Module 5

The Medium Access Sub layer

- Random Access Protocols ALOHA ,CSMA, CSMA/CD,CSMA/CA
- Controlled Access Reservation, Polling and Token Passing Channelization
- FDMA, TDMA , CDMA

The Medium Access Sub Layer :

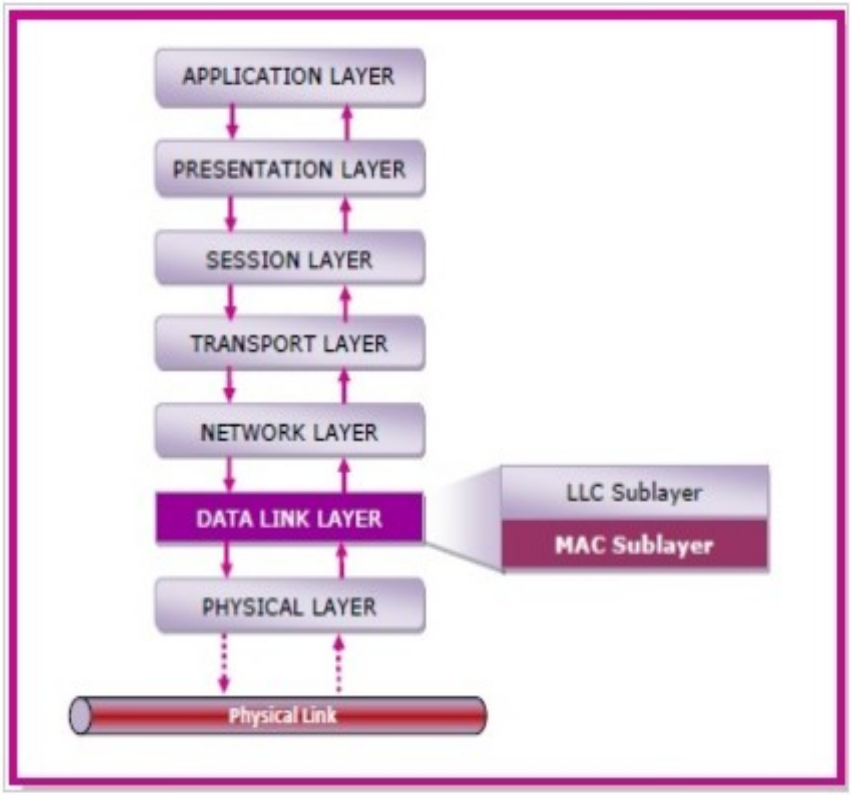
- The Medium Access Control (MAC) data communication Networks. protocol sub-layer, also known as the Medium Access Control, is a sub-layer of the data link layer specified in the seven-layer OSI model.
- The medium access layer was made necessary by systems that share a common communications medium.
- Typically these are local area networks.
- The MAC layer is the “low” part of the second OSI layer, the layer of the “data link”.
- In fact, the IEEE divided this layer into two layers “above” is the control layer the logical connection (Logical Link Control, LLC) and “down” the control layer The medium access (MAC).

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 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.

MAC Addresses

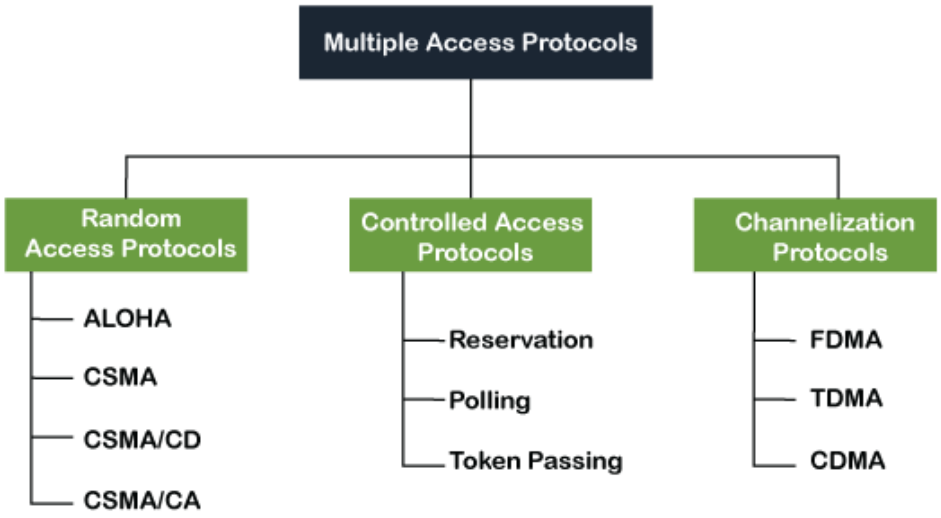
- MAC address or media access control address is a unique identifier allotted to a network interface controller (NIC) of a device.
- It is used as a network address for data transmission within a network segment like Ethernet, Wi-Fi, and Bluetooth.
- MAC address is assigned to a network adapter at the time of manufacturing. It is hardwired or hard-coded in the network interface card (NIC).
- A MAC address comprises of six groups of two hexadecimal digits, separated by hyphens, colons, or no separators. An example of a MAC address is 00:0A:89:5B:F0:11.

