CN - UNIT – 2 (ii – part)

Medium Access sub layer:

- The medium access control (MAC) is a sublayer of the data link layer of the open system interconnections (OSI) reference model for data transmission.
- It is responsible for flow control for transmission medium.
- It controls the transmission of data via remotely shared channels. It sends data over the network.

MAC Layer in the OSI Model:

The Open System Interconnections (OSI) model is a layered networking framework that conceptualizes **how communications should be done between heterogeneous systems.**

The data link layer is the second lowest layer.

It is divided into two sublayers:

* The logical link control (LLC) sublayer

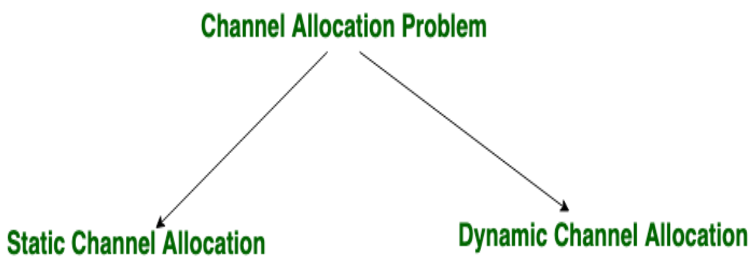
* The medium access control (MAC) sublayer

Functions of MAC Layer:

- It provides an abstraction of the physical layer to the LLC(logical link control) and upper layers of the OSI network.
- It is responsible for encapsulating frames so that they are suitable for transmission via the physical medium.
- It resolves the addressing of source station as well as the destination station, or groups of destination stations.
- It performs multiple access resolutions when more than one data frame is to be transmitted. It determines the channel access methods for transmission.
- It also performs collision resolution and initiating retransmission in case of collisions.
- It generates the frame check sequences and thus contributes to protection against transmission errors.

❖ Channel Allocation Problem:

- ***Channel allocation*** *is a process in which a single channel is divided and allotted to multiple users in order to carry user specific tasks.*
- *There are user's quantity may vary every time the process takes place.*
- *If there are N number of users and channel is divided into N equal-sized sub channels, Each user is assigned one portion.*
- *If the number of users are small and don't vary at times, than Frequency Division Multiplexing can be used as it is a simple and efficient channel bandwidth allocating technique.*



FDM ,TDM ***Pure Aloha, slotted Aloha***

,

Persistent CSMA,

Non -Persistent CSMA ..

I. Static Channel Allocation in LANs and MANs:

- *It is the classical or traditional approach of allocating a single channel among multiple competing users [Frequency Division Multiplexing (FDM)].*
- *if there are N users, the bandwidth is divided into N equal sized portions each user being assigned one portion.*
- *In this way of allocating a single channel among multiple competing users is by using FDM Frequency division multiplexing.*
- *For N number of users the Bandwidth is divided into N equal partitions , each user is assigned for one portion.*
- *Since each user has fixed frequency and fixed Bandwidth .*
- *This is applicable only when number of users are less and each has constant Traffic.*
- *When number of users are large and continuously varying traffic then the bandwidth is divided into equally number of regions .*

It is not efficient to divide into fixed number of **chunks**.

```
T = 1/(U*C-L)
T(FDM) = N*T(1/U(C/N)-L/N)


T = mean time delay, C = capacity of channel, L = arrival rate of frames,
1/U = bits/frame,
N = number of sub channels,
T(FDM) = Frequency Division Multiplexing Time
```

2. Dynamic Channel Allocation:

- *Dynamic channel allocation method is incorporated in all LAN and WAN.*
- *Dynamic channel allocation method can handle all types of traffic condition.*
- *Work station or terminals are independent and work is generated at a constant rate.*
- *A single channel is available for all communication .*
- *All stations can transmits and receive through it.*
- *Two stations are transmits simultaneously the signals collide with each other this process is called* ***collision****.*
- *If collision occur then retrammitts data.*
- *The work station can begin signal transmission at any time or in* ***slotted time*** *assigned to it.*

Possible assumptions include:

1. **Station Model:**
   Assumes that each of N stations independently produce frames. The probability of producing a packet in the interval where It is the constant arrival rate of new frames.
2. **Single Channel Assumption:**
   In this allocation all stations are equivalent and can send and receive on that channel.
3. **Collision Assumption:**
   If two frames overlap in time-wise, then that's collision. Any collision is an error, and both frames must re transmitted. Collisions are only possible error.
4. ***Time*** *can be divided into Slotted or Continuous.*
5. ***Stations*** *can sense a channel is busy before they try it.*

