Data link layer

1.Physical addressing

2.Access control

3.Framing

4.Flow control

5.Error control

LLC

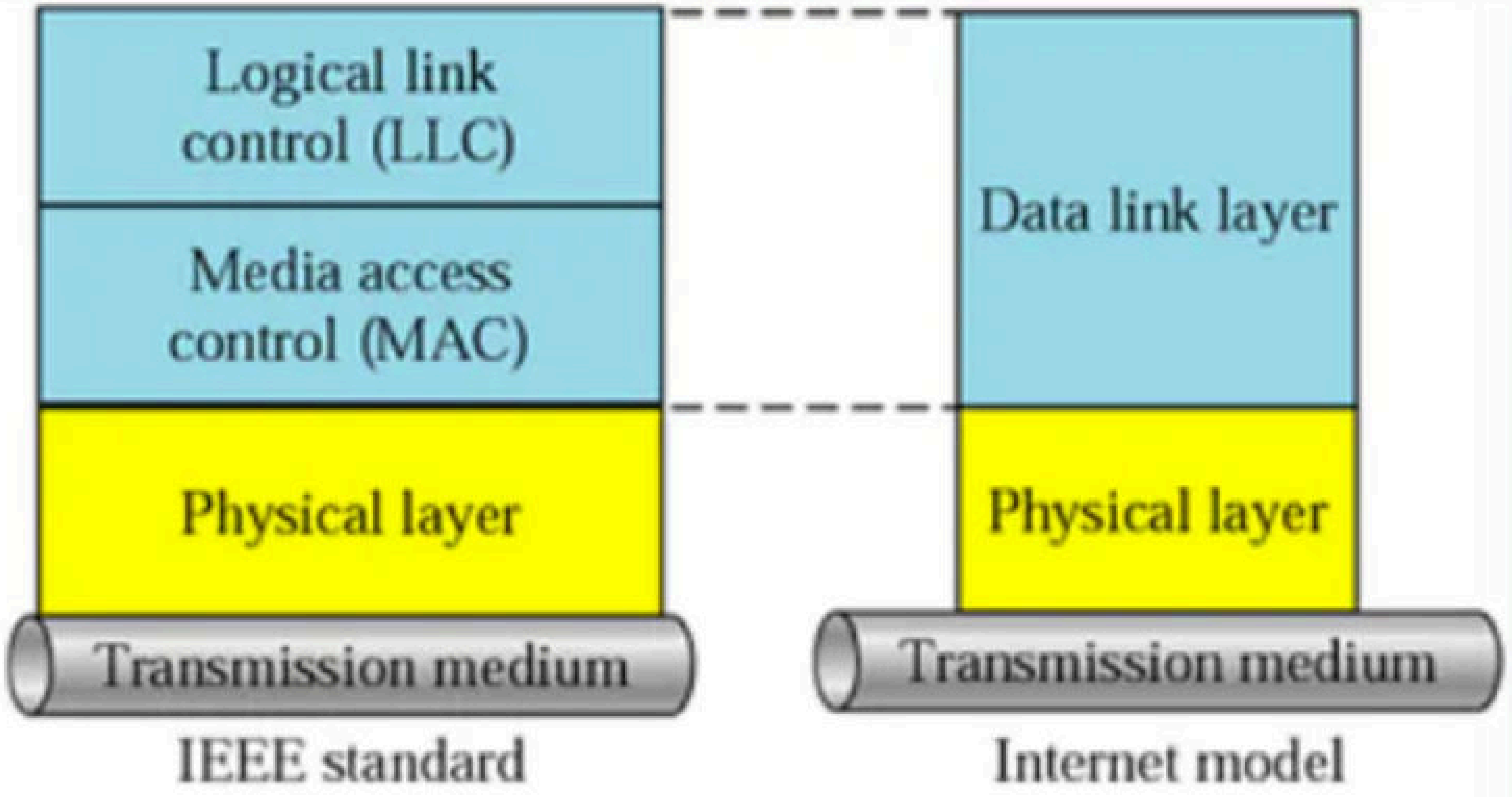
Two Sublayers

1. The IEEE has subdivided the data-link layer into two sublayers: **logical link control (LLC)** (TOP) **and media access control (MAC)** (BOTTOM)**.**

2. ***Media Access Control (MAC):*** It defines the specific access method for each LAN. For example, it defines CSMA/CD as the media access method for Ethernet LANs. Take care of Addressing at the level(Lan technology).

3. Flow control, error control, and part of the framing duties are collected into one sublayer called the *logical link control* (LLC).

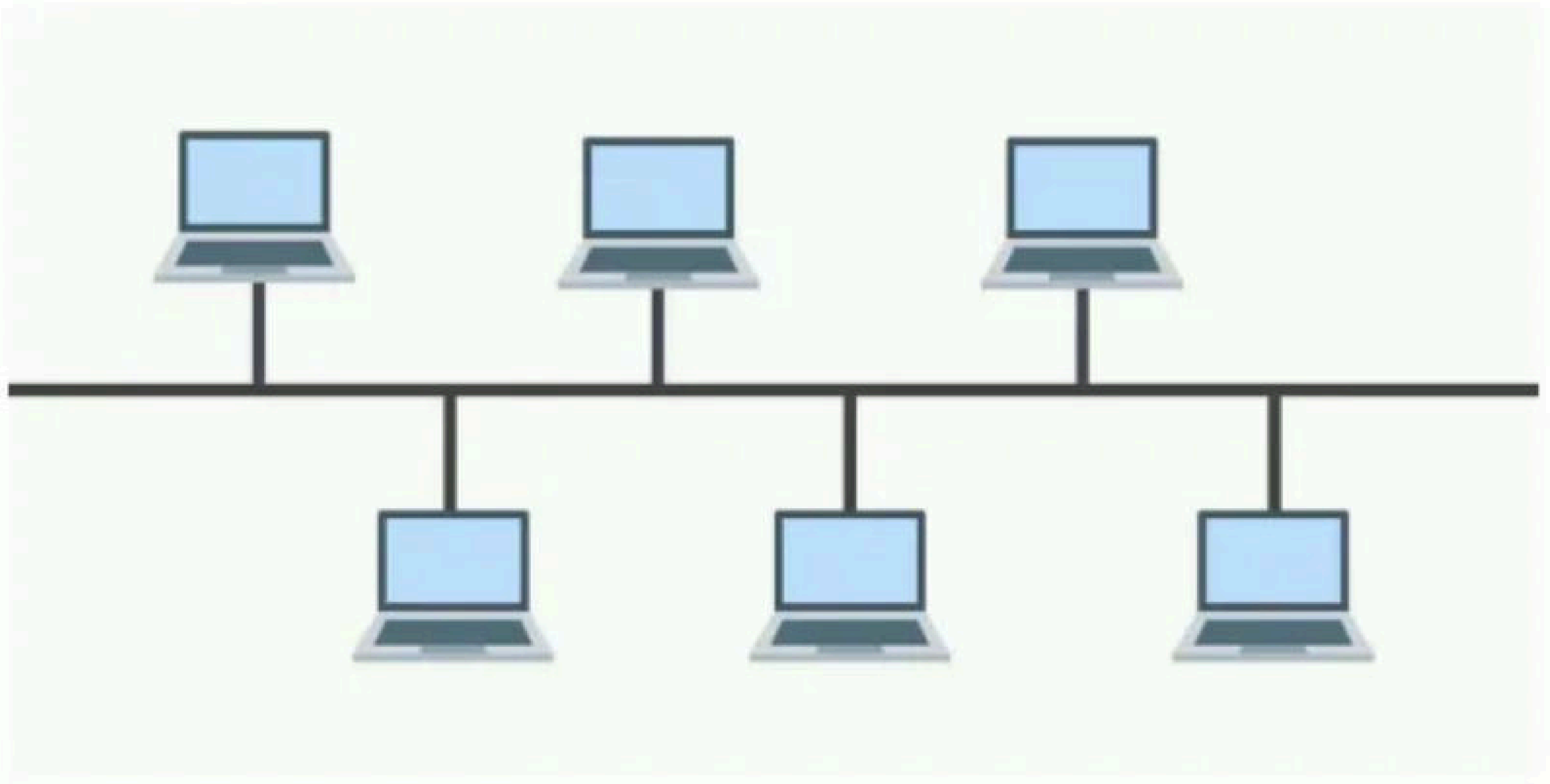
4. Framing is handled in both the LLC sublayer and the MAC sublayer.

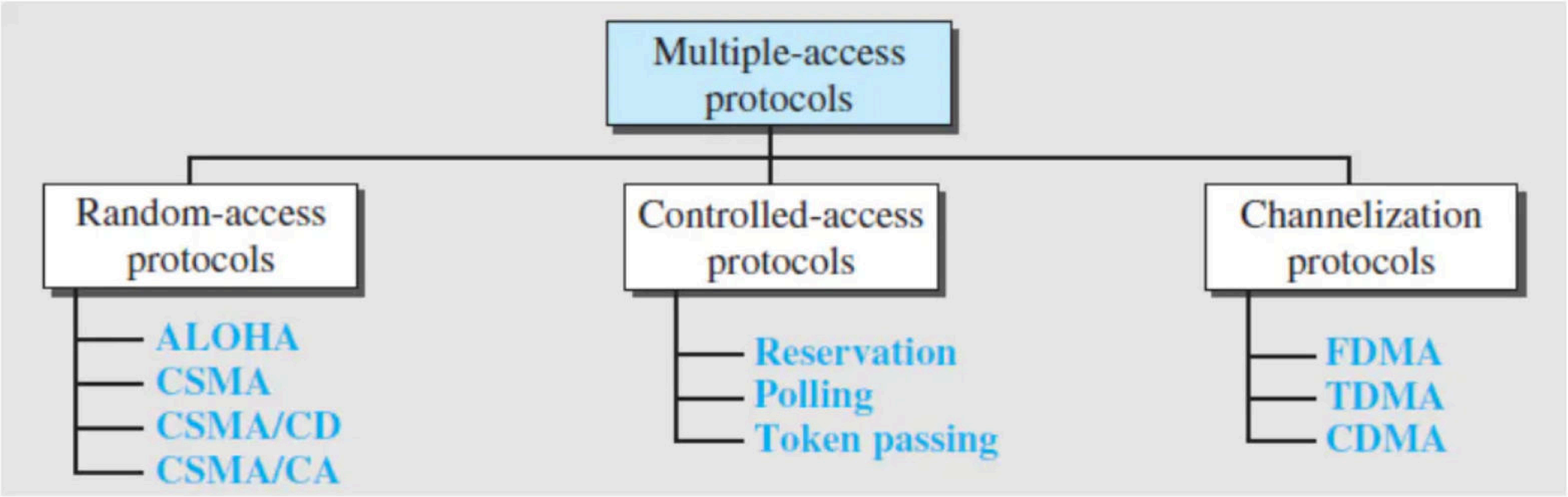


Media Access Control

1. When nodes or stations are connected and use a common link, called a *multipoint* or *broadcast link,* we need a multiple-access protocol to coordinate access to the link.

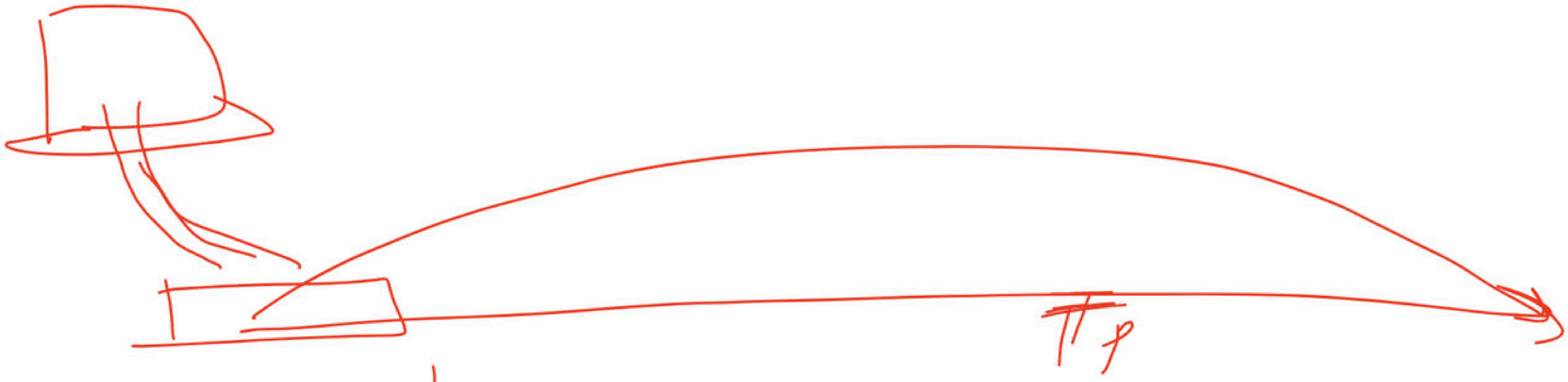
2. Many protocols have been devised to handle access to a shared link. All of these protocols belong to a sublayer in the data-link layer called media access control (MAC).