What is a multiple access protocol?

- When a sender and receiver have a dedicated link to transmit data packets, the data link control is enough to handle the channel.
- Suppose there is no dedicated path to communicate or transfer the data between two devices.
- In that case, multiple stations access the channel and simultaneously transmits the data over the channel.
- It may create collision and cross talk. Hence, the multiple access protocol is required to reduce the collision and avoid crosstalk between the channels.

For example, suppose that there is a classroom full of students. When a teacher asks a question, all the students (small channels) in the class start answering the question at the same time (transferring the data simultaneously). All the students respond at the same time due to which data is overlap or data lost. Therefore it is the responsibility of a teacher (multiple access protocol) to manage the students and make them one answer.

Following are the types of multiple access protocol that is subdivided into the different process as:



A. Random Access Protocol

- In this protocol, all the station has the equal priority to send the data over a channel.
- In random access protocol, one or more stations cannot depend on another station nor any station control another station.
- Depending on the channel's state (idle or busy), each station transmits the data frame.
- However, if more than one station sends the data over a channel, there may be a collision or data conflict.
- Due to the collision, the data frame packets may be lost or changed. And hence, it does not receive by the receiver end.

Following are the different methods of random-access protocols for broadcasting frames on the channel.

❍Aloha

❍CSMA

❍CSMA/CD

❍CSMA/CA

i. Aloha Rules

1.Any station can transmit data to a channel at any time.

2.It does not require any carrier sensing.

3.Collision and data frames may be lost during the transmission of data through multiple stations.

4.Acknowledgment of the frames exists in Aloha. Hence, there is no collision detection.

5.It requires retransmission of data after some random amount of time.

ALOHA :

- ALOHA is a system for coordinating and arbitrating access to a shared communication channel.
- It was developed in the 1970s at the University of Hawaii. The original system used terrestrial radio broadcasting, but the system has been implemented in satellite communication systems.
- A shared communication system like ALOHA requires a method of handling collisions that occur when two or more systems attempt to transmit on the channel at the same time.
- In the ALOHA system, a node transmits whenever data is available to send.
- If another node transmits at the same time, a collision occurs, and the frames that were transmitted are lost.
- However, a node can listen to broadcasts on the medium, even its own, and determine whether the frames were transmitted.

Aloha means "Hello". Aloha is a multiple access protocol at the datalink layer and proposes how multiple terminals access the medium without interference or collision. In 1972 Roberts developed a protocol that would increase the capacity of aloha two fold. The Slotted Aloha protocol involves dividing the time interval into discrete slots and each slot interval corresponds to the time period of one frame. This method requires synchronization between the sending nodes to prevent collisions.

There are two different versions of ALOHA

i) Pure ALOHA

• In pure ALOHA, the stations transmit frames whenever they have data to send.

• When two or more stations transmit simultaneously, there is collision and the frames are destroyed.

