Computer Networks

The Data Link Layer is responsible for transmission of data between two nodes. Its main functions are-

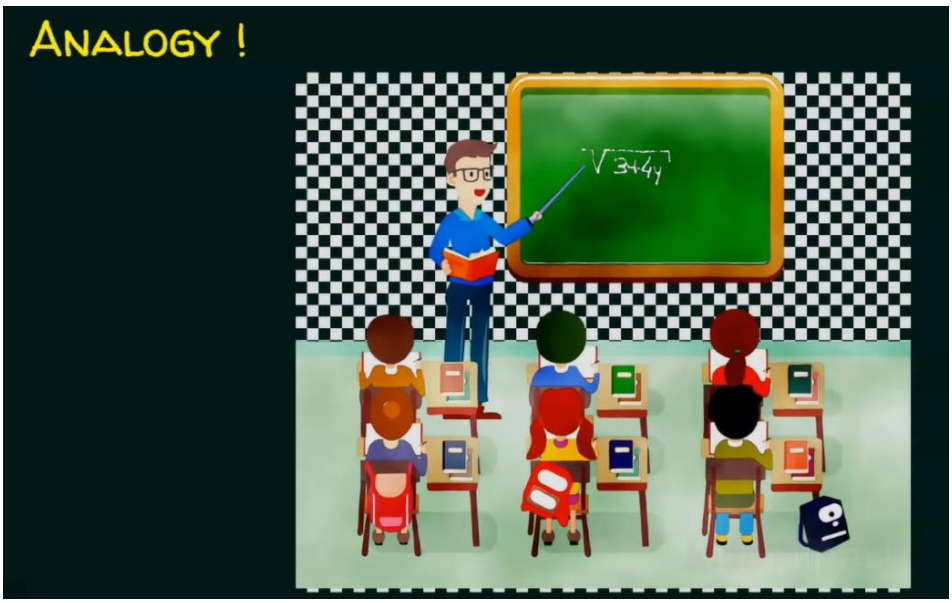
- Data Link Control
- Multiple Access Control

## Data Link Control

The data link control is responsible for reliable transmission of message over transmission channel by using techniques like framing, error control and flow control.

# Multiple Access Protocols

Let’s have an analogy




Suppose, There are full of students in a classroom. Teacher asks a question to students and they started answering simultaneously and a lot of chaos created. Then, how the teacher manage the students? Teacher will make them answer one by one at a time.

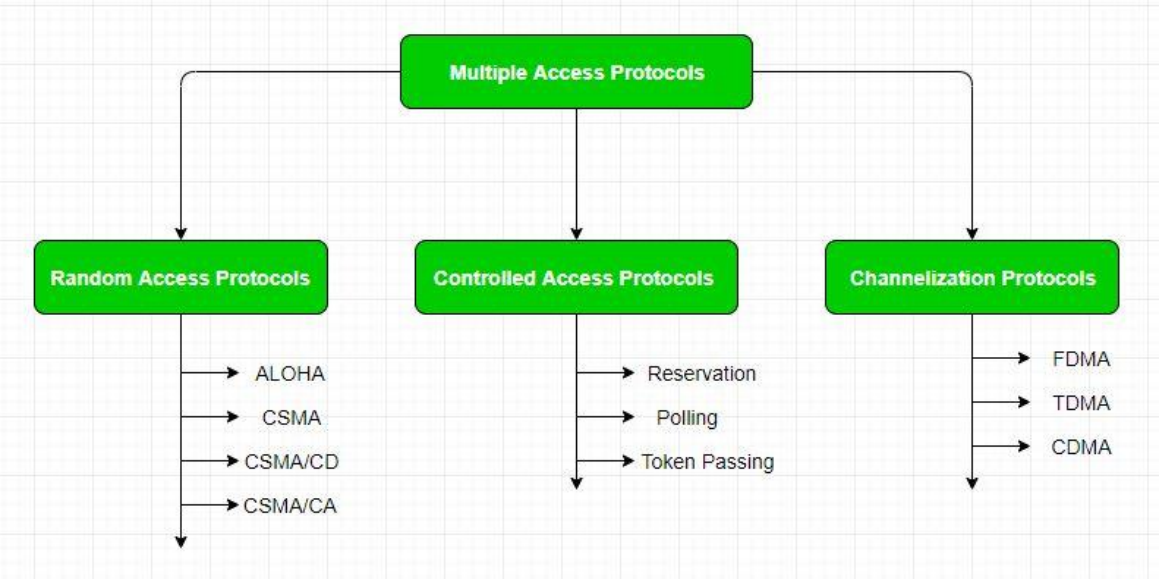
Similarly, in a computer network we have an exclusive channel or medium between sender and receiver then it is ok to send data. But if the channel or medium is shared among many stations or nodes then we can n’t send the data because the channel or node may be already involved in data transmission between two nodes .

If any station or node wants to send data without knowing the status of the channel (busy or idle) then the data can be lost or corrupted.

In analogy, the teacher resolves the students chaos. But in computer network , there is multiple access protocols to resolve chaos.

## Why do we need 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 chaos 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.




## Random Access Protocol

- The name itself says, In Random Access Protocol any station can send data at any time but obviously there are chances for collision.
- In this, all stations have same superiority that is no station has more priority than another station. Any station can send data depending on medium's state( idle or busy).
- In a random access method each station has the right to the medium without being controlled by any other station.
- If more than one station tries to send data, there is an access conflict (COLLISION) and the frame will be either destroyed or modified.

