[WBUT 2014]**
b) ALOHA **[WBUT 2014]**
c) IEEE 802.11 **[WBUT 2015]**
d) Token ring **[WBUT 2016]**

Answer:

a) MAC frame:

Each MAC frame consists of the following basic components:

a) A MAC header, which comprises frame control, duration, address and sequence number information and optionally, traffic category information.
b) A fixed length header check sequence (HCS), which contains the CRC parity bits for frame header that includes the PHY header and the MAC header.
c) A variable length frame body, which contains information specific to the fame type and subtype.
d) A frame check sequence (FCS) which contains an IEEE 32-bit cyclic redundancy code (CRC).

The MAC frame format comprises a set of fields that occur in a fixed order in all frames. The general MAC frame format is illustrated in Figure. Each field is defined in 7.1.3. The maximum size of a MAC frame is 2048 octets.

Octets 2	2	1	1	2	2	2	2	0-2030	4
Frame Control	PNID	Destination Address (DA)	Source Address (SA)	Stream ID	Sequence Number	Duration	HCS	Frame Body	FCS
MAC Header									

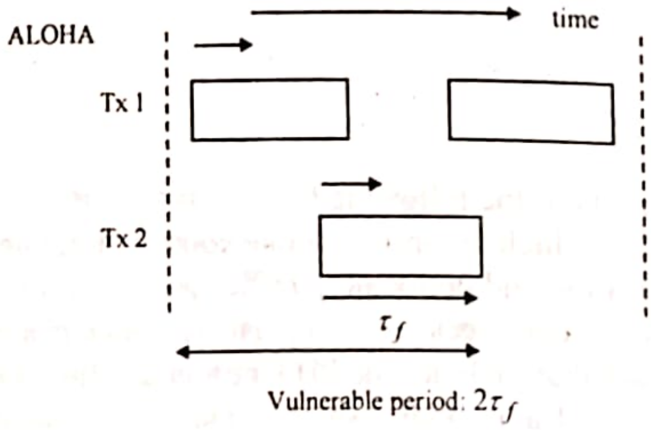
Fig: MAC frame format

b) ALOHA, also called pure ALOHA:

Whenever a user has a frame to send, it simply transmits the frame. If collision occurs, it waits for a random period of time and re-sends it again

- Sender can always find out if its frame was destroyed by listening to channel. For a LAN, feedback is immediate, while for a satellite there is a long delay of 270 ms before sender knows
- If listening while transmitting is not possible, ACKs are needed, e.g. in packet radio, collision from simultaneous transmissions of multiple transmitters is detected by base station, who sends out ACK or NAK accordingly (via reverse channel)

Performance: throughput S (frames/s) which defines average number of frames successfully transmitted per unit time, and average delay D (s) experienced by a frame. Assuming average frame length τf (s) and fixed channel rate, frame transmission can be modelled by Poisson distribution with mean arrival rate λ (frames/s).
Normalised channel traffic or average number of old and new frames submitted per frame time is $G = \lambda \tau f$ (unit in Erlang)
The throughput is then given by
$S = G \times \text{Prob}$ (no collision)



c) IEEE 802.11:
The original 802.11 standard had two variations both offering the same speeds but differing in the RF spread spectrum used. One of the 802.11 used FHSS. This 802.11 variant used the 2.4 GHz radio frequency band and operated with a 1 or 2 Mbps data rate. Since this original standard, wireless implementations have favored DSSS.
The second 802.11 variation used DSSS and specified a 2 Mbps-peak data rate with optional fallback to 1 Mbps in very noisy environments. 802.11, 802.11b and 802.11g use the DSSS spread spectrum, this means that the underlying modulation scheme is very similar between each standard, enabling all DSSS systems to coexist with 2, 11 and 54 Mbps 802.11 standards. Because of the underlying differences between 802.11a and the 802.11b/g, they are not compatible.
Distributed coordination function (DCF) is the fundamental MAC technique of the IEEE 802.11 based WLAN standard. DCF employs a CSMA/CA with Binary exponential backoff algorithm.
DCF requires a station wishing to transmit to listen for the channel status for a DIFS interval. If the channel is found bust during the DIFS interval, the station defers its transmission. In a network where a number of stations contend for the wireless medium. If multiple stations sense the channel busy and defer their access, they will also virtually simultaneously find that the channel is released and then try to seize the channel. As a

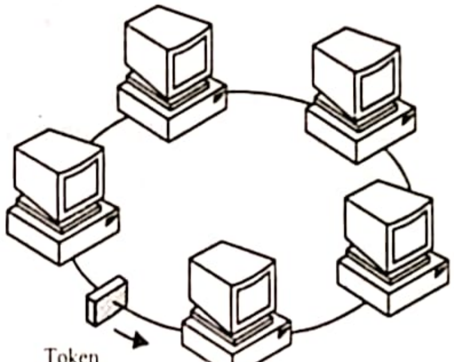
result, collisions may occur. In order to avoid such collisions, DCF also specifies random backoff, which forces a station to defer its access to the channel for an extra period.