6.Carrier Sense: *A station can sense if a channel is already busy before transmission.*

7. No Carrier Sense: *Time out used to sense loss data.*

Sr. No.	Key	Fixed Channel Allocation (FCA)	Dynamic Channel Allocations (DCA)
1	Channel Allocation	Fixed number of channels or voice channels are alloted.	Channels to be alloted are not fixed initially.
2	Blockage	If all channels are occupied, then user call is blocked.	If all channels are blocked, then Base Station(BS) requests more channels from Mobile Station Center(MSC).
3	Frequence Usage	Frequency usage is very high being cell channels are seperated using minimum reuse distance.	Frequency reuse is not maximum because of random channel allocation.
4	Tangible	A hardware can be touched being a physical electronic device.	Softwares being digital can be seen but cannot be touched.
5	Algorithm	No need to complex algorithm.	Algorithm to determine efficient channel availability is quite complex in DCA.
6	Cost	FCA is cheaper than DCA.	DCA is costly as real time computation needed.
7	Cell Allocation	Once call is complete, channel remains with the cell.	Once call is complete, channel is returned back to Mobile Station Center.
8	MSC	Mobile Station Center has less burden.	Mobile Station Center has high signal load, and has more responsibilites.

❖ Multiple Access Protocols:

- *If there is a **dedicated link between the sender and the receiver** then data link control layer is sufficient.*
- *however if there is **no dedicated link present then multiple stations can access the channel simultaneously**.*
- *Hence **multiple access protocols are required to decrease collision and avoid crosstalk.***

For example: *In a classroom full of students, when a teacher asks a question and all the students (or stations) start answering simultaneously (send data at same time) then a lot of collisions is created(data overlap or data lost) then it is the job of the teacher (multiple access protocols) to manage the students and make them answer one at a time.*

I. ALOHA –

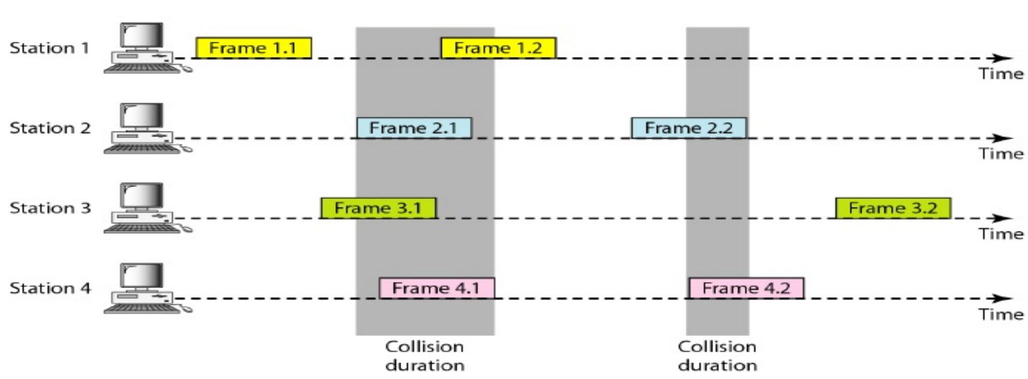
- ***ALOHA is a multiple access protocol for transmission of data via a shared network channel. ... In ALOHA, each node or station transmits a frame without trying to detect whether the transmission channel is idle or busy. If the channel is idle, then the frames will be successfully transmitted***

- It was designed for wireless LAN but is also applicable for shared medium.
- In this, multiple stations can transmit data at the same time and can hence lead to collision and data being garbled (confuse).

1.1 Pure Aloha:

- Pure Aloha is an un-slotted, decentralized, and simple to implement a protocol.
- In pure ALOHA, the stations simply transmit frames whenever they want data to send.
- It does not check whether the channel is busy or not before transmitting.
- In case, two or more stations transmit simultaneously, the collision occurs and frames are destroyed.
- Whenever any station transmits a frame, it expects the acknowledgment from the receiver.
- If it is not received within a specified time, the station assumes that the frame or acknowledgment has been destroyed.
- Then, the station waits for a random amount of time and sends the frame again.
- This randomness helps in avoiding more collisions.
- This scheme works well in small networks where the load is not much. But in largely loaded networks, this scheme fails poorly. This led to the development of Slotted Aloha.
- Since different stations wait for different amount of time, the probability of further collision decreases.

