COMPUTER NETWORKS

UNIT -3

Media Access Control: Random Access: ALOHA, Carrier sense multiple access (CSMA), CSMA with Collision Detection, CSMA with Collision Avoidance,
Controlled Access: Reservation, Polling, Token Passing, **Channelization:** frequency division multipleAccess(FDMA), time division multiple access(TDMA), code division multiple access(CDMA).
Wired LANs: Ethernet, Ethernet Protocol, Standard Ethernet, Fast Ethernet(100 Mbps), Gigabit Ethernet, 10 Gigabit Ethernet.

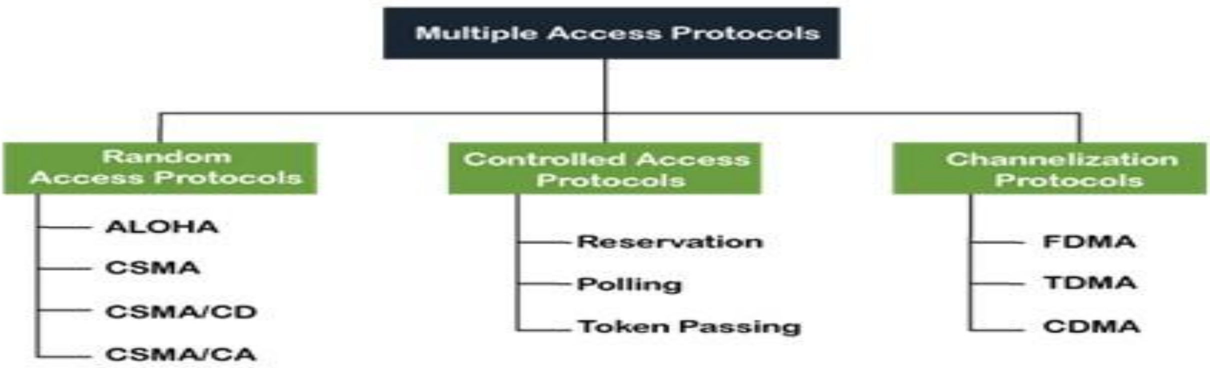
Multiple Access Protocols

- Multiple access protocols are a set of protocols operating in the Medium Access Control sub-layer (MAC sub layer) of the Open Systems Interconnection (OSI) model. These protocols allow a number of nodes or users to access a shared network channel. Several data streams originating from several nodes are transferred through the multi-point transmission channel.

- The objectives of multiple access protocols are optimization of transmission time, minimization of collisions and avoidance of cross-talks.

- **Categories of Multiple Access Protocols**: Multiple access protocols can be broadly classified into three categories –

    1. Random access protocols,
    2. Controlled access protocols, and
    3. Channelization protocols.



Random Access Protocols

Random access protocols assign uniform priority to all connected nodes. Any node can send data if the transmission channel is idle. No fixed time or fixed sequence is given for data transmission.

The four random access protocols are–

1. ALOHA
2. Carrier sense multiple access (CMSA)
3. Carrier sense multiple access with collision detection (CMSA/CD)
4. Carrier sense multiple access with collision avoidance (CMSA/CA)

- **Controlled Access Protocols**

Controlled access protocols allow only one node to send data at a given time. Before initiating transmission, a node seeks information from other nodes to determine which station has the right to send. This avoids collision of messages on the shared channel.

The station can be assigned the right to send by the following three methods–

1. Reservation
2. Polling
3. Token Passing

- **Channelization**

Channelization are a set of methods by which the available bandwidth is divided among the different nodes for simultaneous data transfer.

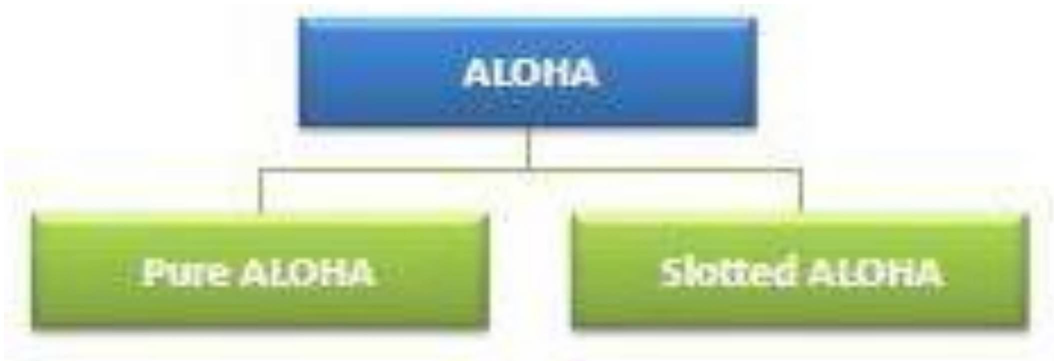
The three channelization methods are–

1. Frequency division multiple access (FDMA)
2. Time division multiple access (TDMA)
3. Code division multiple access (CDMA)

1. ALOHA: It is a multiple access protocol for transmission of data via a shared network channel. It operates in the Medium Access Control sublayer (MAC sublayer) of the Open Systems Interconnection (OSI) model. Using this protocol, several data streams originating from multiple nodes are transferred through a multi-point transmission channel.