Multiple-access protocols
Random-access protocols
Controlled-access protocols
Channelization protocols
ALOHA
CSMA
CSMA/CD
CSMA/CA
Reservation
Polling
Token passing
FDMA
TDMA
CDMA

- **<u>Propagation Delay</u>**: Propagation delay is the time it takes for a bit to travel from point A to point B in the transmission media.
  T_P = (Distance) / (Propagation speed)

- **<u>Transmission Delay (TT)</u>** : A sender needs to put the bits in a packet on the line one by one. If the first bit of the packet is put on the line at time t_1 and the last bit is put on the line at time t_2, transmission delay of the packet is $(t_2 - t_1)$.
  T_t = (Packet length (L)) / (Transmission rate or Bandwidth (B)) = L / B



$T_T = \frac{L}{B}$

Break

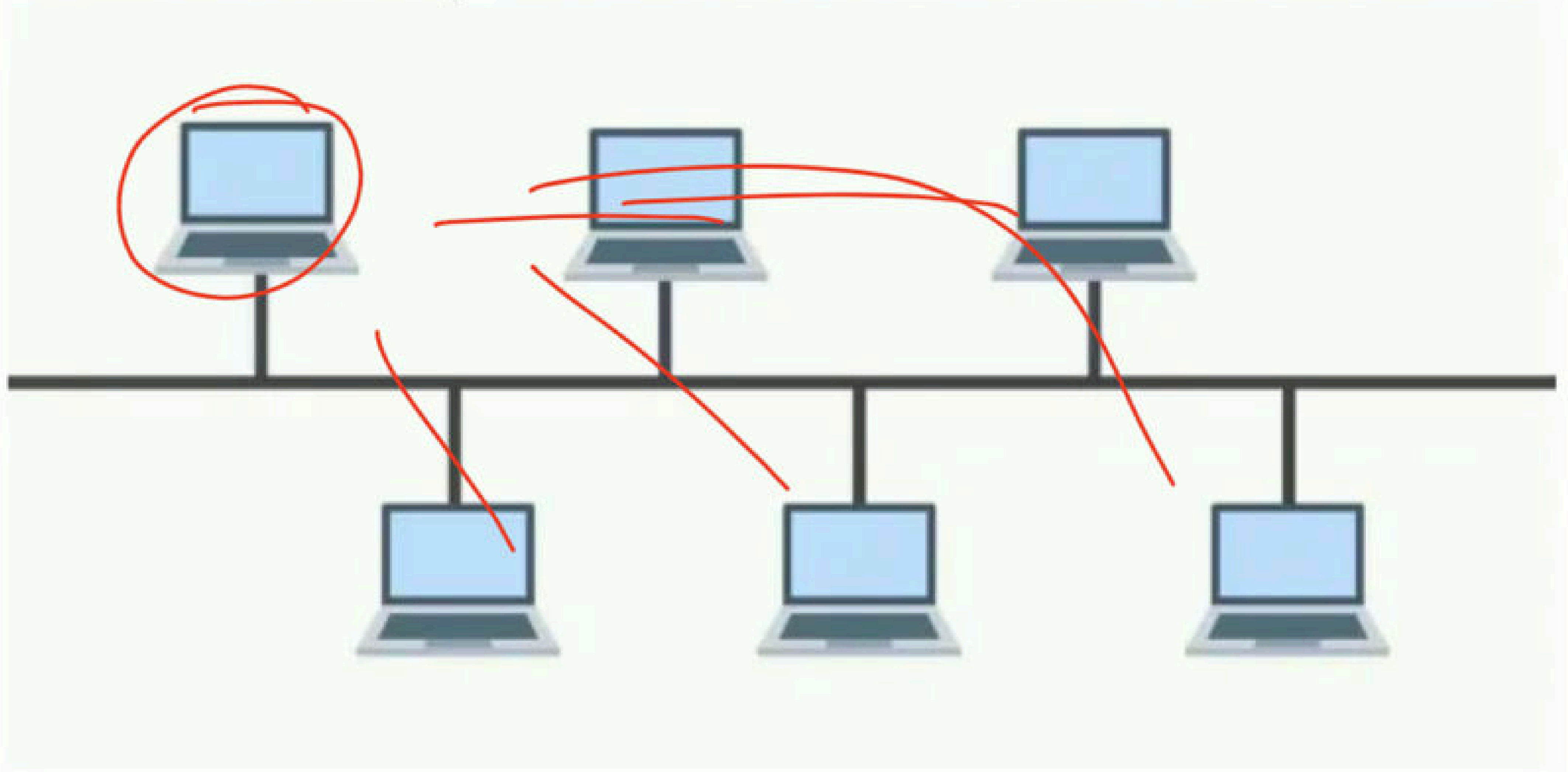
RANDOM ACCESS

1. In random access methods, no station is superior to another station and none is assigned the control over another.

2. No station permits, or does not permit, another station to send.

3. Two features give this method its name.
   - First, there is no scheduled time for a station to transmit. Transmission is random among the stations. That is why these methods are called random access.

   - Second, no rules specify which station should send next. Stations compete with one another to access the medium. That is why these methods are also called contention methods.

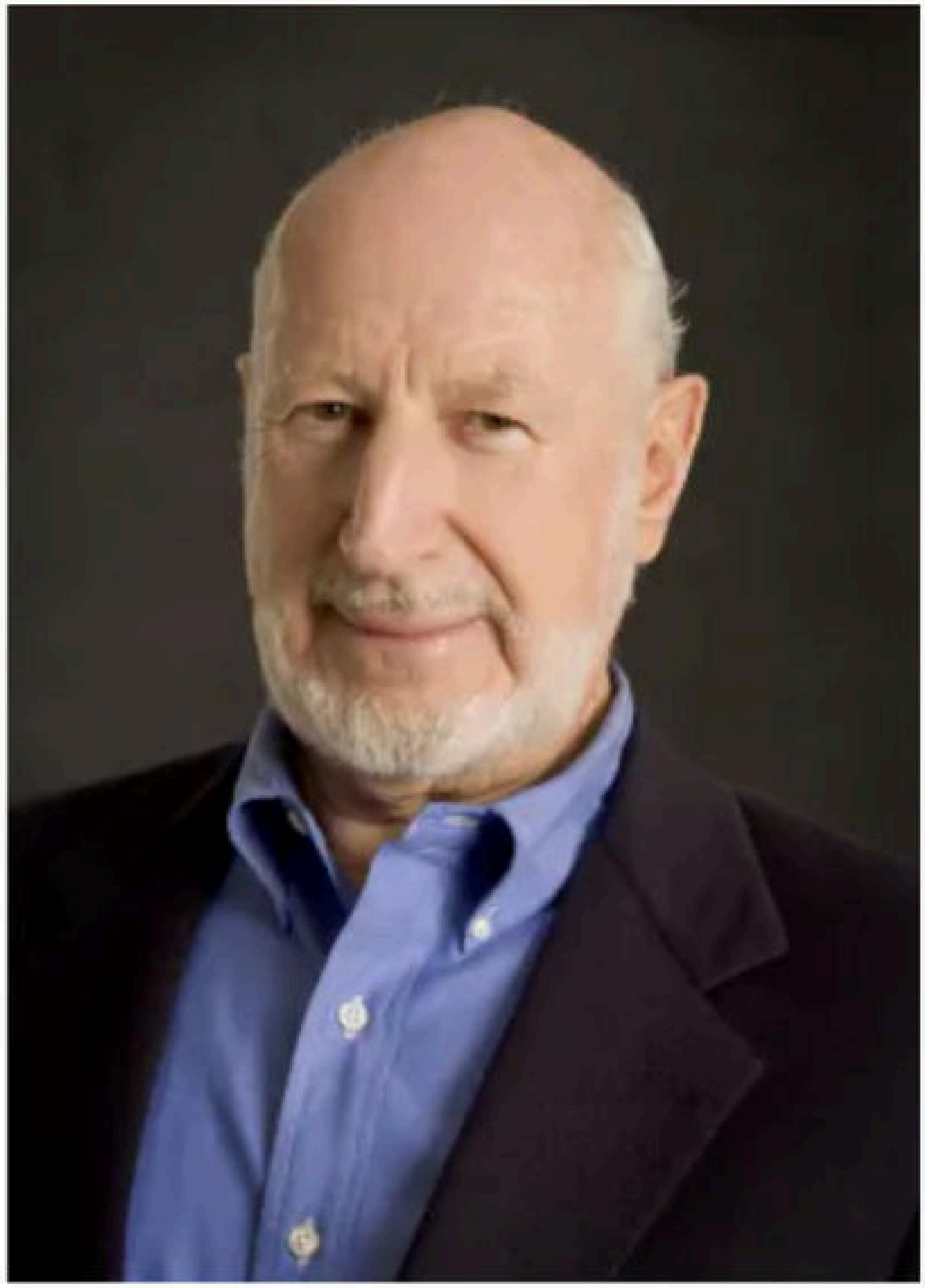


- However, if more than one station tries to send, there is an access conflict-collision-and the frames will be either destroyed or modified.

- All the protocols in Random access approach will answer the following questions
  1. When can the station access the medium?
  2. What can the station do if the medium is busy?
  3. How can the station determine the success or failure of the transmission?
  4. What can the station do if there is an access conflict?

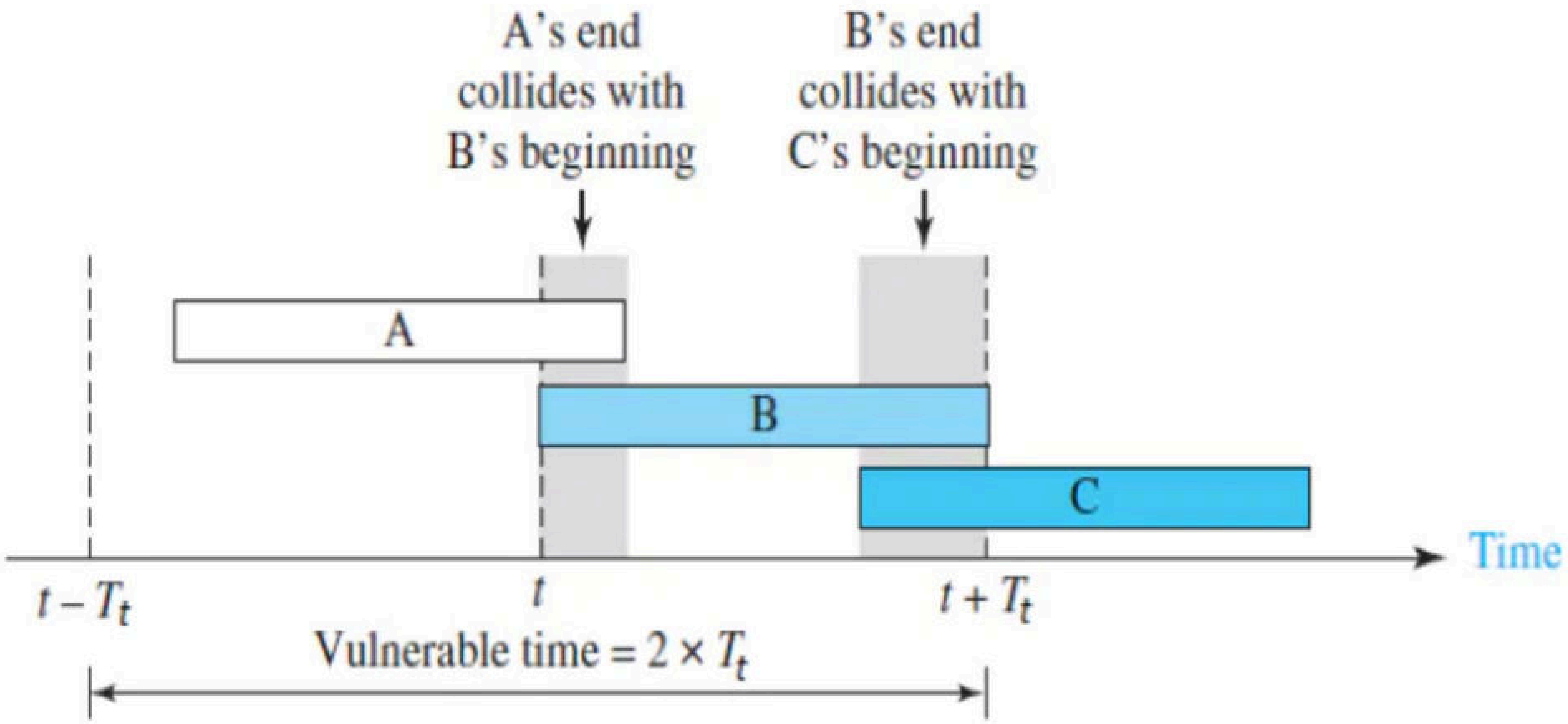
Aloha

- Earliest random-access method, was developed at the University of Hawaii around 1970.
- It was designed for a radio (wireless) LAN, but it can be used on any shared medium.
- The original ALOHA protocol is called pure ALOHA. This is a simple, but elegant protocol.
- The idea is that each station sends a frame whenever it has a frame to send. However, there is the possibility of collision between frames from different stations.



