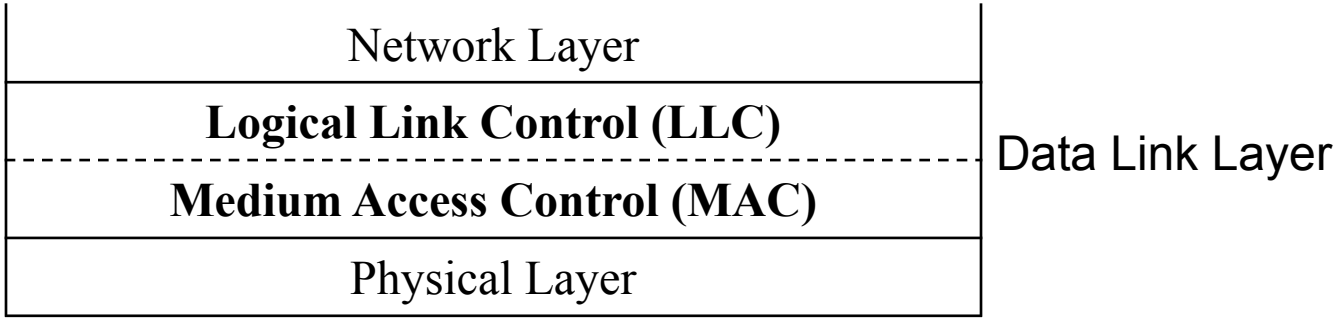
Medium Access Control Sublayer

Introduction

- In broadcast networks, several stations share a single communication channel.
- The major issue in these networks is, which station should transmit data at a given time.
- This process of deciding the turn of different stations is known as **Channel Allocation**.
- To coordinate the access to the channel, **multiple access** protocols are required.
- All these protocols belong to the MAC sublayer.

Introduction



- Data Link layer is divided into two sublayers:
  - Logical Link Control (LLC)
  - Medium Access Control (MAC)
- **LLC** is responsible for error control & flow control.
- **MAC** is responsible for multiple access resolutions.

Channel Allocation Problem

- In broadcast networks, single channel is shared by several stations.
- This channel can be allocated to only one transmitting user at a time.
- There are two different methods of channel allocations:
  - Static Channel Allocation
  - Dynamic Channel Allocation

