CHAPTER 9

Unit III

Multiple Access

Syllabus :
Media access control (MAC), Random access, CSMA, CSMA/CD, CSMA/CA, Controlled access, Reservation, Polling, Token passing, Channelization, FDMA, TDMA, CDMA.

9.1 Introduction :

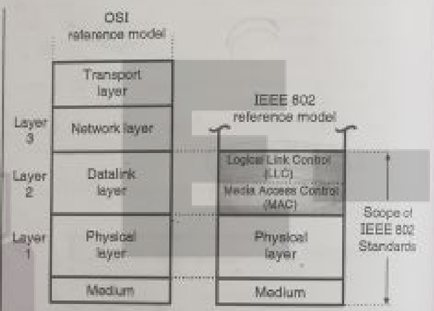
- We can classify the networks into two categories as shown in Fig. 9.1.1.
- In this chapter, we are going to discuss the broadcast networks and their protocols.
- The broadcast channels are also called as **multi-access channels** or **random access channels.**
- In the broadcast networks the most important point is the criteria by which we decide, who is allowed to use the common channel when more than one users want to use it.
- A protocol is used to make this decision.
- Such a protocol, belongs to a sublayer of data link layer called the MAC (Medium Access Control) sublayer.

(G-264)**Fig. 9.1.1**

- The MAC sublayer is very important in LANs because it is a broadcast network.

9.1.1 MAC and LLC Sublayers :

- Fig. 9.1.2 shows the layered OSI model (partial) to show the position of MAC and LLC sublayers.
- We will discuss the broadcast protocols corresponding to the lower layers (1 and 2) of the OSI model as shown in Fig. 9.1.2.
- Fig. 9.1.2 relates the LAN protocols with the OSI architecture. This architecture was developed by IEEE 802 committee and it has been accepted as LAN standard.
- It is called as IEEE 802 reference model. Let discuss this model layer by layer.



(G-265)**Fig. 9.1.2 : IEEE 802 protocol layers compared to OSI model**

Functions of Media Access Control (MAC) sublayer :

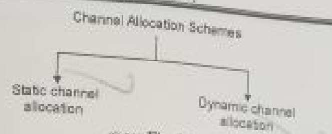
- To perform the control of access to media.
- It performs the unique addressing to stations directly connected to LAN.
- Detection of errors.

Functions of Logical Link Control (LLC) sublayer :

- Error recovery.
- It performs the flow control operation.
- User addressing.

9.2 The Channel Allocation Problem :

- In a broadcast network, the single communication channel is to be allocated to one transmitting user at a time. The other users connected to this medium should wait.
- This is called as channel allocation. There are two different schemes used for channel allocation as shown in Fig. 9.2.1.



(G-266) **Fig. 9.2.1**

9.2.1 Static Channel Allocation in LANs and MANs :

- The traditional way of allocating a single channel, among many users is by means of frequency division multiplexing (FDM).
- The Frequency Division Multiplexing (FDM) and Time Division Multiplexing (TDM) are the examples of static channel allocation.
- In these methods either a fixed frequency band or a fixed time slot is allotted to each user. Thus either the entire available bandwidth or entire time is shared.
- The problem in these methods is that if all the N number of users are not using the channel the channel bandwidth is wasted and if there are more than N users who want to use the channel they cannot do so for the lack of bandwidth.
- For a small number of users and light traffic the static FDM is an efficient method of allocation but its performance is poor for large number of users, bursty and heavy traffic etc.
- The static channel allocation has a poor performance with bursty traffic and hence generally dynamic channel allocation is used, for computer networks where the traffic is of bursty nature.

9.2.2 Dynamic Channel Allocation in LAN and MAN :

- In this method either a fixed frequency or fixed time slot is not allotted to the user. The user can use the single channel as per his requirement. Following assumptions are made for the implementation of this method :

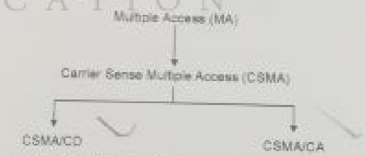
1. Station model – This model consists of N independent stations such as a PC, computer etc. which can generates frames for transmission.
2. Single channel – A single channel is available for all communication.
3. Collision – If frames are transmitted at the same time by two or more stations, there is an overlap in time and the resulting signal is garbled. This is called as collision.
4. Continuous or slotted time – There is no master clock used to divide time into discrete time intervals. So frames can begin at any random instant. This is continuous time. For a slotted time, the time is divided into discrete time slots.
5. Carrier or No carrier sense – Stations sense the channel before transmission or they directly transmit without sensing the channel.

9.3 Multiple Access :

- When a number of stations (users) use a common link of communication system we have to use a multiple access protocol in order to coordinate the access to the common link.
- The three techniques used to deal with the multiple access problem are as follows :
  1. Random Access
  2. Controlled Access
  3. Channelization.
- Let us discuss them one by one.