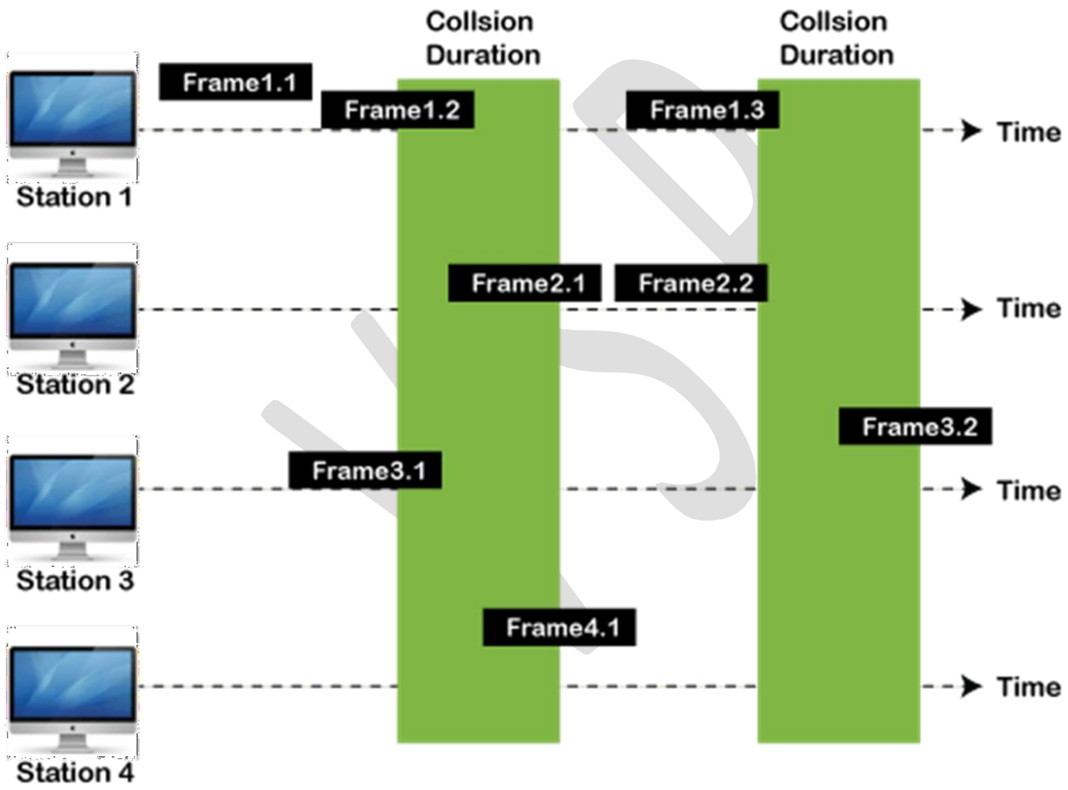
In ALOHA, each node or station transmits a frame without trying to detect whether the transmission channel is idle or busy. If the channel is idle, then the frames will be successfully transmitted. If two frames attempt to occupy the channel simultaneously, collision of frames will occur and the frames will be discarded. These stations may choose to retransmit the corrupted frames repeatedly until successful transmission occurs.

- **Versions of ALOHA Protocols**



- **Pure ALOHA:** In pure ALOHA, the time of transmission is continuous. Whenever a station has an available frame, it sends the frame. If there is collision and the frame is destroyed, the sender waits for a random amount of time before retransmitting it.

Whenever data is available for sending over a channel at stations, we use Pure Aloha. In pure Aloha, when each station transmits data to a channel without checking whether the channel is idle or not, the chances of collision may occur, and the data frame can be lost.



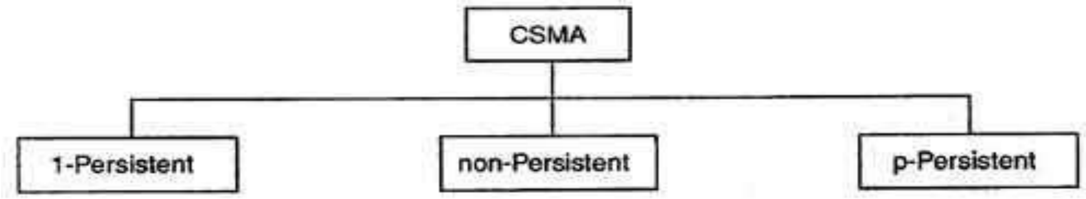
Frames in Pure ALOHA

When any station transmits the data frame to a channel, the pure Aloha waits for the receiver's acknowledgment. If it does not acknowledge the receiver end within the specified time, the station waits for a random amount of time, called the backoff time (Tb). And the station may assume the frame has been lost or destroyed. Therefore, it retransmits the frame until all the data are successfully transmitted to the receiver.

2. Slotted ALOHA: Slotted ALOHA reduces the number of collisions and doubles the capacity of pure ALOHA. The shared channel is divided into a number of discrete time intervals called **slots**. A station can transmit only at the beginning of each slot. However, there can still be collisions if more than one station tries to transmit at the beginning of the same time slot.

The slotted Aloha is designed to overcome the pure Aloha's efficiency because pure Aloha has a very high possibility of frame hitting. In slotted Aloha, the shared channel is divided into a fixed time interval called **slots**.

So that, if a station wants to send a frame to a shared channel, the frame can only be sent at the beginning of the slot, and only one frame is allowed to be sent to each slot. And if the stations are unable to send data to the beginning of the slot, the station will have to wait until the beginning of the slot for the next time. However, the possibility of a collision remains when trying to send a frame at the beginning of two or more station time slot.

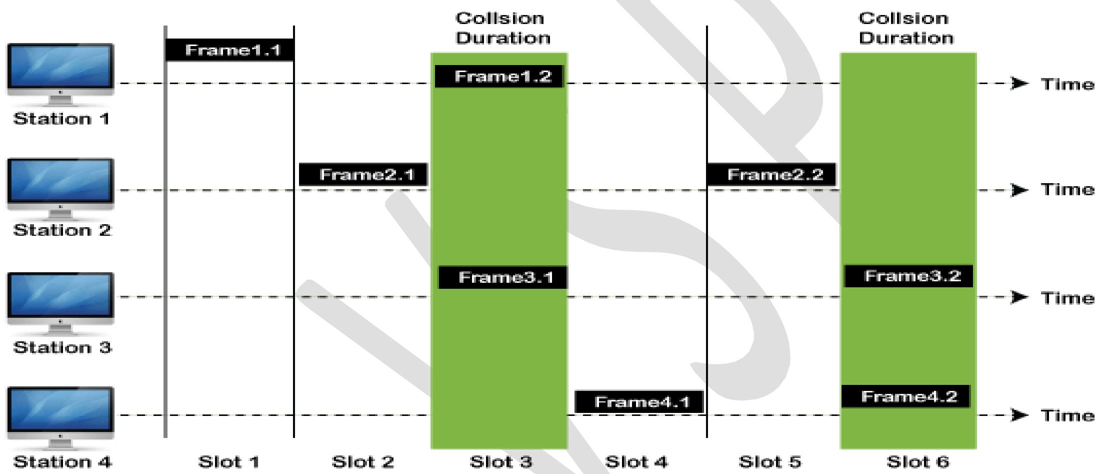


Types of CSMA

2. CSMA (Carrier Sense Multiple Access)

It is a **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.

