UNIT - IV

The Medium Access Control Sublayer:-

(1) **The channel Allocation Problem**: There are two types of channel Allocations: they are :-

Static channel Allocation

Dynamic channel Allocation

(a) **Static channel Allocation**: It is a way of allocating a single channel among multiple users by using one of the multiplexing schemes such as FDM. (Frequency Division Multiplexing).

- If there are N users, the bandwidth is divided into N equal-sized portions with each user being assigned one portion.

  Ex: FM radio stations, each station gets a portion of FM band.

- When the number of senders is large or the traffic is heavy, FDM presents some problems:

(i) If the spectrum is cut into N regions and fewer than N users are currently interested in communicating, large piece of valuable spectrum will be wasted.

(ii) If more than N users want to communicate, some of them will be denied permission for lack of bandwidth.

- Hence dividing the single available channel into some number of static sub channels is inefficient.

(b) <u>Assumptions for Dynamic Channel Allocation</u> :-

There are five key assumptions :-

(i) <u>Station model</u> :- The model consists of 'N' independent stations (eg:- computers, telephones) each with a program or user that generates frames for transmission.

- The expected number of frames generated in an interval of Δt is $\lambda \Delta t$, where λ is a constant.
- Once a frame has been generated, the station is blocked & does nothing until the frame has been successfully transmitted.

(ii) <u>Single channel Assumption</u> :

- A single channel is available for all communication.
- All stations can transmit on it & can receive from it.

(iii) <u>Collision Assumption</u> : If two stations are transmitted simultaneously, they overlap & the resulting signal is damaged. This event is called a collision.

- All stations can detect that a collision has occured.
- A collided frame must be transmitted again later.

(iv) Continuous or slotted time:

- In Continuous time, frame transmission can begin at any instant.
- Alternatively, time may be slotted or divided into discrete intervals (called slots).
- Frame transmissions must begin at the start of the slot. If the slot is already started, the sender should wait until the next slot.
- If a slot contain '0' frames, it corresponds to an idle slot.
  " " '1' frame, it corresponds to a successful transmission.
  " " more frames, " " " " collision.

(v) Carrier Sense or No Carrier Sense:

- With the carrier Sense assumption, stations can identify if the channel is in use before trying to use it.
- No station will attempt to use the channel while it is sensed as busy.
- The station can use the channel while it is sensed as idle.

Multiple Access Protocols :- There are three protocols:

ALOHA
Carrier Sense Multiple Access Protocols (CSMA)
Collision-Free Protocols

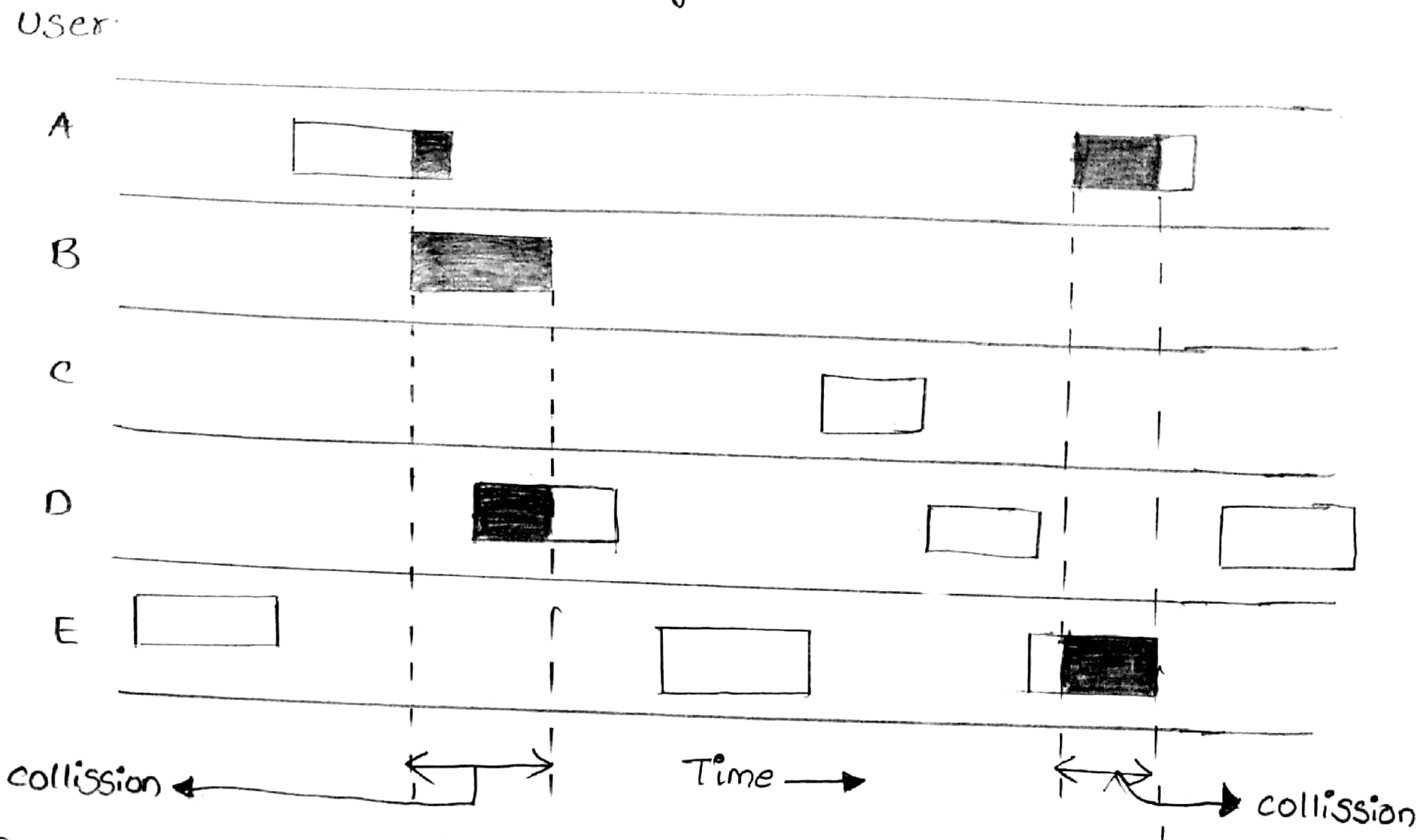
ALOHA :-

- Norman Abramson proposed a method to solve the channel allocation problem called the 'ALOHA' system.
- There are two categories in ALOHA system. They are:-
  Pure Aloha
  Slotted Aloha

