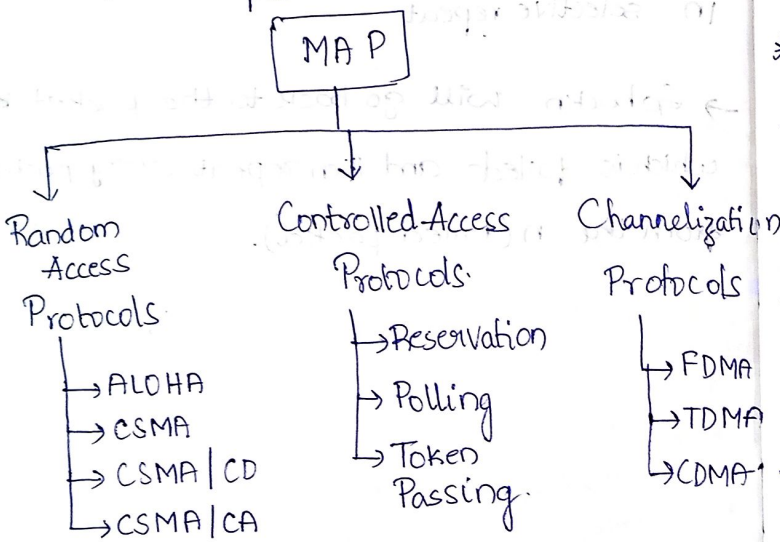
* MULTIPLE ACCESS PROTOCOLS:

→ Data link layer divided into 2 function-oriented sublayers:
- → Data link control
- → Multiple Access Resolution



* ALOHA:

- → used ground-based radio broadcasting
- → applicable to any system in which uncoordinated users are competing for the use of a single shared channel.
- → Types:
  - → Pure
  - → Slotted

} differ wrt whether time is divided into discrete slots.

→ Pure ALOHA : does not require global time synchronization.

→ Slotted ALOHA: ~~does not~~ requires global time synchronization.

* Pure ALOHA:

→ Users transmit whenever they have data to be sent.

→ With LAN; feedback is immediate.

→ If the frame was destroyed; the sender just waits a random amount of time & sends it again.

→ Systems in which multiple users share a common channel in a way that can lead to conflicts are widely known as contention systems.

Throughput for pure ALOHA : $S = G \times e^{-2G}$

Maximum throughput : $S_{max} = 0.184$ when $G = 1/2$

*Slotted ALOHA:

→ Method for doubling the capacity of an ALOHA system.

→ divide time into discrete intervals; each interval corresponding to one frame.

→ In slotted ALOHA; a computer is not permitted to send whenever a carriage return is typed.

→ Continuous pure ALOHA —(wait for the beginning of the next slot.)→ Slotted ALOHA

Throughput for slotted ALOHA: $S = G \times e^{-G}$

Maximum throughput $\Rightarrow S_{max} = 0.368$ when $G = 1$

* CSMA (Carrier Sense Multiple Access):

→ With slotted ALOHA; the best channel utilization that can be achieved $= \frac{1}{e}$.

→ In LAN; however; it is possible for stations to detect what other stations are doing & adapt their behaviour.

→ These networks can achieve a much better utilization than 1/e.

→ Protocols in which stations listen for a carrier and act accordingly are called carrier sense protocols.

*→ persistent CSMA:

- → when a station has data to send; it first listens to the channel; if channel is busy; station waits until the channel becomes idle.
- → This is called 1-persistent because the station transmits with a probability of 1; when it finds the channel idle.