CSMA Access Modes

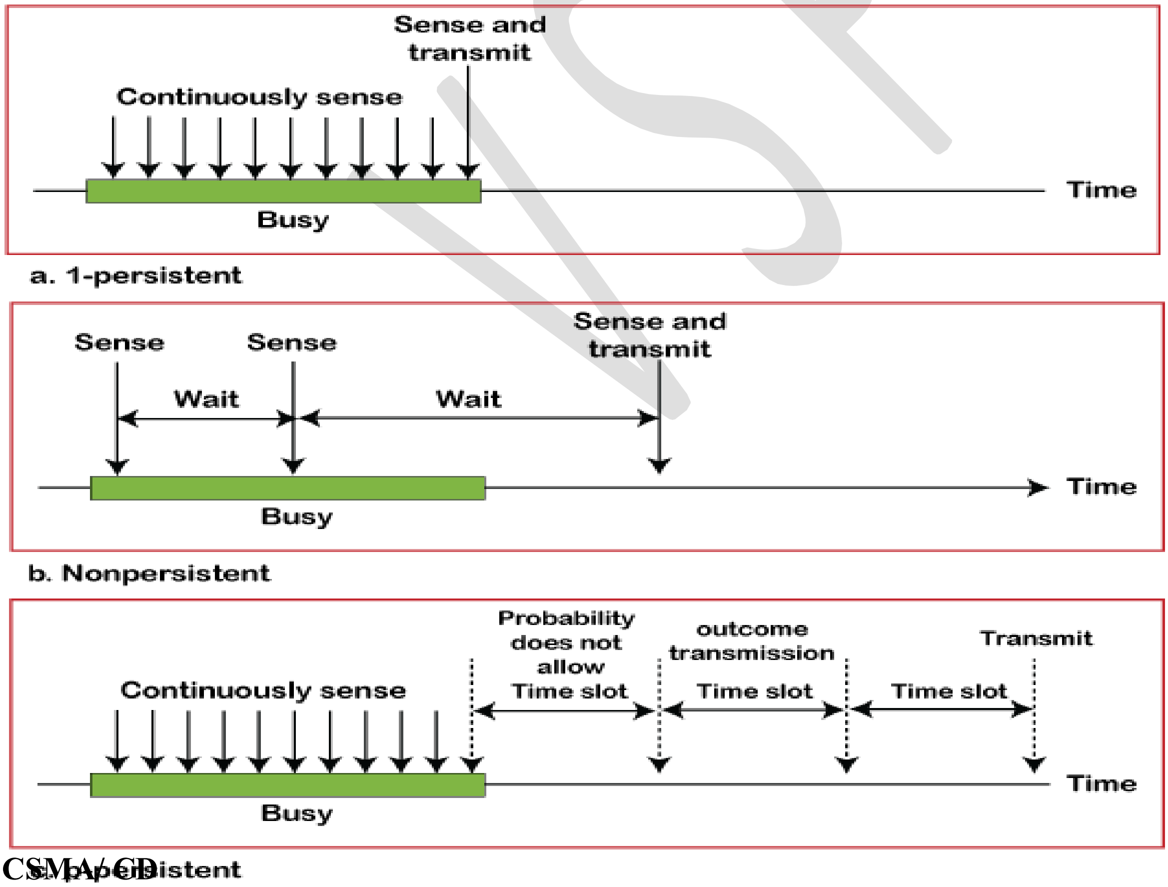


Frames in Slotted ALOHA

- **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.

- **2. 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.

- **3. 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.



3. CSMA/ CD

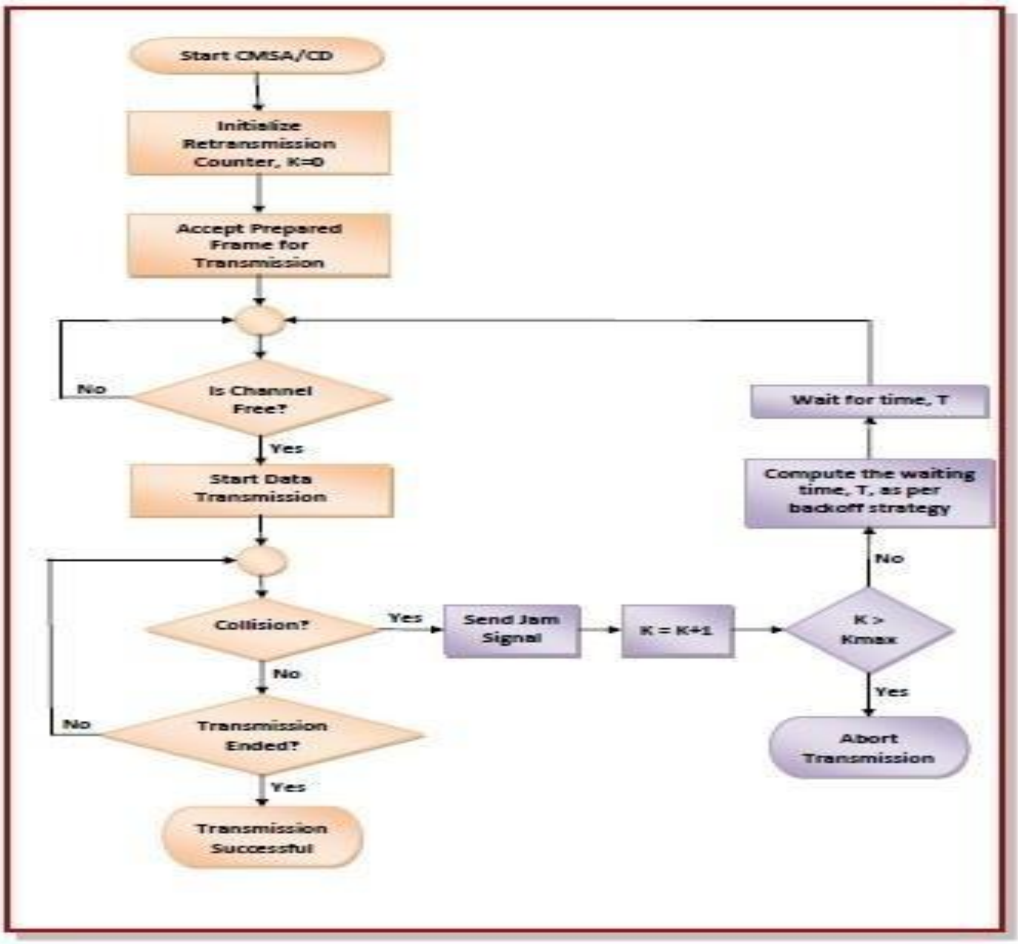
It is a **carrier sense multiple access/ collision detection** network protocol to transmit data frames. The CSMA/CD protocol works with a medium access control layer. Therefore, it first senses the shared channel before broadcasting the frames, and if the channel is idle, it transmits a frame to check whether the transmission was successful. If the frame is successfully received, the station sends another frame. If any collision is detected in the CSMA/CD, the station sends a jam/ stop signal to the shared channel to terminate data transmission. After that, it waits for a random time before sending a frame to a channel.