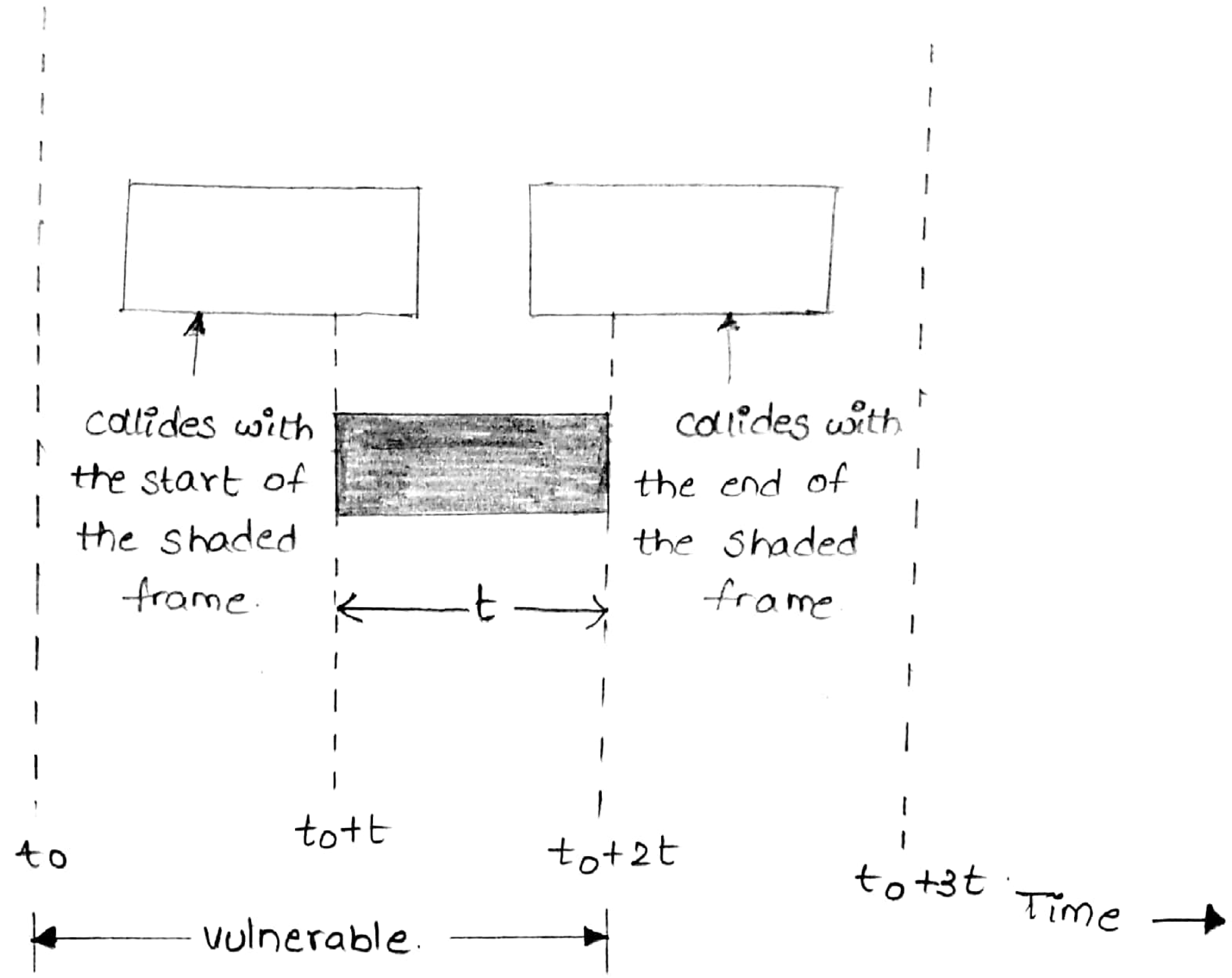
Pure Aloha :-

- In pure aloha, users transmit whenever they have data to be sent.
- There may be collisions & the colliding frames will be damaged.
- If the frame was destroyed, the sender waits a random amount of time & retransmits it again.
- The waiting time must be random or the same frames will collide over and over.
- Systems in which multiple users share a common channel in a way that can lead to conflicts are

known as contention systems.



- In the above diagram, all the frames are of equal length.
- Whenever two frames try to occupy the channel at the same time, there will be a collision & both the frames will be damaged.
- If the first bit of a new frame overlaps with ~~the~~ just the last bit of a frame almost finished, both frames will be totally destroyed and both will have to be retransmitted later.
- The checksum cannot distinguish between a total loss or a near miss.



- Let the mean frame (new) generated by different number of users per frame time be 'S' (frames without collisions). The value of S can be therefore either 0 or 1.

$$\boxed{0 <= S <= 1}$$

- Let the mean frames (new + retransmitted) generated by different number of users per frame time without collisions be 'G'. The value of 'G' is obviously greater than or equal to 'S'.

$$\boxed{G >= S}$$

- At low load, $S = 0$

There will be few collisions. So, few retransmissions are required. So, $\boxed{G=S}$.

- At high load, $S=1$
There will be many collisions, so more retransmissions are required. So, $\boxed{G>S}$.

- If P_0 is the probability that a frame doesn't suffer from any collision, then

$$\boxed{S = G P_0}$$

For pure aloha, $P_0 = e^{-2G}$

$$\therefore \boxed{S = G e^{-2G}}$$

- If $P_r[K]$ is the probability that 'k' frames are generated during a given frame time, then

$$\boxed{P_r[K] = \frac{G^k e^{-G}}{k!}}$$

- With pure aloha, 18% channel utilization is made.

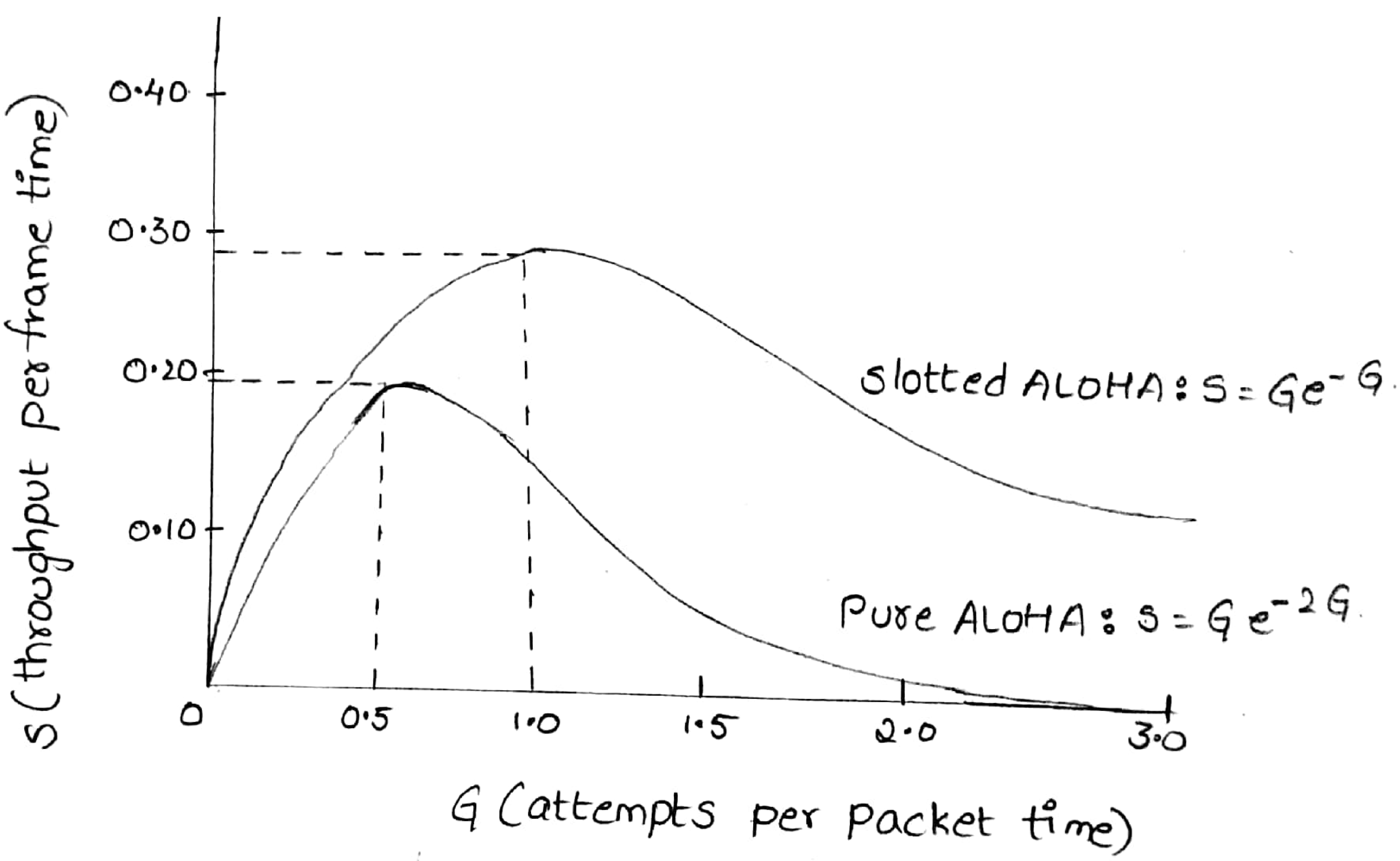
Slotted Aloha :

- In slotted aloha, the time is divided into discrete intervals called slots, each interval corresponding to one frame.

- This approach requires the users to agree on slot boundaries.
- The user is required to wait for the beginning of the next slot.
- The probability of no other traffic during the same slot is e^{-G} which leads to

$$\boxed{S = Ge^{-G}}$$

- In slotted aloha, 36% of channel is utilized.



Carrier Sense Multiple Access Protocols:

Carrier Sense protocols: Protocols in which stations listen for a carrier (ie, transmission) & act accordingly are called carrier sense protocols.