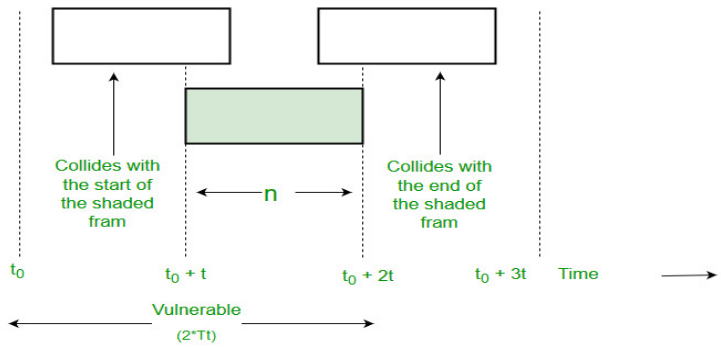
Figure 12.3 *Frames in a pure ALOHA network*



For that to make some assumption:

i) All the frames should be the same length.
ii) Stations can not generate frame while transmitting or trying to transmit frame.

iii)The population of stations attempts to transmit (both new frames and old frames that collided).



Efficiency of Pure ALOHA: Vulnerable Time = 2 * Tt

Throughput= G * e^-2G

where G is number of stations wants to transmit in Tt slot.

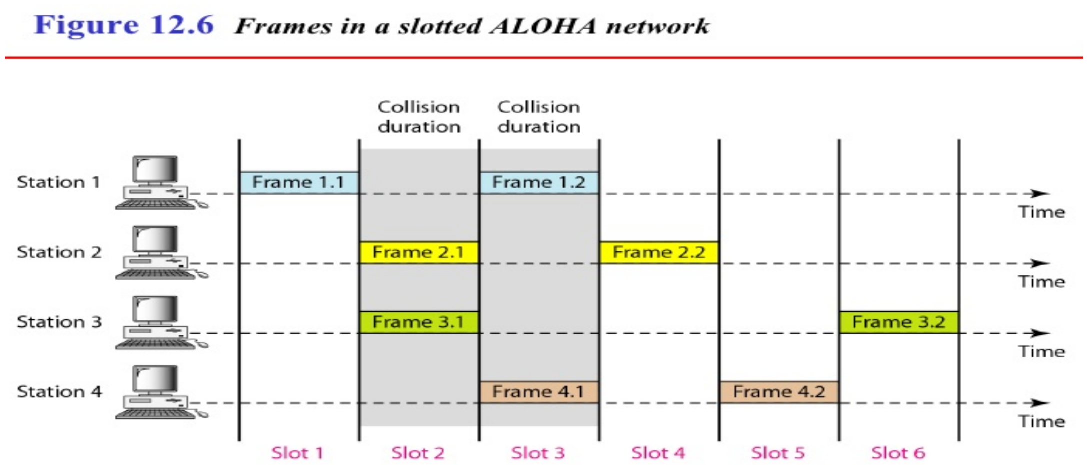
Maximum Efficiency: Maximum Efficiency will be obtained when G=1/2

Throughput (S pure)max = 1/2 * e^-1 = 0.184

1.2 Slotted Aloha:

- It is **similar to pure aloha, except that we divide time into slots and sending of data is allowed only at the beginning of these slots.**
- **If a station misses out the allowed time**, it **must wait for the next slot**.
- This is quite similar to Pure Aloha, **differing only in the way transmissions take place**.
- **Instead of transmitting** right **at demand time**, the **sender waits for some time**.
- In slotted ALOHA, the time of the **shared channel is divided into discrete intervals called Slots.**
- The stations are eligible to **send a frame only at the beginning of the slot** and **only one frame per slot is sent**.
- **If any station is not able to place the frame onto the channel at the beginning of the slot**, it has to **wait until the beginning of the next time slot.**
- There is **still a possibility of collision if two stations try to send at the beginning of the same time slot.**
- **But still the number of collisions** that can possibly take place is **reduced by a large margin and the performance becomes much well compared to Pure Aloha.**