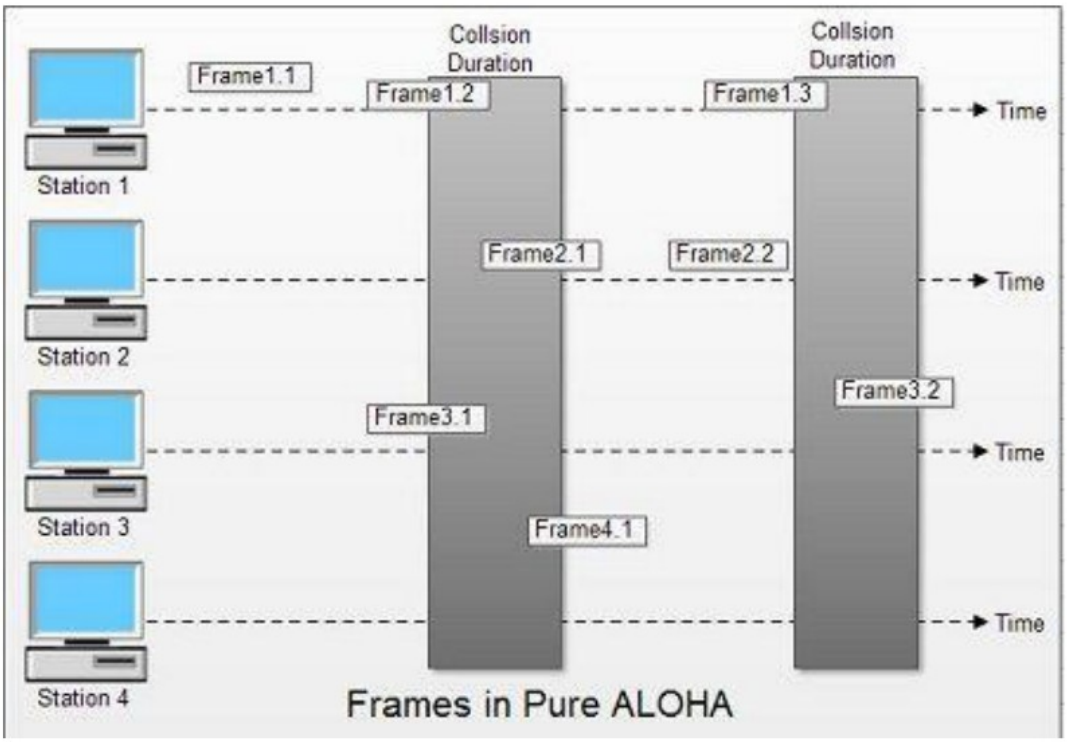
• In pure ALOHA, whenever any station transmits a frame, it expects the acknowledgement from the receiver.

• If acknowledgement is not received within specified time, the station assumes that the frame (or acknowledgement) has been destroyed.

• If the frame is destroyed because of collision the station waits for a random amount of time and sends it again. This waiting time must be random otherwise same frames will collide again and again.

• Therefore pure ALOHA dictates that when time-out period passes, each station must wait for a random amount of time before resending its frame. This randomness will help avoid more collisions.

Figure shows an example of frame collisions in pure ALOHA.



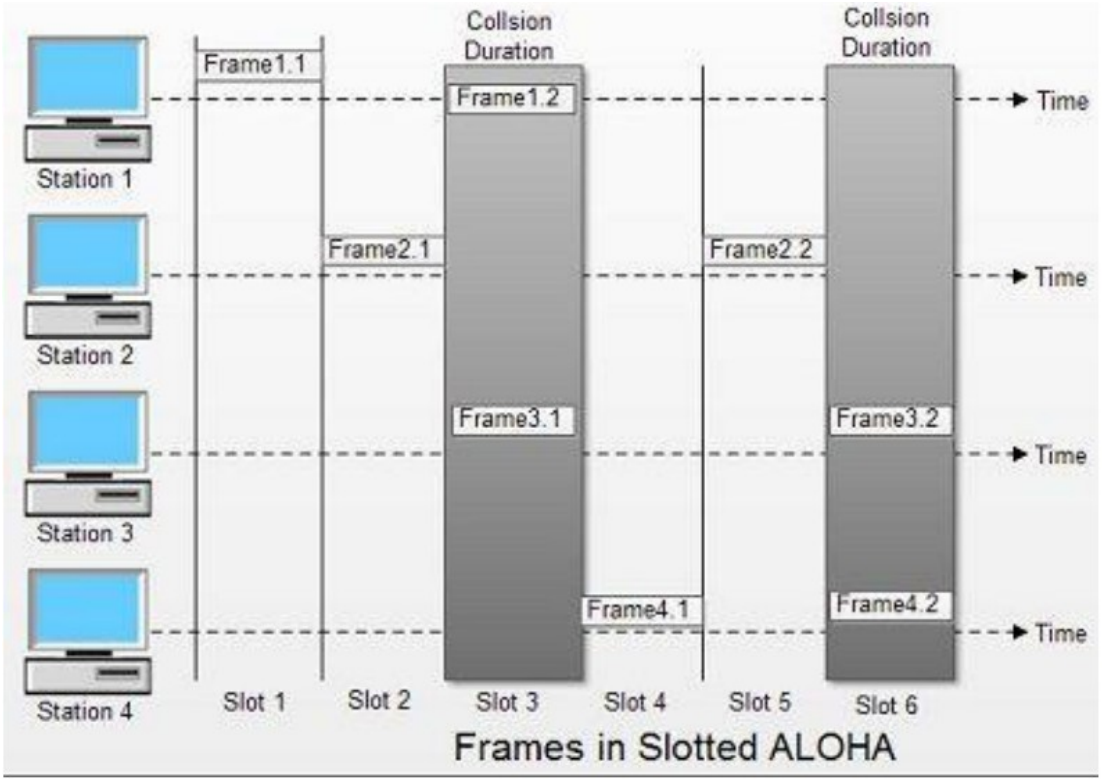
• In fig there are four stations that .contended with one another for access to shared channel. All these stations are transmitting frames. Some of these frames collide because multiple frames are in contention for the shared channel. Only two frames, frame 1.1 and frame 2.2 survive. All other frames are destroyed.