The algorithm of 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 algorithm of 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 backoff period which is generally a function of the number of collisions and restart main algorithm.

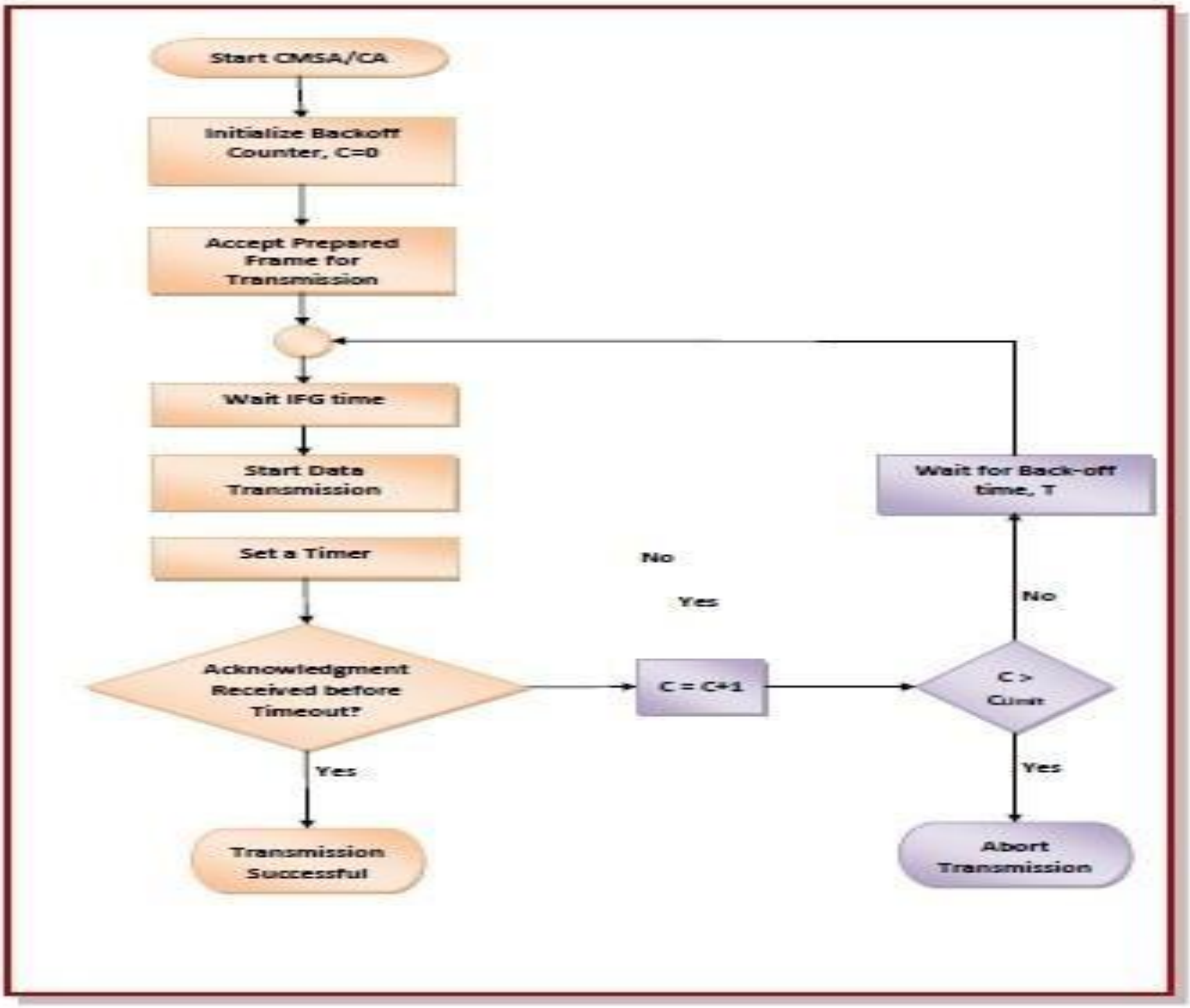


4. CSMA/ CA

It is a **Carrier Sense Multiple Access/Collision Avoidance** network protocol for carrier transmission of data frames. It is a protocol that works with a medium access control layer. When a data frame is sent to a channel, it receives an acknowledgment to check whether the channel is clear. If the station receives only a single (own) acknowledgments, that means the data frame has been successfully transmitted to the receiver. But if it gets two signals (its own and one more in which the collision of frames), a collision of the frame occurs in the shared channel. Detects the collision of the frame when a sender receives an acknowledgment signal.

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.



Comparison between CSMA / CD and CSMA / CA:

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.

Controlled access protocol:

In the Controlled access technique, all stations need to consult with one another in order to find out which station has the right to send the data.

- The controlled access protocols mainly grant permission to send only one node at a time; thus in order to avoid the collisions among the shared mediums.
- No station can send the data unless it has been authorized by the other stations.