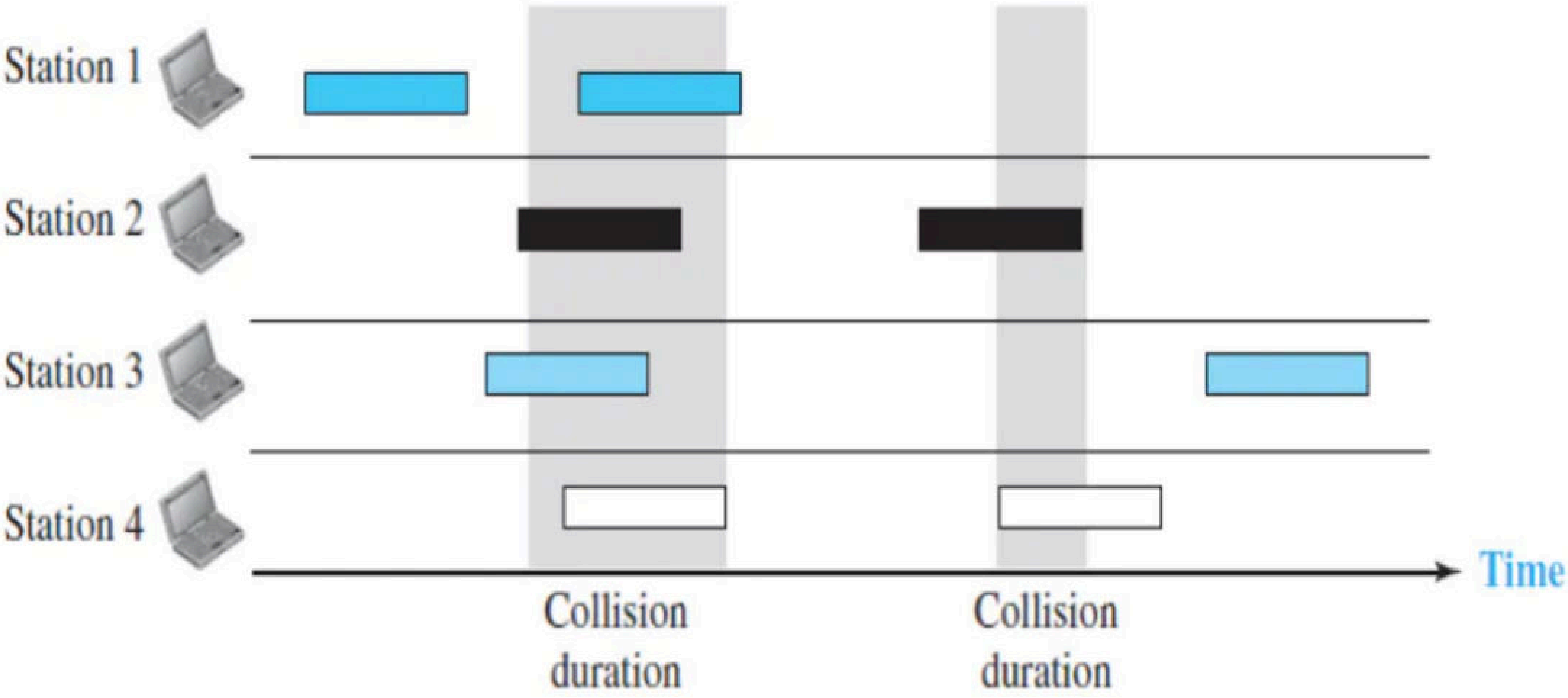
Norman Manuel Abramson

- Vulnerable time in which there is a possibility of collision. We assume that the stations send fixed-length frames with each frame taking T_{fr} S to send.
- Station A sends a frame at time t. Now imagine station B has already sent a frame between t - T_{fr} and t. This leads to a collision between the frames from station A and station B. The end of B's frame collides with the beginning of A's frame.
- On the other hand, suppose that station C sends a frame between t and t + T_{fr}. Here, there is a collision between frames from station A and station C. The beginning of C's frame collides with the end of A's frame. we see that the vulnerable time, during which a collision may occur in pure ALOHA, is 2 times the frame transmission time.
- Pure ALOHA vulnerable time= 2 x T_{fr}

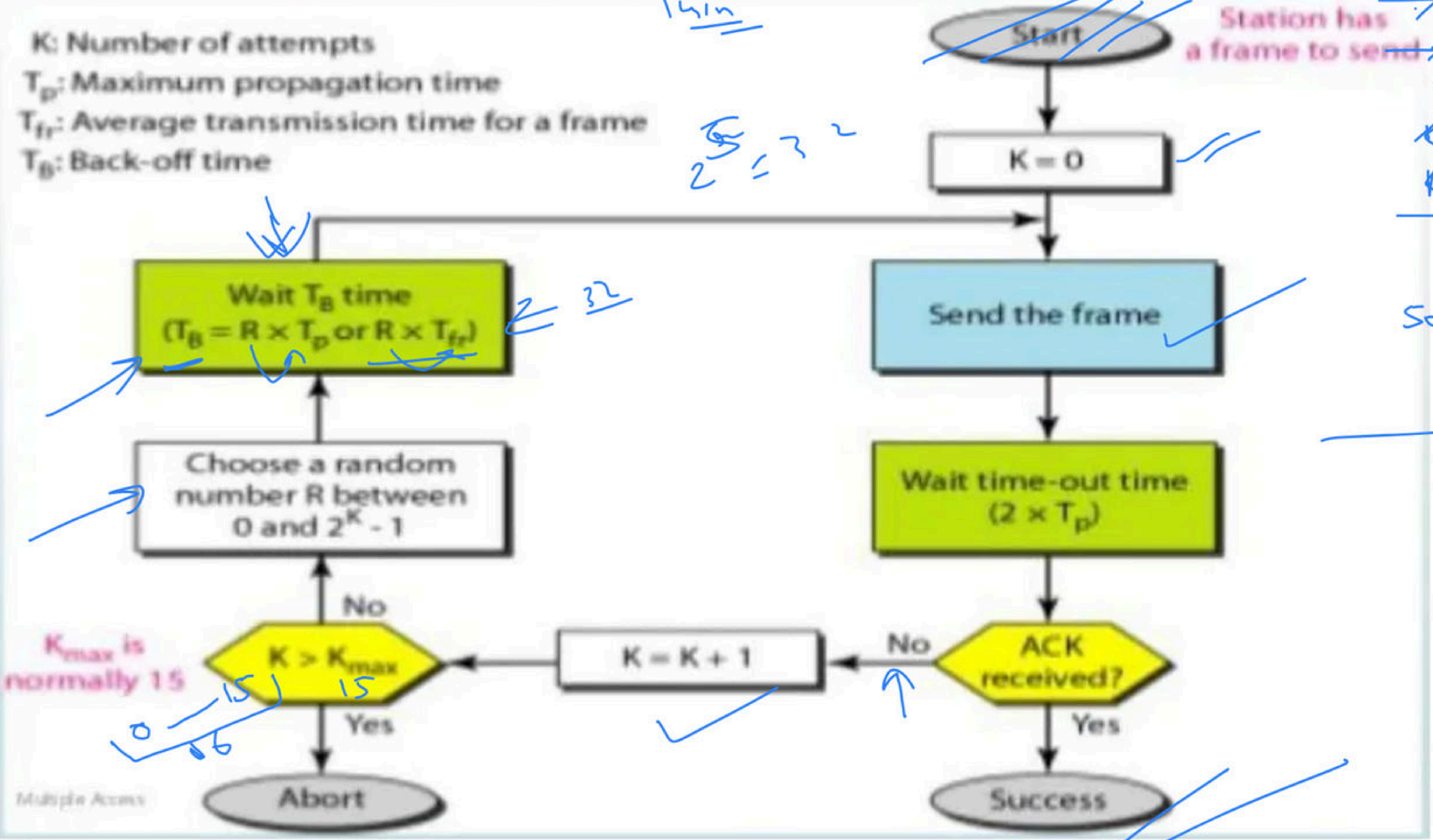


- The pure ALOHA protocol relies on acknowledgments from the receiver. When a station sends a frame, it expects the receiver to send an acknowledgment.

- If the acknowledgment does not arrive in time-out period, the station assumes that the frame (or the acknowledgment) has been destroyed and resends the frame.



Procedure for Pure ALOHA protocol



1min

16

A B

K = 0

K = 1

A	B
0	0
0	1
1	0
1	1

(A) $k=2$	$k=2$ (B)
0	0
0	1
0	2
0	3
1	0
1	1
1	2
1	3
2	0
2	1
2	2
2	3
3	0
3	1
3	2
3	3

75%.

25%.

$0 — 2^k - 1$

$0 — 3$

1 → 100%

2 → 50%

3 → 25%

4 → 12.5%

6.25 —

⋮

16

- If all these stations try to resend their frames after the time-out, the frames will collide again.

- Pure ALOHA dictates that when the time-out period passes, each station waits a random amount of time before resending its frame. The randomness will help avoid more collisions. We call this time the back-off time T_B.

- Pure ALOHA has a second method to prevent congesting the channel with retransmitted frames. After a maximum number of retransmissions attempts K_{max} a station must give up and try later.

Example: The stations on a wireless ALOHA network are a maximum of 600 km apart. If we assume that signals propagate at 3×10^8 m/s . Find back off time possibility after two consecutive collision ?

$T_B = R \times T_p$

$T_p = \frac{D}{S} = \frac{\cancel{6}00 \times 1000 \times 1000}{\cancel{3} \times \cancel{10^8}} = \boxed{2\ ms}$

$\cancel{T_B = R \times T_T}$

$K = 0 \quad K = 1 \quad K = 2$

$R = 0 \text{ --- } 2^k - 1$

0, 1, 2, 3

$0 \times 2ms = 0ms$

$1 \times 2ms = 2ms$

$2 \times 2ms = 4ms$

$3 \times 2ms = 6ms$

Example: A pure ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. What is the requirement to make this frame collision-free?

$L = 200$ bits

$B = 200$ Kbps

$\downarrow$

$V.T \leq 2 \times T_T$

$= 2 \times 1ms$

$= 2ms$

$T_T = \frac{L}{B}$

$= \frac{\cancel{200} \times \cancel{1000}}{\cancel{200} \times \cancel{1000}} = \boxed{1ms}$

Example 12.2

A pure ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. What is the requirement to make this frame collision-free?

Solution

Average frame transmission time T_{fr} is 200 bits/200 kbps or 1 ms. The vulnerable time is 2×1 ms = 2 ms. This means no station should send later than 1 ms before this station starts transmission and no station should start sending during the period (1 ms) that this station is sending.