Static Channel Allocations

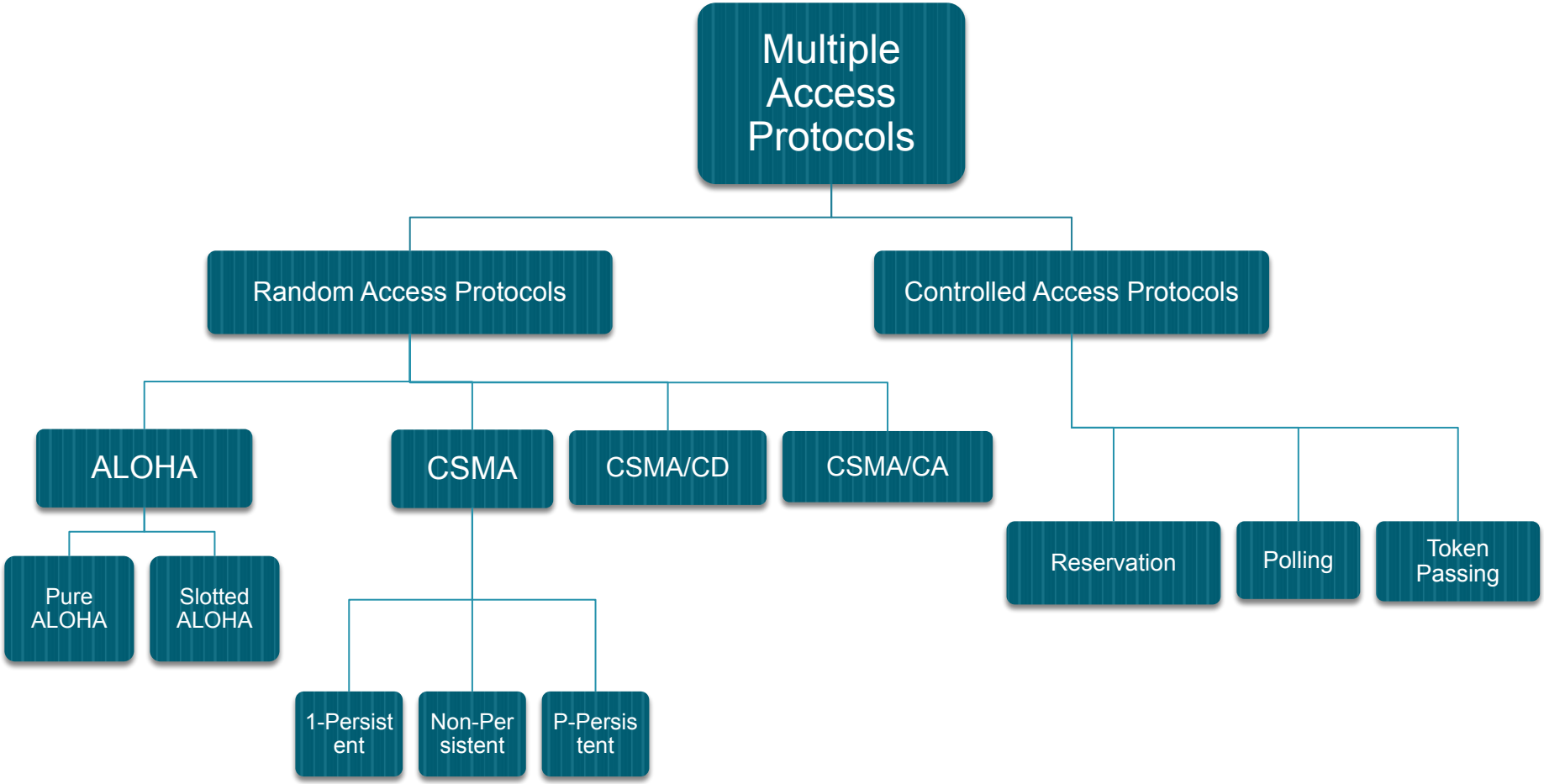
- In this method, a single channel is divided among various users either on the basis of frequency or on the basis of time.
- It either uses FDM (Frequency Division Multiplexing) or TDM (Time Division Multiplexing).
- In FDM, fixed frequency is assigned to each user, whereas, in TDM, fixed time slot is assigned to each user.

Dynamic Channel Allocation

- In this method, no user is assigned fixed frequency or fixed time slot.
- All users are dynamically assigned frequency or time slot, depending upon the requirements of the user.

Multiple Access Protocols

- Many protocols have been defined to handle the access to shared link.
- These protocols are organized in two different groups.:
  - Random Access Protocols
  - Controlled Access Protocols


Multiple Access Protocols
Random Access Protocols
Controlled Access Protocols
ALOHA
CSMA
CSMA/CD
CSMA/CA
Pure ALOHA
Slotted ALOHA
1-Persistent
Non-Persistent
P-Persistent
Reservation
Polling
Token Passing

Random Access Protocols

- It is also called **Contention Method**.
- In this method, there is no control station.
- Any station can send the data.
- The station can make a decision on whether or not to send data. This decision depends on the state of the channel, i.e. channel is busy or idle.
- There is no scheduled time for a stations to transmit. They can transmit in random order.