# ALOHA

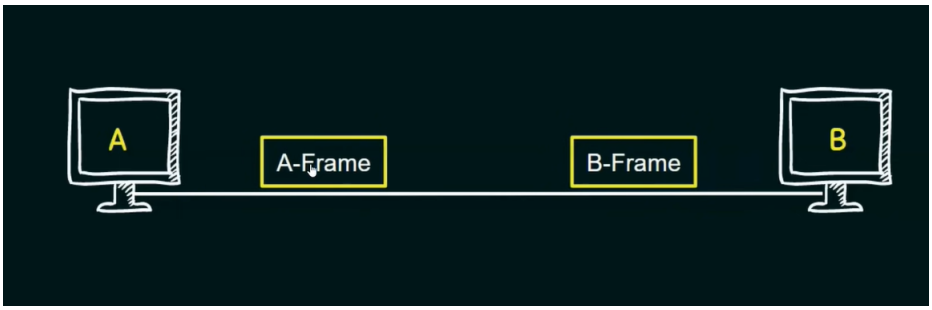
Aloha two types-

- Pure Aloha
- Slotted Aloha

- Aloha is a random access protocol.
- 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.

# Collision


A
A-Frame
B-Frame
B


A
A-Frame
B-Frame
B


COLLISION
Frames lost /
Corrupted
A
BOOM!
B

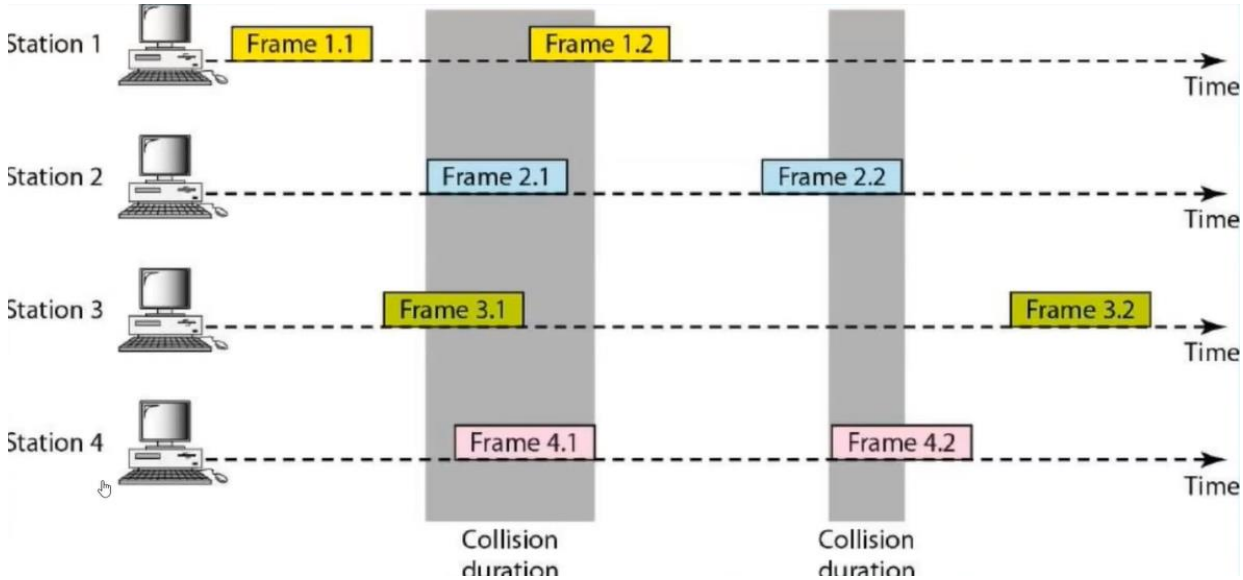



Fig- Pure Aloha

Frame 1.1 won't be collised. But Frame 1.2 , 2.1,3.1,4,1 are collised . Starting point of Frame 2.2 won't collise but Frame 2.2 end portion and frame 4.2 staring portion will be collised. Frame 3.2 are collised free.