Throughput

Let us call G the average number of frames generated by the system during one frame transmission time. Then it can be proven that the average number of successfully transmitted frames for pure ALOHA is $S = G \times e^{-2G}$. The maximum throughput S_{max} is 0.184, for $G = 1/2$. (We can find it by setting the derivative of S with respect to G to 0; see Exercises.) In other words, if one-half a frame is generated during one frame transmission time (one frame during two frame transmission times), then 18.4 percent of these frames reach their destination successfully. We expect $G = 1/2$ to produce the maximum throughput because the vulnerable time is 2 times the frame transmission time. Therefore, if a station generates only one frame in this vulnerable time (and no other stations generate a frame during this time), the frame will reach its destination successfully.

The throughput for pure ALOHA is $S = G \times e^{-2G}$.
The maximum throughput $S_{max} = 1/(2e) = 0.184$ when $G = (1/2)$.

Example 12.3

A pure ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. What is the throughput if the system (all stations together) produces

a. 1000 frames per second?

b. 500 frames per second?

c. 250 frames per second?

Solution

The frame transmission time is 200/200 kbps or 1 ms.

a. If the system creates 1000 frames per second, or 1 frame per millisecond, then $G = 1$. In this case $S = G \times e^{-2G} = 0.135$ (13.5 percent). This means that the throughput is $1000 \times 0.135 = 135$ frames. Only 135 frames out of 1000 will probably survive.

b. If the system creates 500 frames per second, or 1/2 frames per millisecond, then $G = 1/2$. In this case $S = G \times e^{-2G} = 0.184$ (18.4 percent). This means that the throughput is $500 \times 0.184 = 92$ and that only 92 frames out of 500 will probably survive. Note that this is the *maximum* throughput case, percentagewise.

c. If the system creates 250 frames per second, or 1/4 frames per millisecond, then $G = 1/4$. In this case $S = G \times e^{-2G} = 0.152$ (15.2 percent). This means that the throughput is $250 \times 0.152 = 38$. Only 38 frames out of 250 will probably survive.

Q.22 Consider a network using the pure ALOHA medium access control protocol, where each frame is of length 1,000 bits. The channel transmission rate is 1 Mbps (= 10^6 bits per second). The aggregate number of transmissions across all the nodes (including new frame transmissions and retransmitted frames due to collisions) is modelled as a Poisson process with a rate of 1,000 frames per second, Throughput is defined as the average number of frames successfully transmitted per second. The throughput of the network (rounded to the nearest integer) is ________.

(GATE-2021)

Ans. (135) [130 - 140]

Break

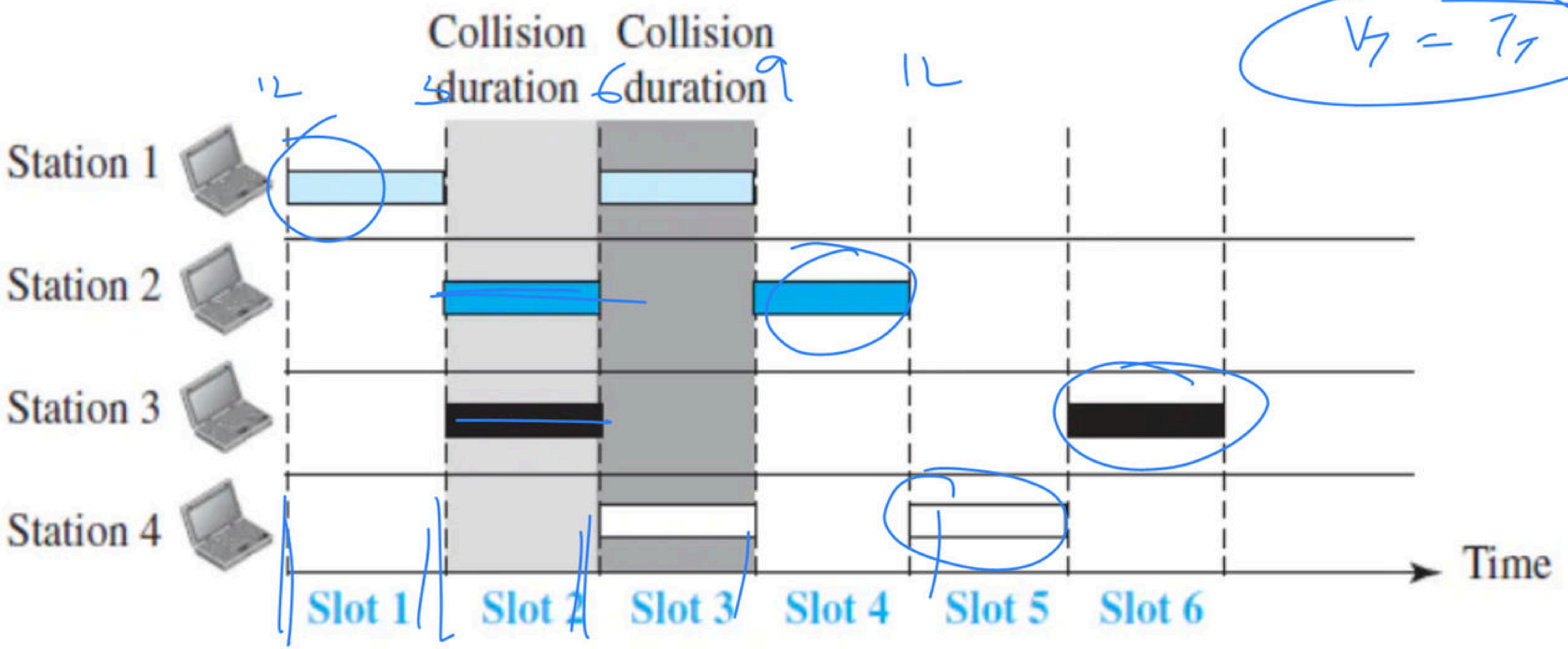
Slotted ALOHA

$V_T = 2 * T_f$

- Pure ALOHA has a vulnerable time of 2 x T_{fr}. This is so because there is no rule that defines when the station can send. A station may send soon after another station has started or soon before another station has finished.

- Slotted ALOHA was invented to improve the efficiency of pure ALOHA. In slotted ALOHA we divide the time into slots of T_{fr} s and force the station to send only at the beginning of the time slot.

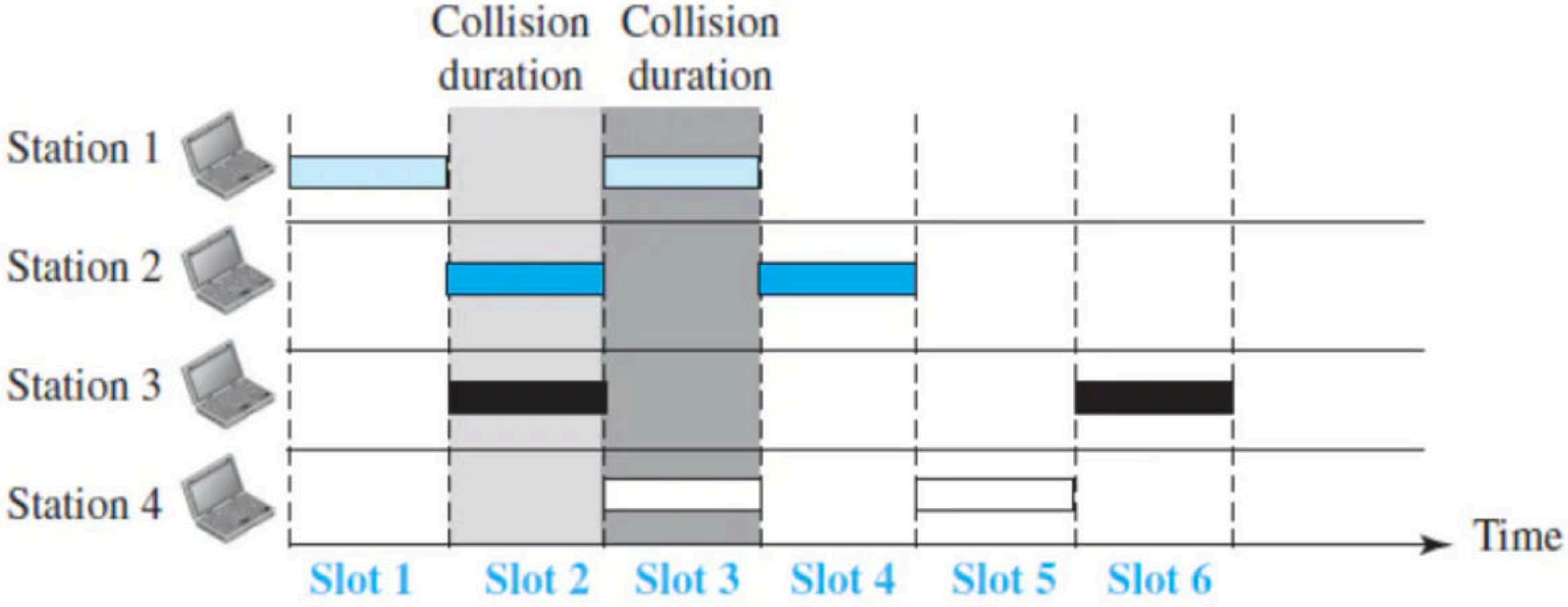
$V_t = T_f$



12:00 12:05 12:10 12:15

- Because a station is allowed to send only at the beginning of the synchronized time slot, if a station misses this moment, it must wait until the beginning of the next time slot. This means that the station which started at the beginning of this slot has already finished sending its frame.

- Off course, there is still the possibility of collision if two stations try to send at the beginning of the same time slot. However, the vulnerable time is now reduced to one-half, equal to T_{fr}



Q Consider a LAN with four nodes S_1, S_2, S_3 and S_4. Time is divided into fixed-size slots, and a node can begin its transmission only at the beginning of a slot. A collision is said to have occurred if more than one node transmits in the same slot. The probabilities of generation of a frame in a time slot by S_1, S_2, S_3 and S_4 are 0.1, 0.2, 0.3 and 0.4, respectively. The probability of sending a frame in the first slot without any collision by any of these four stations is __________. **(Gate-2015) (2 Marks)**

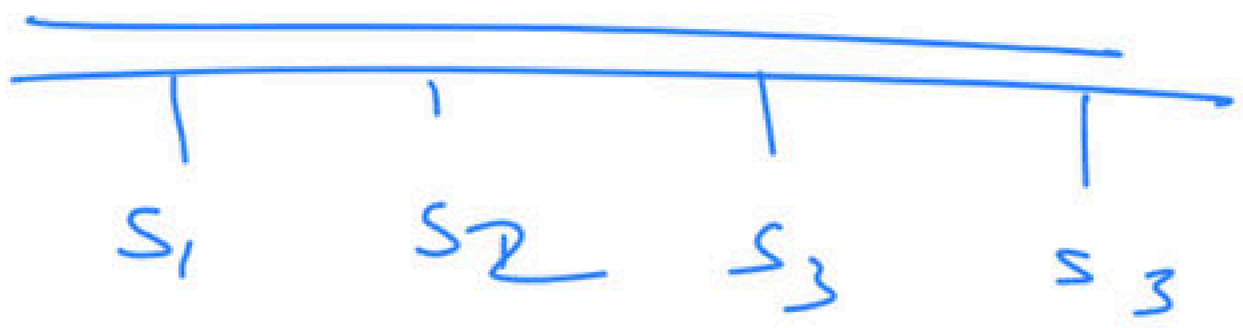
(A) 0.462 **(B)** 0.711 **(C)** 0.5 **(D)** 0.652

37 27 21 15

$S_1 \overline{S_2}\, \overline{S_3}\, \overline{S_4} + \overline{S_1} S_2 \overline{S_3}\, \overline{S_4} + \overline{S_1}\, \overline{S_2} S_3 \overline{S_4} + \overline{S_1}\, \overline{S_2}\, \overline{S_3} S_4$

$\downarrow$

$0.1 \times 0.8 \times .7 \times .6$ + ______ + ______ + ______



Q There are *n* stations in a slotted LAN. Each station attempts to transmit with a probability *p* in each time slot. What is the probability that ONLY one station transmits in a given time slot? **(Gate-2007) (2 Marks)**

a) $np(1-p)^{n-1}$ **b)** $(1-p)^{n-1}$ **c)** $p(1-p)^{n-1}$ **d)** $1-(1-p)^{n-1}$