9.3.1 Random Access :

- In the random access technique there is no control station.
- Each station will have the right to use the common medium without any control over it.
- With increase in number of stations, there is an increased probability of **collision** or **access conflict.**
- The collisions will occur when more than one user tries to access the common medium simultaneously.
- As a result of such collisions some frames can be either modified (due to errors) or destroyed.
- In order to avoid collisions, we have to set up a procedure.
- The evolution of the random access methods is shown in Fig. 9.3.1.



(G-267)**Fig. 9.3.1 : Evolution of random access methods**

9.3.2 Evolution of Random Access Methods :

- The first method in the evolution ladder of Fig. 9.3.1, known as ALOHA used a simple procedure called Multiple Access (MA).
- It was improved to develop the Carrier Sense Multiple Access (CSMA).
- The CSMA further evolved into two methods namely CSMA/CD (CSMA with collision detection) and CSMA/CA (CSMA with collision avoidance) which avoids the collisions.

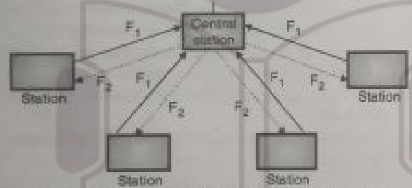
9.4 Multiple Access (ALOHA System) :

ALOHA System :

- Systems in which multiple users share a common channel in a way that can lead to conflicts are widely known as Contention systems.
- The ALOHA system is a contention protocol which was developed at the University of Hawaii in the early 1970's by Norman Abramson and his colleagues.
- The ALOHA system has two versions :
  1. Pure ALOHA – does not require global time synchronisation.
  2. Slotted ALOHA – requires time synchronisation.

9.4.1 Pure ALOHA :

- It works on a very simple principle. Essentially it allows for any station to broadcast at any time. If two signals collide, each station simply waits a random time and try again.
- Collisions are easily detected. As shown in the Fig. 9.4.1, when the central station receives a frame it sends an acknowledgement on a different frequency.



F_1 = Broadcast frequency from the individual stations.
F_2 = Broadcast frequency from the central station.

(G-268)**Fig. 9.4.1 : Pure ALOHA system**

- If a user station receives an acknowledgement it assumes that the transmitted frame was successfully received and if it does get an acknowledgement it assumes that collision had occurred and is ready to retransmit.
- The advantage of pure ALOHA is its simplicity in implementation but it's performance becomes worse as the data traffic on the channel increases.

9.4.2 Protocol Flow Chart for ALOHA :

Fig. 9.4.2 shows the protocol flow chart for ALOHA.

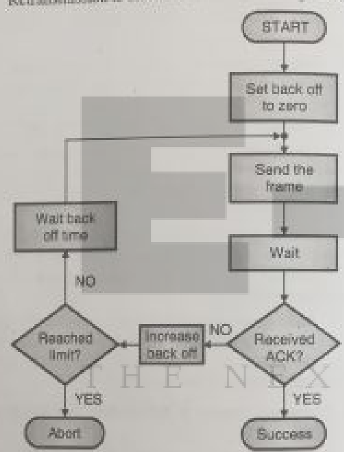
Explanation :

- A station which has a frame ready for transmission will send it.
- Then it waits for some time.
- If it receives the acknowledgement then the transmission is successful.
- Otherwise the station uses a backoff strategy, and will send the packet again.
- After sending the packet many times if there is no acknowledgement then the station aborts the idea of transmission.

Contention system :

Systems in which multiple users share a common channel in such a way that can lead to a conflict or collision are known as the contention systems.

- Whenever two frames try to occupy the channel at the same time, there is bound to be a collision and both will be garbled.
- Retransmission is essential for all the destroyed frames.



(G-269)**Fig. 9.4.2 : Protocol flow chart for ALOHA**

9.4.3 Efficiency of an ALOHA Channel :

- Efficiency of an ALOHA system is that fraction of all transmitted frames which escape collisions i.e. which do not get caught in collisions.
- Consider ∞ number of interactive users at their computers (stations). Each user is either typing or waiting. Initially all of them are in the typing state.
- When a user types a line, the user stops and waits. The station then transmits a frame containing this line and checks the channel to confirm the success. If it is successful then the user will start typing again otherwise the user waits and its frame is retransmitted many time till it is sent successfully.