• Whenever two frames try to occupy the channel at the same time, there will be a collision and both will be damaged. If first bit of a new frame overlaps with just the last bit of a frame almost finished, both frames will be totally destroyed and both will have to be retransmitted.

ii) Slotted ALOHA

• Slotted ALOHA was invented to improve the efficiency of pure ALOHA as chances of collision in pure ALOHA are very high.

• In slotted ALOHA, the time of the shared channel is divided into discrete intervals called slots. The stations can send a frame only at the beginning of the slot and only one frame is sent in each slot.



• In slotted ALOHA, if any station is not able to place the frame onto the channel at the beginning of the slot i.e. it misses the time slot then the station has to wait until the beginning of the next time slot.

• In slotted ALOHA, there is still a possibility of collision if two stations try to send at the beginning of the same time slot as shown in fig.

• Slotted ALOHA still has an edge over pure ALOHA as chances of collision are reduced to one-half.

Carrier Sensed Multiple Access (CSMA) :

- CSMA is a network access method used on shared network topologies such as Ethernet to control access to the network.

- Devices attached to the network cable listen (carrier sense) before transmitting. If the channel is in use, devices wait before transmitting.
- MA (Multiple Access) indicates that many devices can connect to and share the same network.
- All devices have equal access to use the network when it is clear.
- Even though devices attempt to sense whether the network is in use, there is a good chance that two stations will attempt to access it at the same time.
- On large networks, the transmission time between one end of the cable and another is enough that one station may access the cable even though another has already just accessed it.
- There are two methods for avoiding these so-called collisions, listed here :