Q A and B are the only two stations on an Ethernet. Each has a steady queue of frames to send. Both A and B attempt to transmit a frame, collide, and A wins the first backoff race. At the end of this successful transmission by A, both A and B attempt to transmit and collide. The probability that A wins the second backoff race is: **(Gate-2004) (2 Marks)**

(A) 0.5 **(B)** 0.625 **(C)** 0.75 **(D)** 1.0

36 3x 25 12

A K=0 K=1 R=0

B K=0 K=1 R=1

C

T

K=0 K=1 R=0,1

K=1 K=2 R=0123

A	B
0	0
0	1
0	2
0	3
1	0
1	1
1	2
1	3

5/8

Break

Carrier Sense Multiple Access (CSMA)

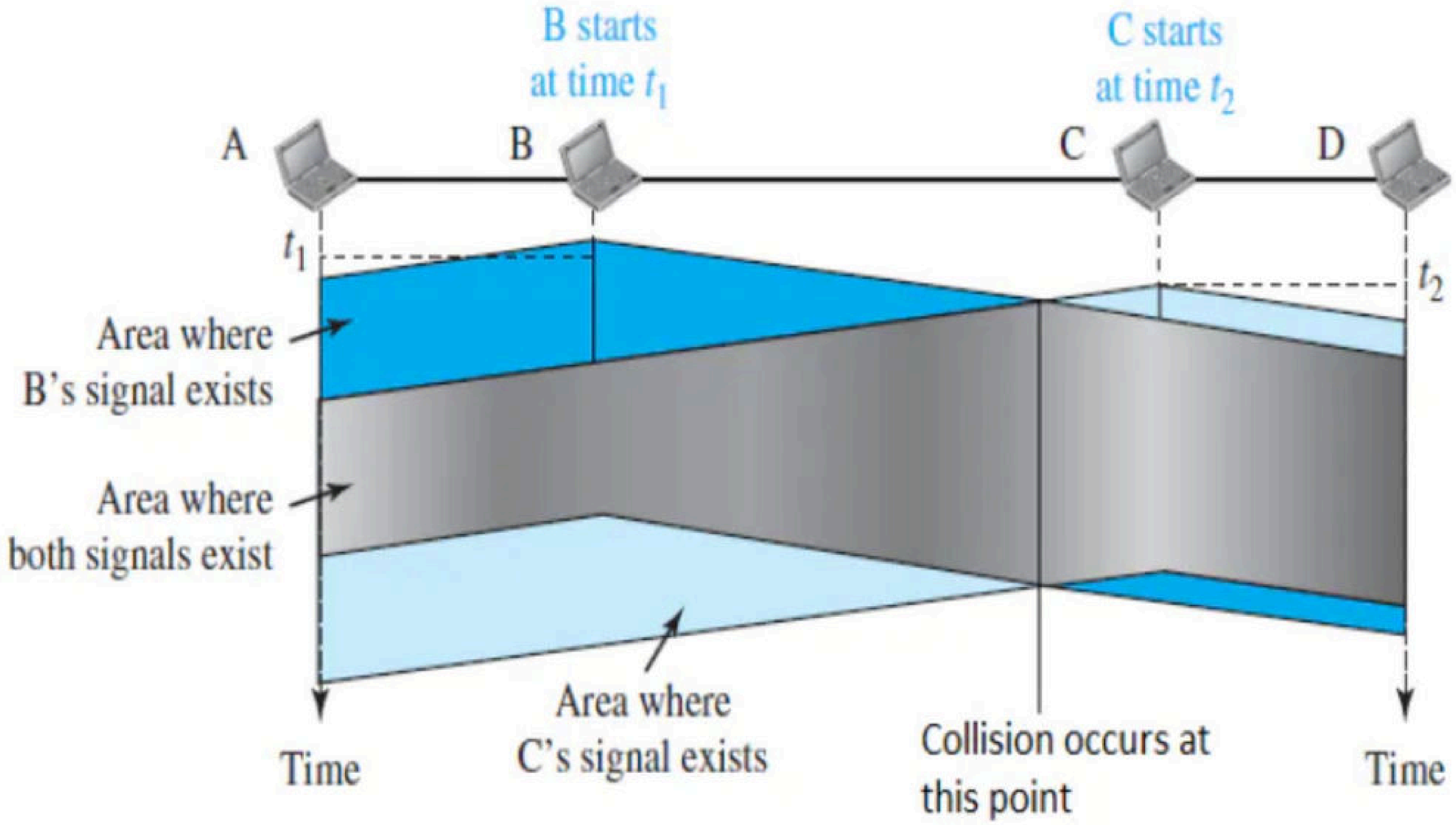
- To minimize the chance of collision and, therefore, increase the performance, the CSMA method was developed. The chance of collision can be reduced if a station senses the medium before trying to use it.

- Carrier sense multiple access (CSMA) requires that each station first listen to the medium (or check the state of the medium) before sending, so "sense before transmit" or" listen before talk." CSMA can reduce the possibility of collision, but it cannot eliminate it.

- The possibility of collision still exists because of propagation delay; when a station sends a frame, it still takes time (although very short) for the first bit to reach every station and for every station to sense it.

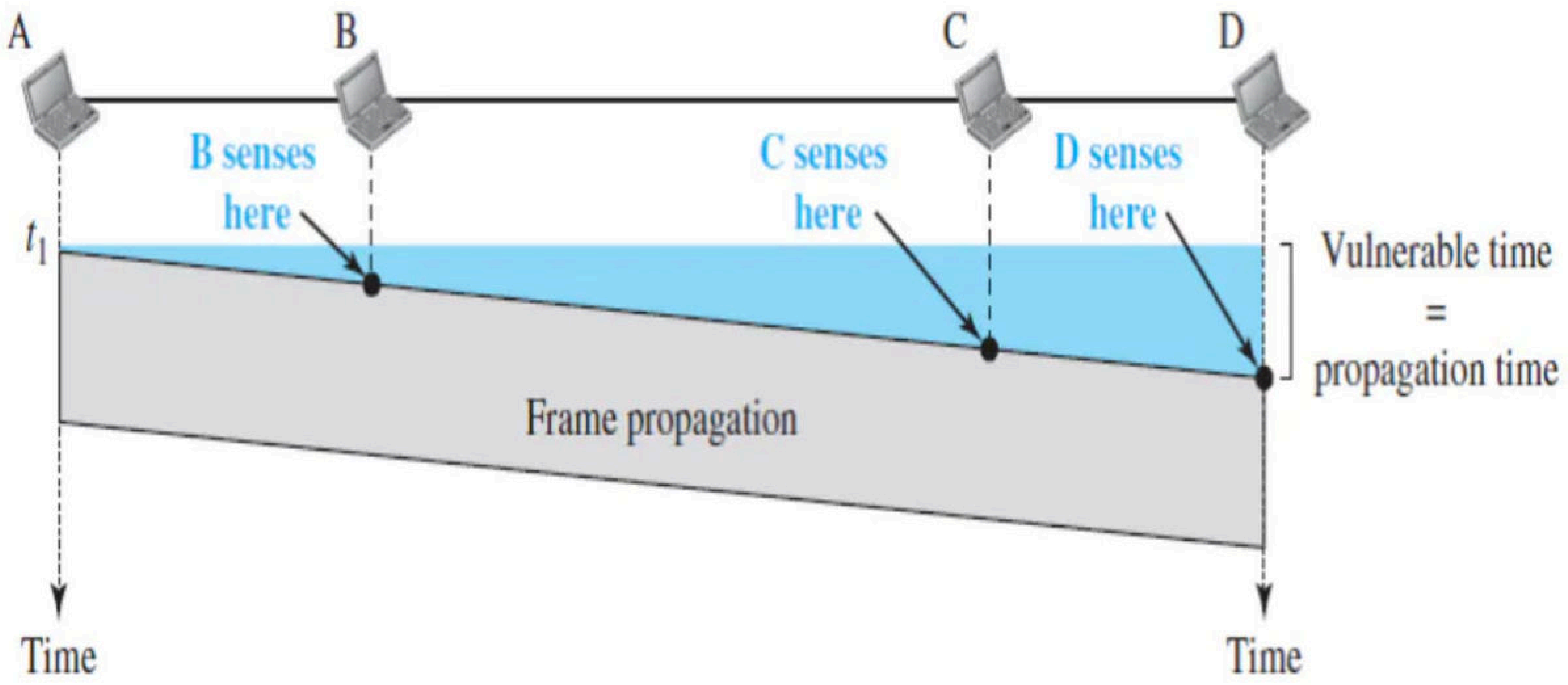
- In other words, a station may sense the medium and find it idle, only because the first bit sent by another station has not yet been received.

- At time t_1 station B senses the medium and finds it idle, so it sends a frame. At time t_2 ($t_2 > t_1$) station C senses the medium and finds it idle because, at this time, the first bits from station B have not reached station C. Station C also sends a frame. The two signals collide and both frames are destroyed.



Vulnerable Time

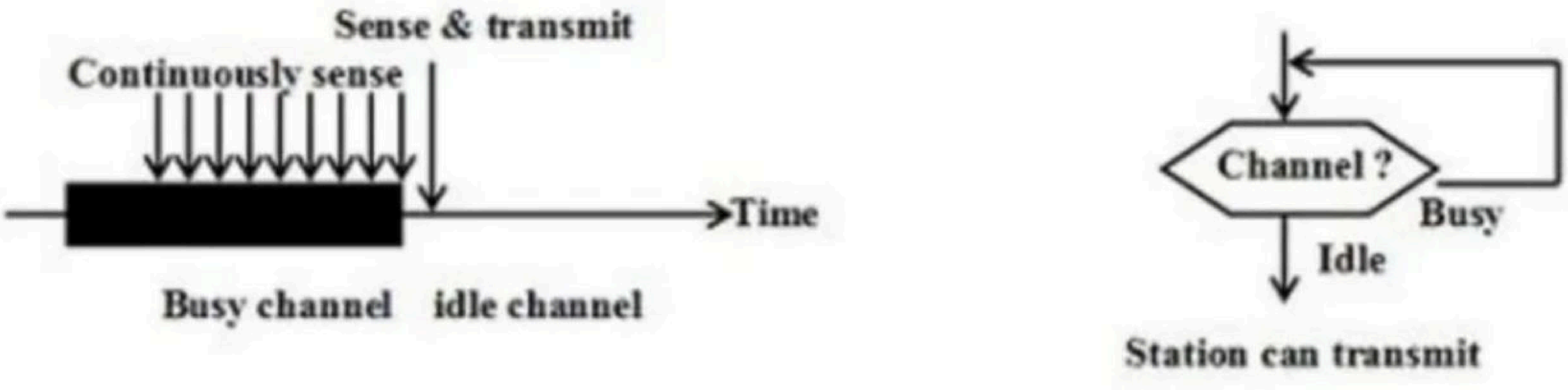
- The vulnerable time for CSMA is the ***propagation time*** *Tp*.
- When a station sends a frame and any other station tries to send a frame during this time, a collision will result.
- But if the first bit of the frame reaches the end of the medium, every station will already have heard the bit and will refrain from sending.
- Station A has sent a frame at time t_1, which reaches the rightmost station, D, at time $t_1 + T_p$.