Frame time :

- Let the frame time be defined as the amount of time required to transmit the standard fixed length frame. Note that

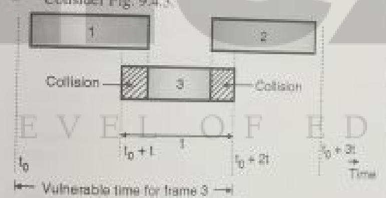
$$\text{Frame time} = \frac{\text{Frame length}}{\text{Bit rate}}$$

- We assume that ∞ number of users generate new frames according to the Poisson's distribution with an average N frames per frame time.
- The value of $N > 1$ indicates that the users are generating frames at a rate higher than that can be handled by the channel. So most of the frames will face collision. Hence $0 < N < 1$ in order to reduce number of collisions.
- Let there be k transmission attempts (including retransmissions) per frame time.
- The probability of k transmissions per frame time is also Poisson. Let the mean of number of transmissions be G per frame time. So $G \geq N$.
- At low load $N = 0$ there will be less number of collisions so less number of retransmissions and $G = N$.
- With increase in load there are many collisions so $G > N$. Combining all these we can say that for all the loads the throughput is given by,

$$S = GP_0$$

Where P_0 = Probability that a frame does not suffer a collision.

- Consider Fig. 9.4.3.



(G-270)**Fig. 9.4.3**

- What is the condition for frame 3 in Fig. 9.4.3 to arrive undamaged without collision ? Let t = Time required to send a frame. If frame 1 is generated at any instant between t_0 to $(t_0 + t)$ then it will collide with frame 3. Similarly any frame 2 generated between $(t_0 + t)$ and $(t_0 + 2t)$ also collides with frame 3.
- As per Poisson's distribution, the probability of generating k frames during a given frame time is given by,

$$P[k] = \frac{G^k e^{-G}}{k!}$$

- So the probability of generating zero frames i.e. k = 0 is

$$P_0 = \frac{G^0 e^{-G}}{0!} = e^{-G}$$

- If an interval is two frame time long, the mean number of frames generated during that interval is 2G.
- The probability that no other frame is transmitted during the Vulnerable period (time when collision can take place) is,

$$P_0 = e^{-2G}$$

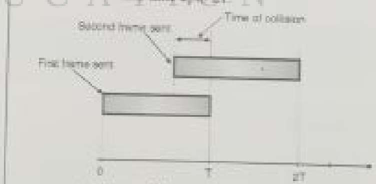
- But throughput $S = G P_0$

$$\therefore \quad S = Ge^{-2G}$$

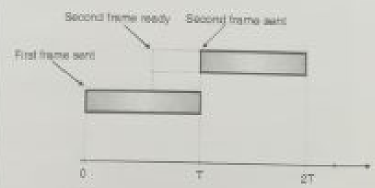
- Fig. 9.4.5 shows the relation between the offered traffic G and the throughput S. It shows that the maximum throughput occurs at G = 0.5 and S_{max} = 0.184. So the best possible channel utilization is on 18.4 percent.

9.4.4 Slotted ALOHA :

- To overcome the disadvantage of the pure ALOHA system (of low capacity) Robert published a method for doubling the capacity of traffic on the channel.
- In this method it was proposed that the time be divided up into discrete intervals and each interval correspond to one frame.
- This method requires that the users agree on the slot boundaries. In this method for achieving synchronisation one special station emits a pip at the start of each interval, like a clock. This method is known as the slotted ALOHA system.
- Collisions occur if any part of two transmission overlaps. Suppose that T is time required for one transmission and that two stations must transmit.
- The total time required for both stations to do so successfully is 2T as shown in Fig. 9.4.4. In case of pure ALOHA allowing a station to transmit at arbitrary times can waste time upto 2T.



(a) Transmission using pure ALOHA



(b) Transmission using slotted ALOHA

(G-271)**Fig. 9.4.4**

- As an alternative, in the slotted ALOHA method the time is divided into intervals (slots) of T units each and require each station to begin each transmission at the beginning of a slot.
- In other words, even if station is ready to send in the middle of a slot, it must wait until the beginning of the next one as shown in Fig. 9.4.4(b).
- In this method a collision occurs when both stations become ready in the same slot.
- Slotted ALOHA is thus a discrete time system whereas pure ALOHA is a continuous time system.
- The vulnerable period has been reduced to half that of pure ALOHA, the throughput for slotted ALOHA is given by,

$$S = Ge^{-G}$$

- The maximum throughput corresponds to G = 1 and it is given by $S_{max} = 1/e = 0.368$ as shown in Fig. 9.4.5. So for a slotted ALOHA with G = 1 the probability of success is 37%. The probability of empty slots is,

$$P(k) = \frac{G^k e^{-G}}{k!}$$

For G = 1 and k = 0 we get P (k = 0) = 0.368.

- And the probability of collisions is 26 %.
- The probability of transmission requiring exactly k attempts (i.e. k – 1 collisions followed by one success) is given by,

$$P_k = e^{-G}(1 - e^{-G})^{k-1}$$

- And the expected number of transmissions E per carriage return typed is

$$E = e^G$$

Conclusion : As E depends exponentially on G, with a small increase in G, there is a large increase in E and drastic fall in performance.