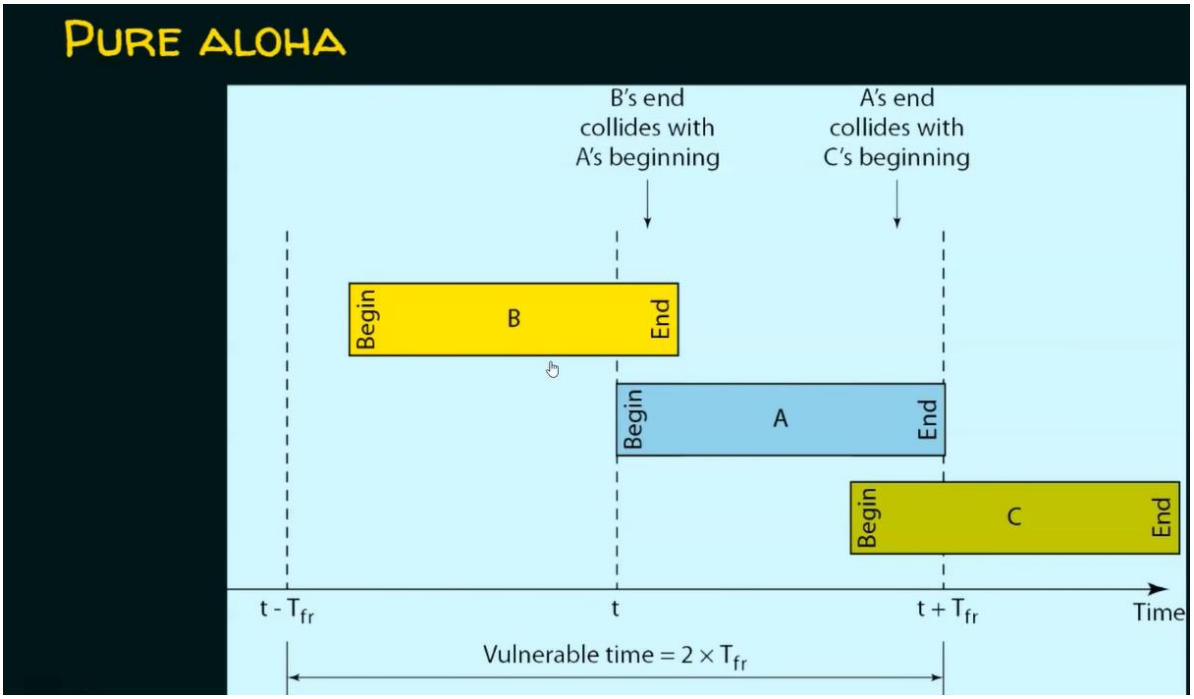
# Pure Aloha

- Pure Aloha allows station to transmit whenever they have data to be sent.
- When a station sends data it waits for an acknowledgement.
- If the acknowledgement doesn't come within the allotted time then the station waits **for a random amount of time** called back-off time (Tb) and re-sends the data.

To avoid collision random amount of time is generated. If there is fixed amount of time there may be possibility of collision.

- Since, different stations wait for different amount of time, the probability of further collision decreases.
- The throughput of pure aloha is maximized when frames are of uniform length. If frames are not so, there can be collision between them.

https://www.youtube.com/watch?v=j4-r0e7DjqY&ab_channel=NesoAcademy

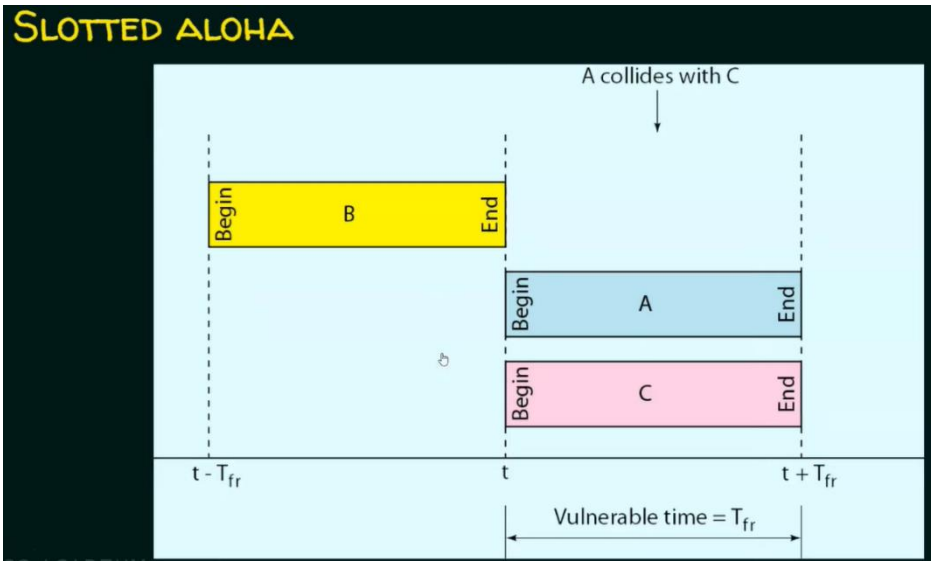



To avoid collision frame transmission time must be 2* each frame transmission time. Thus, a certain frame needs previous T time to be free because if there is no gap of previous extra T time there will be collised with another frame.

This is Pure ALOHA Strategy

# Slotted Aloha

- Slotted Aloha divides the time of shared channel into discrete intervals called as **time slots**.
- Any station can transmit its data in any time slot.
- The only condition is that station must start its transmission from the beginning of the time slot.
- If the beginning of the slot is missed, then station has to wait until the beginning of the next time slot.
- A collision may occur if two or more stations try to transmit data at the beginning of the same time slot.

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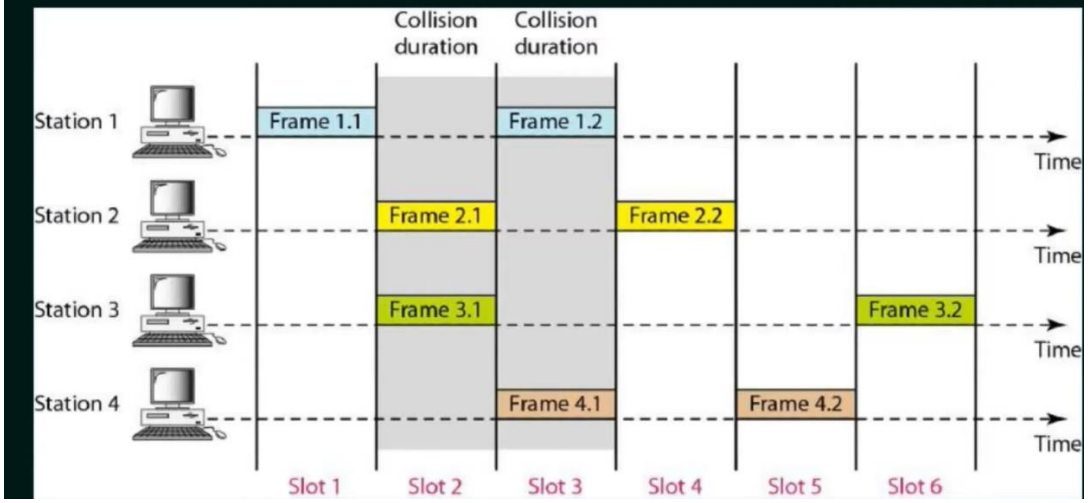
# Slotted ALOHA