Persistence Methods

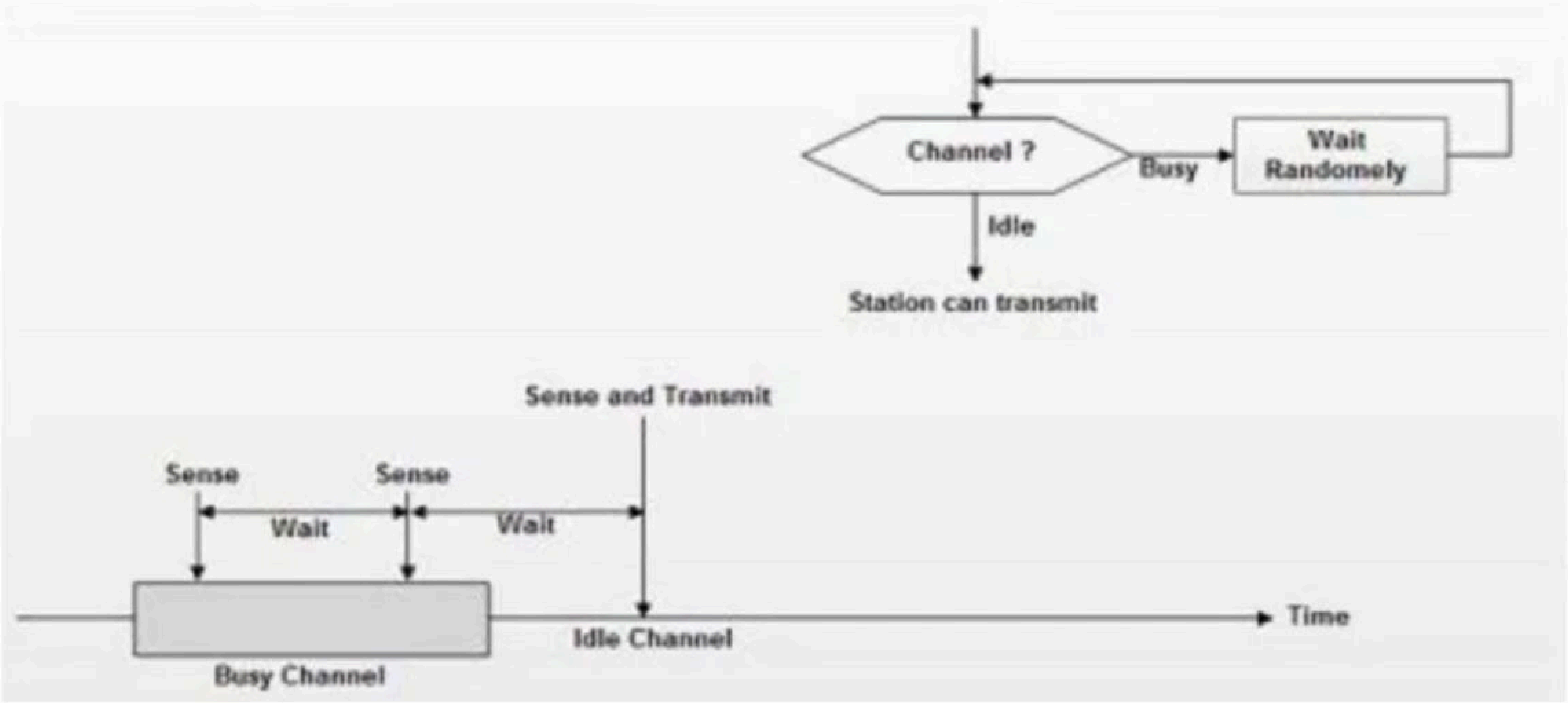
- What should a station do if the channel is busy? What should a station do if the channel is idle?
- Three methods have been devised to answer these questions:
    - 1-persistent method
    - Non-persistent method
    - P-persistent method.

- **1-Persistent**
  - The 1-persistent method is simple and straightforward. In this method, after the station finds the line idle, it sends its frame immediately (with probability 1). This method has the highest chance of collision because two or more stations may find the line idle and send their frames immediately.

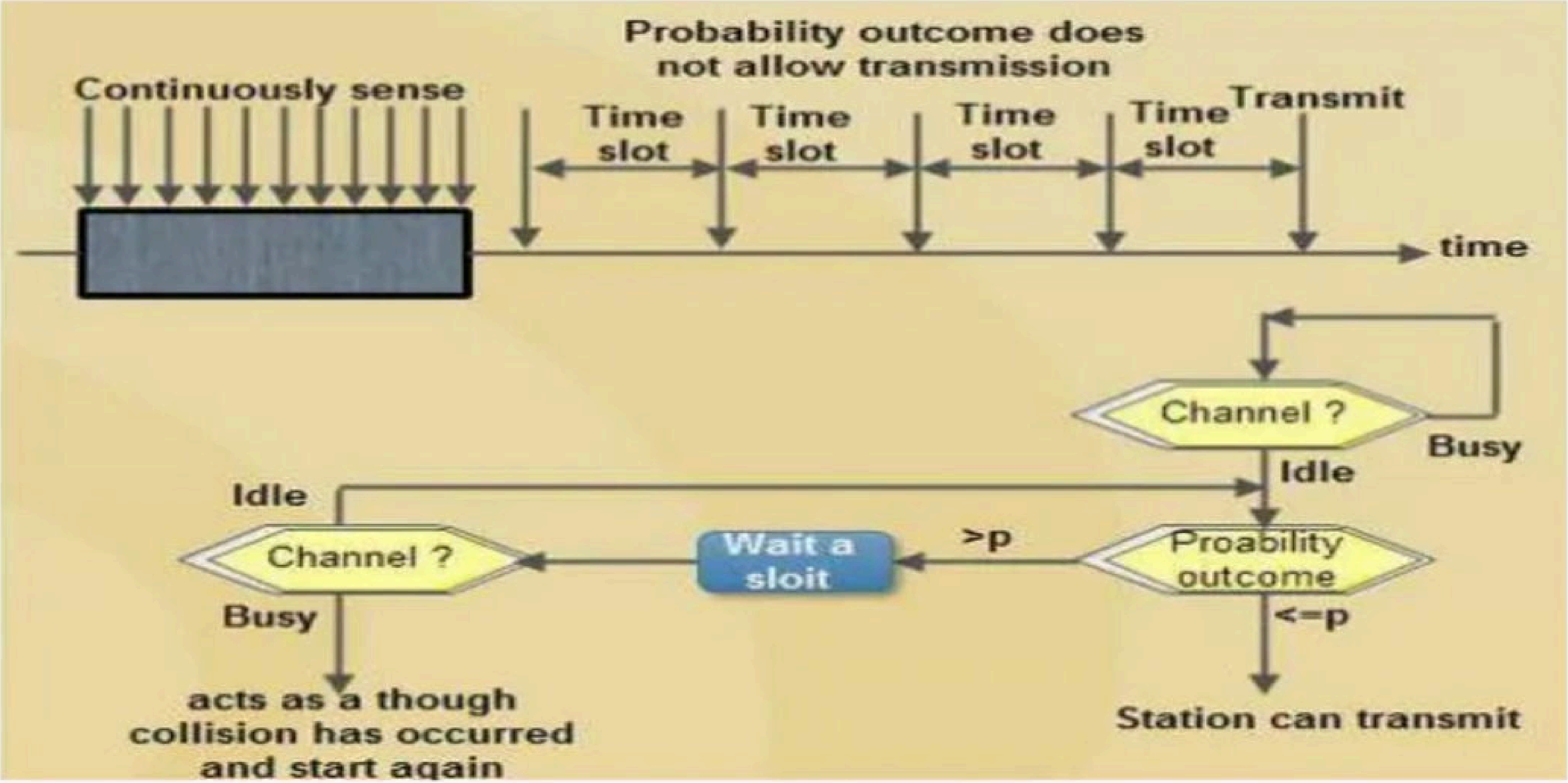


1-persistent CSMA

- **Nonpersistent**
  - In the nonpersistent method, a station that has a frame to send senses the line. If the line is idle, it sends immediately. If the line is not idle, it waits a random amount of time and then senses the line again.
  - The nonpersistent approach reduces the chance of collision because it is unlikely that two or more stations will wait the same amount of time and retry to send simultaneously. However, this method reduces the efficiency of the network because the medium remains idle when there may be stations with frames to send.



- **<u>P-Persistent</u>**
  - The p-persistent approach combines the advantages of the other two strategies. It reduces the chance of collision and improves efficiency. In this method, after the station finds the line idle it follows these steps:
  - With probability p, the station sends its frame.
  - With probability q = 1 - p, the station waits for the beginning of the next time slot and checks the line again.
    - a. If the line is idle, it goes to step 1.
    - b. If the line is busy, it acts as though a collision has occurred and uses the backoff procedure.



Break

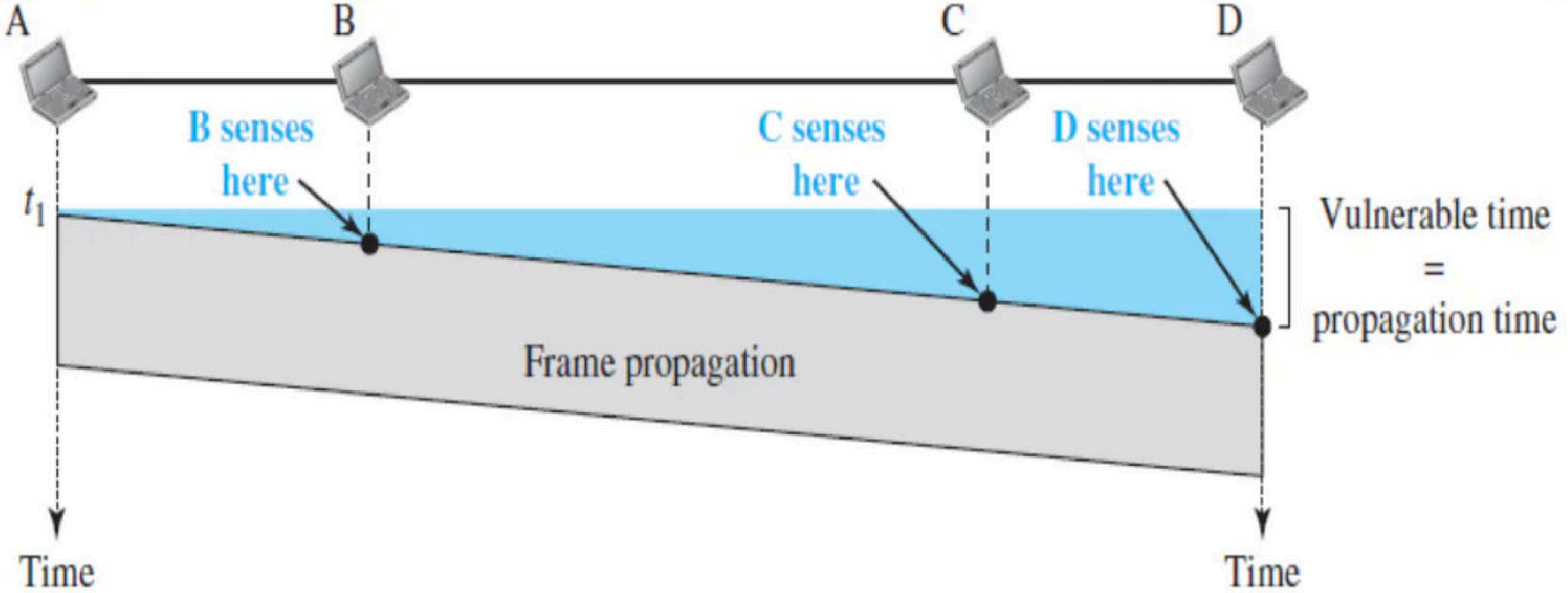
Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

- In this method, a station monitors the medium after it sends a frame to see if the transmission was successful. If so, the station is finished. If, however, there is a collision, the frame is sent again.

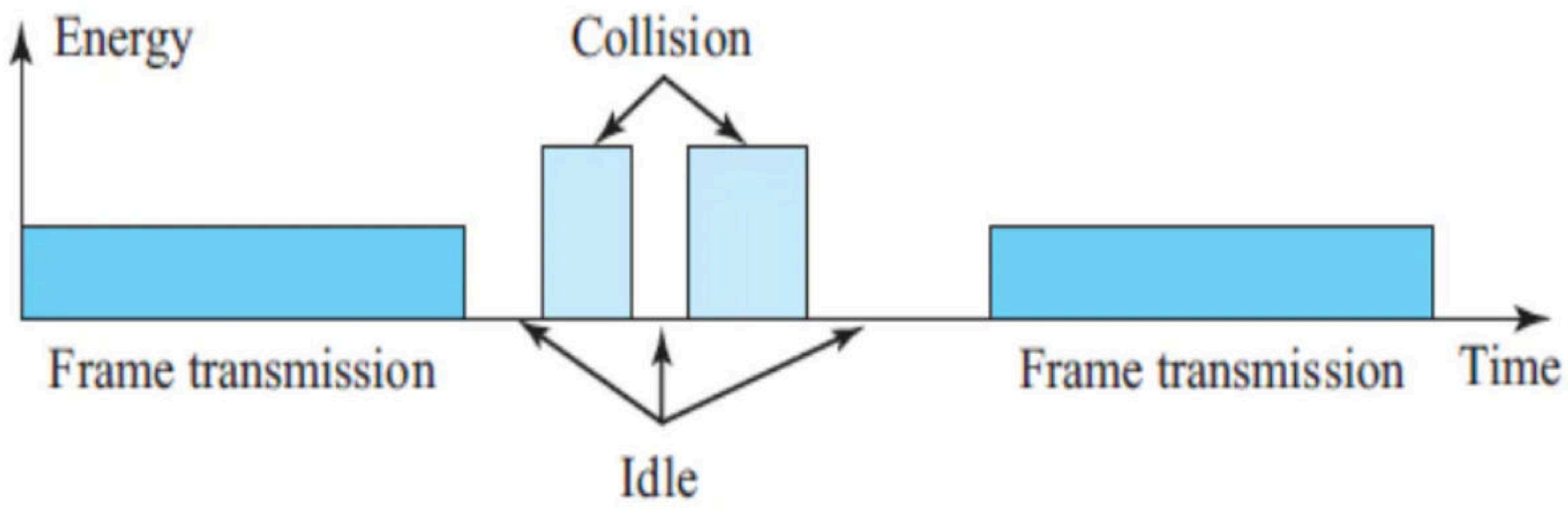
- Minimum Frame Size - For CSMA / CD to work, we need a restriction on the minimum frame size. Before sending the last bit of the frame, the sending station must detect a collision, if any, and abort the transmission.