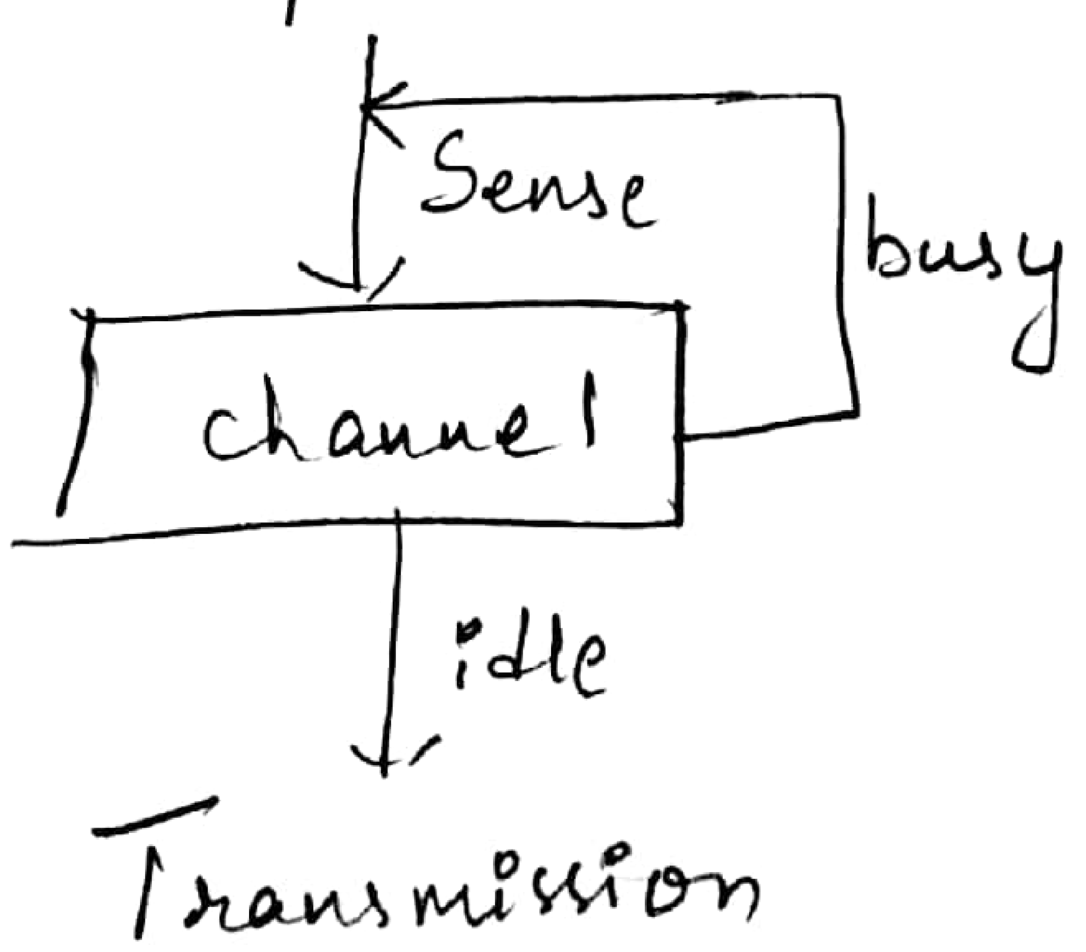
- There are three types of carrier sense protocols. They are :- 1- persistent CSMA

Non- persistent CSMA

P- persistent CSMA

ⓐ <u>1- persistent CSMA</u> :

- When a station has data to send, it first listens to the channel, if channel = busy then the station waits until it becomes idle.
- When the channel is idle, it transmits a frame. If a collision occurs, the station waits for a random amount of time & retransmits.
- It is called 1- persistent because the station transmits with probability = 1.



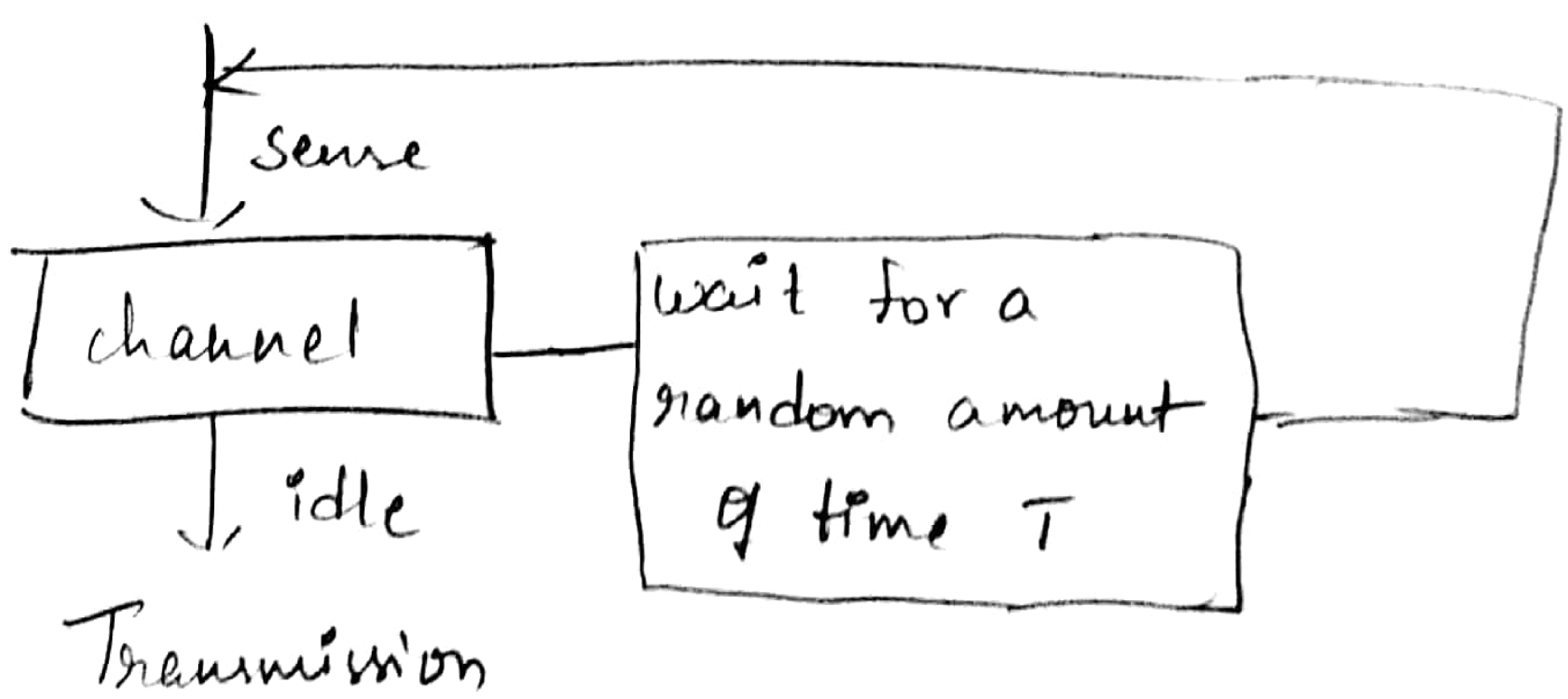
<u>Problems</u> :-

- If a station becomes ready to send (just after another station begins), it senses the channel to be idle (bcz of propagation delay of the first) & will begin sending, which results in a collision.

- If two stations become ready in the middle of third station's transmission, both will politely wait until the transmission ends & both will begin transmitting exactly simultaneously, resulting in a collision.

Non-persistant CSMA :

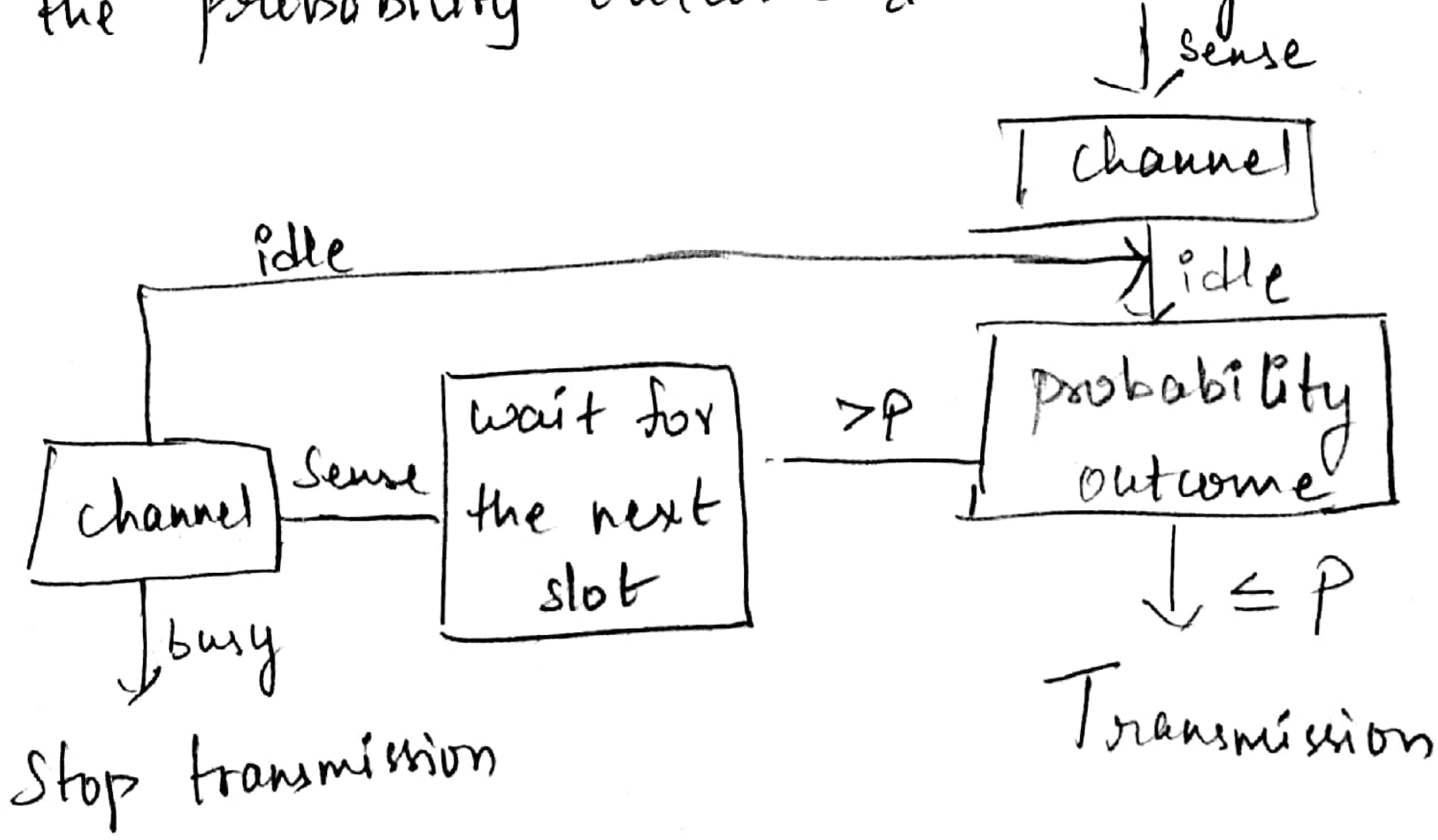
- A station senses the channel before sending.
- If channel is idle, it starts the transmission.
- If channel is busy, the station does not continually sense it for the purpose of seizing it immediately upon detecting the end of the previous transmission.
- Instead, it waits a random amount of time & then repeats the algorithm.