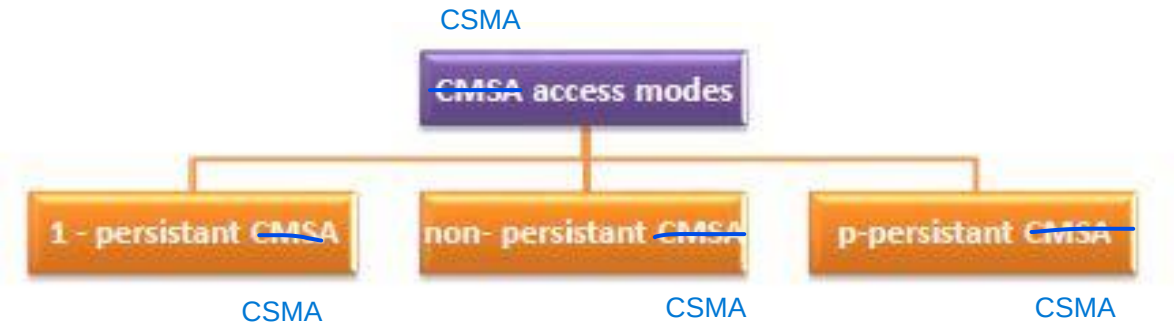


# Pure AlohaVs Slotted Aloha

| Pure Aloha | Slotted Aloha |
|---|---|
| Any station can transmit the data at any time. | Any station can transmit the data at the beginning of any time slot. |
| The time is continuous and not globally synchronized. | The time is discrete and globally synchronized. |
| Vulnerable time in which collision may occur $= 2 \times T_{Fr}$ | Vulnerable time in which collision may occur $= T_{Fr}$ |
| Probability of successful transmission of data packet= $G \times e^{-2G}$ | Probability of successful transmission of data packet= $G \times e^{-G}$ |
| Maximum efficiency = 18.4% (Occurs at G = 1/2) | Maximum efficiency = 36.8% ( Occurs at G = 1) |
| Main advantage: Simplicity in implementation. | Main advantage: It reduces the number of collisions to half and doubles the efficiency of pure aloha. |

## Carrier Sense Multiple Access(CSMA)

**Carrier sense multiple access** based on media access protocol to sense the traffic on a channel (idle or busy) before transmitting the data. It means that if the channel is idle, the station can send data to the channel. Otherwise, it must wait until the channel becomes idle. Hence, it reduces the chances of a collision on a transmission medium.



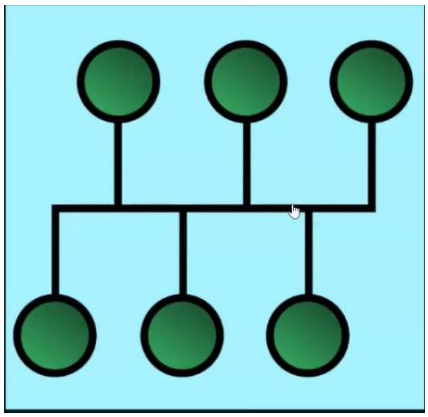


Fig-1

## 1-Persistent CSMA

- ★ Before sending the data, the station first listens to the channel to see if anyone else is transmitting the data at that moment.
- ★ If the channel is idle, the station transmits a frame.
- ★ If busy, then it senses 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 as 1-Persistent CSMA.
- ★ The propagation delay has an important effect on the performance of the protocol.

The longer the propagation delay, the more important this effect becomes and the worse the performance of the protocol.

Problem- If each node in fig-1 continuously checking/sence the channel and each node find it busy and after certain amount of time the channel becomes idle and instantly each node started to send data and collision occurred. In this CSMA, there is a high chance of collision.

## Non/O-persistant

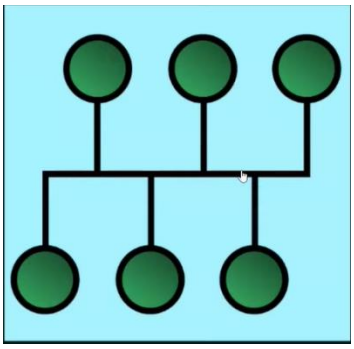


Fig-2

- ★ Before sending, a station senses the channel. If no one else is sending, the station begins doing so itself.
- ★ However, if the channel is already in use, the station does not continually sense it for the purpose of seizing it immediately upon detecting the end of the previous transmission.
- ★ Instead, it waits a random period of time and then repeats the algorithm. Consequently, this algorithm leads to better channel utilization but longer delays than 1-persistent CSMA.

Each node in fig-2 waits random amount of time . Suppose, each node sences and find the medium/channel is busy. So, each node waits for a random amount of time. Suppose, Node A waits for 5 min and Node B waits for 10 min and Node C 15 min. Again, at this moment, the channel becomes free. But nodes are waiting 5 min,10min,15 min respectively. In this whole time, before 10 min each node needs to wait. But this method , collision rate is less than 1 persistant.