The protocols lies under the category of Controlled access are as follows:

1. **Reservation**
2. **Polling**
3. **Token Passing**

Let us discuss each protocol one by one:

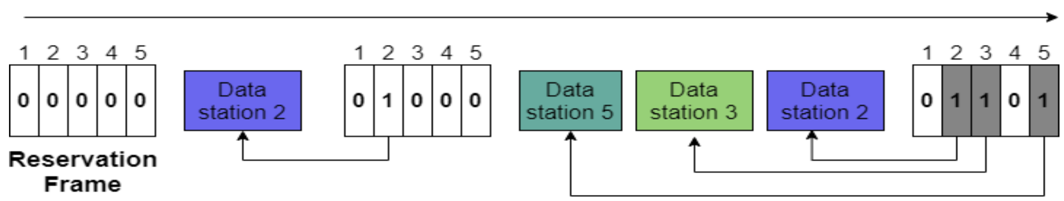
1. Reservation

In this method, a station needs to make a reservation before sending the data.

- Time is mainly divided into intervals.
- Also, in each interval, a reservation frame precedes the data frame that is sent in that interval.
- Suppose if there are **'N'** stations in the system in that case there are exactly **'N'** reservation minislots in the reservation frame; where each minislot belongs to a station.
- Whenever a station needs to send the data frame, then the station makes a reservation in its own minislot.
- Then the stations that have made reservations can send their data after the reservation frame.

Example

Let us take an example of 5 stations and a 5-minislot reservation frame. In the first interval, the station 2,3 and 5 have made the reservations. While in the second interval only station 2 has made the reservations.



2. Polling

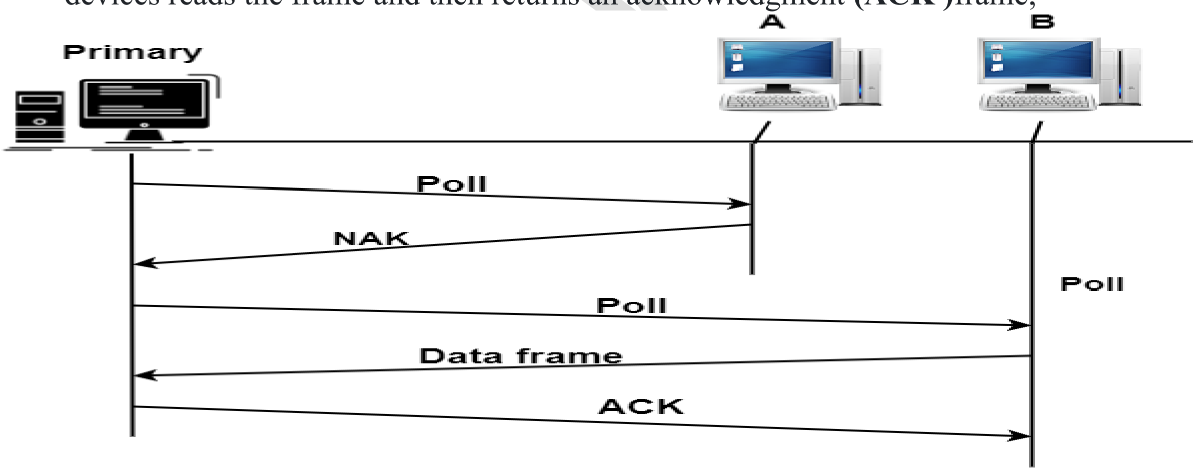
The polling method mainly works with those topologies where one device is designated as the primary station and the other device is designated as the secondary station.

- All the exchange of data must be made through the primary device even though the final destination is the secondary device.
- Thus to impose order on a network that is of independent users, and in order to establish one station in the network that will act as a controller and periodically polls all other stations is simply referred to as **polling**.
- The Primary device mainly controls the link while the secondary device follows the instructions of the primary device.
- The responsibility is on the primary device in order to determine which device is allowed to use the channel at a given time.
- Therefore the primary device is always an initiator of the session.

Poll Function

In case if primary devices want to receive the data, then it usually asks the secondary devices if they have anything to send. This is commonly known as **Poll Function**.

- There is a **poll function** that is mainly used by the primary devices in order to solicit transmissions from the secondary devices.
- When the primary device is ready to receive the data then it must **ask(poll)** each secondary device in turn if it has anything to send.
- If the secondary device has data to transmit then it sends the data frame, otherwise, it sends a **negative acknowledgment (NAK)**.
- After that in case of the negative response, the primary then polls the next secondary, in the same manner until it finds the one with the data to send. When the primary device received a positive response that means (a data frame), then the primary devices reads the frame and then returns an acknowledgment **(ACK)**frame,