P-persistant CSMA :

- It applies to slotted channels.

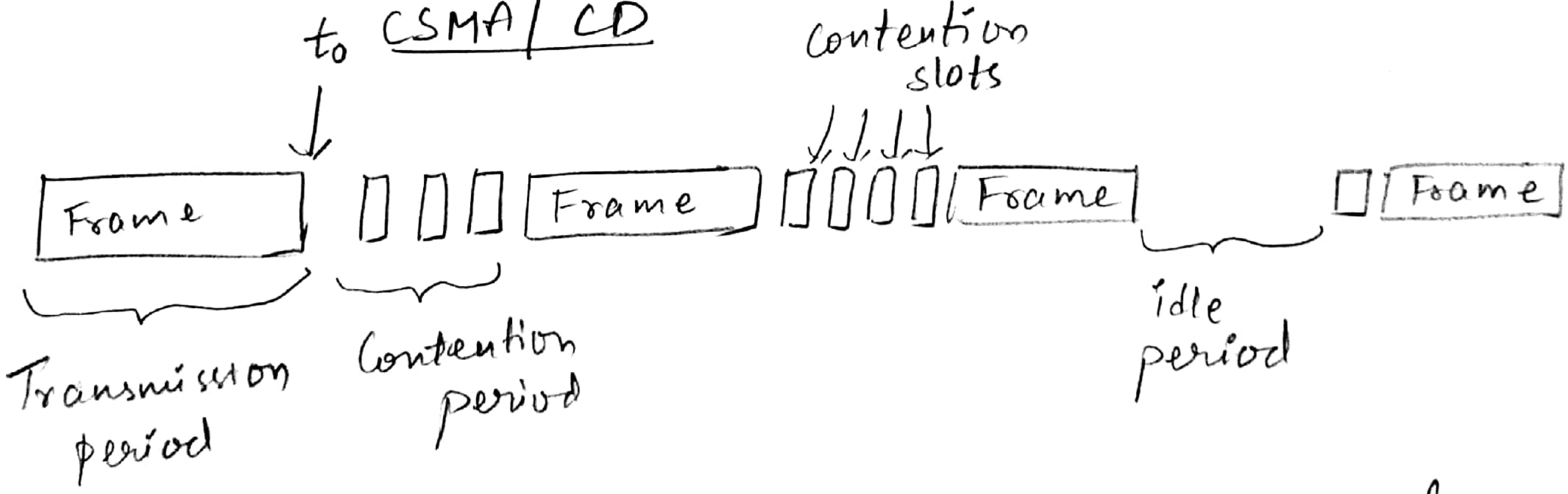
- When station is ready to send, it senses the channel.
- If the channel is busy, station waits until the channel becomes idle.
- If the channel is idle, the station calculates the probability outcome, if it is less than or equal to 'p' [which is the predefined probability value], then the station performs the transmission.
- If the probability outcome is greater than p, then the station waits until the next time slot and again senses the channel.
- Now ~~age~~ if the channel is busy, the station stops the transmission.
- If the channel is idle, it again calculates the probability outcome & the algorithm repeats.



CSMA with collision Detection (CSMA/CD protocol): 12

- In this protocol, the stations abort their transmissions as soon as they detect a collision.
- If two stations sense the channel to be idle & begin transmitting simultaneously, they will both detect the collision almost immediately.
- Rather than finish transmitting their frames, which are damaged any way, they should immediately stop transmitting as soon as the collision is detected.
- Quickly terminating damaged frames saves time & bandwidth.

CSMA/CD



- At t_0, station has finished transmitting its frame.
- Any other station can send the frame now.
- If two or more stations decide to transmit simultaneously, there will be a collision.

- If a station detects a collision, it aborts its transmission, waits a random period of time & then tries again (assuming that no other station has started transmitting).
- Therefore CSMA/CD model will consist of alternating contention & transmission periods with idle periods occuring when all stations are quiet.

Collision - Free Protocols :

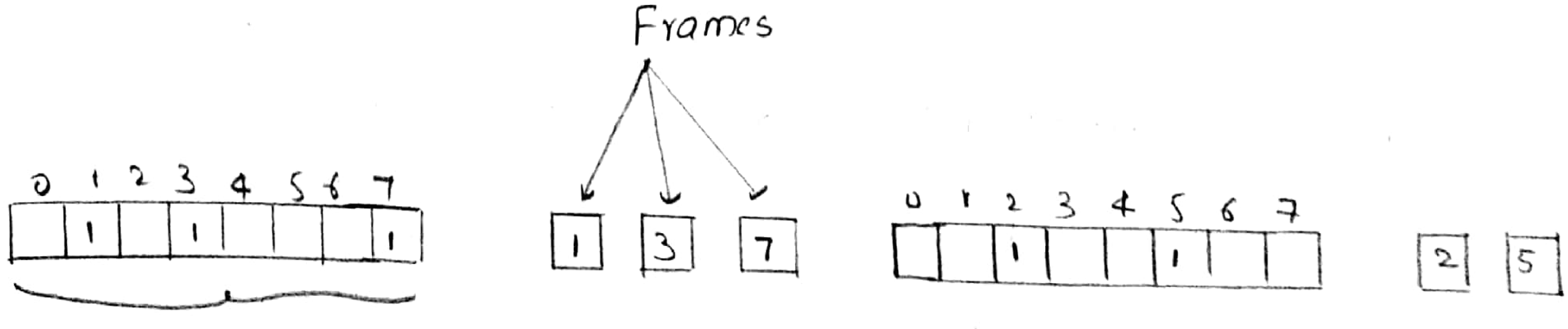
There are three protocols :

Bit-map protocol

Token passing (token ring or token bus protocol)

Binary Count down protocol.

(a) Bit-map protocol :



