802.11 Services : 802.11 standard defines the following services.

(a) Association Service : This service is used by the mobile stations to connect themselves to APs. (Access Point)

(b) Reassociation service : This service lets a station change its preferred AP.

(c) Dissociate service : It is used to break the relationship b/w station and AP.

(d) Authentication : Stations must authenticate before they can send frames via the AP. There are two schemes for authentication :- They are:

- WEP (Wired Equipment Privacy) : In this scheme, authentication is done with a pre shared key before association
- WPA2 (Wi-Fi Protected Access 2) : AP will talk to an authentication server that has a username and password database to determine if the station is allowed to access the N/w.

(e) Distribution service : Once the frames reach the AP, this service determines how to route them.

- If the destination is local to the AP, the frames can be sent out directly over the air.
- Otherwise, they will have to be forwarded.

(f) Integration service : This service handles any translation that is needed for a frame to be sent outside the 802-11 LAN, or to arrive from outside the 802-11 LAN.

(g) Delivery Service : This service allow stations to transmit & receive data using the protocols.

(h) Privacy service : 802-11 is not guaranteed to be reliable. It must deal with detecting & correcting errors

- For information sent over a wireless LAN to be kept confidential, it must be encrypted.
- This service manages the details of encryption & decryp
- The encryption Alg is based on AES (Advanced Encryption Standard).

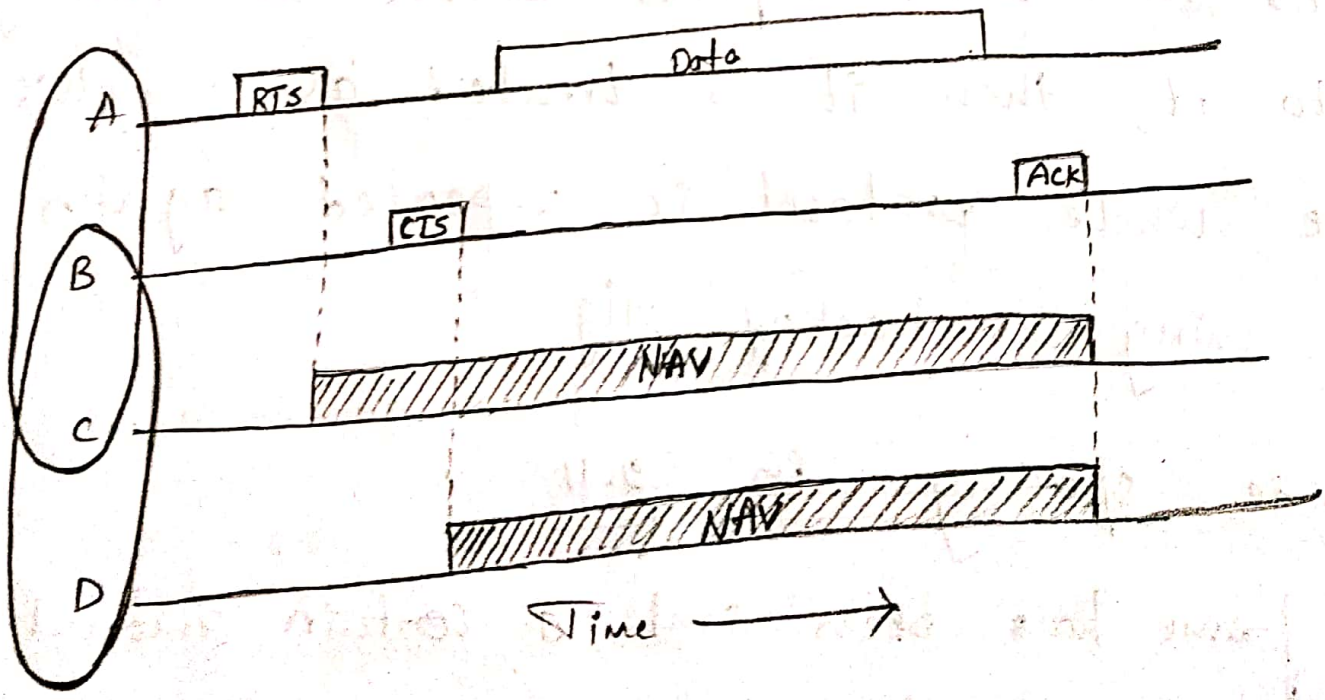
(i) QoS traffic Scheduling service : This service handles the traffic with different priorities.

(j) Transmit power control service : This service gives stations the information they need to meet regulatory limits on transmit power that vary from region to region.