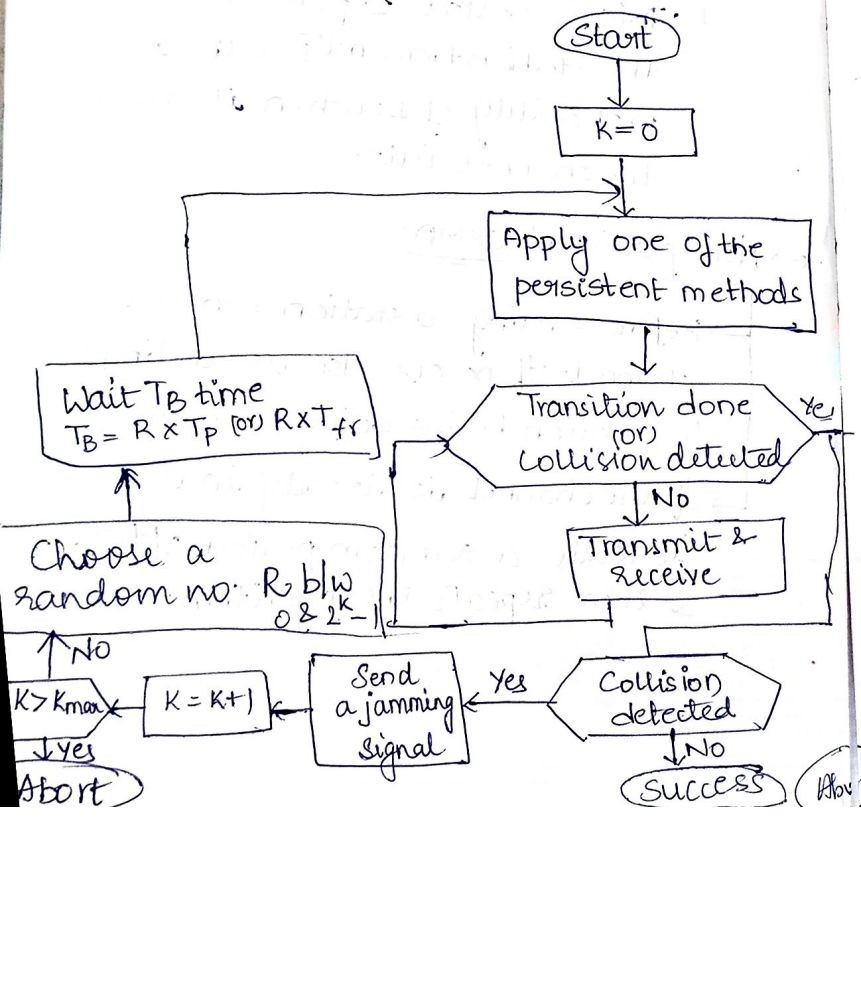
*→ Non-persistent CSMA:

- → Before sending; a station senses a channel. If no one else is sending; the station begins doing so itself.
- → If the channel is already in use; it waits a random period of time & then repeats the algorithm.

* P-persistent CSMA:

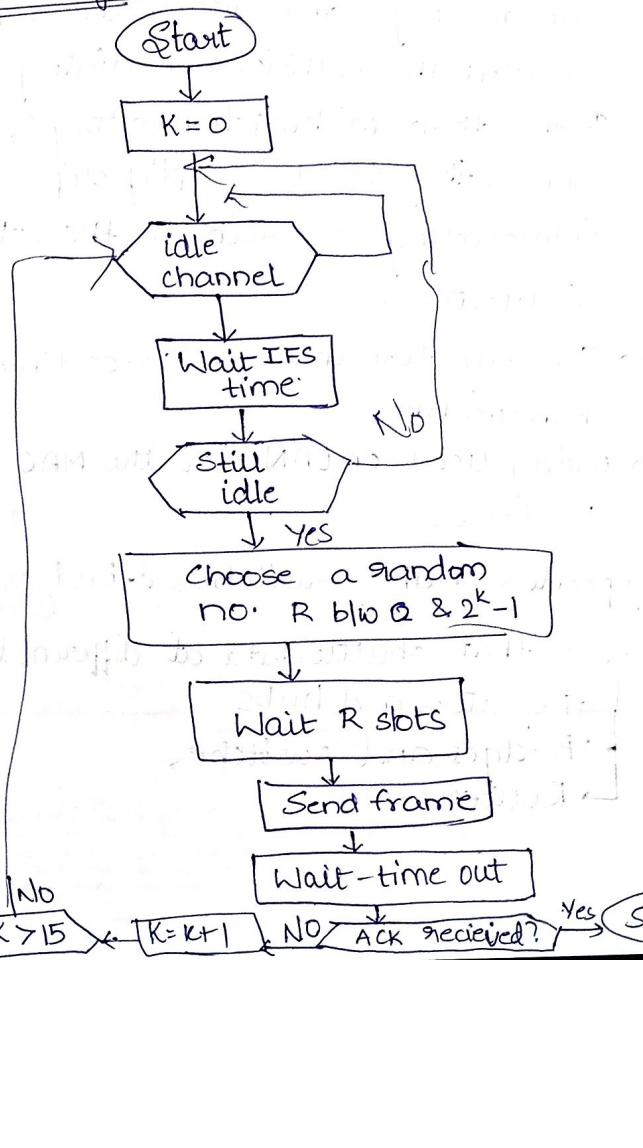
- applies to slotted channels.
- when a station becomes ready to send; it senses the channel. If it is idle; it transmits with a probability p.
- probability: $q = 1 - P$