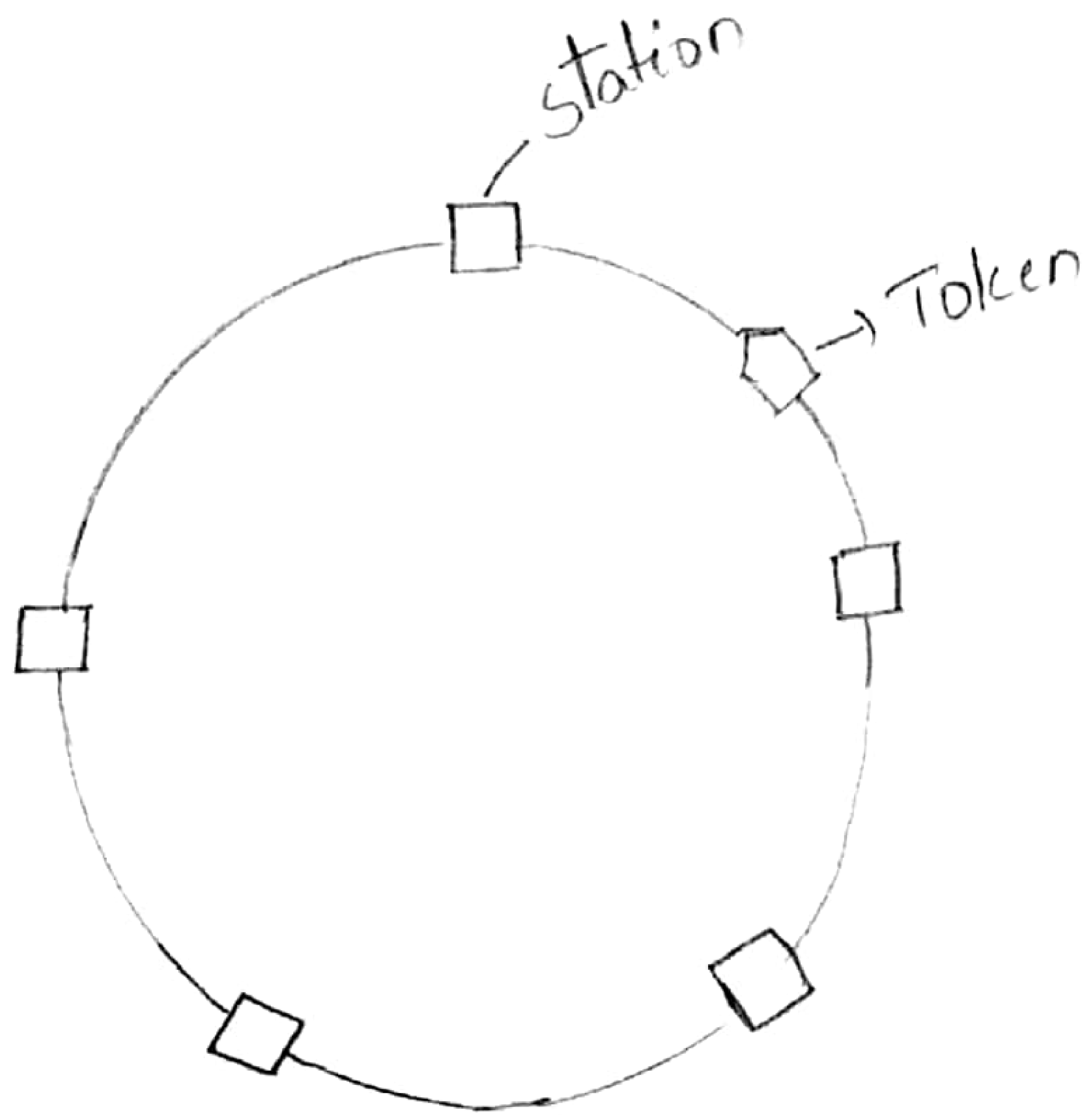
8 contention slots

- In this protocol, each contention period consists of exactly 'N' slots.
- If station 0 has a frame to send, it transmits a '1' bit during the zeroth slot.
- No other station is allowed to transmit during this slot.
- Regardless of what station 0 does, station 1 gets the opportunity to transmit a 1 during slot 1, but only if it has a frame queued.
- In general, station j may announce that it has a frame to send by inserting a 1 bit into slot j.
- After all N slots have passed by, each station has complete knowledge of which stations wish to transmit.
- If a station becomes ready just after its bit slot has passed by, it is out of luck & must remain silent until every station has had a chance & the bit map has come around again.
- Protocols like this in which the desire to transmit is broadcast before the actual transmission are called reservation protocols.

(B) Token passing :

- In token passing, a small message called a token is passed from one station to the next.
- The token represents permission to send.
- If a station has a frame queued for transmission when it receives the token, it can send that frame before it passes the token to the next station.
- If it has no queued frame, it simply passes the token.
- It is called token ring/token bus protocol.
- The stations are connected one to the next in a single ring.
- Frames are transmitted in the direction of the token.
- They will circulate around the ring & reach whichever station is the destination.
- We do not need a physical ring to implement token passing.
- The channel connecting the station might be a single long bus.

- Each station then uses the bus to send the token to the next station.



(c) Binary Countdown protocol :

	0	1	2	3
0 0 1 0	0	–	–	–
0 1 0 0	0	–	–	–
1 0 0 1	1	0	0	–
1 0 1 0	1	0	1	0
	1	0	1	0

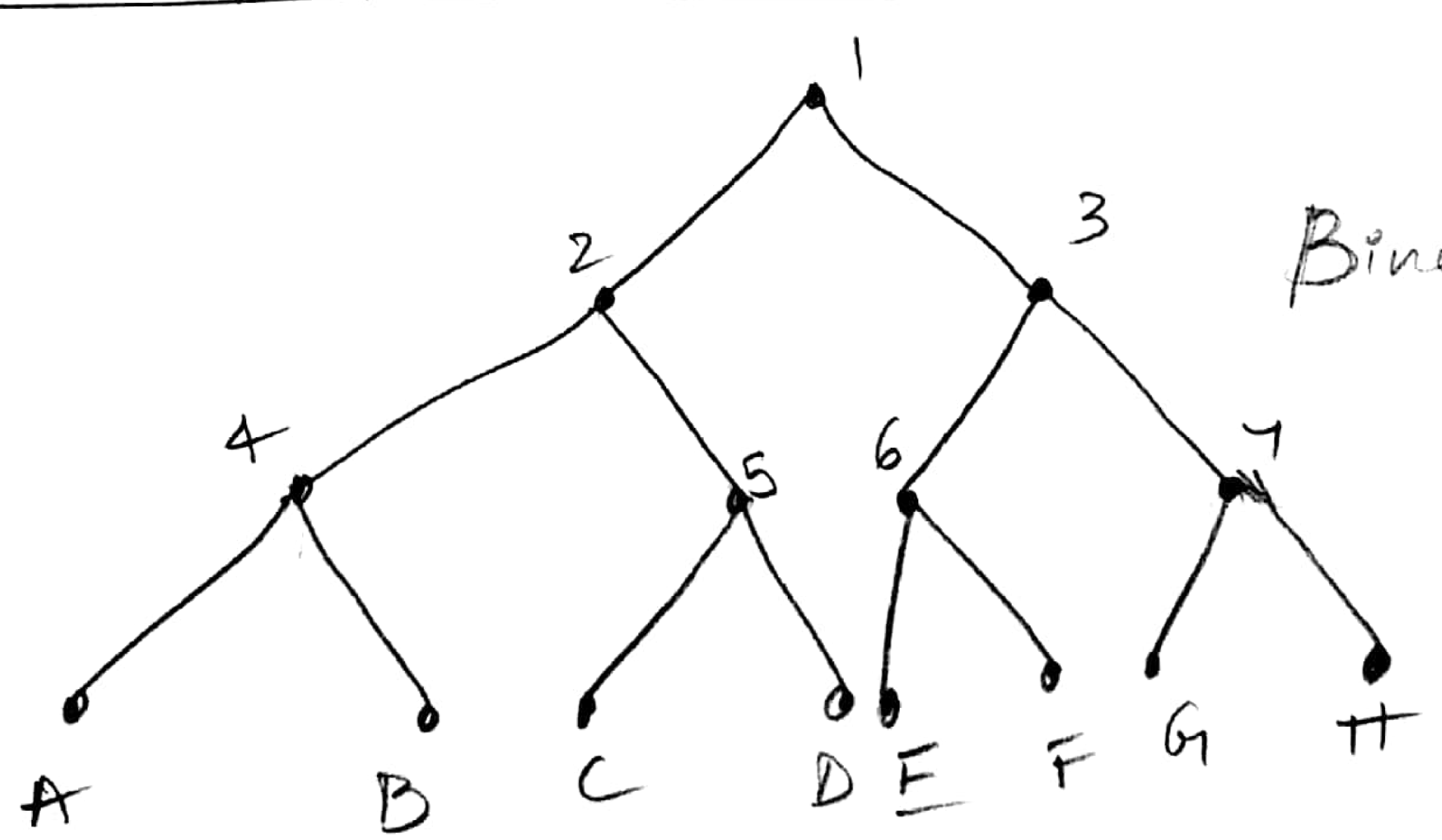
- A station wanting to use the channel now broadcasts its address as a binary bit string.
- All addresses are assumed to be the same length. The bits in each address position from different stations are BOOLEAN Ored together.
- To avoid conflicts, a rule must be applied: As soon as a station sees that a high order bit position that is 0 in its address has been overwritten with a 1, it gives up.
- For example, if stations 0010, 0100, 1001 & 1010 are trying to get the channel, in the first bit time the stations transmit 0, 0, 1 & 1 resp. These are ORed together to form a 1.
- Stations 0010 and 0100 see ~~that~~ the 1 and know that a higher numbered station is competing for the channel, so they give up for the current round. Stations 1001 and 1010 continue.
- The next bit is 0, and both stations continue. The next bit is 1, so station 1001 gives up.
- The winner is station 1010 because it has the highest address.

- Now, station 1010 can transmit a frame, after which another cycle starts.