p-persistant

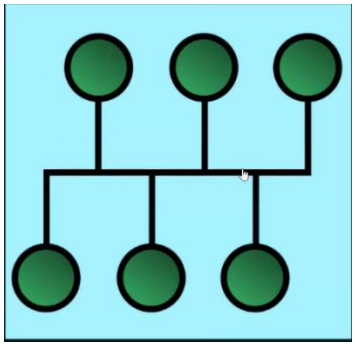
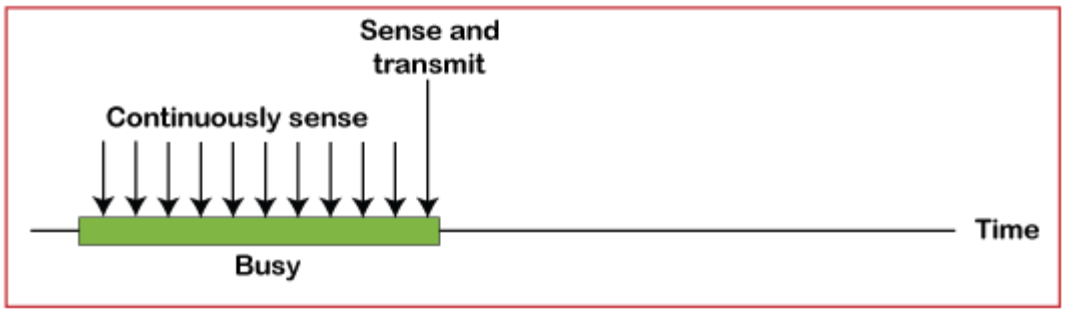


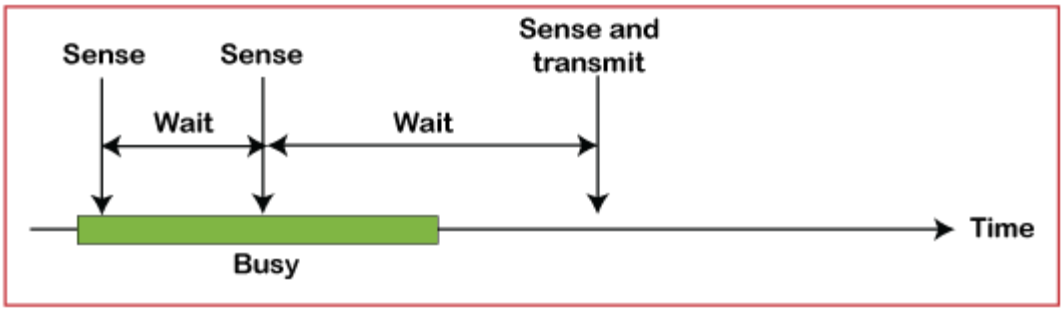
Fig-3

## P–PERSISTENT CSMA

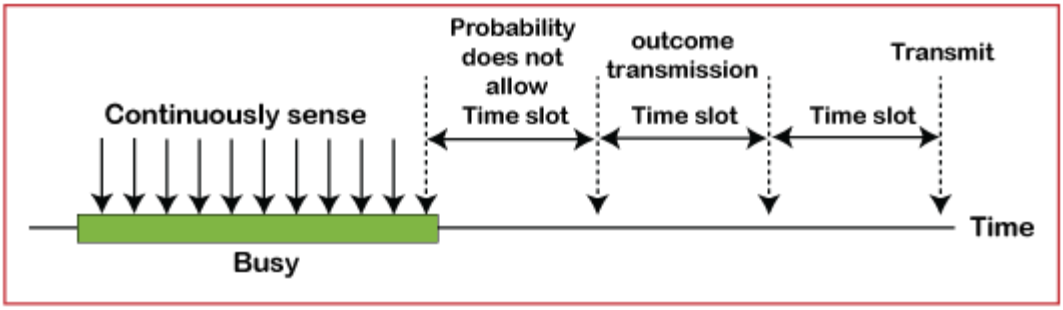
- ★ It applies to slotted channels.
- ★ When a station becomes ready to send, it senses the channel.
- ★ If it is idle, it transmits with a probability P.
- ★ With a probability Q=1–P, it defers until the next slot.
- ★ If that slot is also idle, it either transmits or defers again, with probabilities P and Q.
- ★ This process is repeated until either the frame has been transmitted or another station has begun transmitting.
- ★ In the latter case, the unlucky station acts as if there had been a collision (i.e., it waits a random time and starts again).
- ★ If the station initially senses the channel busy, it waits until the next slot and applies the above algorithm.