9.4.5 Comparison of Pure and Slotted ALOHA :

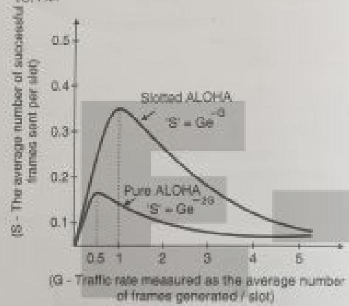
- A mathematical model can be created for the relationship between the number of frames transmitted and the number of frames transmitted successfully.
- Let G represent the traffic measured as the average number of frames generated per slot.
- Let S be the success rate measured as the average number of frames sent successfully per slot.
- The relationship between G and S for both pure and slotted ALOHA is given as follows :

Pure ALOHA → $S = Ge^{-2G}$

Slotted ALOHA → $S = Ge^{-G}$

Where e is the mathematical constant = 2.718.

- From the above equation a success rate curve for pure and slotted ALOHA can be plotted as shown in Fig. 9.4.5.
- As seen in the Fig. 9.4.5 both graphs have the same shape. If G is small so is S, which means that if few frames are generated few frames will be transmitted successfully.
- As G increases so does S but upto a certain point. As G continues to increase S approaches to 0 which means that if more frames are generated there will be more collisions and the success rate will fall to 0.
- Similarly for pure ALOHA the maximum occurs at G = 0.5 for which S = 1/2e = 0.184 which means the rate of successful transmissions is approximately 18.4%.



(G-272)Fig. 9.4.5 : Comparison of pure and slotted ALOHA

As seen from the graph the maximum for slotted ALOHA occurs at G = 1 for which S = 1/e = 0.368. In other words the rate of successful transmissions is approximately 0.368 frames per slot time or 37% of the time will be spent on successful transmissions.

- Hence the slotted ALOHA has a double throughput efficiency than the pure ALOHA system.
- The maximum utilization achievable using CSMA can be increased much beyond that obtainable using ALOHA or slotted ALOHA.
- The maximum utilization is dependent on length of the frame and on the propagation time.
- With increase in the length of the frame or reduction in the propagation time the utilization gets improved.

9.5 Carrier Sense Multiple Access (CSMA) :

The CSMA protocol operates on the principle of carrier sensing. In this protocol, a station listens to see the presence of transmission (carrier) on the cable and decides to act accordingly.

Non-Persistent CSMA :

- In this scheme, if a station wants to transmit a frame and it finds that the channel is busy (some other station is transmitting) then it will wait for fixed interval of time.

- After this time, it again checks the status of the channel and if the channel is free it will transmit.

1-Persistent CSMA :

- In this scheme the station which wants to transmit, continuously monitors the channel until it is idle and then transmits immediately.
- The disadvantage of this strategy is that if two stations are waiting then they will transmit simultaneously and collision will take place. This will then require retransmission.

P-Persistent CSMA :

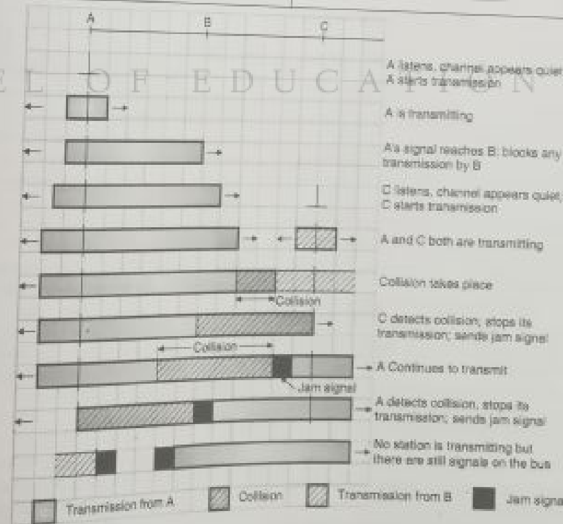
- The possibility of such collisions and retransmissions is reduced in the p-persistent CSMA. In this scheme all the waiting stations are not allowed to transmit simultaneously as soon as the channel becomes idle.
- A station is assumed to be transmitting with a probability "p". For example if p = 1/6 and if 6 stations are waiting then on an average only one station will transmit and others will wait.

9.5.1 Carrier Sense Multiple Access/Collision Detection (CSMA/CD) :

The CSMA/CD specifications have been standardized by IEEE 802.3 standard. It is a very widely used MAC protocol.