Limited Contention Protocols :

- In these protocols, we combine the properties of contention - based protocols (CSMA) & collision-free protocols (contention-free protocols)
- Designing a new protocol that uses contention at low load & collision-free technique at high load. Such protocols are called as limited contention protocol.

The Adaptive Tree Walk Protocol :



Binary tree

- Initially all the stations are allowed to try to acquire the channel.
- If any station is able to acquire the channel, it sends its frame

- If there is collision, then all the stations are divided ~~it~~ into two equal groups and only one of these groups compete for slot 1.
- If one of its member acquires the channel then the next is reserved for the other group.
- On the other hand, if there is a collision then that group is subdivided and the same process is followed.
- In this protocol, all the stations are organized in a binary tree.

Wireless LAN protocols :

- Consider wireless LAN is using CSMA, then it just listens for other transmissions & only transmit if the channel is sensed as idle.
- The problems faced while using wireless LAN are:-

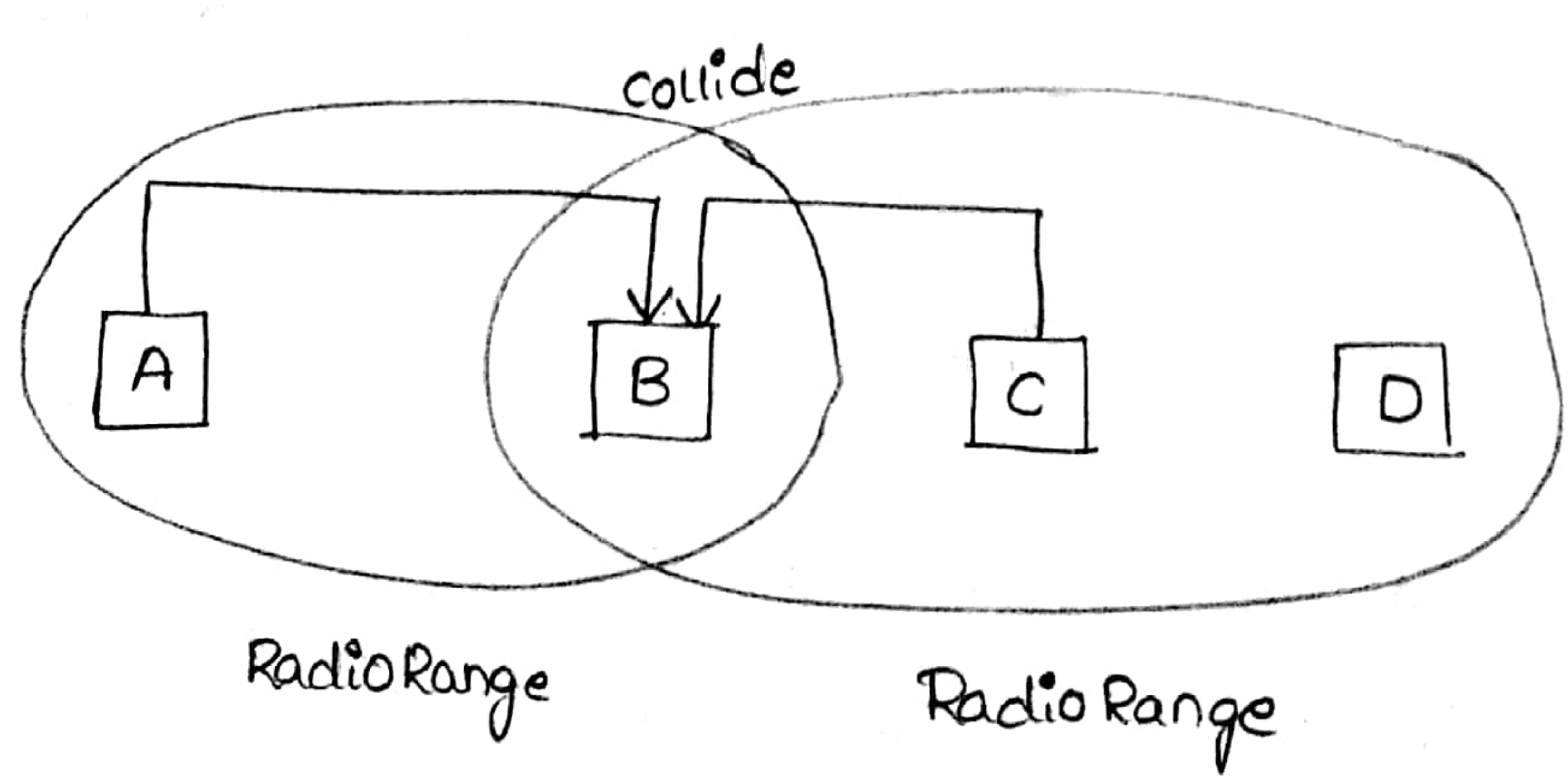
  Hidden Terminal Problem
  Exposed Terminal Problem

- To understand the problems, consider the foll diagram, where four wireless stations are given.

- The radio range is such that A and B are within each other's range and can potentially interfere with one another.
- C can also potentially interfere with both B & D but not with A.

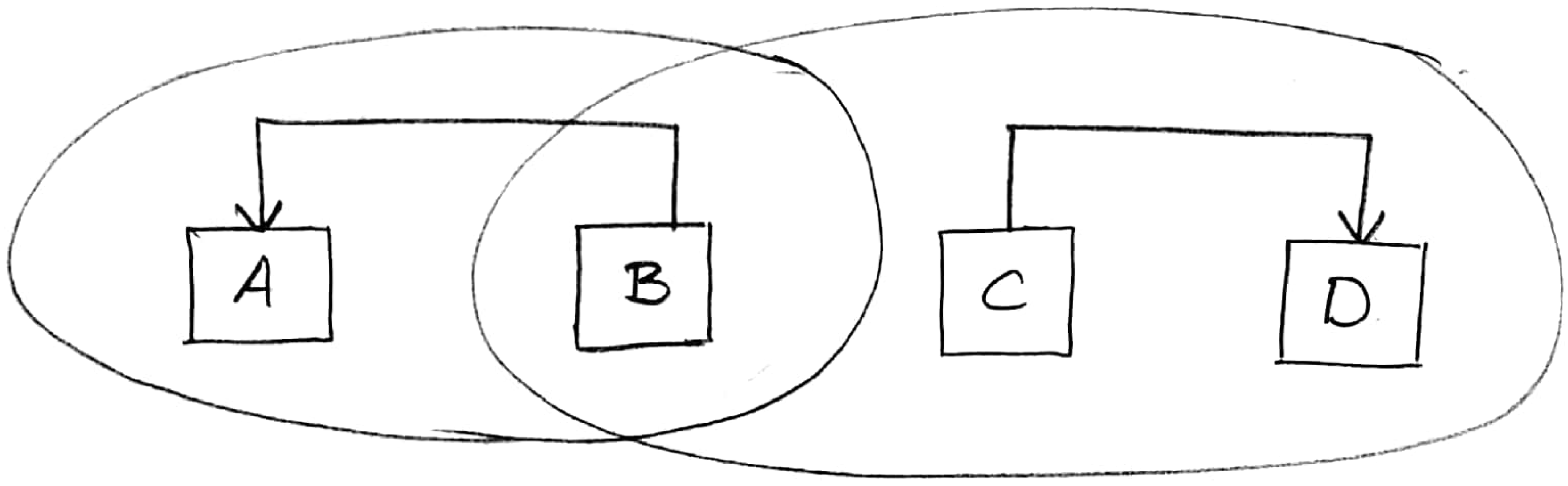
ⓐ Hidden Terminal Problem :

- Consider that A wants to transmit to B, C also wants to transmit to B.
- A started transmitting to B.
- When 'C' wants to transmit, it senses the medium, it will not hear A because A is out of range.
- Thus C will falsely conclude that it can transmit to B.
- If C starts transmitting, it will interfere at B, damaging the frame from A.
- ~~A~~ The problem araised bcz 'A' is hidden from 'C' hence it is called as hidden terminal problem.