- This **reduces the probability of collision.**



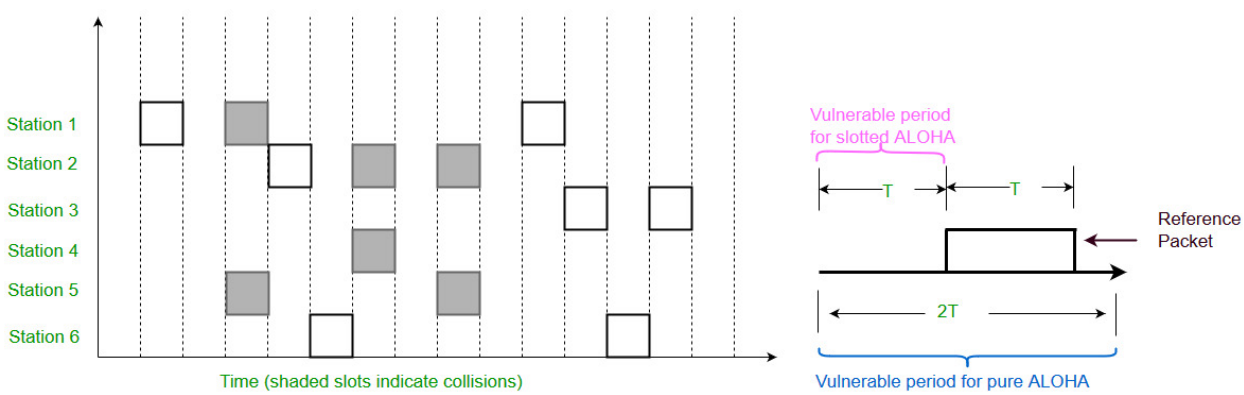
Collision is possible for only the current slot. Therefore, Vulnerable Time is Tt.

Vulnerable Time = Frame transmission time. V=Tt

The average amount of transmission-attempts for 2 consecutive frame

Efficiency of Slotted ALOHA: $S_{slotted} = G * e^{-G}$

Maximum Efficiency: $(S_{slotted})_{max} = 1 * e^{-1} = 1/e = 0.368$



Difference b/w Pure Aloha and Slotted Aloha :

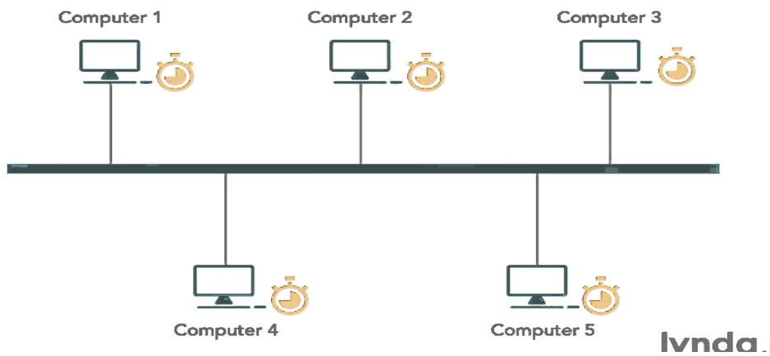
	Key	Pure Aloha	Slotted Aloha
1	Time Slot	In Pure Aloha, any station can transmit data at any time.	In Slotted Aloha, any station can transmit data only at beginning of any time slot.
2	Time	Frames are transmitted in arbitrary time	Time is divided up to discrete slot , the frame is sent at the starting of a slot.
3	Time	In Pure Aloha, time is continuous and is not globally synchronized.	In Slotted Aloha, time is discrete and is globally synchronized.
4	Vulnerable time	Vulnerable time is 2 times of frame transmission time. Ie. Vulnerable time = 2 x Tt.	Vulnerable time is one half of pure aloha. Vulnerable time = Tt.
5	Probability	Probability of successful transmission of data packet = $G \times e^{-2G}$	Probability of successful transmission of data packet = $G \times e^{-G}$
6	Maximum efficiency	Maximum efficiency = 18.4%.	Maximum efficiency = 36.8%.
7	Number of collisions	Does to reduces the number of collisions.	Slotted Aloha reduces the number of collisions to half thus doubles the efficiency.

2. CSMA – (Carrier Sense Multiple Access)

- ***Carrier*** *means channel or medium .*
- *To* ***minimize the chance of collision*** *and therefore to* ***Increase the performance****.*
- *Principle of CSMA "* ***Sense(identify) before transmit the data or listen before transmits the data".***
- ***Without sensing the channel state*** *to transmits the data through the channel collision may occur.*
- ***Carrier busy = Transmission is taking place.***
- ***Carrier idle = No transmission currently taking place.***
- *Carrier Sense Multiple Access ensures fewer collisions as the station is required to first sense the medium (for idle or busy) before transmitting data.*
- *If it is idle then it sends data, otherwise it waits till the channel becomes idle.*
- *However there is still chance of collision in CSMA due to* ***propagation delay.***

For ***example****, if station A wants to send data, it will first sense the medium . If it finds the channel idle,* it will start sending data. However, by the time the first bit of data is transmitted (delayed due to propagation delay) from station A, if station B requests to send data and senses the medium it will also find it idle and will also send data. This will result in collision of data from station A and B.