Random Access Protocols

- There is no rule that decides which station should send next.
- If two stations transmit at the same time, there is collision and the frames are lost.
- The various random access methods are:
  - ALOHA
  - CSMA (Carrier Sense Multiple Access)
  - CSMA/CD (Carrier Sense Multiple Access with Collision Detection)
  - CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance)

ALOHA

- ALOHA was developed at University of Hawaii in early 1970s by Norman Abramson.
- It was used for ground based radio broadcasting.
- In this method, stations share a common channel.
- When two stations transmit simultaneously, collision occurs and frames are lost.
- There are two different versions of ALOHA:
  - Pure ALOHA
  - Slotted ALOHA

Pure ALOHA

- In pure ALOHA, stations transmit frames whenever they have data to send.
- When two stations transmit simultaneously, there is collision and frames are lost.
- In pure ALOHA, whenever any station transmits a frame, it expects an acknowledgement from the receiver.
- If acknowledgement is not received within specified time, the station assumes that the frame has been lost.

Pure ALOHA

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

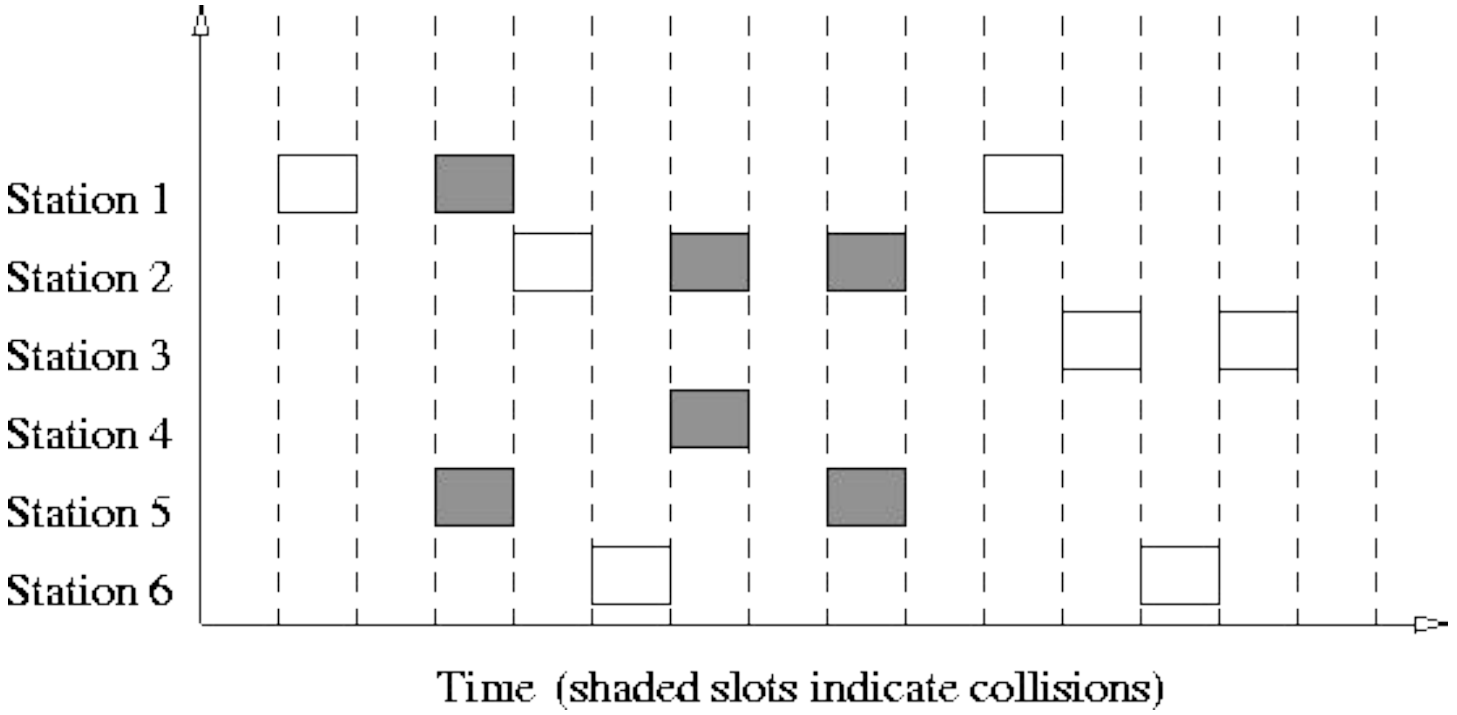
Pure ALOHA


Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Time (shaded slots indicate collisions)