Point coordination function (PCF) is a Media Access Control (MAC) technique used in IEEE 802.11 based WLANs. It resides in a point coordinator also known as Access Point (AP), to coordinate the communication within the network. The AP waits for PIFS duration rather than DIFS duration to grasp the channel. PIFS is less than DIFS duration and hence the point coordinator always has the priority to access the channel.

The PCF is located directly above the Distributed Coordination Function (DCF), in the IEEE 802.11 MAC Architecture. Channel access in PCF mode is centralized and hence the point coordinator sends CF-Poll frame to the PCF capable station to permit it to transmit a frame. In case the polled stations does not have any frames to send, then it must transmit null frame.

d) Token Ring Network:

- Token Ring is formed by the nodes connected in ring format as shown in the diagram below. The principle used in the token ring network is that a token is circulating in the ring and whichever node grabs that token will have right to transmit the data.
- Whenever a station wants to transmit a frame it inverts a single bit of the 3-byte token which instantaneously changes it into a normal data packet. Because there is only one token, there can almost be one transmission at a time.
- Since the token rotates in the ring it is guaranteed that every node gets the token with in some specified time. So there is an upper bound on the time of waiting to grab the token so that starvation is avoided.
- There is also an upper limit of 250 on the number of nodes in the network.
- To distinguish the normal data packets from token (control packet) a special sequence is assigned to the token packet. When any node gets the token it first sends the data it wants to send, then recirculates the token.



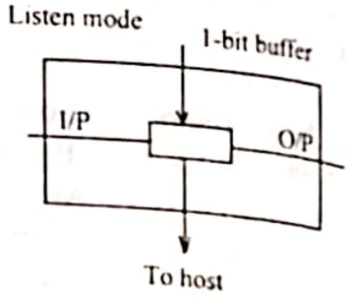
If a node transmits the token and nobody wants to send the data the token comes back to the sender. If the first bit of the token reaches the sender before the transmission of the last bit, then error situation arises. So to avoid this we should have:

propagation delay + transmission of n-bits (1-bit delay in each node) > transmission of the token time

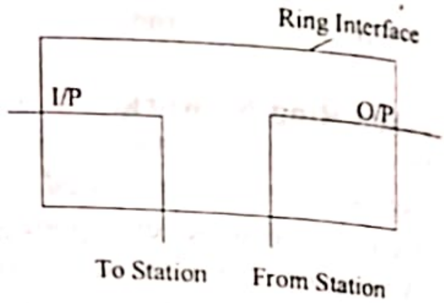
A station may hold the token for the token-holding time. which is 10 ms unless the installation sets a different value. If there is enough time left after the first frame has been transmitted to send more frames, then these frames may be sent as well. After all pending frames have been transmitted or the transmission frame would exceed the token-holding time, the station regenerates the 3-byte token frame and puts it back on the ring.

Modes of Operation

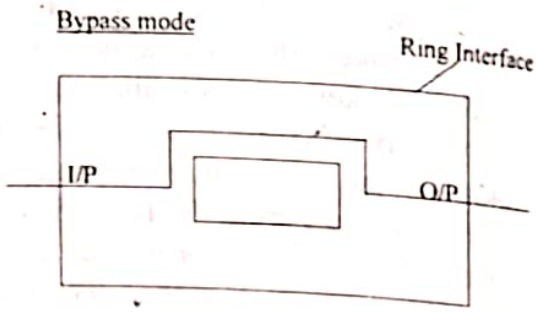
1. Listen Mode: In this mode the node listens to the data and transmits the data to the next node. In this mode there is a one-bit delay associated with the transmission.



2. Transmit Mode: In this mode the node just discards the any data and puts the data onto the network.



3. By-pass Mode: In this mode reached when the node is down. Any data is just bypassed. There is no one-bit delay in this mode.