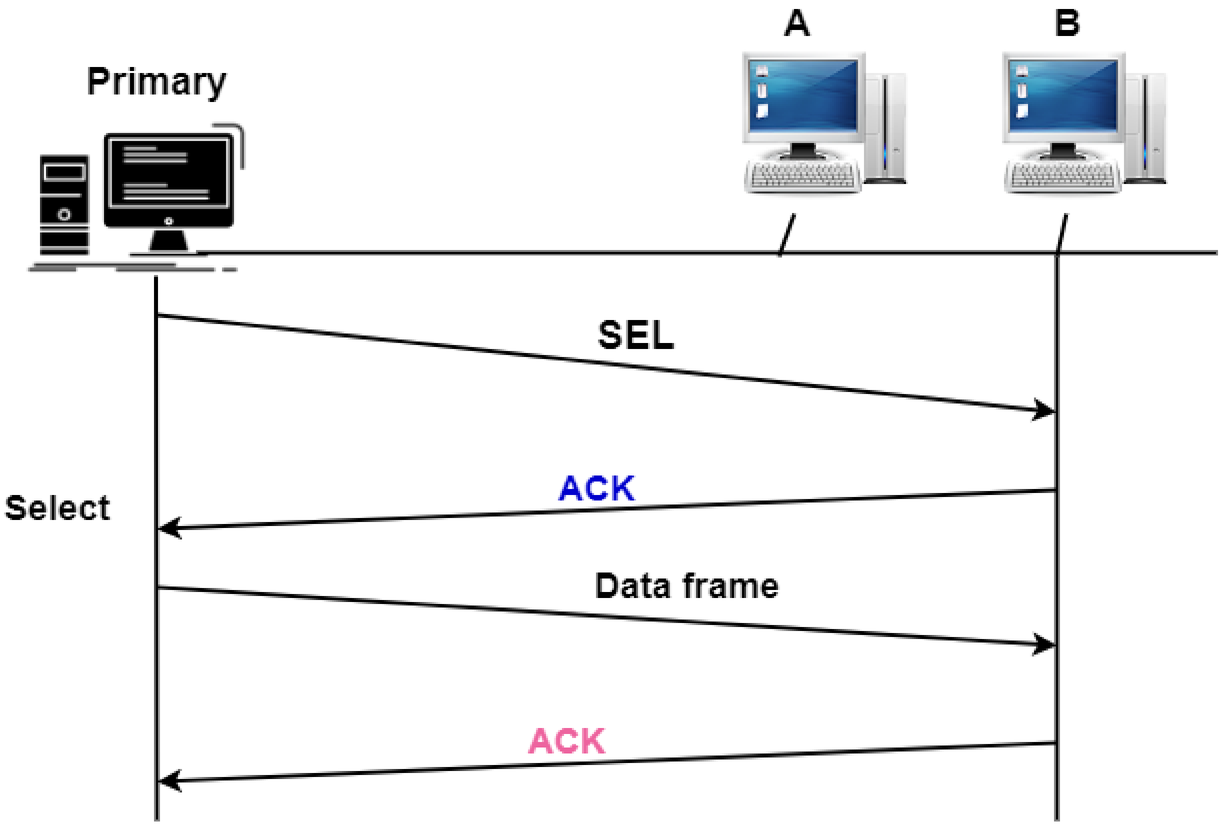


Select Function

In case, if the primary device wants to send the data then it tells the secondary devices in order to get ready to receive the data. This is commonly known as the **Select function**.

- Thus the **select function** is used by the primary device when it has something to send.
- We had already told you that the **primary device** always **controls the link.**

- Before sending the data frame, a select **(SEL) frame is** created and transmitted by the primary device, and one field of the SEL frame includes the address of the intended secondary.
- The primary device alerts the secondary devices for the upcoming transmission and after that wait for an acknowledgment (ACK) of the secondary devices.



Advantages of Polling

Given below are some benefits of the Polling technique:

1. The minimum and maximum access times and data rates on the channel are predictable and fixed.
2. There is the assignment of priority in order to ensure faster access from some secondary.

Drawbacks

There are some cons of the polling method and these are as follows:

- There is a high dependency on the reliability of the controller
- The increase in the turnaround time leads to the reduction of the data rate of the channel under low loads.

3. Token Passing

In the token passing methods, all the stations are organized in the form of a logical ring. We can also say that for each station there is a predecessor and a successor.

- The predecessor is the station that is logically before the station in the ring; while the successor is the station that is after the station in the ring. The station that is accessing the channel now is the **current station**.
- Basically, a special bit pattern or a small message that circulates from one station to the next station in some predefined order is commonly known as a **token**.
- Possessing the token mainly gives the station the right to access the channel and to send its data.
- When any station has some data to send, then it waits until it receives a token from its predecessor. After receiving the token, it holds it and then sends its data. When any station has no more data in order to send then it releases the token and then passes the token to the next logical station in the ring.
- Also, the station cannot send the data until it receives the token again in the next round.
- In Token passing, when a station receives the token and has no data to send then it just passes the token to the next station.
- The problem that occurs due to the Token passing technique is the duplication of tokens or loss of tokens. The insertion of the new station, removal of a station, also needs to be tackled for correct and reliable operation of the token passing technique.

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.

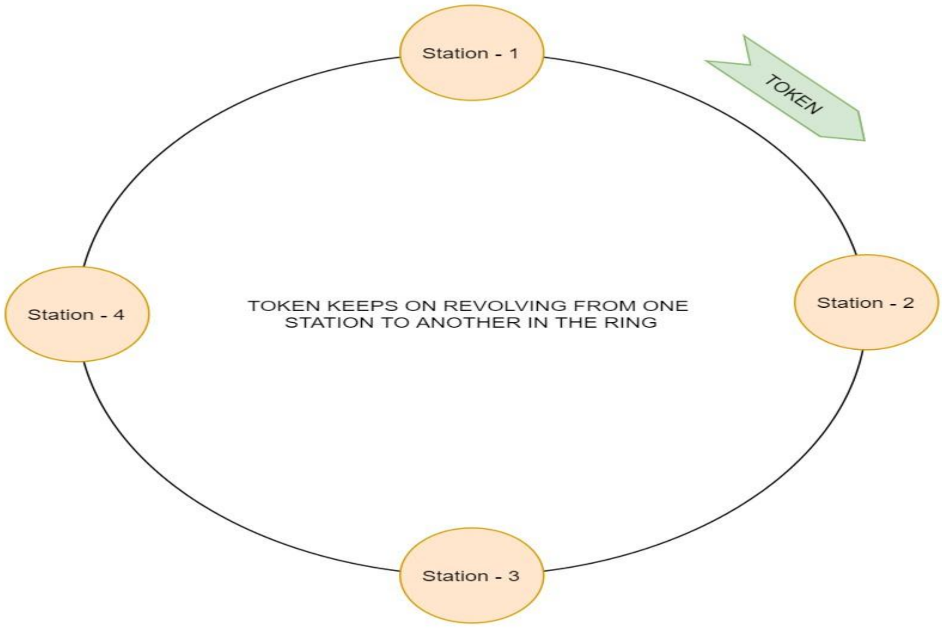
Throughput is a measure of the successful traffic in the communication channel.

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 its 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.