Media access control :

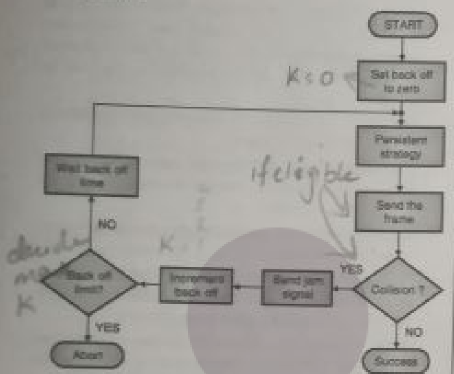
- The problem in CSMA explained earlier is that a transmitting station continues to transmit its frame even though a collision occurs.
- The channel time is unnecessarily wasted due to this. In CSMA/CD, if a station receives other transmissions when it is transmitting, then a collision can be detected as soon as it occurs and the transmission time can be saved.
- As soon as a collision is detected, the transmitting stations release a jam signal.
- The jam signal will alert the other stations. The stations then are not supposed to transmit immediately after the collision has occurred.
- Otherwise there is a possibility that the same frames would collide again.
- After some "back off" delay time the stations will retry the transmission. If again the collision takes place then the back off time is increased progressively.
- A careful design can achieve efficiencies of more than 90% using CSMA/CD. This scheme is as shown in Fig. 9.5.1.



(G-273)Fig. 9.5.1 : CSMA/CD scheme

9.5.2 CSMA/CD Procedure :

- Fig. 9.5.2 shows a flow chart for the CSMA/CD protocol.



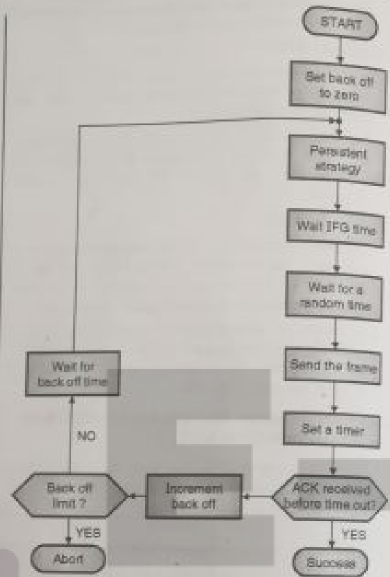
(G-276)Fig. 9.5.2 : CSMA/CD procedure

Explanation :

- The station that has a ready frame sets the back off parameter to zero.
- Then it senses the line using one of the persistent strategies.
- It then sends the frame, if there is no collision for a period corresponding to one complete frame, then the transmission is successful.
- Otherwise (in the event of collision) the station sends the jam signal to inform the other stations about the collision.
- The station then increments the back off time and waits for a random back off time and sends the frame again.
- If the back off has reached its limit then the station aborts the transmission.
- CSMA/CD is used for the traditional Ethernet.
- CSMA/CD is an important protocol. IEEE 802.3 (Ethernet) is an example of CSMA/CD. It is an international standard.
- The MAC sublayer protocol does not guarantee reliable delivery. Even in absence of collision the receiver may not have copied the frame correctly.

9.5.3 CSMA/CA :

- The long form CSMA/CA is CSMA protocol with collision avoidance.
- Fig. 9.5.3 shows the flow chart explaining the principle of CSMA/CA.



(G-277)Fig. 9.5.3 : CSMA/CA procedure

- The station ready to transmit, senses the line by using one of the persistent strategies.
- As soon as it find the line to be idle, the station waits for a time equal to an IFG (Interframe gap).
- It then waits for some more random time and sends the frame.
- After sending the frame, it sets a timer and waits for the acknowledgement from the receiver.
- If the acknowledgement is received before expiry of the timer, then the transmission is successful.
- But if the transmitting station does not receive the expected acknowledgement before the timer expiry then it increments the back off parameter, waits for the back off time and senses the line again. CSMA/CA completely avoids the collision.

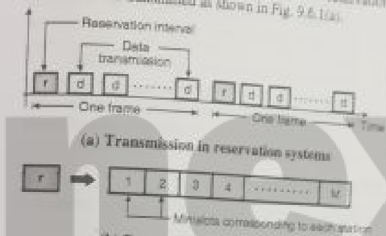
9.6 Controlled Access :

- In the previous section we have discussed the random access approach for sharing a transmission medium.
- The random access approach is simpler to implement and are useful in handling the light traffic.
- In this section we will discuss the scheduling approaches to the medium access control.

- There are three important approaches in the scheduling approach as follows :
  1. Reservation system
  2. Polling system
  3. Token passing ring networks.

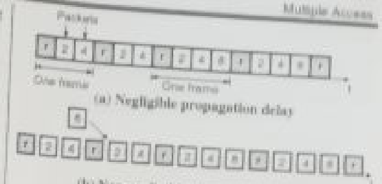
9.6.1 Reservation Systems :

- The principle of reservation system can be understood from Fig. 9.6.1.
- In this system each station transmits a single packet at the full rate R bps. The transmissions from the stations can be organized into frames of variable length.
- Before each frame a reserved slot or reservation interval is transmitted as shown in Fig. 9.6.1(a).