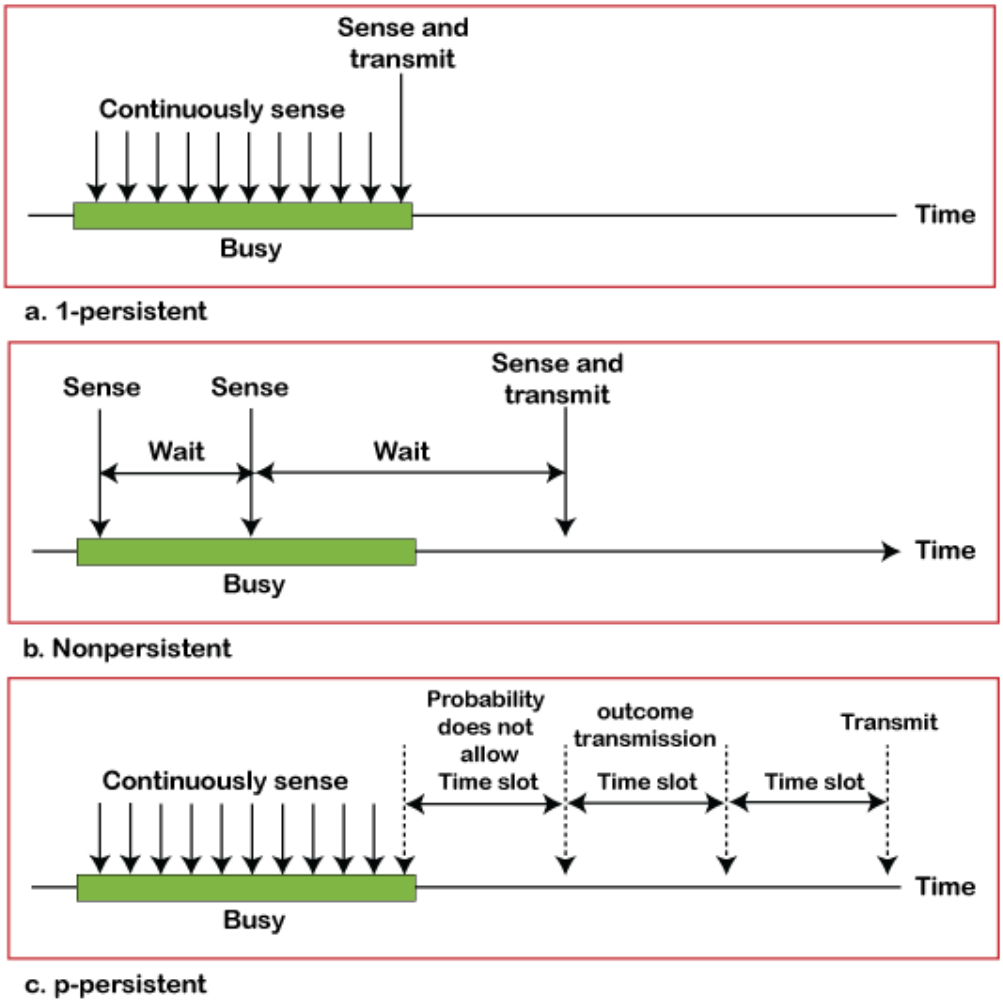
CSMA Access Modes

1-Persistent: In the 1-Persistent mode of CSMA that defines each node, first sense the shared channel and if the channel is idle, it immediately sends the data. Else it must wait and keep track of the status of the channel to be idle and broadcast the frame unconditionally as soon as the channel is idle.

Non-Persistent: It is the access mode of CSMA that defines before transmitting the data, each node must sense the channel, and if the channel is inactive, it immediately sends the data. Otherwise, the station must wait for a random time (not continuously), and when the channel is found to be idle, it transmits the frames.

P-Persistent: It is the combination of 1-Persistent and Non-persistent modes. The P-Persistent mode defines that each node senses the channel, and if the channel is inactive, it sends a frame with a **P** probability. If the data is not transmitted, it waits for a (**q = 1-p probability**) random time and resumes the frame with the next time slot.

O- Persistent: It is an O-persistent method that defines the superiority of the station before the transmission of the frame on the shared channel. If it is found that the channel is inactive, each station waits for its turn to retransmit the data.



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

- CD (collision detection) defines what happens when two devices sense a clear channel, then attempt to transmit at the same time.
- A collision occurs, and both devices stop transmission, wait for a random amount of time, and then retransmit.
- This is the technique used to access the 802.3 Ethernet network channel.

- This method handles collisions as they occur, but if the bus is constantly busy, collisions can occur so often that performance drops drastically.
- It is estimated that network traffic must be less than 40 percent of the bus capacity for the network to operate efficiently.
- If distances are long, time lags occur that may result in inappropriate carrier sensing, and hence collisions.

CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance) :

- In CA collision avoidance), collisions are avoided because each node signals its intent to transmit before actually doing so.
- This method is not popular because it requires excessive overhead that reduces performance.

Following are the methods used in the CSMA/ CA to avoid the collision:

Interframe space: In this method, the station waits for the channel to become idle, and if it gets the channel is idle, it does not immediately send the data. Instead of this, it waits for some time, and this time period is called the **Interframe** space or IFS. However, the IFS time is often used to define the priority of the station.

Contention window: In the Contention window, the total time is divided into different slots. When the station/ sender is ready to transmit the data frame, it chooses a random slot number of slots as **wait time**. If the channel is still busy, it does not restart the entire process, except that it restarts the timer only to send data packets when the channel is inactive.