(k) Dynamic frequency selection service : It gives the stations information they need to transmit on different frequencies

802.11 MAC Sublayer Protocol :

- To overcome hidden terminal problem and exposed terminal problem, 802.11 defines channel sensing to consist of both physical sensing & virtual sensing.
- With physical sensing, each station checks the medium to see if there is a valid signal.
- With virtual sensing, each station keeps a logical record of when the channel is in use by tracking the NAV (Network Allocation Vecto
- NAV field indicates that the channel will be busy for the period indicated by NAV.
- RTS/CTS mechanism is also used along with the NAV field.

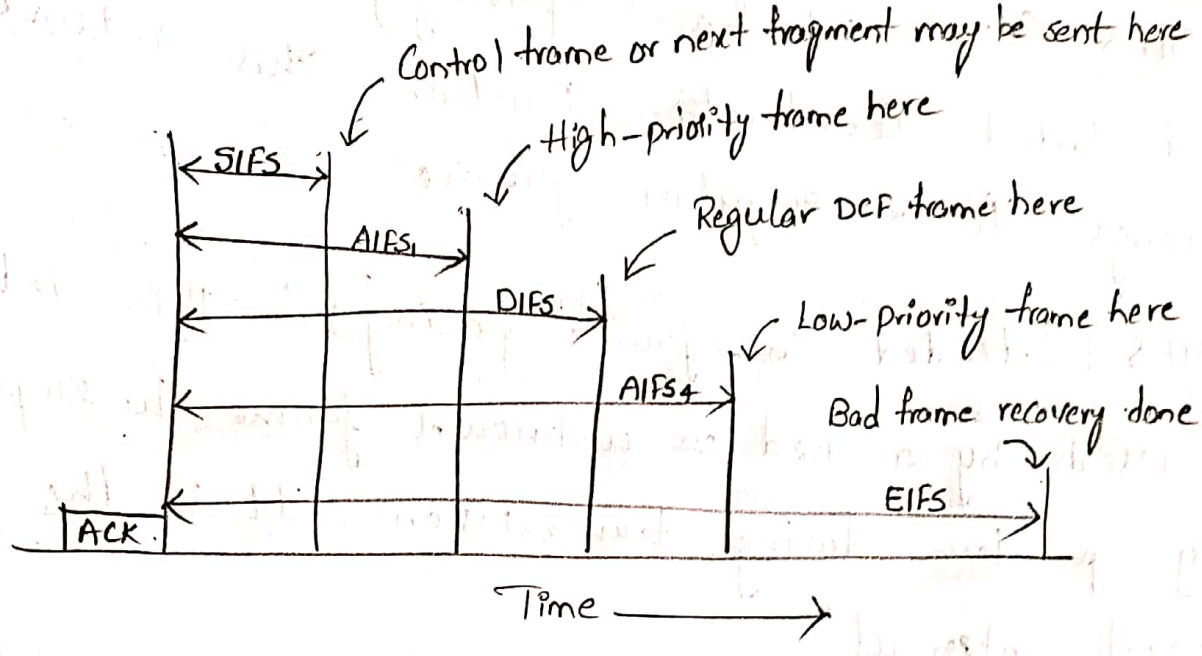


Virtual channel sensing using CSMA/CA

- In the above example, C is a station with range of A, also within range of B, D is station within range of B but not within range of A.
- Now consider that A wants to send to B.
- Then A sends an RTS frame to B to request permission to send it a frame.
- When B receives RTS, it answers with a CTS frame to indicate that the channel is clear to send.
- When A receives CTS frame, it sends its frame and starts an ACK timer.
- When B receives the data, it responds with an ACK frame.
- If A's ACK timer expires before the ACK gets back to it, then it is treated as a collision & the whole protocol is repeated again after using a backoff Alg.

Interframe spacing in 802.11

- After a frame has been sent, a certain amount of idle time is required before any station may send a frame to check that the channel is no longer in use.
- The different time intervals for diff kinds of frames is as follows.



Interframe Spacing in 802.11

- Five intervals are shown in the above diagram.

(a) SIFS (Short Interframe Spacing): It is the shortest interval. This interval belongs to a control frame. (ex- CTS, RTS).

(b) AIFS (Arbitration Interframe Spacing): In AIFS, two intervals are included for two different priority level.
- $AIFS_1$ is smaller than DIFS but longer than SIFS. $AIFS_1$ belongs to high-priority frames.
- $AIFS_4$ is larger than DIFS. It belongs to low-priority frames.

(c) DIFS : (DCF Interframe Spacing): DCF means Distributed Coordination Function. This interval belongs to a regular frame.

(d) EIFS (Extended Interframe Spacing) : This interval is used by a bad or unknown frame, to report any problem during transmission. It is the largest interval.