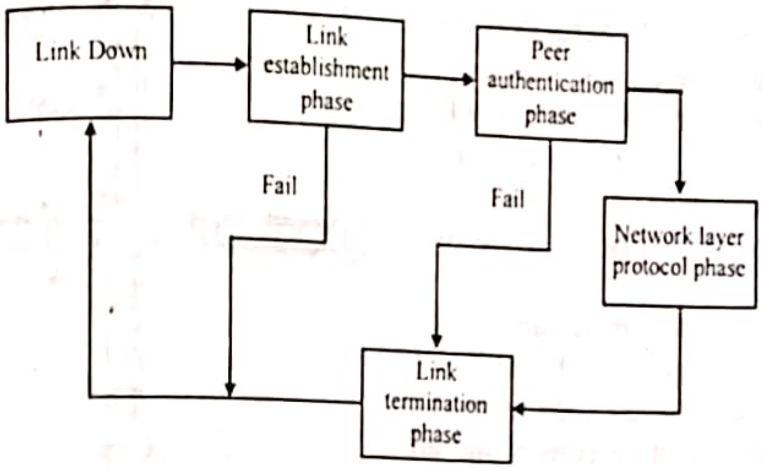


2. a) Why address field is always set to all 1's in PPP frame format?
b) Draw the simplified phase diagram for bringing up a line up and bringing it down in PPP and explain various phases.
c) Name three protocols that make up the PPP stack.
d) Ethernet technology is based on broadcast protocol. Explain. What happens when a collision occurs in Ethernet communication? [MODEL QUESTION]

Answer:

a) The address field of PPP header indicates which recipient receives the frame. Now PPP being a point-to-point protocol, there can be only one recipient. Hence the address must always be all 1-s.

b)



c) SLIP, PAP, CHAP.

d) In Ethernet, when any channel transmits data, it is actually put on the shared channel and hence is available to all stations. No station sends (can send) data in a way where it is only available for the destination station and nobody else. Hence, Ethernet is based on broadcast principle. When collision happens in Ethernet, the colliding stations "back off", i.e., they stop transmitting immediately and waits for a random amount of time before sensing the channel again.

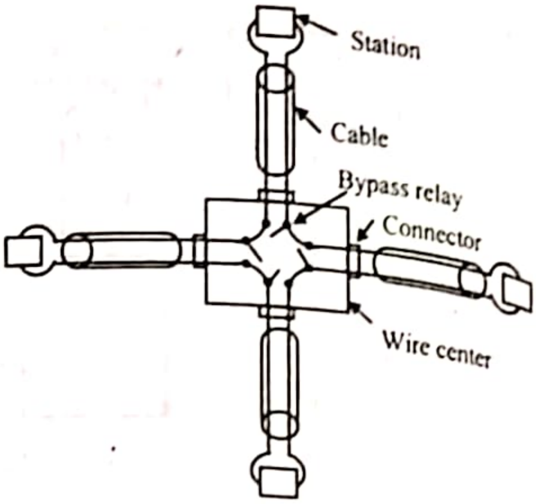
3. a) Differentiate between non-persistent and I-persistent CSMA. How is the chance of collision reduced in CSMA/CD?
b) How does the receiver acknowledge a frame in token ring?
c) What is the function of wire center in token ring?
d) How a new station is introduced in token bus?
e) Describe the frame format in HDLC. **[MODEL QUESTION]**

Answer:

a) In CSMA, a solution having data to send first distance to the channel to see if anyone else is transmitting at that moment. If the channel is busy, the station waits till it finds the channel idle. If the station finds the channel free in 1-persistent CSMA, it transmits a frame (i.e., it transmits with probability 1). In non-persistent CSMA, the station does not continually sense the channel if it found the channel busy when it tried to transmit. Instead, it waits for a random period of time before trying again.
In CSMA/CD, which is a special case of 1-persistent CSMA, the transmitting station stops transmitting immediately upon sensing a collision, and backs off for a random time. This way channel bandwidth is saved because the entire frame is not transmitted incase of collision.

b) In 802.5 token ring, a special bit pattern called a "token" circulates around an idle network. A transmitting a station must first seize the token to start transmitting. The frame format keep a bit reserved for ACK, which is set to zero during transmission. The destination station ACK-s the frame by setting this bit to one but also re-adjusts the checksum.

c) One problem of any ring network is that a cable break anywhere kills the entire network. A wire center solves this problem. Through logically a ring, physically each end station is connected to the wire center using at least two twisted pairs, as shown in the figure.
Inside the wire center there are bypass relays driven by currents from the station. If the ring breaks or a station goes down, the relays do not get the drive current and are released, carrying the problematic station to be passed.