(b) Exposed Terminal Problem:

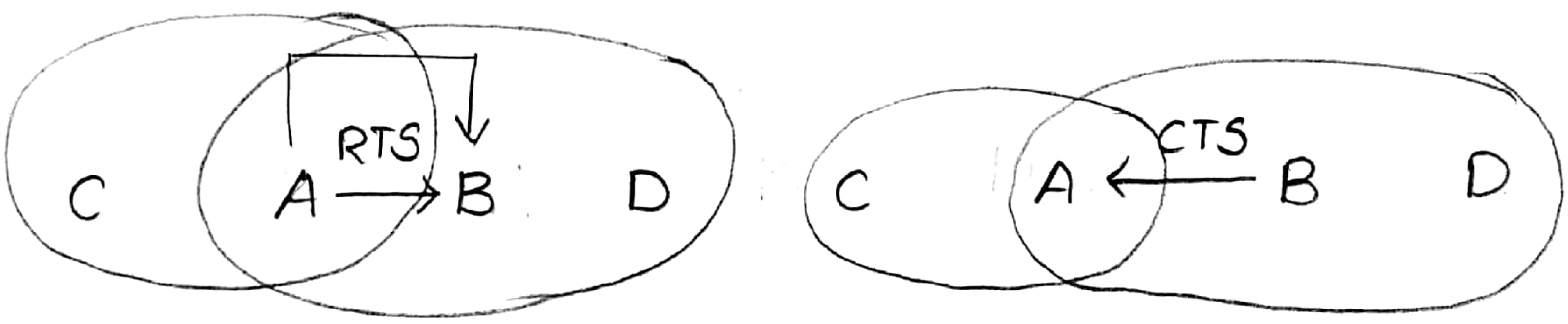
- Consider that 'B' is transmitting to A and C wants to transmit to D.
- When 'C' wants to transmit, it senses the medium, it will hear a transmission and fasely conclude that it may not send to D.
- So, C stops the transmission to D.
- In this problem, a node is prevented from sending the packets to other nodes bcz of a neighbouring transmitter.



MACA (Multiple Access with Collision Avoidance):

- A common protocol used for wireless LANs is MACA.
- In this protocol, when A wants to transmit to B, A sends RTS (Request To Send) frame to B.
- This blocks the neighbouring node from transmitting.

- Upon sensing RTS from A to B, C becomes silent.
- B replies 'A' with CTS (Clear To Send) frame. This blocks the neighbouring node from transmitting.
- Upon sensing CTS from B to A, D becomes silent.
- When CTS is received by A, then A starts the transmission.
- So, whenever a sender wants to perform transmission, it should send RTS & receive CTS.



RTS – Request to send

CTS – clear to send.

Wireless LANS :

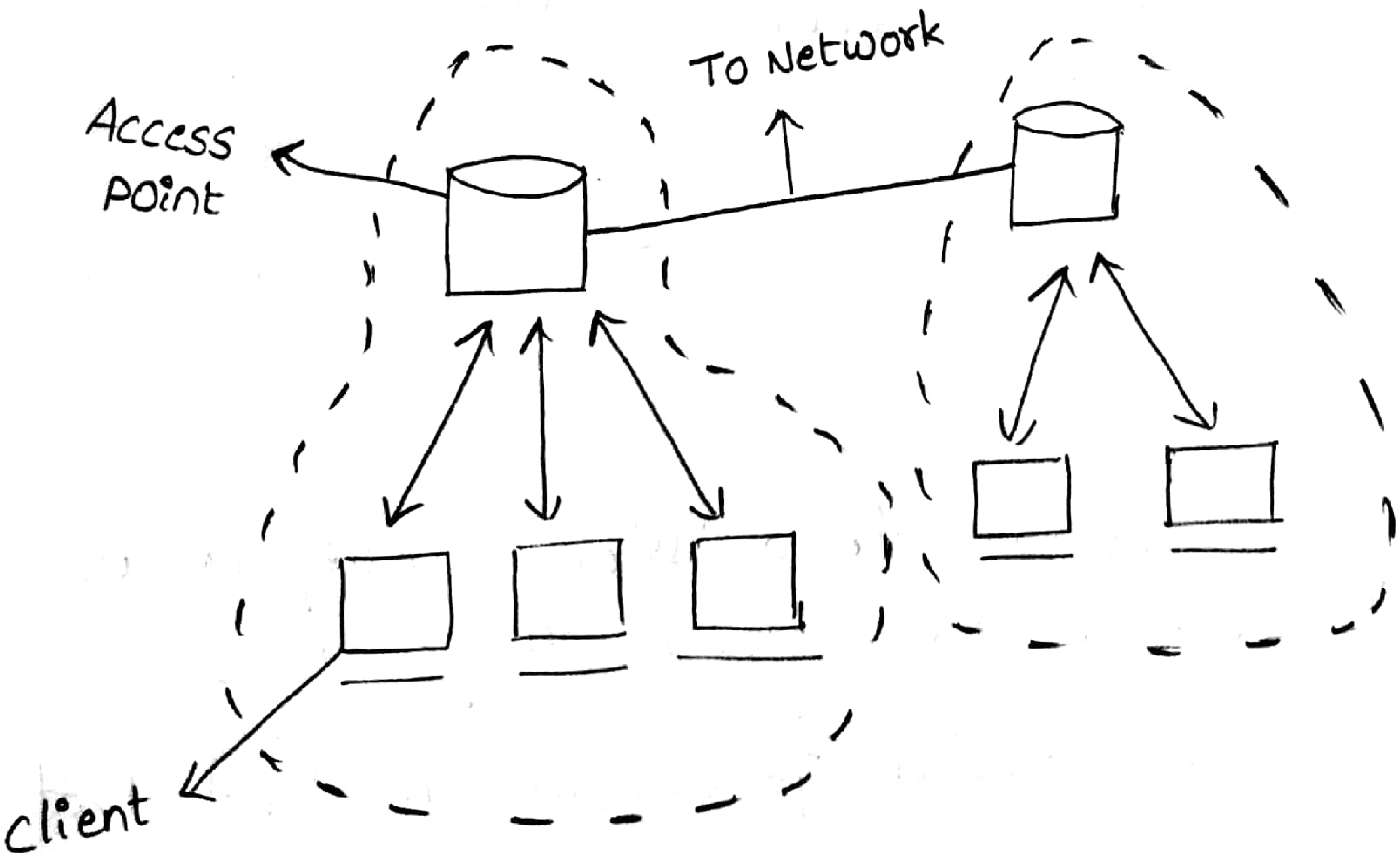
(1) The 802.11 Architecture and Protocol Stack :

802.11 Architecture : 802.11 networks can be used in two modes.

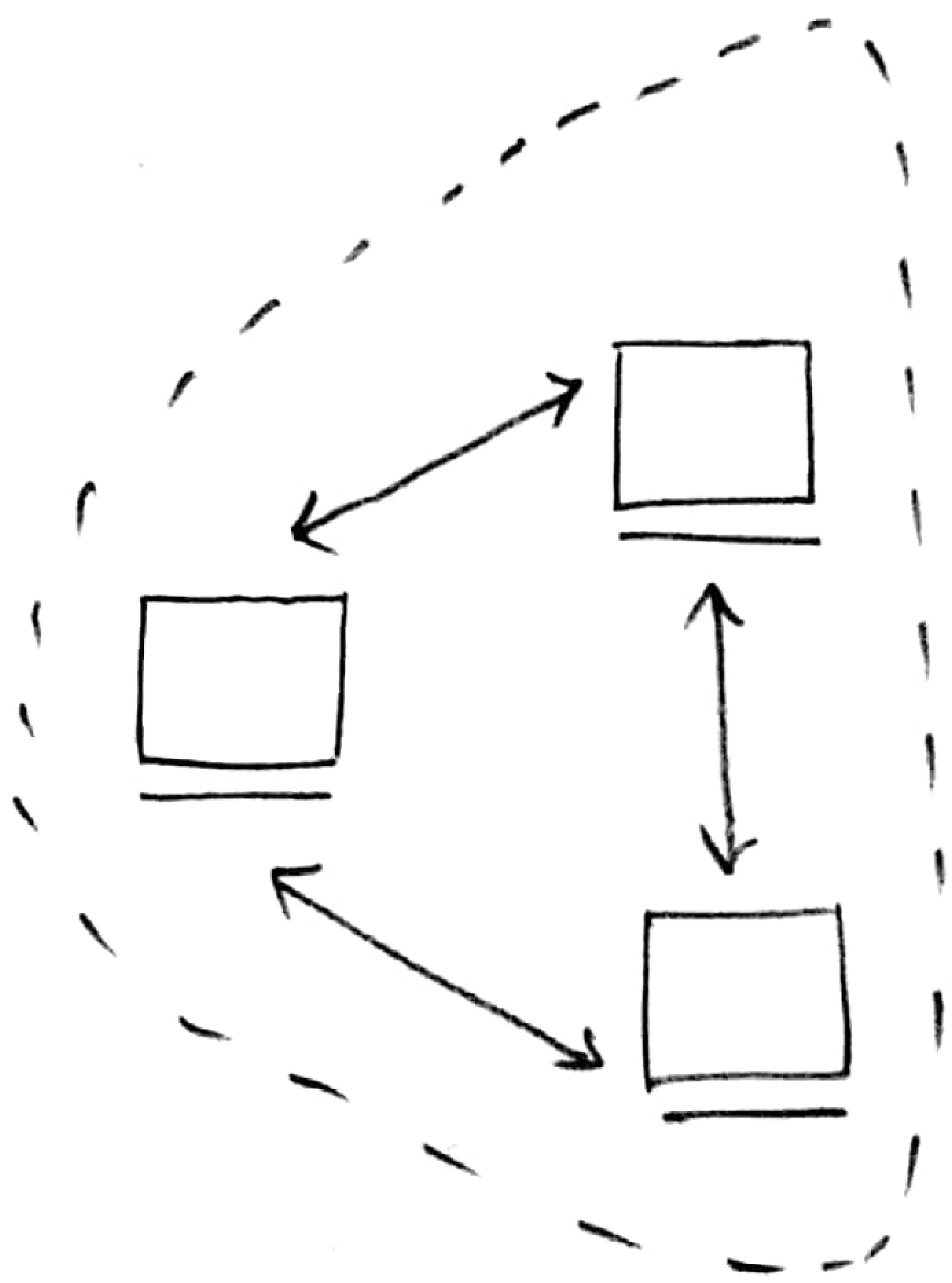
They are:- Infrastructure mode
Adhoc mode.