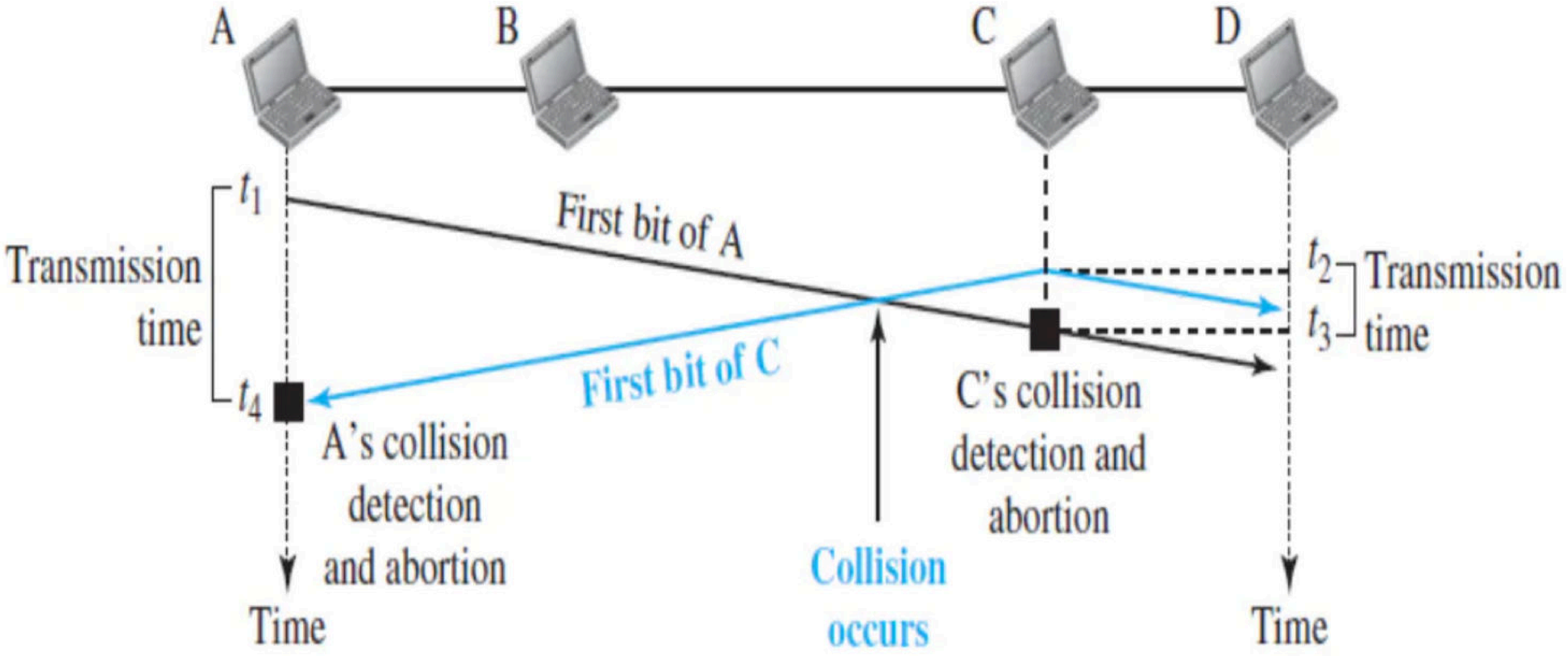
- This is so because the station, once the entire frame is sent, does not monitor the line for collision detection. Therefore, the frame transmission time T_{fr} must be at least two times the maximum propagation time Tp.

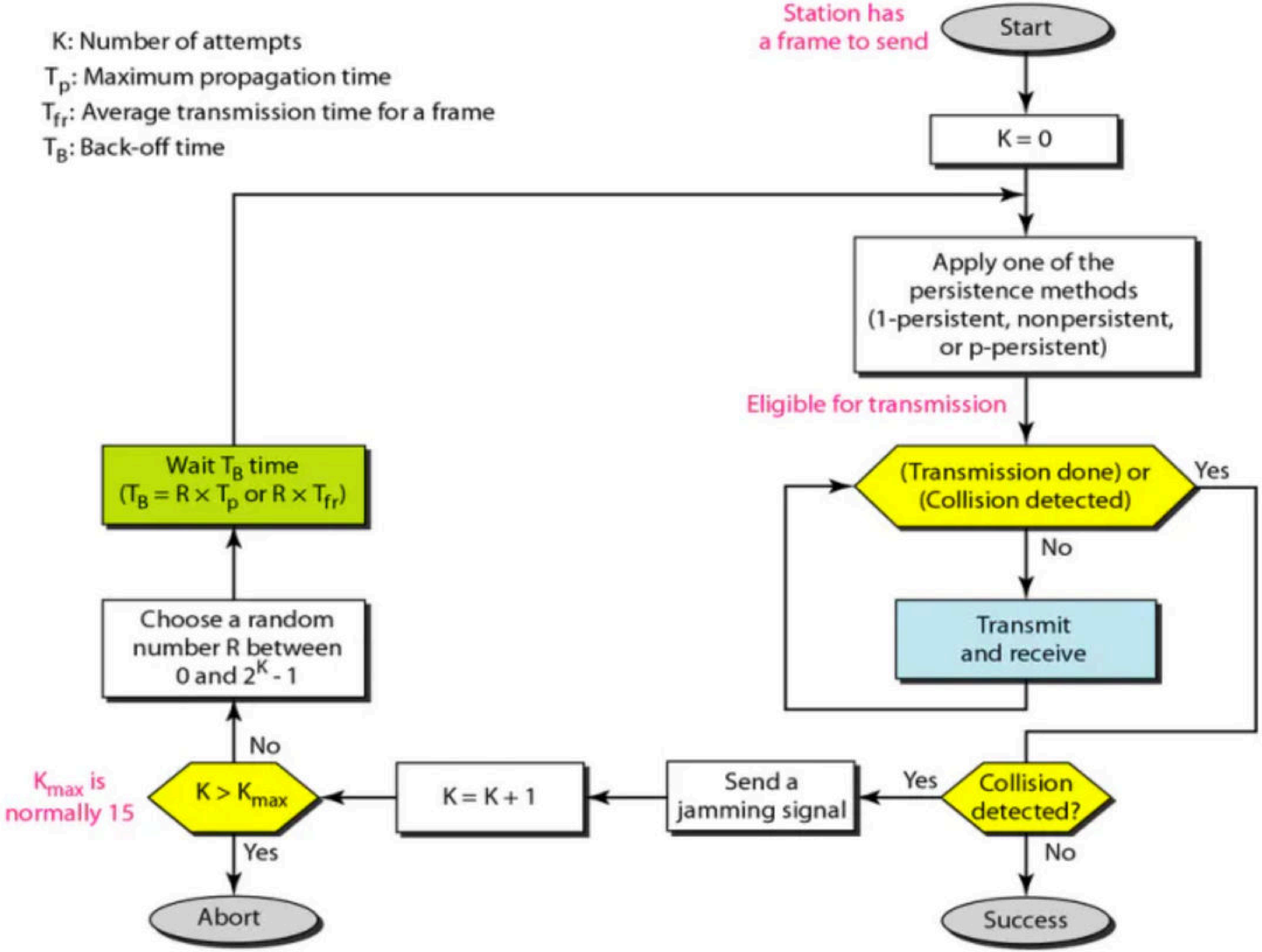
- To understand the reason, let us think about the worst-case scenario. If the two stations involved in a collision are the maximum distance apart, the signal from the first takes time T_p to reach the second, and the effect of the collision takes another time T_p to reach the first. So the requirement is that the first station must still be transmitting after $2T_p$.


A
B
C
D
B senses here
C senses here
D senses here
t_1
Vulnerable time = propagation time
Frame propagation
Time
Time

- **Energy Level**
  - We can say that the level of energy in a channel can have three values: zero, normal, and abnormal. At the zero level, the channel is idle. At the normal level, a station has successfully captured the channel and is sending its frame.
  - At the abnormal level, there is a collision and the level of the energy is twice the normal level. A station that has a frame to send or is sending a frame needs to monitor the energy level to determine if the channel is idle, busy, or in collision mode.




A
B
C
D
t_1
Transmission time
First bit of A
t_2
t_3
Transmission time
First bit of C
t_4
A's collision detection and abortion
C's collision detection and abortion
Collision occurs
Time
Time


K: Number of attempts
T_p: Maximum propagation time
T_{fr}: Average transmission time for a frame
T_B: Back-off time
Station has a frame to send
Start
K = 0
Apply one of the persistence methods (1-persistent, nonpersistent, or p-persistent)
Eligible for transmission
(Transmission done) or (Collision detected)
Yes
No
Transmit and receive
Wait T_B time ($T_B = R \times T_p$ or $R \times T_{fr}$)
Choose a random number R between 0 and $2^K - 1$
No
K_{max} is normally 15
$K > K_{max}$
Yes
Abort
K = K + 1
Send a jamming signal
Yes
Collision detected?
No
Success

Example: A network using CSMA/CD has a bandwidth of 10 Mbps. If the maximum propagation time is 25.6 μs, what is the minimum size of the frame?

Q A network has a data transmission bandwidth of 20×10^6 bits per second. It uses CSMA/CD in the MAC layer. The maximum signal propagation time from one node to another node is 40 microseconds. The minimum size of a frame in the network is __________ bytes. **(Gate-2016) (2 Marks)**

Q Consider a CSMA/CD network that transmits data at a rate of 100 Mbps (10^8 bits per second) over a 1 km (kilometre) cable with no repeaters. If the minimum frame size required for this network is 1250 bytes, what is the signal speed (km/sec) in the cable? **(Gate-2015) (1 Marks)**

(A) 8000 **(B)** 10000 **(C)** 16000 **(D)** 20000

Q A network with CSMA/CD protocol in the MAC layer is running at 1 Gbps over a 1 km cable with no repeaters. The signal speed in the cable is 2×10^8 m/sec. The minimum frame size for this network should be **(Gate-2005) (2 Marks)**

(A) 10000 bits **(B)** 10000 bytes **(C)** 5000 bits **(D)** 5000 bytes

Q A 2 km long broadcast LAN has 10^7 bps bandwidth and uses CSMA/CD. The signal travels along the wire at 2×10^8 m/s. What is the minimum packet size that can be used on this network?
(Gate-2003) (2 Marks)

(A) 50 bytes **(B)** 100 bytes **(C)** 200 bytes **(D)** None of these

Q The minimum frame size required for a CSMA/CD based computer network running at 1 Gbps on a 200m cable with a link speed of 2×10^8m/s is **(Gate-2008) (2 Marks)**