(L-733)Fig. 9.6.1 : Basic reservation system

- Fig. 9.6.1(b) shows the details of the reservation interval "r". The reservation interval consists of M minislots with one slot allotted to each station.
- These minislots are used by the stations to indicate that they have a packet to transmit in the corresponding frame.
- The station that wants to transmit packet by broadcasting their reservation bit during the appropriate minislot.
- All the stations will listen to the reservation interval and then determine the order in which packet transmissions in the corresponding frame would take place.
- The frame length would correspond to the number of stations which have a packet to transmit.
- If the length of the packet is variable, then it can be handled if the reservation message includes packet length information.
- This reservation system that we discussed is called as the basic reservation system.
- The basic reservation system can be improved by using the time division multiplexing scheme. In the improved reservation system the idle time slots are allotted to the other stations.
- The operation of the basic reservation system can be explained with the help of Fig. 9.6.2.



(L-734)Fig. 9.6.2 : Operation of reservation system with negligible and non-negligible delays

- Refer Fig. 9.6.2(a) which shows a system with negligible propagation delay. In the first frame, only the stations 2 and 4 transmit their packets. But in the middle portion, station 8 also wants to transmit its packet. So the frame gets expanded from two slots to three slots.
- The maximum throughput from this system can be attained when all the stations transmit their packet in each frame.
- The corresponding maximum throughput is given by,

$$\rho_{max} = \frac{1}{1+v} \quad \text{... for one packet reservation/minislot}$$

- If $v << 1$ then the value of ρ_{max} can be very high.
- Now refer Fig. 9.6.2(b) which shows a reservation system with some finite non zero propagation delay which cannot be neglected. In this system the stations will transmit their reservations in the same way as they used to do before.
- It is possible to modify the basic reservation system so that stations can reserve more than one slot per packet transmission per minislot.
- Let us assume that a minislot can reserve any upto k packets.

  Then the maximum achievable throughput is given by,

$$\rho_{max} = \frac{1}{1+(v/k)} \quad \text{... for k packet reservation/minislot}$$

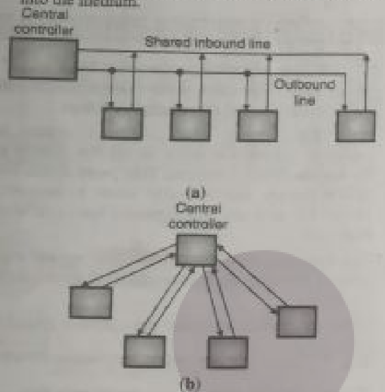
- Note that this value of ρ_{max} will be higher than that for the single packet reservation/minislot.

Effect of number of stations (M) :

- The reservation intervals introduce overhead which is proportional to M. That means the reservation interval becomes $M \times v$.
- As the number of stations (M) become very large, this overhead will become significant. This then becomes a serious problem.
- This problem can be sorted out by not allocating a minislot to each station and then instead making the stations to compete for a reservation of minislot by using a random access technique such as ALOHA or slotted ALOHA.

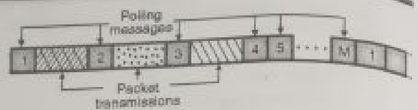
9.6.2 Polling :

- Now consider polling system shown in Fig. 9.6.3. In this system the stations access the common medium one by one (by taking turns).
- At any given time only one of the stations will transmit into the medium.



(L-735) Fig. 9.6.3 : Examples of polling systems

- When a station finishes its transmitting, then some mechanism is used to pass the right of transmission to another station which wants to transmit next.
- There are different ways of passing the right of transmission from one station to the other station.
- Fig. 9.6.3(a) shows a scheme in which M stations communicate with a central controller. The outbound line is used for carrying the information from the central controller to the M users whereas the shared inbound line is required to carry the information from users to the central computer.
- Thus the inbound line acts as the shared medium that requires a medium access control (MAC).
- The host computer acts as a central controller. It sends control messages which co-ordinate the transmissions from the stations.
- The central controller sends a polling message to a particular station. That station sends its message on the shared inbound line. Once this process is over, the station gives a go-ahead message.
- It is possible that the central controller may poll the stations in a round robin (serial) fashion or it may do it according to some pre-determined rule.
- Fig. 9.6.3(b) shows another system where it is possible to use polling. The central controller of this system can make use of radio transmission.
- Fig. 9.6.4 shows the sequence of polling messages.



(L-736) Fig. 9.6.4 : Polling messages and transmissions in a polling system

- Station 1 gets the polling message first. The polling message will propagate. It is received by all stations but only station 1 begins transmission. All this process needs a time called **walk time.**
- The next period is occupied by the transmission from station 1.
- This period will then be followed by the walk time corresponding to station-2. This process will continue until all the M stations are polled. Thus in this system the stations are polled in the round robin manner.
- The walk time can be considered to be an overhead in the polling system because it is an unproductive time. The total walk time τ' is the sum of walk time corresponding to each station.