Ethernet (802.3).

- There are two kinds of Ethernet. They are:-

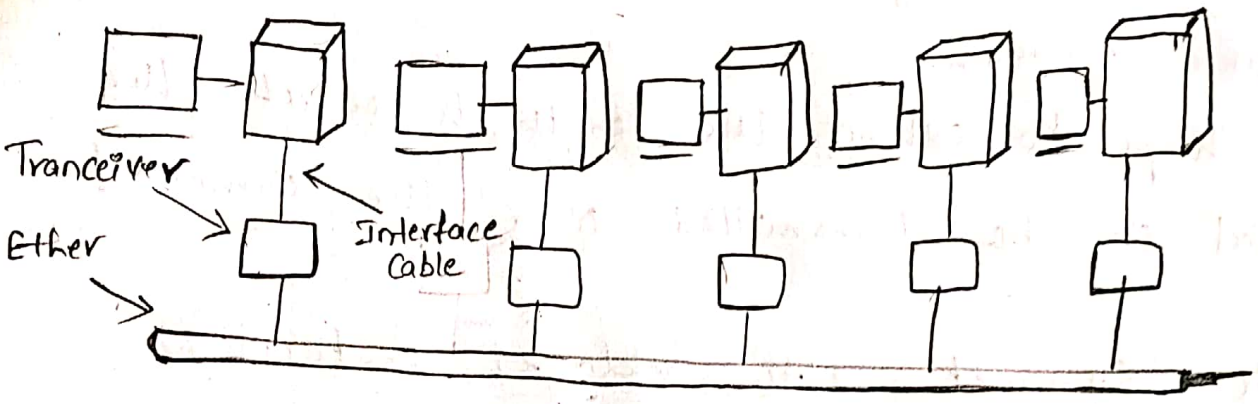
Classic Ethernet : It solves the multiple acces problem. Speed rate: 3 to 10 Mbps

Switched Ethernet :- In this, devices called switches are used to connect different computers.

Speed rate - 100 Mbps called Fast Ethernet
1000 Mbps called Gigabit .
10,000 Mbps called 10-gigabit .

Classic Ethernet Physical Layer :-

- There are two kinds of classic Ethernet. They are:- Thick Ethernet and Thin Ethernet.



Architecture of Classic Ethernet

Thick Ethernet	Thin Ethernet
- It uses thick cable for interconnection	- It uses thinner coaxial cable.
- It is also called Thicknet	- It is also called Thinnet
- It is called 10Base5	- It is called 10Base2
transmission speed = 10 Mbits/sec	- ~~It is called~~ transmission speed = 10 Mbits/s
Cable length = 500 m	Cable length = 200 m

Repeater: To allow larger Networks, multiple cables can be connected by repeaters.

It is a physical layer device that receives, regenerates and retransmits signals in both directions.

- It regenerates the signal over the same n/w.

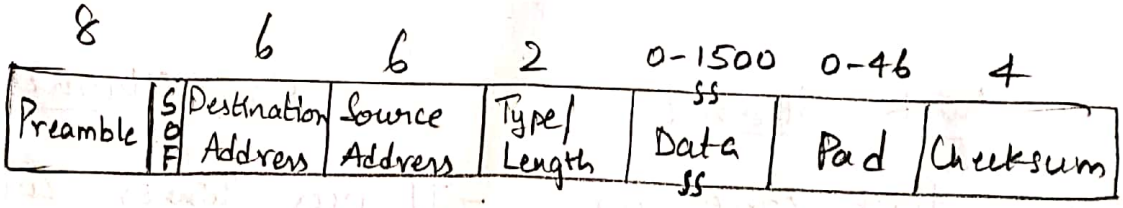
When the signal becomes weak, repeater copies the

the signal bit by bit & regenerate it to its original strength.

- It helps to extend the length to which the signal can be transmitted over the same n/w.

Classic Ethernet MAC Sublayer Protocol

802.3 Frame Format :



- Preamble : This is seven bytes long & it consists of a pattern of alternating one's & zero's, this informs the receiving stations that a frame is starting as well as enabling synchronization.
- SOF (Start of Frame delimiter) : This consists of one byte & contains and alternating pattern of one's & zero's but ending in two ones. The last two 1 bits tell the receiver that the rest of the frame is about to start

Destination address : It is 6 bytes long. This field contains the address of station for which the data is to be sent. The left most bit indicates whether the destination address is an individual address or group address.

- An individual address is denoted by zero, group address is denoted by one.
- the next bit in DA indicates whether the address is globally administered or local.
- If the address is globally administered, the bit is zero locally administered, the bit is one.
- The remaining 46 bits are used for DA.