a. 1-persistent

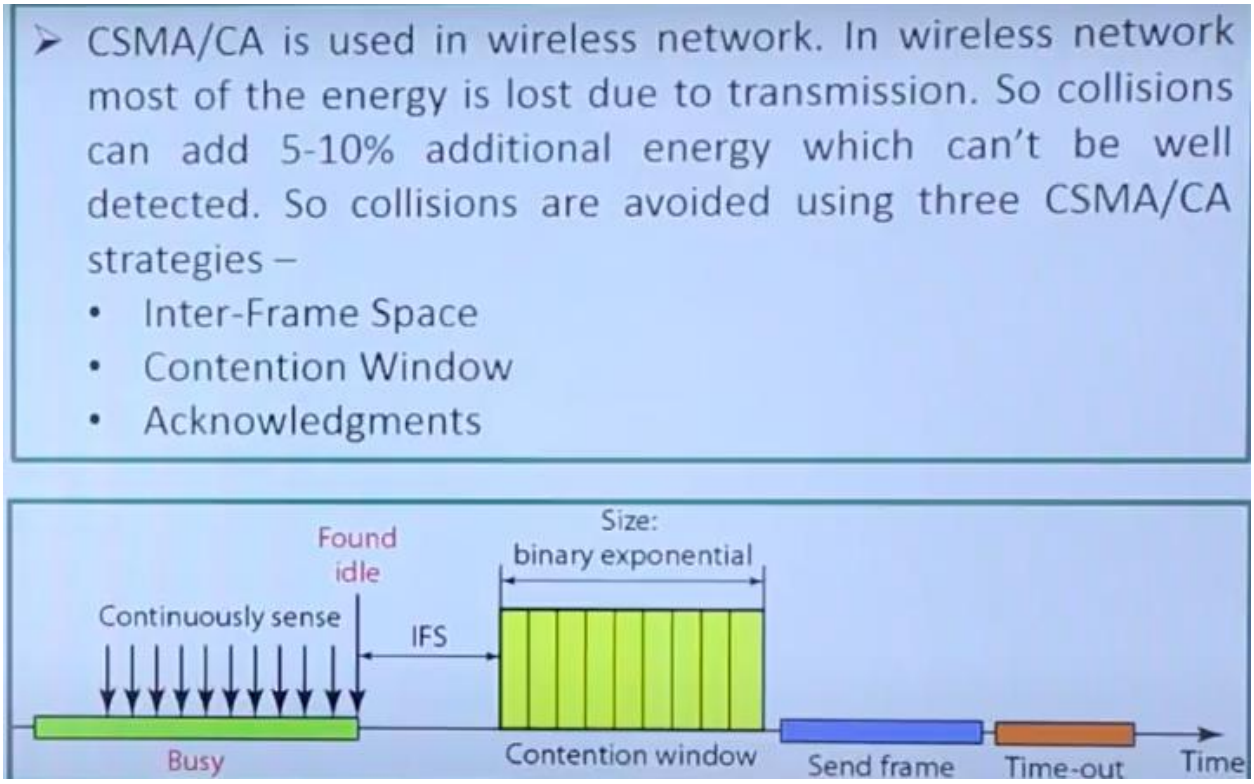



b. Nonpersistent




c. p-persistent

# CSMA/CA



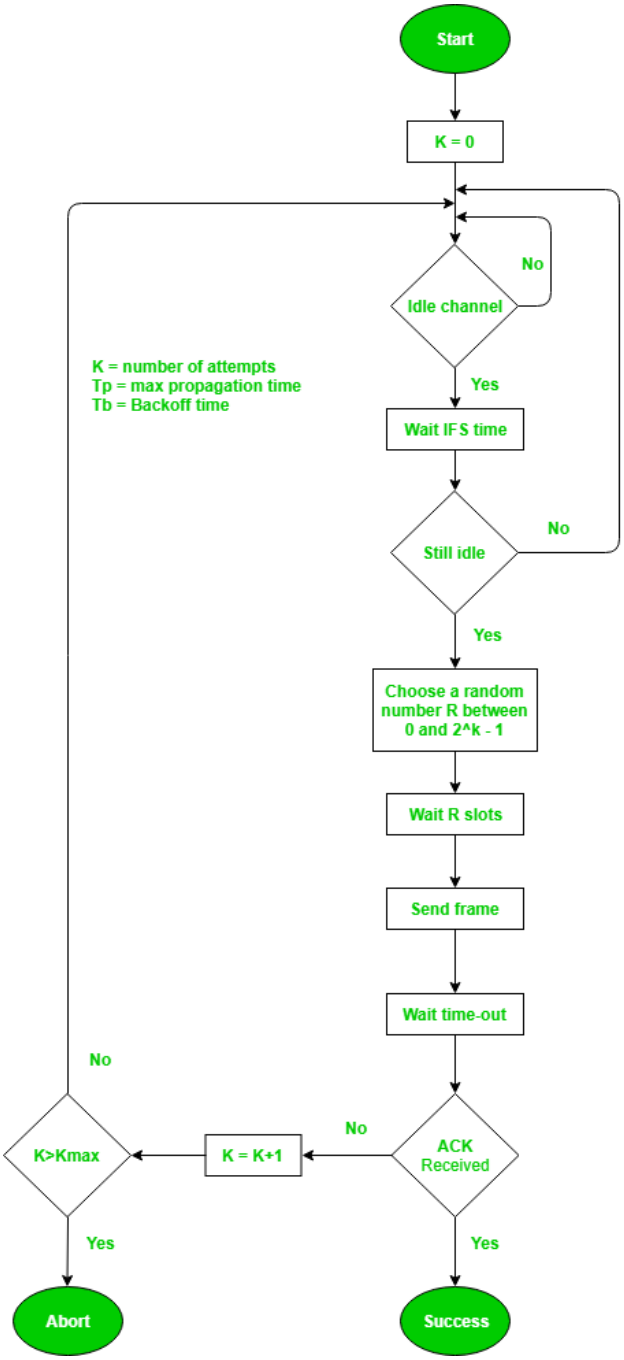

Three types of strategies:

1. **InterFrame Space (IFS) –** When a station finds the channel busy it senses the channel again, when the station finds a channel to be idle it waits for a period of time called **IFS time**. IFS can also be used to define the priority of a station or a frame. Higher the IFS lower is the priority.

2. **Contention Window –** It is the amount of time divided into slots. A station that is ready to send frames chooses a random number of slots as **wait time**.

3. **Acknowledgements –** The positive acknowledgements and time-out timer can help guarantee a successful transmission of the frame.

# CSMA/CA Working Diagram



# CSMA/CD

CSMA / CD stands for Carrier Sense Multiple Access / Collision Detection.

This access control method works as follows-

## Step-01: Sensing the Carrier-

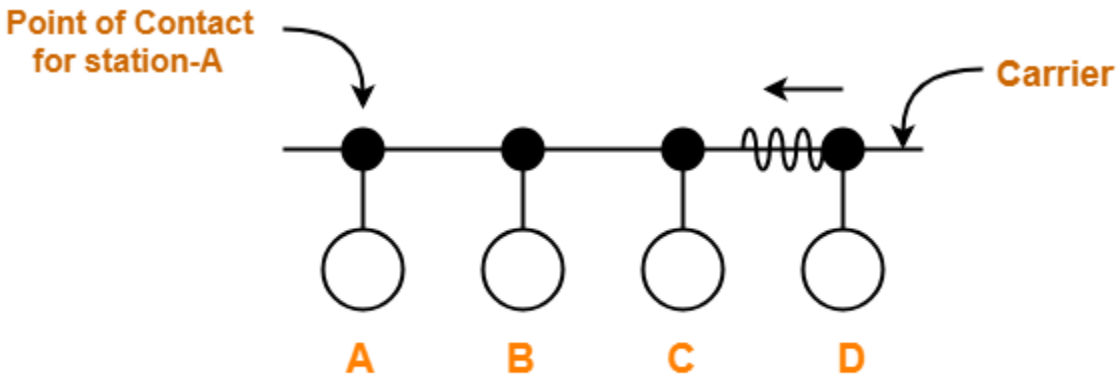
- Any station willing to transmit the data senses the carrier.
- If it finds the carrier free, it starts transmitting its data packet otherwise not.