* Flow diagram for the CSMA/CD:



→ In CSMA/CA; if the station finds the channel busy; it does not restart the timer of the contention window; it stops the timer & restarts it when the channel becomes idle.

* Flow diagram for CSMA/CA:



* CSMA with Collision detection: CSMA/CD

→ This is an improvement for stations to abort their transmissions as soon as they detect collision.

→ If 2 stations sense the channel to be idle and begin transmitting simultaneously, we detect the collision immediately. Rather than finishing transmitting of frames; they should abruptly stop transmitting as soon as the collision is detected.

→ Quickly terminating saves time & bandwidth.

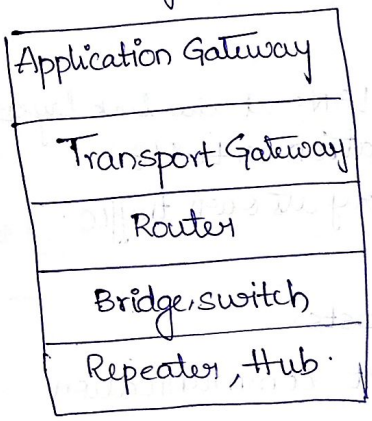
→ Widely used on LANs in the MAC Sub layer.

* Repeaters, hubs, switches & bridges.

→ Devices that shuttle data at different layers
- Repeaters and hubs
- Bridges and switches
- Routers

→ Switch protocols and mechanisms:
- Full-duplex transfers
- Self-learning of switch table.
- Spanning trees.

→ Shuttling data at different layers:
- Network layer: packets (routers)
- Link layer: frames (bridges & switches)
- Physical layer: electrical signals (repeaters and hubs).



* Repeaters:

* Imposes a limit on the length of LA
* Repeaters join LANs together.
* Analog electronic device.
* transmits an amplified copy.

*→ Hubs

* Joins multiple input lines electrically
* Designed to hold multiple line cards
* Do not necessarily amplify the signal

Limitations of Hubs & Repeaters:

→ Aggregate throughput is limited.
→ Cannot support multiple LAN technologies.
→ Limitations on maximum nodes & distances.

→ Bridges

Connects 2 (or) more LANs at the link layer.
Looks up the destination in table.
Each segment can carry its own traffic.

Switches

used to connect hosts.
support concurrent communication

edicated Access & Full duplex.

↓ direct connection to switch
ather than
shared LAN connection

↓ Each connection can send in both directions.

→ Each connection is bidirectional point to point link.

*→ Switch breaks subnet into LAN segments.
*→ Switch filters packets.
*→ Segments support separate transmissions

*Advantages of Bridges/Switches over Hubs/Repeaters:

→ Only forwards frames as needed
→ Improves privacy by limiting scope of frames.
→ Can join segments using different technologies.

*Disadvantages:

→ Delay ; → Need to learn where to forward frames
→ Higher costs

*→ Cut-through switching:

→ Buffering a frame takes time.
→ Buffering delay can be high fraction of total delay.
→ Start transmitting as soon as possible

* Switches forward frames selectively

* Switch Table:
  - Maps destination MAC address to outgoing interface
  - When a frame arrives
    - Inspect the source MAC address.
    - Store the mapping in table
  - Handling Misses:
    - Forward the frame out all of the interfaces

* Flooding can lead to loops:
  - Switches sometimes need to broadcast frames
  - Broadcasting is implemented by flooding

Solution: Spanning trees:
- Ensure topology has no loops
- Spanning tree: subgraph that contains no cycles.

* Advantages of Switches over routers:
- Fast filtering & forwarding of frames

- Disadvantages:
  - Topology restricted to spanning tree.
  - Large networks require large ARP tables.