- The possibility of Collison still exists because of propagation delay ; a station may sense the medium and find it is idle because the first bit sent by another station has not yet been received.



2. 1 Persistent and Non persistent CSMA

Types of CSMA:

a. **1-Persistent CSMA.**

b. **P-Persistent CSMA.**

c. **Non-Persistent CSMA.**

d. **0-Persistent CSMA.**

CSMA access modes-

a. 1-persistent CSMA:

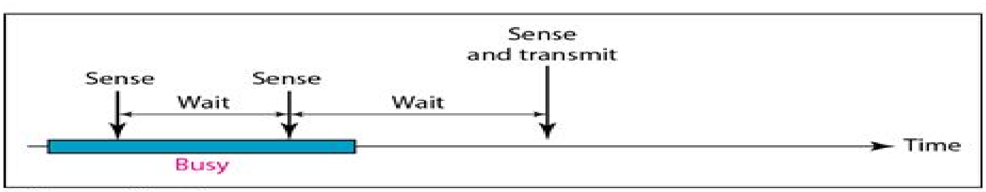
- Before sending the data the station **first listens** to the channel to see if anyone else to transmitting the data at this moment.
- IF **Listen Primitive tell if the channel is busy or idle** if it is idle to transmits the data other wise wait until free .
- If the **channel is idle** the station transmits the frame.
- If **channel is busy** then it **sense the transmission medium continuously until it becomes idle.**
- **Since the station** transmits the frame with the probability of 1 when the carrier or channel is idle , this scheme of CSMA is called 1- Persistent CSMA.
- The propagation delay has an important effect on the performance of the protocol.
- The node senses the channel, if idle it sends the data, otherwise it continuously keeps on checking the medium for being idle and transmits unconditionally(with 1 probability) as soon as the channel gets idle.

- The **longer propagation delay** . The importance is **more effected because <u>performance of protocol is decreases.</u>**

a. 1-persistent

b. Non-Persistent CSMA:

- Before sending, a station senses the channel , if No one else is sending the station begins doing so itself.
- If the channel is already in use the station **does not sense (checks) continuously** for the purpose of seizing it immediately upon **detecting the end of the previous transmission.**
- **It waits for random period of time not continuously. But in I-persistent continuously sensing(checking)**
- In this Non –persistent CSMA when the station having a frame to transmit and find that the channel is busy , **it backs off for fixed interval of time .**
- **It checks the channel again and** if the channel is free then it transmits.
- **The back off delay is determined by the transmission time of a frame , propagation time and other systems parameters.**
- **If the channel is already in use the station does not continuously** sense it for the purpose of seizing it immediately upon **detecting the end of the previous transmission.**
- The node senses the channel, if idle it sends the data, otherwise it checks the medium after a random amount of time (not continuously) and transmits when found idle.
- **But is waits random amount period of time and again it checks for activity.**

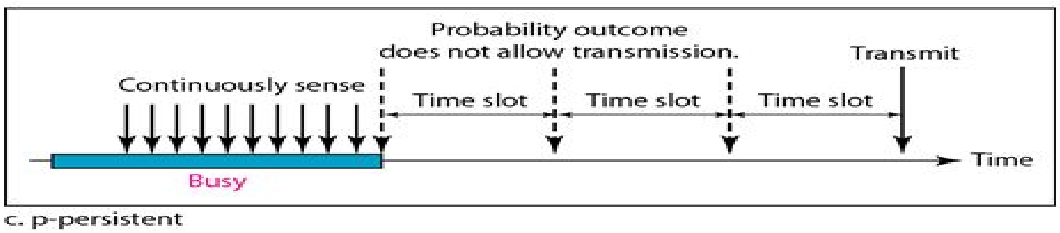


b. Nonpersistent

c. P-persistent CSMA:

- **It applies to Slotted channels.**

- **When a station is ready to send it sense (checks) the channel.**
- **If it is idle , it transmits with a probability p.**
- The node senses the medium, if idle it sends the data with p probability. If the data is not transmitted ((1-p) probability) then it waits for some time and checks the medium again, now if it is found idle then it send with p probability. This repeat continues until the frame is sent.
- 1. If the channel is idle transmits the probability p ,and delay one time unit with probability (1-P).
- 2. If the channel is Busy , listen until idle repeat step 1.
- 3. If transmission is delayed one time unit repeat step 1.