Acknowledgment: In the acknowledgment method, the sender station sends the data frame to the shared channel if the acknowledgment is not received ahead of time.

B. Controlled Access Protocol

It is a method of reducing data frame collision on a shared channel. In the controlled access method, each station interacts and decides to send a data frame by a particular station approved by all other stations. It means that a single station cannot send the data frames unless all other stations are not approved. It has three types of controlled access: **Reservation, Polling**, and **Token Passing**.

i. Reservation in Computer Network

Whenever we travel from a train or an airplane, the first thing we do is to reserve our seats, similarly here a station must make a reservation first before transmitting any data-frames.

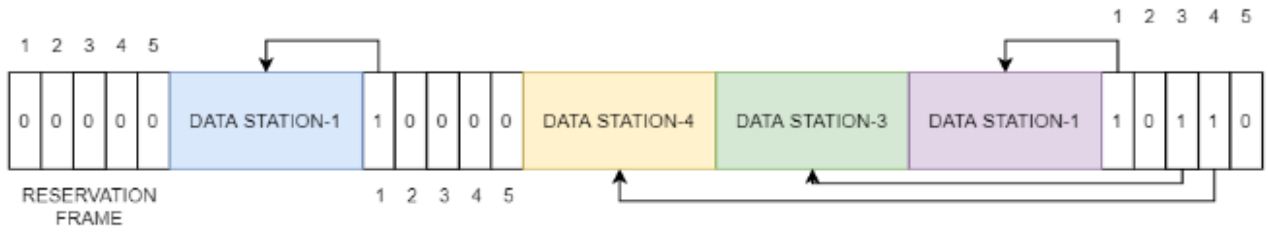
This reservation in Computer Network timeline consists of two kinds of periods:

1. Reservation interval of a fixed time duration
2. Data transmission period of variable frames

Consider there are 4 stations then the reservation intervals are divided into 4 slots so that each station has a slot. Means if n number of stations are there then n slot will be allotted.

- Now let us assume that these 4 stations are 4 friends, now is friend-1 speaks in his slot-1 then no other friend can speak at this time.
- Similarly, if station-1 transmits a 1-bit data-frame in slot-1 then at that time no other station can transmit its data-frames and they must wait for their time slot.
- After all the slots have transmitted and checked then each station knows which station now wishes for transmission.
- The biggest advantage of this method is since all stations agree on which station is next to transmit then there are no possible collisions.

The illustration below shows a scenario with five stations with a five-slot reservation frame. here, in the time interval station 1,3,4 are the only stations with reservations and in the second interval station-1 is the only station with a reservation.



2**). Polling in Computer Network**

Recall your school or college classroom, what was the first thing the teacher does after entering the class? The answer is roll call or attendance. Let's compare the scenario. The teacher calls roll number 1 and gets a response if he/she is present then switches to the next roll number, say roll number two and roll number 2 is absent, so the teacher gets no response in return or say a negative response. Similarly, in a computer network there is a primary station or controller (teacher) and all other stations are secondary (students), the primary station sends a message to each station. The message which is sent by the primary station consists of the address of the station which is selected for granting access.

- The point to remember is that all the nodes receive the message but the addressed one responds and sends data in return, but if the station has no data to transmit then it sends a message called **Poll Reject or NAK** (negative acknowledgment).
- But this method has some drawbacks like the high overhead of the polling messages and high dependence on the reliability of the primary station.
    - We calculate the efficiency of this method in terms of time for polling & time required for transmission of data.

        Tpoll = time for polling

        Tt = time required for transmission of data

So, **efficiency = Tt / (Tt + Tpoll)**

- Whenever the primary station wants to recieve the data, it asks the secondary stations present in its channel, this method is **polling**.

3). Token Passing in Computer Network

Now, say 4 people are sitting on a round table and only that person can speak who has the token.

- In computer networks a token is a special bit pattern that allows the token possessing system to send data or we can say that a token represents permission to transmit data.
- The token circulation around the table (or a network ring) is in a predefined order. A station can only pass the token to its adjacent station and not to any other station in the network.
- If a station has some data queued for transmission it can not transmit the data until it receives the token and makes sure it has transmitted all the data before passing on the received token.
- This method has some drawbacks like duplication of token or sometimes the token is damaged or lost during the circulation, or some times if we introduce a new station or remove an existing station from the network, this leads to a huge disturbance, which should be taken care of so that the efficiency of the method is not affected.
- The performance of a token ring is governed by 2 parameters, which are delay and throughput.
- **Delay** is a measure of the time; it is the time difference between a packet ready for transmission and when it is transmitted. Hence, the average time required to send a token to the next station is a/N.