Source address : It is 6 bytes long. It is the address of sending station. As it is always an individual address, the left most bit is always a zero

Type :- It is 2 bytes long. It indicates the frame type.

Data & pad : It contains the data, it may be upto 1500 bytes long. If the data is above 1500 byte then padding field is used for more data.

Checksum. It is 4 bytes long. It contains a 32-bit CRC.

CSMA/CD with Binary Exponential Alg:

- It is used to schedule retransmissions after collision.
- If a collision takes place b/w 2 stations they may restart transmission as soon as they can after the collision.
- This will always lead to another collision and form an infinite loop of collisions leading to a collision.
- To prevent this, backoff Alg is used.

Backoff Alg:

The stations involved in collision randomly pick an integer from the set k ie., {0, 1}. This set is called the contention window.

If the stations collide again bcz they picked the same integer, the contention window size is doubled & it becomes {0, 1, 2, 3}.

Now the stations involved in second collision randomly pick an integer from the set {0, 1, 2, 3} & wait that number of time slots before trying again.

Before they try to transmit, they listen to the channel & transmit only if the channel is idle.
- This causes the station which picked the smallest integer in the contention window to succeed in transmitting its frame.
- So, Backoff alg defines a waiting time for the stations involved in collision ie., for how much time the station should wait to re-transmi

Fast Ethernet :

- The ethernet whose speed is 100 Mbit/s, it is called as Fast ethernet.
- It belongs to IEEE 802.u standard.
- It consists of three sub-standards. They are:-

(a) 100Base-T4 :-

- It uses four pairs of category 3 UTP cables.
- Two of the four pairs are bi-directional the other two pairs are unidirectional.
- Of the four pairs, one is always to the hub, one is always from the hub and other two are switchable to the current transmission direction. (sending, receiving)
- Cable length is less than 100m.

Gigabit Ethernet:

- The ethernet whose speed is 1000 Mbits/s, it is called as Gigabit Ethernet.
- It belongs to IEEE 802.3 ab/z standard.
- It supports two different modes. They are:-
  - Full - duplex mode
  - Half - duplex mode

Full - duplex mode: In this configuration, there is a central switch connected to computers.
- All lines are buffered so that each computer and switch is free to send frames whenever it wants.

The sender does not have to sense the channel to see if anybody else is using it, hence CSMA/CD protocol is not used.

Half - duplex mode:

It is used when the computers are connected to a hub rather than a switch.

A hub does not buffer the incoming frames. In this mode, collisions are possible. So, CSMA/CD protocol is required.

It consists of four sub-standards.

(a) 1000 Base - SX:

- It uses Fiber optic cable which is a multimode fiber.
- The cable length is maximum 550 m.

(b) 1000 Base - LX:

- It uses Fiber optic cable which may be single mode or multimode.
- The cable length is maximum 5000 m.

(c) 1000 Base - CX:

- It uses 2 pairs of STP cables.
- The cable length is maximum 25 m.

(d) 1000 Base - T:

- It uses 4 pairs of category 5 UTP cables.
- The cable length is maximum 100 m.

10 - Gigabit Ethernet:

Ethernet whose speed is 10,000 Mbit/s, it is known as 10 - Gigabit Ethernet.

It supports only full-duplex operation.

So CSMA/CD is not used.

- It consists of 5 sub-standards :-

(a) 10GBase-SR :

- It uses Fiber-optic cables.
- It uses a multimode fiber.
- The cable length is max 300m.

(b) 10GBase-LR :

- It uses Fiber-optic cables.
- The fiber used is only single-mode fiber.
- The cable length is max 10 km.

(c) 10GBase-ER :

- It uses fiber-optic cables.
- The fiber used is only single-mode fiber.
- The cable length is 40 km.

(d) 10GBase-CX4 :

- It uses 4 pairs of twinaxial copper cables.
- The cable length is maximum 15m.

(e) 10GBase-T :

- It uses 4 pairs of category 6a UTP cables.
- The cable length is maximum 100m.

Ethernet Performance :

- Consider that 'k' stations are ready to transmit

$$A = kp(1-p)^{k-1}$$

P = probability of each station transmitting during a contention slot.

A = probability that some station acquires the channel in that slot.

- Channel efficiency $= \frac{P}{P + 2T/A}$

P = time taken for frame to transmit

2T = duration of each slot.

- Channel efficiency in terms of F, B, L :

$$\text{channel efficiency} = \frac{1}{1 + 2BLe/CF}$$

B = Network Bandwidth

L = Cable length

F = Frame length

C = Speed of Signal propagation

e = Number of contention slots per frame.