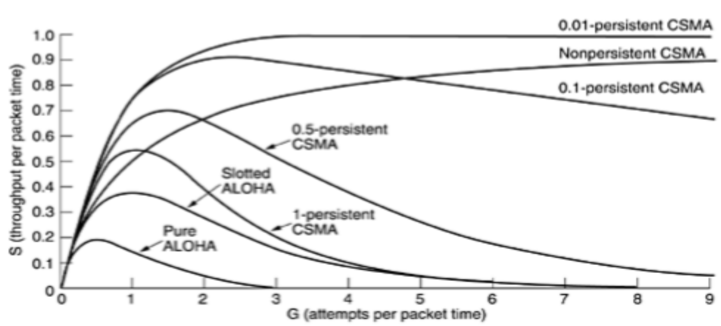


c. p-persistent

d. O-persistent CSMA:

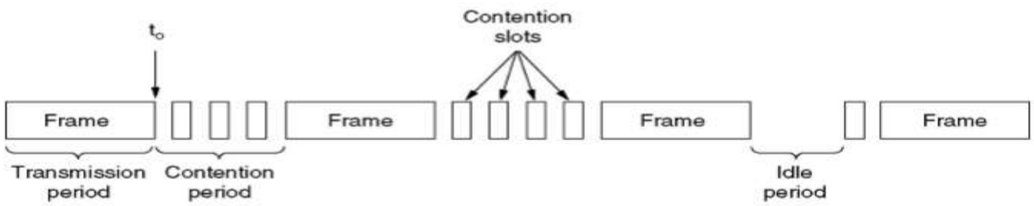
- Each node is assigned at transmission order by a **supervisory node.**
- Superiority of nodes is decided before and transmission occurs in that order.
- If the medium is idle, node waits for its time slot to send data.
- All the decisions take care by the supervisory node.

Fig : Comparison of the channel utilization versus load for various random access protocols.



CSMA/CD – (CSMA with Collision Detection) :

- Carrier sense multiple access with collision detection.
- Stations can terminate transmission of data if collision is detected.
- Carrier Sense Multiple Access with Collision Detection (CSMA/CD) is a network protocol for carrier transmission that operates in the Medium Access Control (MAC) layer.
- It senses or listens whether the shared channel for transmission is busy or not, and defers transmissions until the channel is free.
- The collision detection technology detects collisions by sensing transmissions from other stations.
- EX: If 2 stations sense the channel to be idle and begin transmitting simultaneously , they will both detect the collision .
- Immediately stop the transmission quickly terminating the damaged frames and **Save Time and Bandwidth.**
- On detection of a collision, the station stops transmitting, sends a jam signal, and then waits for a random time interval before retransmission.



CSMA-CD

The Steps for CSMA/CD is:

- When a frame is ready, the transmitting station checks whether the channel is idle or busy.
- If the channel is busy, the station waits until the channel becomes idle.
- If the channel is idle, the station starts transmitting and continually monitors the channel to detect collision.
- If a collision is detected, the station starts the **collision resolution algorithm**.
- The station resets the retransmission counters and completes frame transmission.

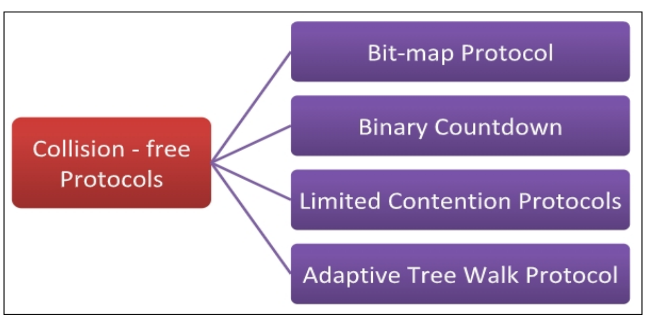
The Steps for Collision Resolution is:

- The station continues transmission of the current frame for a specified time along with a jam signal, to ensure that all the other stations detect collision.
- The station increments the retransmission counter.
- If the maximum number of retransmission attempts is reached, then the station aborts transmission.
- Otherwise, the station waits for a back off period which is generally a function of the number of collisions and restart main algorithm.