## How?

- Each station can sense the carrier only at its point of contact with the carrier.
- It is not possible for any station to sense the entire carrier.
- Thus, there is a huge possibility that a station might sense the carrier free when it is not.

## Example-

Consider the following scenario-




(Bus Topology)

At the current instance,

- If station A senses the carrier at its point of contact, then it will find the carrier free.
- But the carrier is actually not free because station D is already transmitting its data.
- If station A starts transmitting its data now, then it might lead to a collision with the data transmitted by station D.

## Step-02: Detecting the Collision-

In CSMA / CD,

- It is the responsibility of the transmitting station to detect the collision.
- For detecting the collision, CSMA / CD implements the following condition.
- This condition is followed by each station-

| Transmission delay >= 2 x Propagation delay |
|---|

## Meaning-

According to this condition

- Each station must transmit the data packet of size whose transmission delay is at least twice its propagation delay.
- If the size of data packet is smaller, then collision detection would not be possible.

## Length Of Data Packet-

We know-

- Transmission delay = Length of data packet (L) / Bandwidth (B)
- Propagation delay = Distance between the two stations (D) / Propagation speed (V)

Substituting values in the above condition, we get-

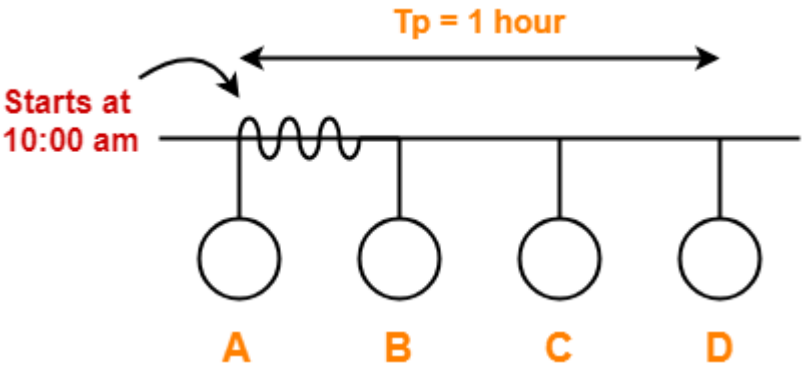
L / B >= 2 x D / V -Thus,

| L >= 2 x B x D / V |
|---|

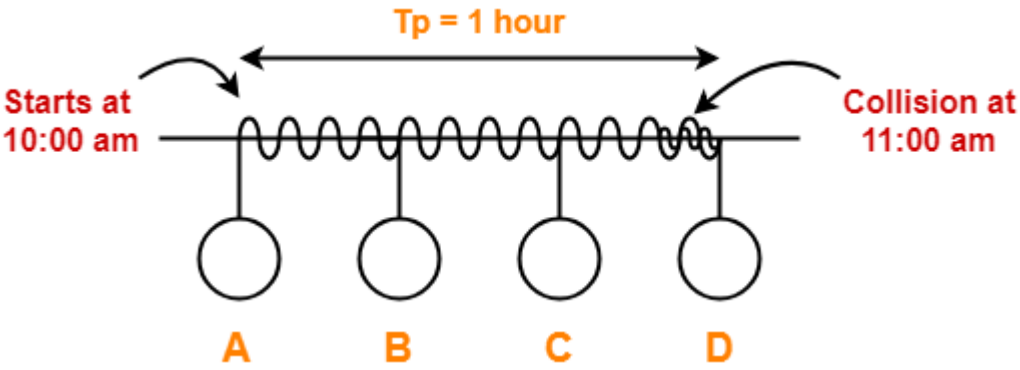
## Understanding the Condition To Detect Collision With Example

- Consider at time 10:00 am, station A senses the carrier.
- It finds the carrier free and starts transmitting its data packet to station D.
- Let the propagation delay be 1 hour.

(We are considering station D for the worst case)




- Let us consider the scenario at time 10:59:59:59 when the packet is about to reach the station D.
- At this time, station D senses the carrier.
- It finds the carrier free and starts transmitting its data packet.
- Now, as soon as station D starts transmitting its data packet, a collision occurs with the data packet of station A at time 11:00 am.




- After collision occurs, the collided signal starts travelling in the backward direction.
- The collided signal takes 1 hour to reach the station A after the collision has occurred.

- For station A to detect the collided signal, it must be still transmitting the data.
- So, transmission delay of station A must be >= 1 hour + 1 hour >= 2 hours to detect the collision.
- That is why, for detecting the collision, condition is $T_t >= 2T_p$.

Two cases are possible-

Case-01:

If no collided signal comes back during the transmission,

- It indicates that no collision has occurred.
- The data packet is transmitted successfully.

Case-02:

If the collided signal comes back during the transmission,

- It indicates that the collision has occurred.
- The data packet is not transmitted successfully.
- Step-03 is followed.