9.6.3 Token Passing :

- Token is a special frame which is used to authorize a particular station for transmission.
- In the token passing method, the token is given to that station, which is authorized to send its data. Thus the station that has the token with it can transmit others listen.

(L-737) Fig. 9.6.5 : Token passing network

- In a token passing network, each station has a predecessor and successor as shown in Fig. 9.6.5.
- The frames travel in one direction. They come from the predecessor and go to the successor as shown in Fig. 9.6.5.
- A token frame is circulated around the ring when no data is being transmitted and the line is idle.
- The stations which are ready to send data, will wait for the token. As the token circulates the first ready station in the ring will grab the circulating token and transmit one or more frames.
- This station will keep sending the frames as long as it has frames to send or the allotted time is not complete.
- It then passes this token on the ring from which the next ready to transmit station will grab it.

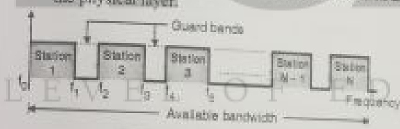
- This is the simplest possible token passing technique in which all the stations have equal priority or right to send.
- In the practical system, some other features such as priority and reservation are added.

9.7 Channelization :

- This is a multiple access method in which the total bandwidth of the common link is shared in the frequency domain, the time domain or through codes.
- Depending on the method of sharing there are three channelization techniques :
  1. FDMA : Frequency Division Multiple Access
  2. TDMA : Time Division Multiple Access
  3. CDMA : Code Division Multiple Access.

9.7.1 FDMA :

- In the frequency division multiple access (FDMA), the available channel (medium) bandwidth is shared by all the stations. That means each station will have its own specific slot reserved in the entire channel bandwidth.
- So each station uses its allocated frequency band to send its data. Each band is thus reserved for a specific station. e.g. the frequency band f_0 to f_1 is for station-1, then f_2 to f_3 is for station-2 and so on.
- The concept of FDMA is illustrated in Fig. 9.7.1.
- FDMA is a data link layer protocol which uses FDM at the physical layer.



(L-739) Fig. 9.7.1 : Concept of FDMA

- Guard bands are provided in between the adjacent frequency slots. e.g. $(f_1 - f_2)$ is a guard band between the bands allotted to stations 1 and 2. Guard bands avoid the adjacent channel interference.
- FDMA is used in cellular phones and satellite networks.

Advantages of FDMA :

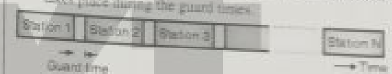
1. All the stations can operate continuously all 24 hours without having to wait for their turn to come.
2. The power required for transmission depends on the number of channels being transmitted.
3. The signal to noise ratio is improved due to the use of FM.
4. No synchronization is necessary.

Disadvantages of FDMA :

1. Each channel or earth station can use only a part of the total satellite bandwidth.
2. Inspite of guard bands being provided, there is some adjacent channel interference present.
3. As FM is used, it requires larger bandwidth, hence less number of channels will be accommodated in the bandwidth of a satellite.
4. Due to the nonlinearity of companders, the intermodulation products are generated.

9.7.2 TDMA :

- TDMA stands for Time Division Multiple Access.
- In TDMA, the entire bandwidth can be used by every user (station) but not simultaneously.
- A station can use the entire bandwidth only for the allocated time slot.
- Thus each channel is allocated a time slot only during which it can send its data. Thus the time is shared, frequency band is not shared.
- Fig. 9.7.2 illustrates the concept of TDMA. Guard times are inserted between the adjacent time slots in order to prevent any cross talk. Not data transmission takes place during the guard times.



(L-740) Fig. 9.7.2 : Concept of TDMA

- TDMA is a data link layer protocol which uses TDM at the physical layer.
- TDMA finds its application in cellular phones and satellite networks.

Advantage of TDMA :

Since only one station is present at any given time, the generation of intermodulation products will not take place.

Disadvantage of TDMA :

TDMA needs synchronization which makes it more complicated as compared to FDMA.

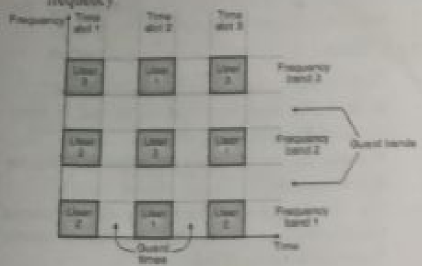
9.7.3 Code Division Multiple Access (CDMA) :

- An alternative to FDMA and TDMA is an another system called Code Division Multiple Access (CDMA). The most important feature of CDMA is as follows :

> In CDMA more than one user is allowed to share a channel or subchannel with the help of direct-sequence spread spectrum (DS-SS) signals.