(a) Infrastructure mode : In this mode, each client is associated with an AP (Access Point) that is in turn connected to the network.

- The client sends & receives its packets via the AP.
- Several access points may be connected together called a distribution system.
- In this case, clients can send frames to other clients via their APs.



(a) Infrastructure mode

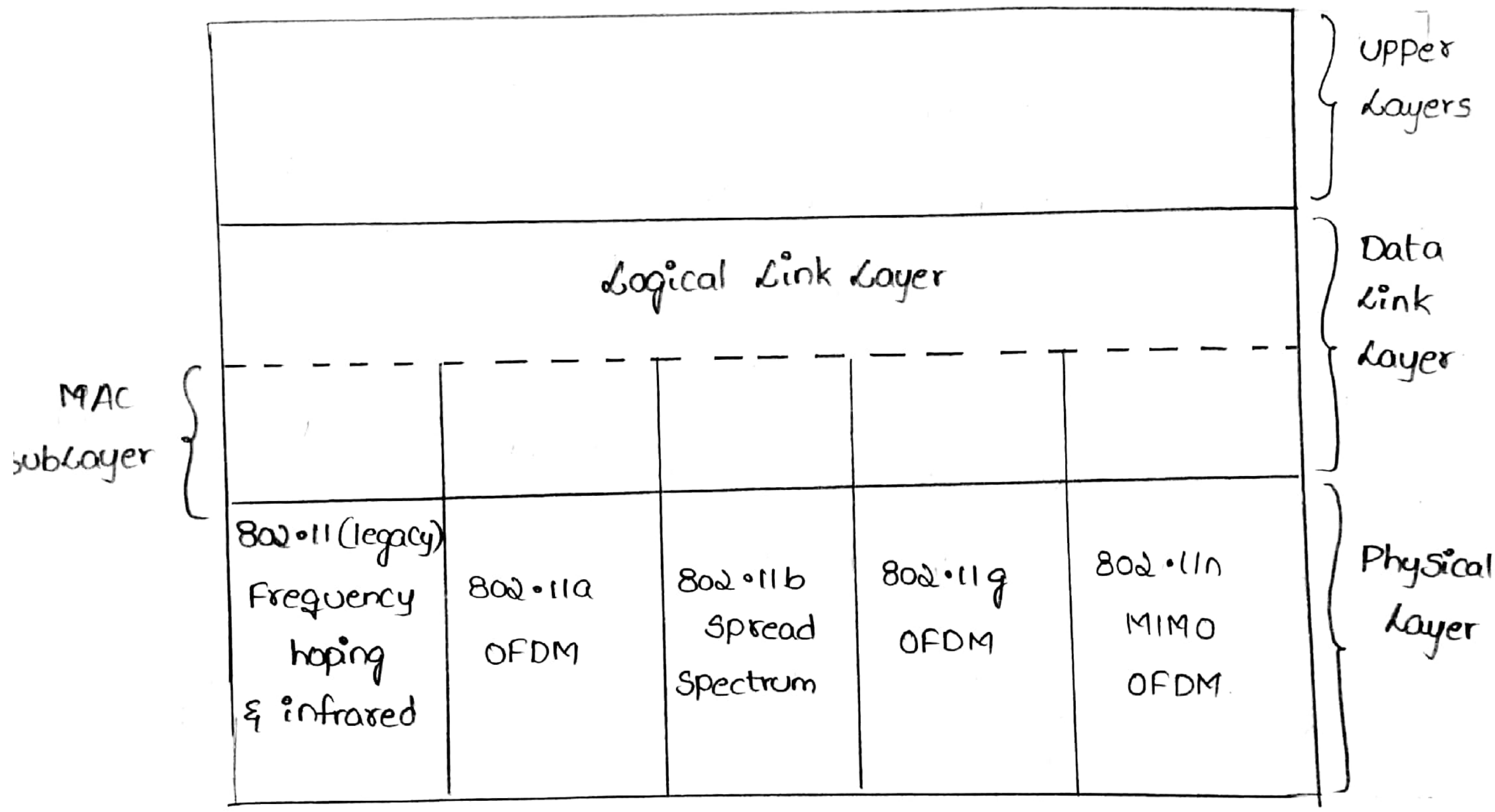


(b) Adhoc mode

(b) Adhoc mode :

- This mode is a collection of computers that are associated so that they can directly send frames to each other.
- There is no access point.

802.11 protocol stack :



802.11 physical layer : Several transmission techniques are included in this layer. They are:-

(a) **802.11 b** : It is a spread spectrum method that supports rates of 1, 2, 5.5 & 11 Mbps.
B of transmitted signal > B of original msg.

- In real, the operating rate is nearly always 11 Mbps
- It is similar to CDMA system.

(b) 802.11a : It is a method based on OFDM (Orthogonal Frequency Division Multiplexing) bcz OFDM uses the spectrum efficiently and resists wireless signal degradations.

- Bits are sent over 52 sub carriers in parallel, 48 carrying data & 4 used for synchronization.
- 802.11a can run at eight different rates, ranging from 6 to 54 Mbps.
- these rates are faster than 802.11b rates.

(c) 802.11g :- It copies the OFDM modulation methods of 802.11a. It works as 802.11a.

- It offers the same rates as 802.11a (6 to 54 Mbps).

All the above 802.11 variants can be confusing for customers, so it is common for products to support 802.11a/b/g in a single NIC.

(d) 802.11n : The goal of 802.11n was throughput of atleast 100 Mbps.

- It allows a group of frames to be sent together.
- It uses MIMO (Multiple I/p Multiple O/p) antenna technology.
- In MIMO, it uses multiple antennae at sender and multiple antennae at receiver.

- 802.11n uses upto four antennas to transmit 4 streams of data at the same time.

Data Link Layer :- It consists of two sublayers:

ⓐ **MAC sublayer** : It determines how the channel is allocated and determines who gets the chance to transmit next.

ⓑ **LLC sublayer** : Its job is to hide the differences b/w different 802 variants.

802.11 Frame Structure :

Bytes	2	2	6	6	6	2	0-2312	4
	Frame Control	Duration	Address 1 (recipient)	Address 2 (transmitter)	Address 3	Sequence	Data	Check Sequence

	Version = 00	Type = 10	SubType = 0000	To DS	From DS	More frag.	Retry	Pwr. mgt.	More data	Protected	Order
Bits	2	2	4	1	1	1	1	1	1	1	1

Frame structure consists of 8 fields. They are:-

① Frame Control field : This field is made up of 11 sub fields.

ⓐ Protocol version : It is set to 00. It is there to allow future version of 802.11 to operate at the same time in the same cell.

ⓑ Type : The type of the frame is given. It may be data, control or management frame. For a regular data frame it is set to 10 in binary

ⓒ Subtype : The subtype of the frame is given. Eg :- RTS or CTS. For a regular data frame subtype field is set of 0000 in binary.

ⓓ To DS and From DS : These bits are set to indicate whether the frame is going to or coming from the N/w connected to the APs, which is called the distribution system.

ⓔ More fragments : This bit means that more fragments will follow.

ⓕ Retry : This bit makes a retransmission of a frame

ⓖ Power management : This bit indicates that the sender is going into power-save mode.

(h) More data: This bit indicates that the sender ~~is going~~ has additional frames for the receiver.

(i) Protected Frame: This bit indicates that the frame body has been encrypted for security.

(j) Order :- This bit tells the receiver that the higher layer expects the sequence of frames to arrive strictly in order.

(2) Duration field: This tells how long the frame and its ACK will occupy the channel.

(3) Address1 (recipient) :- It indicates the add of receiver.

(4) Address 2 (transmitter) :- It indicates the add of transmitter.

(5) Address3 : It is an extra field for address.

(6) Sequence field :- It indicates the sequence ~~num~~ number of the frame so that duplicates can be detected.

(7) Data field :- It contains the data to be send or received

(8) Frame check Sequence : It indicates the 32-bit CRC.