CSMA/CA (collision Avoidance) or (Collision free protocols):

- CSMA/CA stands for Carrier Sense Multiple Access/ Collision Avoidance.
- It is a network protocol for transmission. It operates in the Medium Access Control Layer. This protocol is effective before the collision.
- CSMA/CA is effective before a collision.
- CSMA/CA is generally used in wireless networks.
- CSMA/CA minimizes the risk of collision.
- CSMA/CA initially transmits the intent to send the data, once an acknowledgment is received, the sender sends the data.
- CSMA/CA is part of the IEEE 802.11 standard.
- CSMA/CA is similar in efficiency as CSMA.
- In computer networks, when more than one station tries to transmit simultaneously via a shared channel, the transmitted data is garbled. This event is called collision.
- The Medium Access Control (MAC) layer of the OSI model is responsible for handling collision of frames.
- Collision – free protocols are devised so that collisions do not occur.
- Protocols like CSMA/CD and CSMA/CA nullifies the possibility of collisions once the transmission channel is acquired by any station.
- However, collision can still occur during the contention period if more than one stations starts to transmit at the same time.
- Collision – free protocols resolves collision in the contention period and so the possibilities of collisions are eliminated.

Types of Collision – free Protocols:

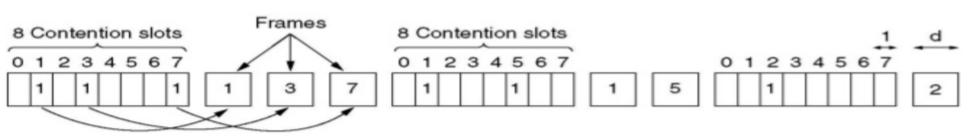


a. Bit – map Protocol: (Reservation protocol) :

- In bit map protocol, the contention period is divided into N slots, where N is the total number of stations sharing the channel.
- If a station has a frame to send, it sets the corresponding bit in the slot.
- So, before transmission, each station knows whether the other stations want to transmit.
- Collisions are avoided by mutual agreement among the contending stations on who gets the channel.
- Suppose that there are 10 stations. So the number of contention slots will be 10.
- If the stations 2, 3, 8 and 9 wish to transmit, they will set the corresponding slots to 1 as shown in the following diagram:
- Once each station announces itself, one of them gets the channel based upon any agreed criteria.
- Generally, transmission is done in the order of the slot numbers.
- Each station has complete knowledge whether every other station wants to transmit or not, before transmission starts. So, all possibilities of collisions are eliminated.

- In our first collision-free protocol, the basic bit-map method, each contention period consists of exactly N slots.
- If station 0 has a frame to send, it transmits a 1 bit during the zeroth slot.
- No other station is allowed to transmit during this slot. Regardless of what station 0 does, station 1 gets the opportunity to transmit a 1 during slot 1, but only if it has a frame queued.
- In general, station j may announce that it has a frame to send by inserting a 1 bit into slot j.
- After all N slots have passed by, each station has complete knowledge of which stations wish to transmit.
- Since everyone agrees on who goes next, there will never be any collisions.

The basic bit-map protocol



b. Binary Countdown:

- In Binary count down protocol all the stations on the channel are assigned a fixed length binary addresses.

- If any station wants to transmits a message or data first it broad cast its address into binary bit string . String with higher order bit.
- Different station addresses are together to decide the priority of transmitting the data.

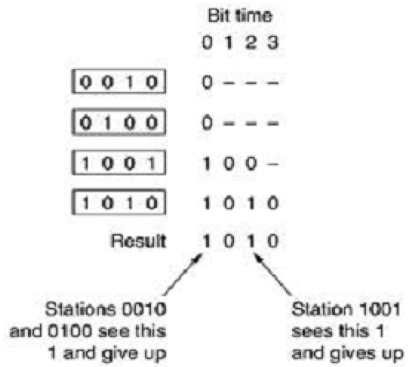


Figure . The binary countdown protocol. A dash indicates silence.

For example: if stations 0010, 0100, 1001, and 1010 are all trying to get the channel, in the first bit time the stations transmit 0, 0, 1, and 1, respectively. These are ORed together to form a 1. Stations 0010 and 0100 see the 1 and know that a higher-numbered station is competing for the channel, so they give up for the current round. Stations 1001 and 1010 continue.