Slotted ALOHA

- Slotted ALOHA was invented to improve the efficiency of pure ALOHA.
- In slotted ALOHA, time of the channel is divided into intervals called slots.
- The station can send a frame only at the beginning of the slot and only one frame is sent in each slot.
- 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 next time slot.
- There is still a possibility of collision if two stations try to send at the beginning of the same time slot.

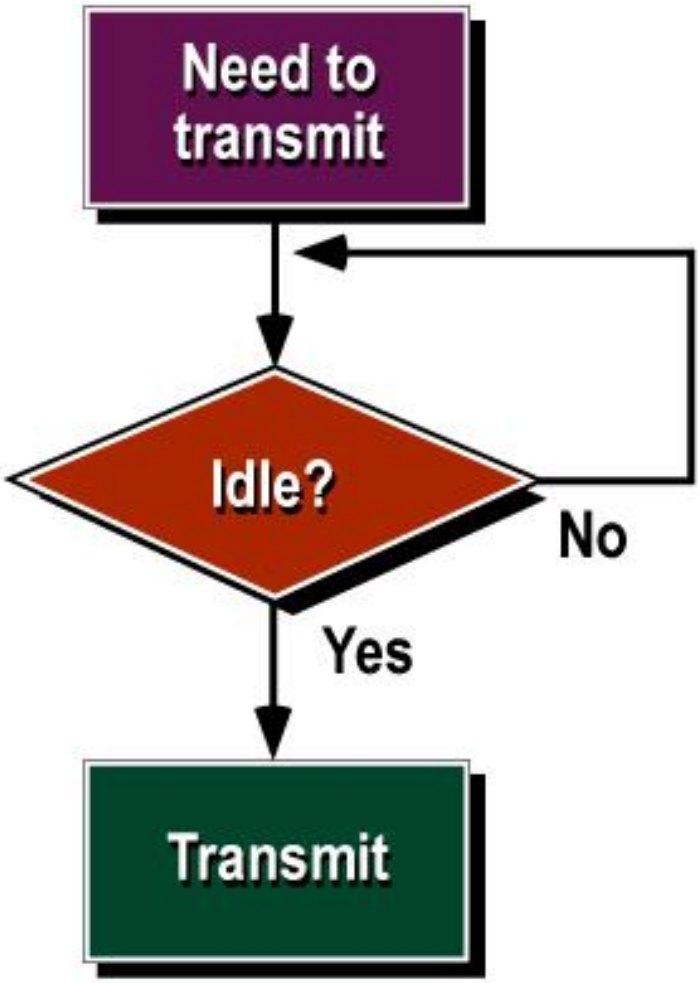
Slotted ALOHA



Carrier Sense Multiple Access (CSMA)

- CSMA was developed to overcome the problems of ALOHA i.e. to minimize the chances of collision.
- CSMA is based on the principle of "carrier sense".
- The station sense the carrier or channel before transmitting a frame.
- It means the station checks whether the channel is idle or busy.
- The chances of collision reduces to a great extent if a station checks the channel before

Carrier Sense Multiple Access (CSMA)



Carrier Sense Multiple Access (CSMA)

- The chances of collision still exists because of propagation delay.
- The frame transmitted by one station takes some time to reach the other station.
- In the meantime, other station may sense the channel to be idle and transmit its frames.
- This results in the collision.