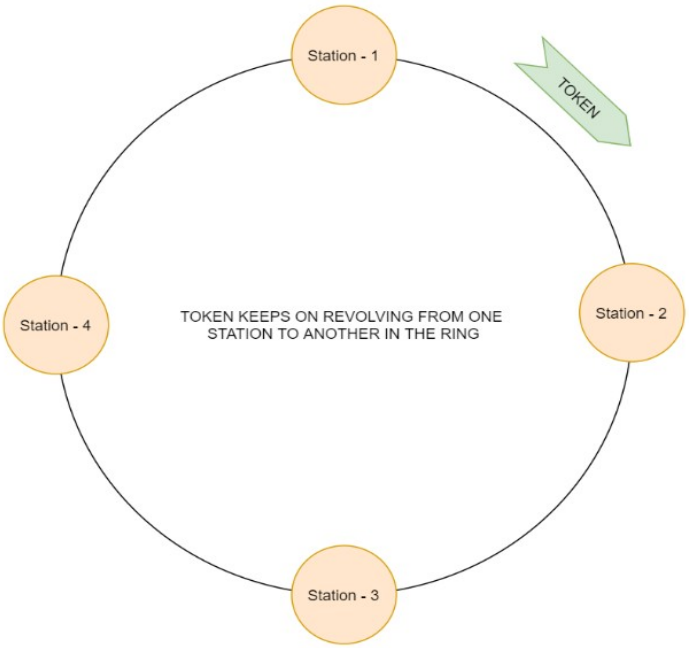
- **Throughput** is a measure of the successful traffic in the communication channel.

  Throughput, S = 1/ (1 + a/N) for a<1

  S = 1/[a(1+1/N)] for a>1, here N = number of stations & a = Tp/Tt

  Tp = propagation delay &Tt = transmission delay

In the diagram below when station-1 posses the token it starts transmitting all the data-frames which are in it's queue. now after transmission, station-1 passes the token to station-2 and so on. Station-1 can now transmit data again, only when all the stations in the network have transmitted their data and passed the token.



Channelization Protocols

- It is a channelization protocol that allows the total usable bandwidth in a shared channel to be shared across multiple stations based on their time, distance and codes. It can access all the stations at the same time to send the data frames to the channel.
- Following are the various methods to access the channel based on their time, distance and codes:

1.FDMA (Frequency Division Multiple Access)

2.TDMA (Time Division Multiple Access)

3.CDMA (Code Division Multiple Access)

FDMA

- It is a frequency division multiple access (**FDMA**) method used to divide the available bandwidth into equal bands so that multiple users can send data through a different frequency to the subchannel.
- Each station is reserved with a particular band to prevent the crosstalk between the channels and interferences of stations.

TDMA

- Time Division Multiple Access (**TDMA**) is a channel access method.
- It allows the same frequency bandwidth to be shared across multiple stations. And to avoid collisions in the shared channel, it divides the channel into different frequency slots that allocate stations to transmit the data frames.
- The same **frequency** bandwidth into the shared channel by dividing the signal into various time slots to transmit it.
- However, TDMA has an overhead of synchronization that specifies each station's time slot by adding synchronization bits to each slot.

CDMA

- The code division multiple access (CDMA)is a channel access method.
- In CDMA, all stations can simultaneously send the data over the same channel.
- It means that it allows each station to transmit the data frames with full frequency on the shared channel at all times.

- It does not require the division of bandwidth on a shared channel based on time slots.
- If multiple stations send data to a channel simultaneously, their data frames are separated by a unique code sequence.
- Each station has a different unique code for transmitting the data over a shared channel.
- For example, there are multiple users in a room that are continuously speaking.
- Data is received by the users if only two-person interact with each other using the same language.
- Similarly, in the network, if different stations communicate with each other simultaneously with different code language.

Reference Link

https://www.lkouniv.ac.in/site/writereaddata/siteContent 20200329162359610 3rohit_yadav_engg_Computer_Network_2.pdf

https://www.geeksforgeeks.org/carrier-sense-multiple-access-csma/