## Step-03: Releasing Jam Signal-

- Jam signal is a 48 bit signal.
- It is released by the transmitting stations as soon as they detect a collision.
- It alerts the other stations not to transmit their data immediately after the collision.
- Otherwise, there is a possibility of collision again with the same data packet.
- Ethernet sends the jam signal at a frequency other than the frequency of data signals.
- This ensures that jam signal does not collide with the data signals undergone collision.

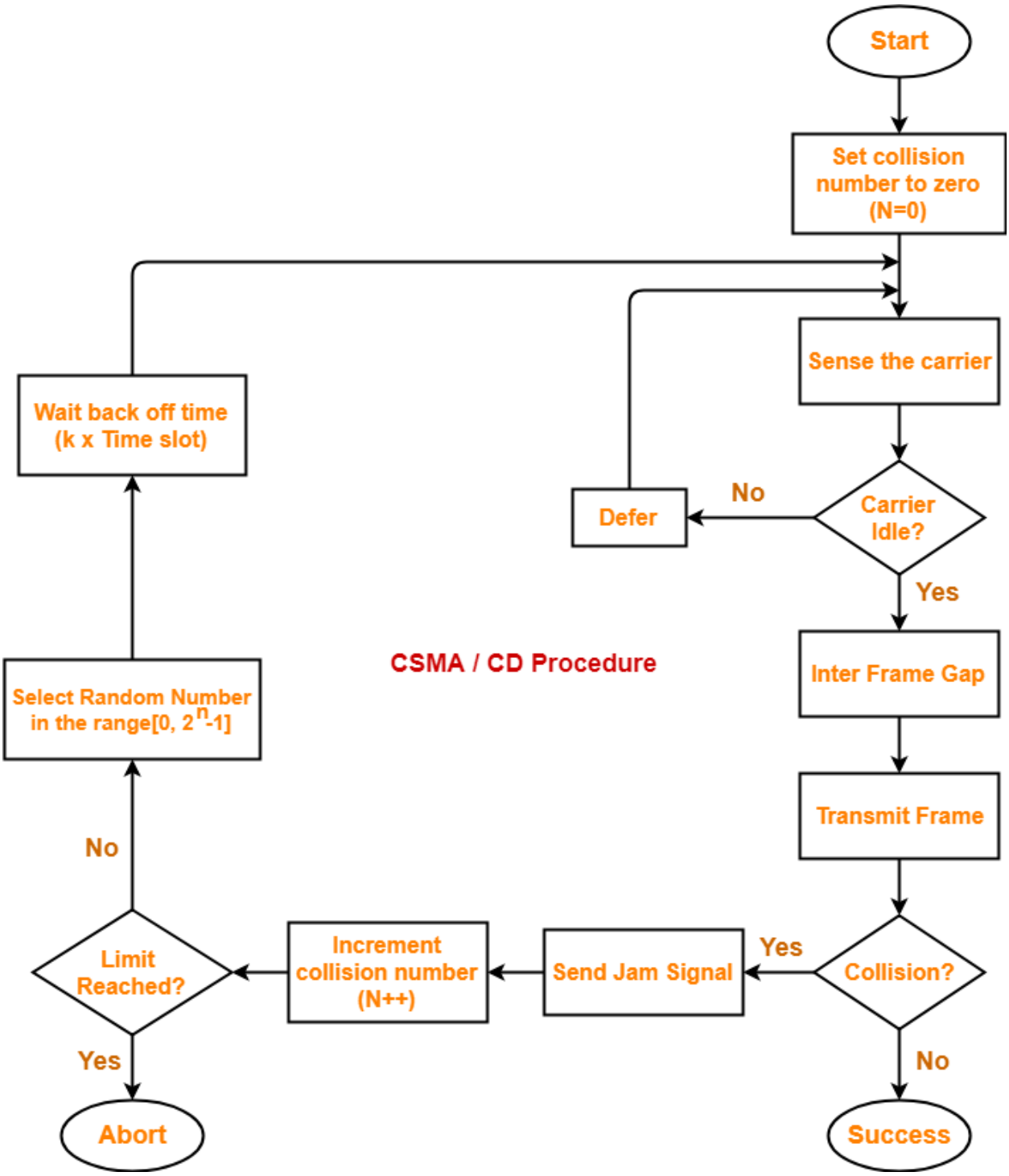
## Step-04: Waiting For Back Off Time-

- After the collision, the transmitting station waits for some random amount of time called as **back off time**.
- After back off time, it tries transmitting the data packet again.

- If again the collision occurs, then station again waits for some random back off time and then tries again.
- The station keeps trying until the back off time reaches its limit.
- After the limit is reached, station aborts the transmission.
- Back off time is calculated using **Back Off Algorithm**.

## CSMA / CD Flowchart-

The following CSMA / CD flowchart represents the CSMA / CD procedure-



| S. No | CSMA CD | CSMA CA |
|---|---|---|
| 1. | It is the type of CSMA to detect the collision on a shared channel. | It is the type of CSMA to avoid collision on a shared channel. |
| 2. | It is the collision detection protocol. | It is the collision avoidance protocol. |
| 3. | It is used in 802.3 Ethernet network cable. | It is used in the 802.11 Ethernet network. |
| 4. | It works in wired networks. | It works in wireless networks. |
| 5. | It is effective after collision detection on a network. | It is effective before collision detection on a network. |
| 6. | Whenever a data packet conflicts in a shared channel, it resends the data frame. | Whereas the CSMA CA waits until the channel is busy and does not recover after a collision. |
| 7. | It minimizes the recovery time. | It minimizes the risk of collision. |
| 8. | The efficiency of CSMA CD is high as compared to CSMA. | The efficiency of CSMA CA is similar to CSMA. |
| 9. | It is more popular than the CSMA CA protocol. | It is less popular than CSMA CD. |