Carrier Sense Multiple Access (CSMA)

- There are three different types of CSMA protocols:
  - 1-Persistent CSMA
  - Non-Persistent CSMA
  - P-Persistent CSMA

1-Persistent CSMA

- In this method, station that wants to transmit data, continuously senses the channel to check whether the channel is idle or busy.
- If the channel is busy, station waits until it becomes idle.
- When the station detects an idle channel, it immediately transmits the frame.
- This method has the highest chance of collision because two or more stations may find channel to be idle at the same time and transmit their frames.

Non-Persistent CSMA

- A station that has a frame to send, senses the channel.
- If the channel is idle, it sends immediately.
- If the channel is busy, it waits a random amount of time and then senses the channel again.
- It reduces the chance of collision because the stations wait for a random amount of time .
- It is unlikely that two or more stations will wait for the same amount of time and will retransmit at the same time.

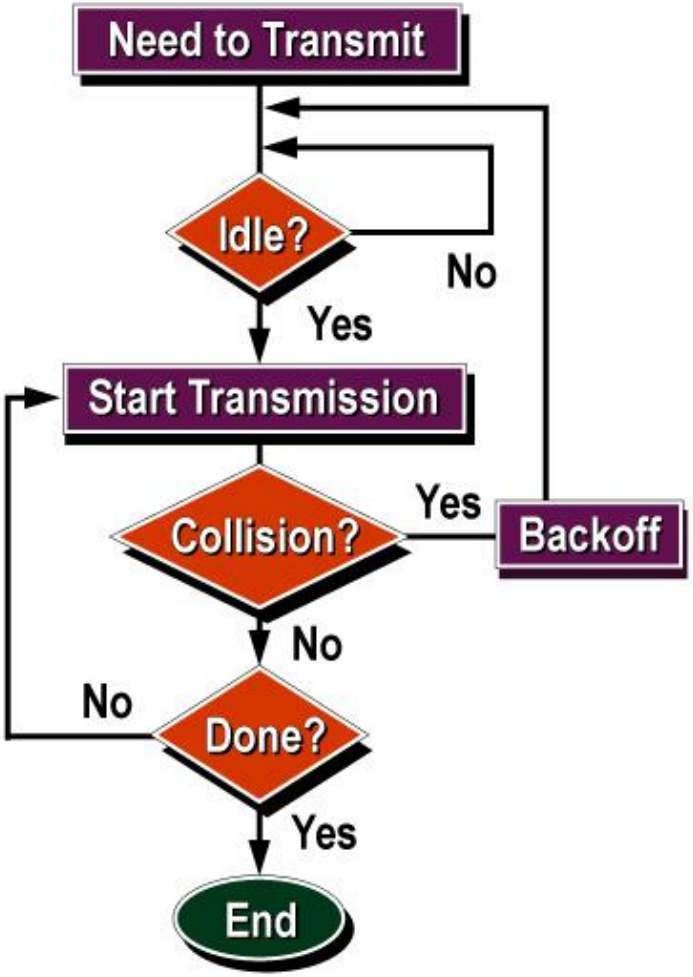
P-Persistent CSMA

- In this method, the channel has time slots such that the time slot duration is equal to or greater than the maximum propagation delay time.
- When a station is ready to send, it senses the channel.
- If the channel is busy, station waits until next slot.
- If the channel is idle, it transmits the frame.
- It reduces the chance of collision and improves the efficiency of the network.

CSMA with Collision Detection (CSMA/CD)

- In this protocol, the station senses the channel before transmitting the frame. If the channel is busy, the station waits.
- Additional feature in CSMA/CD is that the stations can detect collisions.
- The stations abort their transmission as soon as they detect collision.
- This feature is not present in CSMA.
- The stations continue to transmit even though they find that collision has occurred.