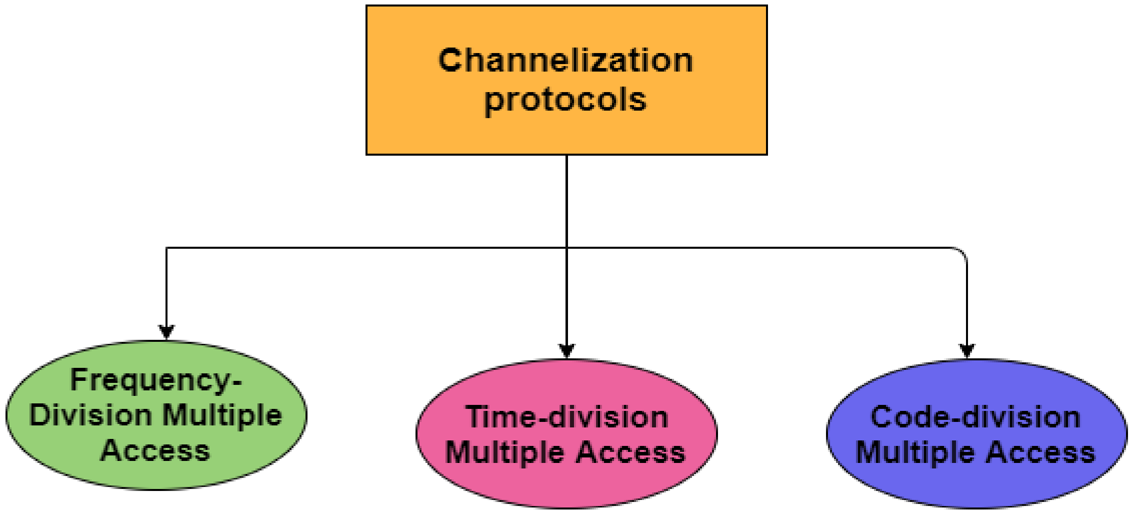
Note: It is important to note that A token can only work in that channel, for which it is generated, and not for any other.

Channelization protocols

Channelization is basically a method that provides the multiple-access and in this, the available bandwidth of the link is shared in time, frequency, or through the code in between the different stations.

Channelization Protocols are broadly classified as follows:

- FDMA(Frequency-Division Multiple Access)
- TDMA(Time-Division Multiple Access)
- CDMA(Code-Division Multiple Access)

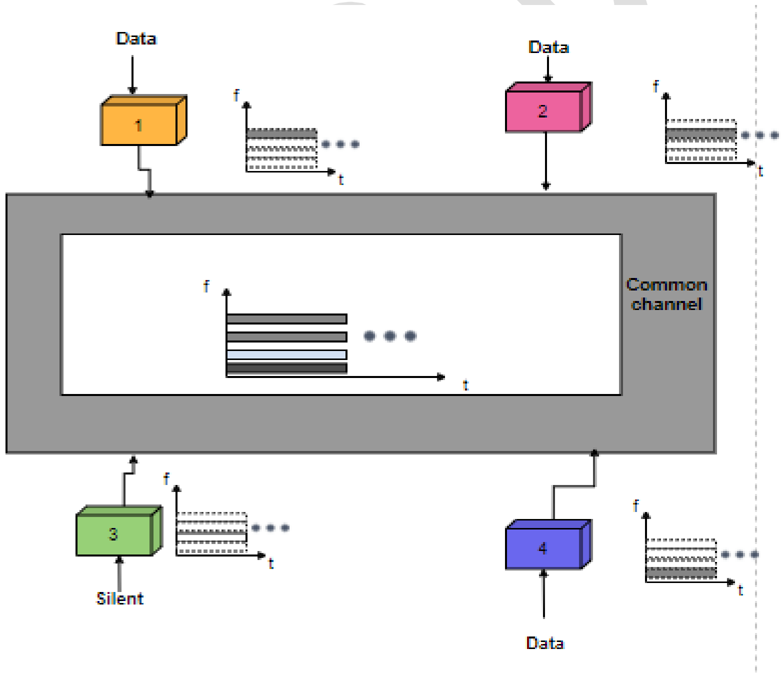


Let us discuss the above-given techniques one by one:

1. Frequency-Division Multiple Access

With the help of this technique, the available bandwidth is divided into frequency bands. Each station is allocated a band in order to send its data. Or in other words, we can say that each band is reserved for a specific station and it belongs to the station all the time.

- Each station makes use of the **bandpass filter** in order to confine the **frequencies of the transmitter.**
- In order to prevent station interferences, the allocated bands are separated from one another with the help of small **guard bands.**
- The Frequency-division multiple access mainly specifies a predetermined frequency for the entire period of communication.
- Stream of data can be easily used with the help of FDMA.



Advantages of FDMA

Given below are some of the benefits of using the FDMA technique:

This technique is efficient when the traffic is uniformly constant.

- In case if the channel is not in use then it sits idle.
- FDMA is simple algorithmically and the complexity is less.
- For FDMA there is no restriction regarding the type of baseband or the type of modulation.

Disadvantages of FDMA

- By using FDMA, the maximum flow rate per channel is fixed and small.

2. Time-Division Multiple Access

Time-Division Multiple access is another method to access the channel for shared medium networks.

- With the help of this technique, the stations share the bandwidth of the channel in time.
- A time slot is allocated to each station during which it can send the data.
- Data is transmitted by each station in the assigned time slot.
- There is a problem in using TDMA and it is due to TDMA the synchronization cannot be achieved between the different stations.
- When using the TDMA technique then each station needs to know the beginning of its slot and the location of its slot.
- If the stations are spread over a large area, then there occur propagation delays; in order to compensate this guard, times are used.
- The data link layer in each station mainly tells its physical layer to use the allocated time slot.

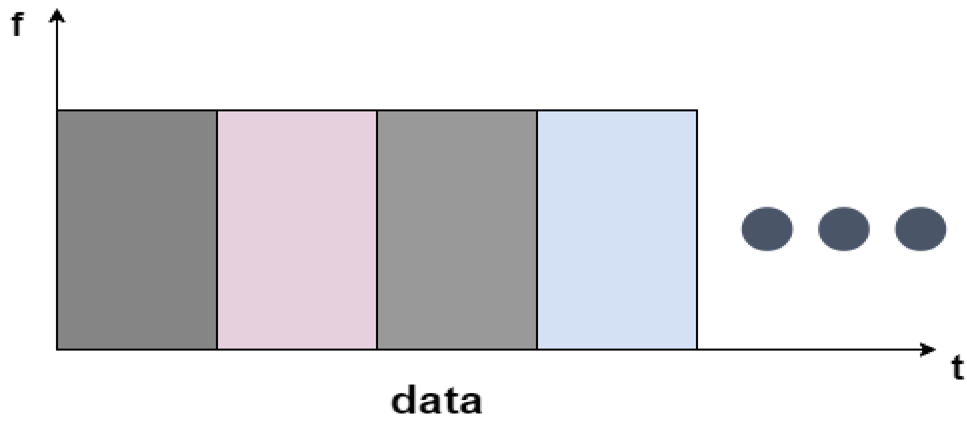


Figure: Time-Division media access.