- In CDMA each user is given a unique code sequence or signature sequence. This sequence allows the user to spread the information signal across the assigned frequency band.
- At the receiver the signal is recovered by using the same code sequence. At the receiver, the signals received from various users are separated by checking the cross-correlation of the received signal with each possible user signature sequence.

- In CDMA the users access the channel in a random manner. Hence the signals transmitted by multiple users will completely overlap both in time and in frequency.



(1-741) Fig. 9.7.3 : Structure of CDMA showing the guard bands and the guard times

- The CDMA signals are spread in frequency. Therefore the demodulation and separation of these signals at the receiver can be achieved by using the pseudorandom code sequence. CDMA is sometimes also called as Spread Spectrum Multiple Access (SSMA).
- In CDMA as the bandwidth as well as time of the channel is being shared by the users, it is necessary to introduce the guard times and guard bands as shown in Fig. 9.7.3.
- CDMA does not need any synchronization, but the code sequences or signature waveforms are required to be used.

9.7.4 Comparison of FDMA, TDMA and CDMA :

Sr. No.	FDMA	TDMA	CDMA
1.	Overall bandwidth is shared among many stations.	Time sharing takes place.	Sharing of bandwidth and time both takes place.
2.	Due to nonlinearity of devices inter modulation products are generated due to interference between adjacent channels.	Due to incorrect synchronization there can be an interference between the adjacent time slots.	Both type of interferences will be present.
3.	Synchronization is not necessary.	Synchronization is essential.	Synchronization is not necessary.
4.	Code word is not required.	Code word is not required.	Code words are required.
5.	Guard bands between adjacent channels are necessary.	Guard times between adjacent time slots are necessary.	Guard bands and Guard times both are necessary.

Review Questions

Q. 1 Explain the layered architecture of LAN explaining the function of the LLC and MAC sublayer.

Q. 2 What is static and dynamic channel allocation ?

Q. 3 Compare and explain the pure and slotted ALOHA system.

Q. 4 Explain the different CSMA protocols.

Q. 5 What is CSMA with collision detection ?

Q. 6 Explain the FDDI system.

Q. 7 What are the functions of a transceiver ?

Q. 8 Why there is no need of CSMA/CD for a full duplex Ethernet LAN ?

Q. 9 Explain CSMA/CD.

Q. 10 What is CSMA/CA ?

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CHAPTER 10

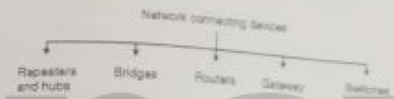
Unit III

Connecting Devices & Virtual LANs

Syllabus :
Connecting devices and virtual LANs, Connecting devices, Hubs, Link layer switches, Routers.

10.1 Network Connecting Devices :

- Different types of network connecting devices are as shown in Fig. 10.1.1.



(10-344) Fig. 10.1.1

- The relation between OSI reference model and various connecting devices is shown in Fig. 10.1.2.

Network connecting devices :

- Two or more devices are connected to each other for the purpose of sharing data or resources from a network.
- A LAN may be spread over a larger distance than its media can handle effectively. The number of stations also can be more than a number which can be handled and managed properly. Such networks should be subdivided into smaller networks and these smaller subnetworks should be connected to each other through connecting devices.
- A device called a repeater is inserted into the network to increase the coverable distance or a device called a bridge can be inserted for traffic management.
- When two or more separate networks are connected for exchanging data or resources it creates an internetwork. Routers and gateways are used for internetworking.
- Each of these device type interacts with protocols at different layers of the OSI model.
- Repeaters act only upon the electrical components of a signal and are therefore active only at the physical layer.
- Bridges utilize addressing protocols and can affect the flow control of a single LAN. Bridges are most active at the data link layer.
- Routers provide links between two separate but same type LANs and are active at the network layer.
- Finally gateways provide translation services between incompatible LANs or applications and are active in all of the layers. Connecting devices and the OSI model is shown in Fig. 10.1.2.

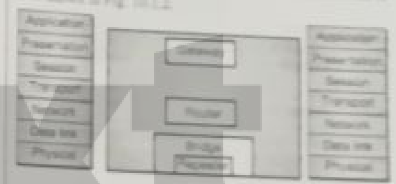


Fig. 10.1.2 : Connecting devices and OSI model

Categories of connecting devices

Fig. 10.1.2 shows the relationship between the connecting devices and various layers of the internet model.

Table 10.1.1 : Role of networking devices

Sr. No.	Name of the device	Role
1.	Passive hub	Operate below the physical layer.
2.	Repeater	Regenerates the original signal. Operates in the physical layer.
3.	Bridge	Bridges utilize the address protocol. They can carry out the traffic management. They are most active in the data link layer.
4.	Routers	Routers provide connections between two separate but compatible networks. It works in the network layer.
5.	Gateways	Gateways provide translation services between incompatible networks and works in all the layers.