CSMA with Collision Detection (CSMA/CD)



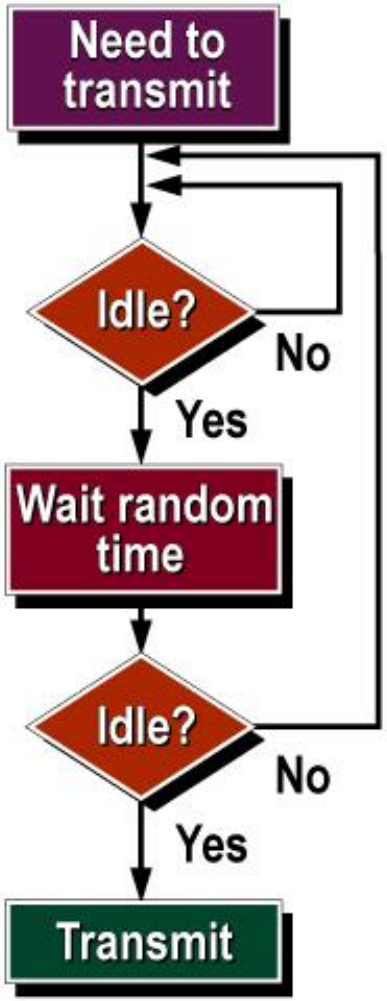
CSMA with Collision Detection (CSMA/CD)

- In CSMA/CD, the station that sends its data on the channel, continues to sense the channel even after data transmission.
- If collision is detected, the station aborts its transmission and waits for a random amount of time & sends its data again.
- As soon as a collision is detected, the transmitting station release a ***jam*** signal.
- Jam signal alerts other stations. Stations are not supposed to transmit immediately after the collision has occurred.

CSMA with Collision Avoidance (CSMA/CA)

- This protocol is used in wireless networks because they cannot detect the collision.
- So, the only solution is collision avoidance.
- It avoids the collision by using three basic techniques:
  - Interframe Space
  - Contention Window
  - Acknowledgements

CSMA with Collision Avoidance (CSMA/CA)



Interframe Space

- Whenever the channel is found idle, the station does not transmit immediately.
- It waits for a period of time called Interframe Space (IFS).
- When channel is sensed idle, it may be possible that some distant station may have already started transmitting.
- Therefore, the purpose of IFS time is to allow this transmitted signal to reach its destination.
- If after this IFS time, channel is still idle, the station can send the frames.

Contention Window

- Contention window is the amount of time divided into slots.
- Station that is ready to send chooses a random number of slots as its waiting time.
- The number of slots in the window changes with time.
- It means that it is set of one slot for the first time, and then doubles each time the station cannot detect an idle channel after the IFS time.
- In contention window, the station needs to

Acknowledgment

- Despite all the precautions, collisions may occur and destroy the data.
- Positive acknowledgement and the time-out timer helps guarantee that the receiver has received the frame.

Controlled Access Protocol

- In this method, the stations consult each other to find which station has a right to send.
- A station cannot send unless it has been authorized by other station.
- The different controlled access methods are:
  - Reservation
  - Polling
  - Token Passing

Reservation

- In this method, a station needs to make a reservation before sending data.
- The time is divided into intervals. In each interval, a reservation frame precedes the data frames sent in that interval.
- If there are N stations, then there are exactly N reservation slots in the reservation frame.
- Each slot belongs to a station.
- When a station needs to send a frame, it makes a reservation in its own slot.
- The stations that have made reservations can send their frames after the reservation frame.

Polling

- Polling method works in those networks where primary and secondary stations exist.
- All data exchanges are made through primary device even when the final destination is a secondary device.
- Primary device controls the link and secondary device follow the instructions.

Token Passing

- Token passing method is used in those networks where the stations are organized in a logical ring.
- In such networks, a special packet called token is circulated through the ring.
- Station that possesses the token has the right to access the channel.
- Whenever any station has some data to send, it waits for the token. It transmits data only after it gets the possession of token.
- After transmitting the data, the station releases the token and passes it to the next station in th ring.
- If any station that receives the token has no data to send, it simply passes the token to the next station in the ring.