Four stations connected via a wire center

d) In 802.4 token but is physically linear or free shaped but logically organized as a ring. Just after power on, a station is not in the ring. The 802.4 standards specify a complex methodology for such a station to join the ring. Periodically, the token holder sends a SOLICIT-SUCCESSOR frame to solicit bids from stations willing to join. If no station bids to enter within a "response window", normal business follows. If exactly on new station bids, it is included in the ring. If more than one station bids, there will be collision. The token holder then runs an arbitration algorithm that starts with broadcasting a RESOLVE-CONTENTION frame.

e)

Bits	8	8	8	≥0	16	8
	0 1 1 1 1 1 1 0	Address	Control	Data	Checksum	0 1 1 1 1 1 1 0

Fig: Frame format for bit-oriented protocols

The HDLC frame has a starting flag byte (7EH) followed by an 8-bit Address to identify a terminal in a multi-terminal line. The 8-bit control field is used for sequence numbers, acknowledgements etc. The data field is arbitrarily long. After the data is a 16-bit CRC field based on CRC-CCITT generator polynomial. The frame ends with a flag byte. There are three kinds of frames – Information, Supervisory and Unnumbered.

4. a) How is CSMA a clear improvement over ALOHA? How is it further improved by implementing CSMA/CD?
b) Suppose in a CSMA/CD LAN, the maximum end to end propagation delay is 25.6 μsecond. If the LAN is operating in 100Mbps, then what will be the minimum frame length (in bytes) of the LAN? [MODEL QUESTION]

Answer:

a) In both slotted and pure ALOHA, a node's decision to transmit is made independently of the activity of the other nodes attached to the broadcast channel. In particular, a node neither pays attention to whether another node happens to be transmitting when it begins to transmit, nor stops transmitting if another node begins to interfere with its transmission.

Listen before speaking: If someone else is speaking. wait until they are done. To the channel before transmitting if a frame from another node is currently being transmitted into the channel, a node then waits ("backs off") a random amount of time and then again senses the channel. If the channel is sensed to be idle, the node then begins frame transmission. Otherwise, the node waits another random amount of time and repeats this process.

In CSMA, the "listen before speaking" principle is employed. A node listens to the channel before transmitting. If a frame from another node is currently being transmitted, a node "backs off" for some (random) time before sensing if the channel has become idle and so on.

In CSMA/CD, additionally "collision-detection" is employed. A node additionally checks whether a frame put on the channel "collides" with another frame transmitted by another channel. In such a case the node again "backs off" and repeats listening before speaking.

b) RTT = 51.2 μsecond

Minimum frame length = (100 Mbps * 51.2 μs) = 5120 bits = 640 octets.

5. What is the difference between bit oriented and byte oriented protocols?

[MODEL QUESTION]

Answer:

In bit oriented Protocol, a flag is used to frame the bits sent. Simply put, you have a flag (01111110) and the required bits are sent after the flag and you end the transmission again with a flag. Using this method you can send any number of bits of any length. Another important fact is the zero insertion method used. Say for example, you want to send the bit string 01111110. You cannot do this because it will be interpreted as a flag. However, by adding a zero after 5 consecutive 1's as a standard, this bit stream can be send. The transmitter sends the string as 011111010 and the receiver removes the zero after 5 consecutive 1's and stores the data as 01111110.

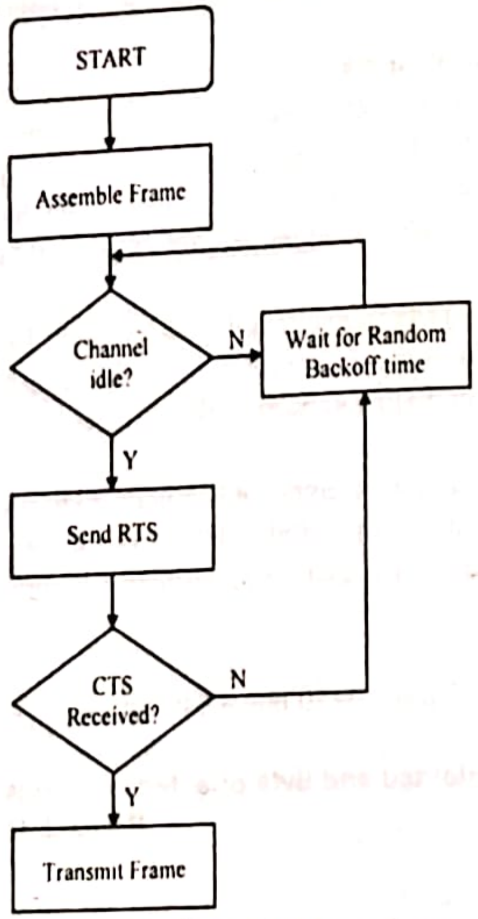
In byte oriented protocol (character oriented protocol) the receiver considers 8 bits at a time and figures out the relevant character. This system is used when communicating with printers and keyboards which use ASCII characters exclusively. (All the ASCII characters can be covered by 8 bits (256 characters). The main disadvantage of COP is that you cannot send 9 or 10 bits, arbitrary bits. Furthermore, in COP there are special characters – channel control characters, e.g. SYN character which is used to synchronize the receiver and the transmitter. These characters cannot be transferred as data. They will be misread as control characters.