The next bit is 0, and both stations continue. The next bit is 1, so station 1001 **gives up**. The winner is station 1010 because it has the highest address. After winning the bidding, it may now transmit a frame, after which another bidding cycle starts. The protocol is illustrated in Fig. . It has the property that higher-numbered stations have a higher priority than lower numbered stations, which may be either good or bad, depending on the context.

c. Limited Contention Protocols:

These protocols combines the advantages of collision based protocols and collision free protocols.

Under light load, they behave like ALOHA scheme. Under heavy load, they behave like bitmap protocols.

when more than one station tries to transmit simultaneously via a shared channel, the transmitted data is garbled, an event called collision. In collision based protocols like ALOHA, all stations are permitted to transmit a frame without trying to detect whether the transmission channel is idle or busy. In slotted ALOHA, the shared channel is divided into a number of discrete time intervals called slots. Any station having a frame can start transmitting at the beginning of a slot. Since, this works very good under light loads, limited contention protocols behave like slotted ALOHA under low loads.

d. <u>Adaptive Tree Walk Protocol:</u>

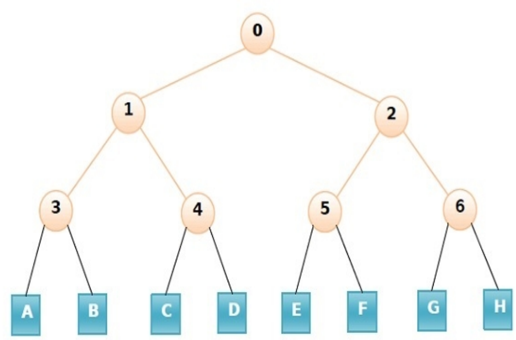
Adaptive Tree Walk Protocol is a technique for transmitting data over shared channels that combines the advantages of collision based protocols and collision free protocols.

In computer networks, when more than one station tries to transmit simultaneously via a shared channel, the transmitted data is garbled, an event called collision. In collision based protocols like ALOHA, all stations are permitted to transmit a frame without trying to detect whether the transmission channel is idle or busy. This works very good under light loads. Under heavy loads, collision free protocols are suitable, since channel access is resolved in the contention period that eliminates the possibilities of collisions.

In adaptive tree walk protocol, the stationed are partitioned into groups in a hierarchical manner. The contention period is divided into discrete time slots, and for each slot the contention rights of the stations are limited. Under light loads, all the stations can participate for contention each slot like ALOHA. However, under heavy loads, only a group can try for a given slot.

Working Principle:

In adaptive tree walk protocol, the stations or nodes are arranged in the form of a binary tree as shown in the diagram. Here, the internal nodes (marked from 0 to 6) represent the groups while the leaf nodes (marked A to H) are the stations contending for network access.



EXAMPLE :

Initially all nodes (A, B ……. G, H) are permitted to compete for the channel. If a node is successful in acquiring the channel, it transmits its frame. In case of collision,

The nodes are divided into two groups −

Stations under the group 1, i.e. A, B, C, D

Stations under the group 2, i.e. E, F, G, H

Nodes belonging to only one of them is permitted for competing. Say, for slot 1, all stations under group 1 are allowed to contend. If one of the stations successfully acquires the channel, then it transmits to completion. In the next slot, i.e. slot 2, all stations under group 2 can contend.

However, if there is a collision, then the stations are further divided into groups as follows −

Stations under the group 3, i.e. A, B

Stations under the group 4, i.e. C, D

Stations under the group 5, i.e. E, F

Stations under the group 6, i.e. G, H

In order to locate the contending stations, depth-first search algorithm is used. The same principle of contention is applied, only for those groups that has some contending stations. The division continues if collisions occur, until each group contains only 1 node.

Difference b/w CSMA/CD and CSMA/CA :

Sr. No.	Key	CSMA/CA	CSMA/CD
1	Effectiveness	CSMA/CA is effective before a collision.	CSMA/CD is effective after a collision.
2	Network Type	CSMA/CA is generally used in wireless networks.	CSMA/CD is generally used in wired networks.
3	Recovery Time	CSMA/CA minimizes the risk of collision.	CSMA/CD reduces recovery time.
4	Conflict Management	CSMA/CA initially transmits the intent to send the data, once an acknowledgment is received, the sender sends the data.	CSMA/CD resends the data frame in case a conflict occurs during transmission.
5	IEEE Standards	CSMA/CA is part of the IEEE 802.11 standard.	CSMA/CD is part of the IEEE 802.3 standard.
6	Efficiency	CSMA/CA is similar in efficiency as CSMA.	CSMA/CD is more efficient than CSMA.