Some examples of TDMA are as follows;

- personal digital Cellular(PDC)
- Integrated digital enhanced network.
- Universal terrestrial radio access(UTRA)

3. Code-Division Multiple Access

CDMA(code-division multiple access) is another technique used for channelization.

- CDMA technique differs from the FDMA because only one channel occupies the entire bandwidth of the link.
- The CDMA technique differs from the TDMA because all the stations can send data simultaneously as there is no timesharing.
- The CDMA technique simply means communication with different codes.
- In the CDMA technique, there is only one channel that carries all the transmission simultaneously.

- CDMA is mainly based upon the coding theory; where each station is assigned a code, Code is a sequence of numbers called chips.
- The data from the different stations can be transmitted simultaneously but using different code languages.

Advantages of CDMA

Given below are some of the advantages of using the CDMA technique:

- Provide high voice quality.
- CDMA operates at low power levels.
- The capacity of the system is higher than the TDMA and FDMA.
- CDMA is better cost-effective.

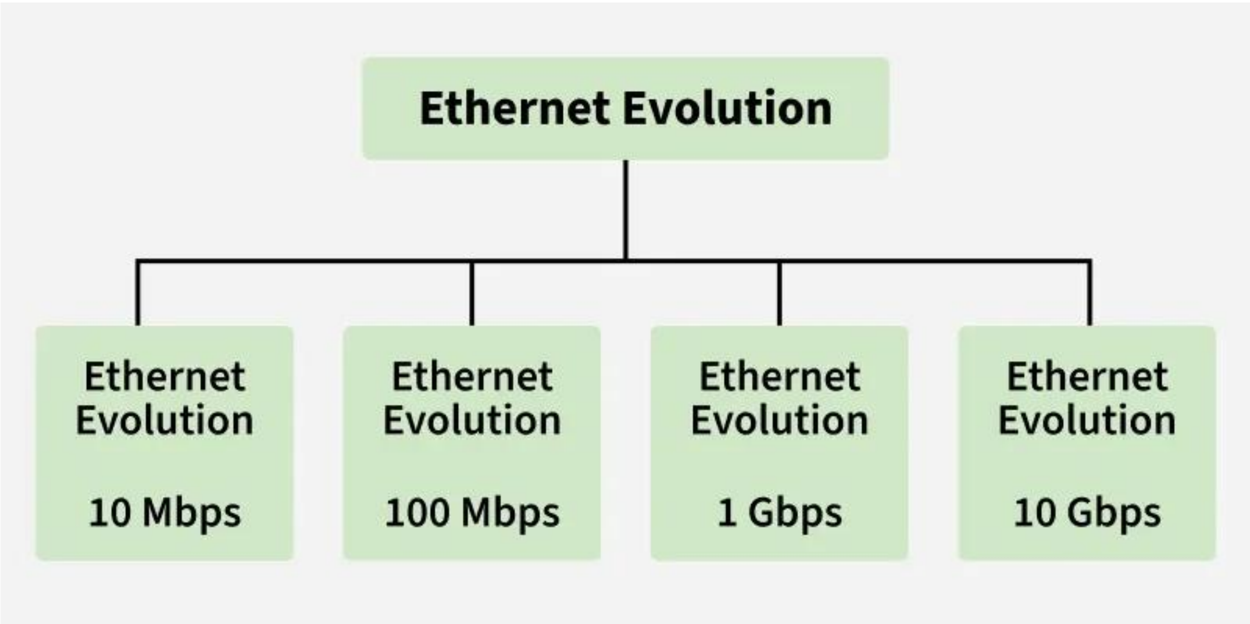
Ethernet

A Local Area Network (LAN) is a high-speed data communication system interconnecting devices within a limited scope such as offices or campuses. While LANs may use wired or wireless media, Ethernet (IEEE 802.3) dominates as the primary wired LAN standard. It provides standardized framing, efficient media access control, and scalable physical layer options, enabling reliable communication from 10 Mbps to multi-hundred-gigabit speeds.

Evolution of Ethernet

Ethernet was invented by Robert Metcalfe in 1973, initially offering a data rate of 2.94 Mbps.

- **1982:** Ethernet Version 2 standardized with 10 Mbps.
- **1983:** IEEE 802.3 standardization accelerated adoption.
- Over time, Ethernet evolved to support 100 Mbps (Fast Ethernet), 1 Gbps (Gigabit Ethernet), 10 Gbps, 40 Gbps, 100 Gbps, and even 400 Gbps.



Types of Ethernet

1. Fast Ethernet

- **Speed:** 100 Mbps
- **Media:** Twisted pair (CAT5) and fiber optic cables
- **Variants:** 100BASE - TX, 100BASE - FX, 100BASE - T4

2. Gigabit Ethernet

- **Speed:** 1 Gbps (1000 Mbps)
- **Media:** CAT5e, CAT6, and fiber optic cables
- Common in modern office and home networks

3. 10 - Gigabit Ethernet

- **Speed:** 10 Gbps
- **Media:** CAT6a, CAT7, and fiber optic cables
- Supports long distances (up to 10 km with fiber)
- Widely used in data centers and enterprise backbones

4. Switch Ethernet

- Uses network switches for dedicated connections
- Each device gets a separate collision domain
- Supports speeds from 10 Mbps to 10 Gbps

Key Features of Ethernet

- **Speed:** Supports from 10 Mbps to 400 Gbps.
- **Reliability:** Error detection ensures accurate data transfer.
- **Cost - effectiveness:** Inexpensive and widely available.
- **Interoperability:** Standardized under IEEE 802.3, ensuring compatibility.
- **Security:** Supports encryption and authentication mechanisms.
- **Scalability:** Easily accommodates additional devices.
- **Broad compatibility:** Works seamlessly with protocols like TCP/IP, HTTP, FTP.

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