6. a) Discuss CSMA/CA with the help of a flowchart. **[MODEL QUESTION]**

b) Why is CSMA/CD not implemented in WLAN?

Answer:

a)



The flow chart for CSMA/CA is given above.

When station receives data to transmit, it converts it into frames of appropriates size. Then it waits to see if the channel is idle and backs of for a random time if not idle. When the channel becomes idle, the station transmits a special sequence called "Request to Send" (RTS) to the receiver and awaits for a short while for the receiver in turn to send the special "Clear to Send" (CTS) sequence. Only upon receiving a CTS does the station transmits frames. Or else, it again backs off.

b) In Wireless LAN, a transmitter never gets to know whether its data got corrupted while on way. That is, it never can detect collision. Hence, CSMA/CD, which is based on collision detection, is based on collision detection, is not used in WLAN.

7. Write short notes on the following:

a) IEEE 802.5 **[MODEL QUESTION]**

b) FDDI **[MODEL QUESTION]**

Answer:

a) IEEE 802.5:

Token Ring is a LAN protocol defined in the IEEE 802.5 where all stations are connected in a ring and each station can directly hear transmissions only from its immediate neighbor. Permission to transmit is granted by a message (token) that circulates around the ring.

Token Ring as defined in IEEE 802.5 is originated from the IBM Token Ring LAN technologies. Both are based on the Token Passing technologies. While them differ in minor ways but generally compatible with each other.

Token-passing networks move a small frame, called a token, around the network. Possession of the token grants the right to transmit. If a node receiving the token has no information to send, it seizes the token, alters 1 bit of the token (which turns the token into a start-of-frame sequence), appends the information that it wants to transmit, and sends this information to the next station on the ring. While the information frame is circling the ring, no token is on the network, which means that other stations wanting to transmit must wait. Therefore, collisions cannot occur in Token Ring networks.

The information frame circulates the ring until it reaches the intended destination station, which copies the information for further processing. The information frame continues to circle the ring and is finally removed when it reaches the sending station. The sending station can check the returning frame to see whether the frame was seen and subsequently copied by the destination.

Unlike Ethernet CSMA/CD networks, token-passing networks are deterministic, which means that it is possible to calculate the maximum time that will pass before any end station will be capable of transmitting. This feature and several reliability features make Token Ring networks ideal for applications in which delay must be predictable and robust network operation is important.

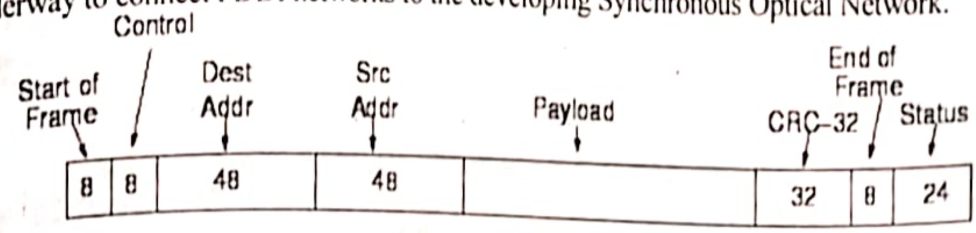
The Fiber Distributed-Data Interface (FDDI) also uses the Token Passing protocol.

b) FDDI:

FDDI (Fiber-Distributed Data Interface) is a standard for data transmission on fiber optic lines in that can extend in range up to 200 km (124 miles). The FDDI protocol is based on the token ring protocol. In addition to being large geographically, an FDDI local area network can support thousands of users.

An FDDI network contains two token rings, one for possible backup in case the primary ring fails. The primary ring offers up to 100 Mbps capacity. If the secondary ring is not needed for backup, it can also carry data, extending capacity to 200 Mbps. The single ring can extend the maximum distance; a dual ring can extend 100 km (62 miles).

FDDI is a product of American National Standards Committee X3-T9 and conforms to the open system interconnect (OSI) model of functional layering. It can be used to interconnect LANs using other protocols. FDDI-II is a version of FDDI that adds the capability to add circuit-switched service to the network so that voice signals can also be handled. Work is underway to connect FDDI networks to the developing Synchronous Optical Network.



(all sizes in bits)