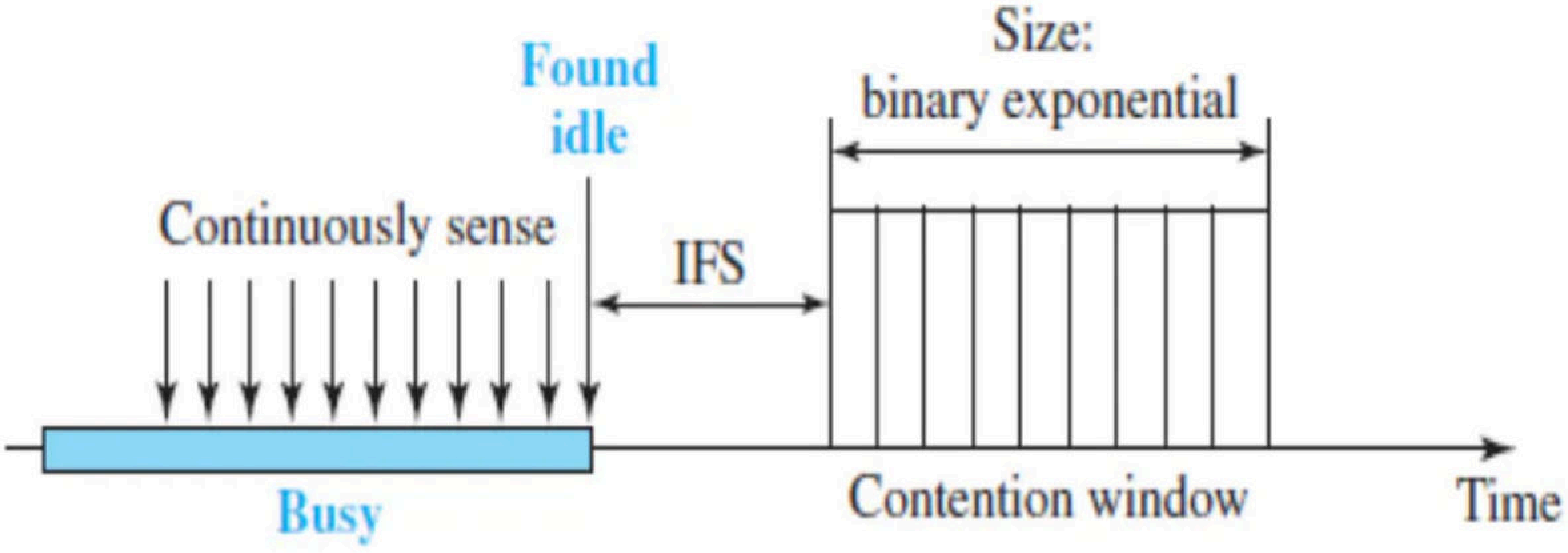
(A) 125 bytes **(B)** 250 bytes **(C)** 500 bytes **(D)** None of these

Q Consider a simple communication system where multiple nodes are connected by a shared broadcast medium (like Ethernet or wireless). The nodes in the system use the following carrier-sense based medium access protocol. A node that receives a packet to transmit will carrier-sense the medium for 5 units of time. If the node does not detect any other transmission in this duration, it starts transmitting its packet in the next time unit. If the node detects another transmission, it waits until this other transmission finishes, and then begins to carrier-sense for 5 time units again. Once they start to transmit, nodes do not perform any collision detection and continue transmission even if a collision occurs. All transmissions last for 20 units of time. Assume that the transmission signal travels at the speed of 10 meters per unit time in the medium. Assume that the system has two nodes P and Q, located at a distance *d* meters from each other. P starts transmitting a packet at time *t=0* after successfully completing its carrier-sense phase. Node Q has a packet to transmit at time *t=0* and begins to carrier-sense the medium. The maximum distance *d* (in meters, rounded to the closest integer) that allows Q to successfully avoid a collision between its proposed transmission and P's ongoing transmission is ___________. **(Gate-2018) (2 Marks)**

Break

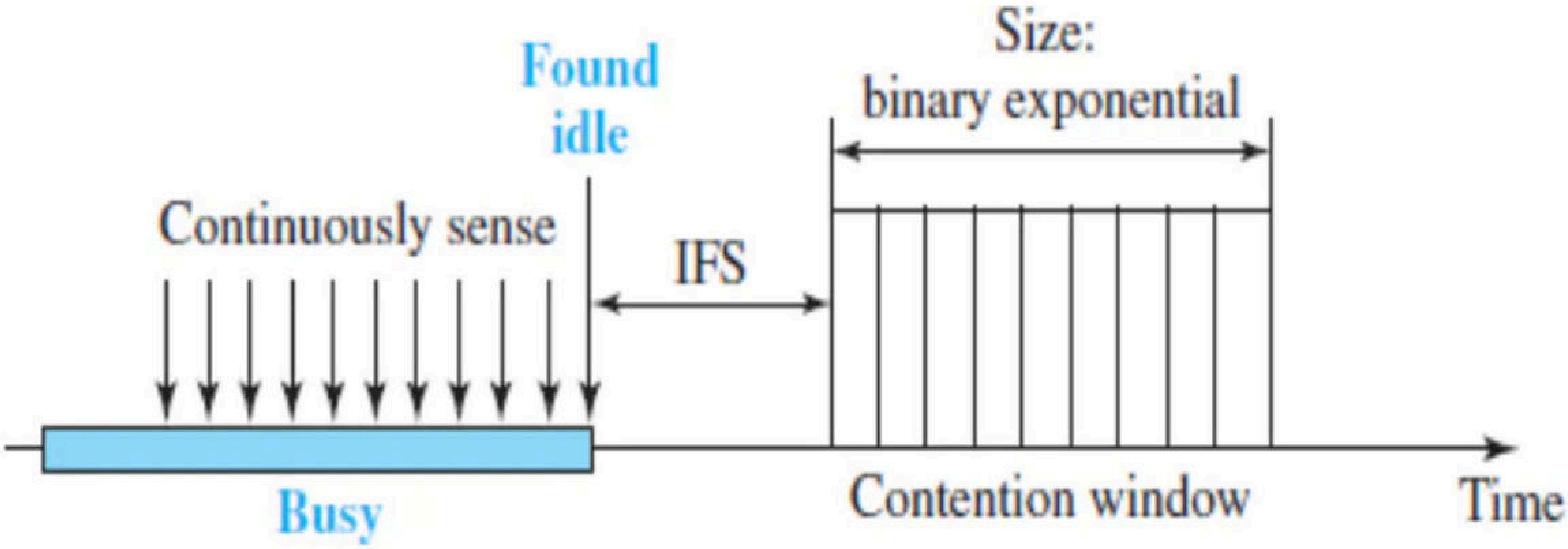
Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)

- In a wireless network, much of the sent energy is lost in transmission. The received signal has very little energy. Therefore, a collision may add only 5 to 10 percent additional energy. This is not useful for effective collision detection.
- We need to avoid collisions on wireless networks because they cannot be detected. Carrier sense multiple access with collision avoidance (CSMA / CA) was invented for this network. Collisions are avoided through the use of CSMA / CA
- three strategies: the interframe space, the contention window, and acknowledgment



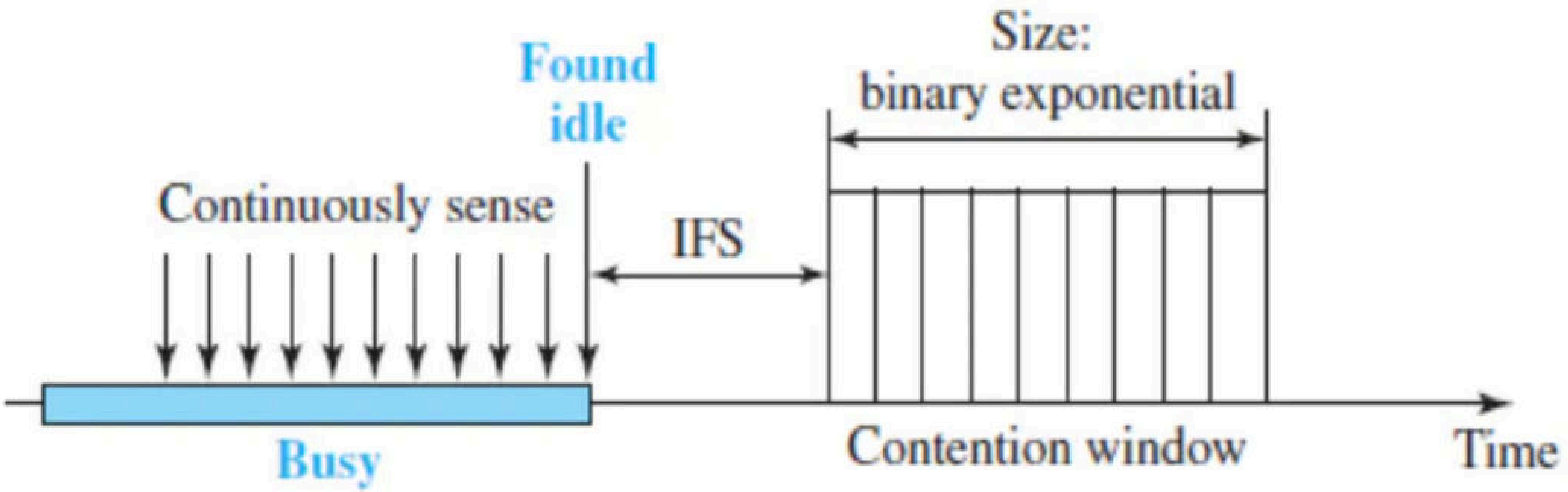
- **Interframe Space (IFS)**
  - First, collisions are avoided by deferring transmission even if the channel is found idle. When an idle channel is found, the station does not send immediately. It waits for a period of time called the interframe space or IFS.

  - The IFS time allows the front of the transmitted signal by the distant station to reach this station. If after the IFS time the channel is still idle, the station can send, but it still needs to wait a time equal to the contention time. The IFS variable can also be used to prioritize stations or frame types.

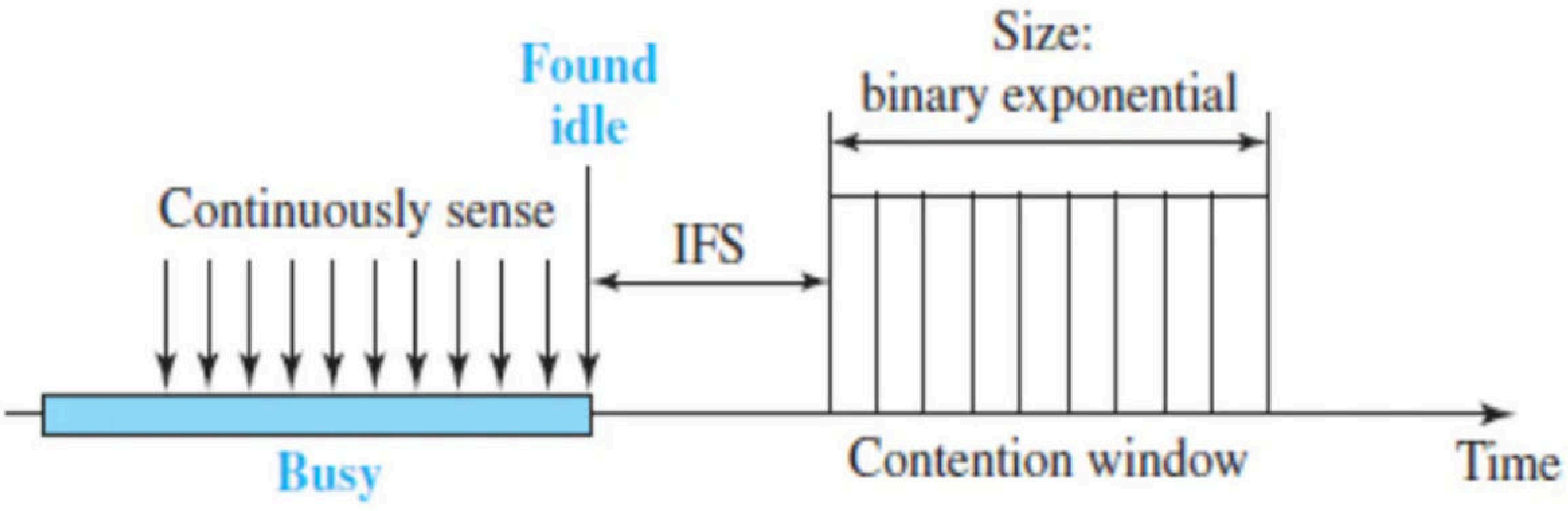


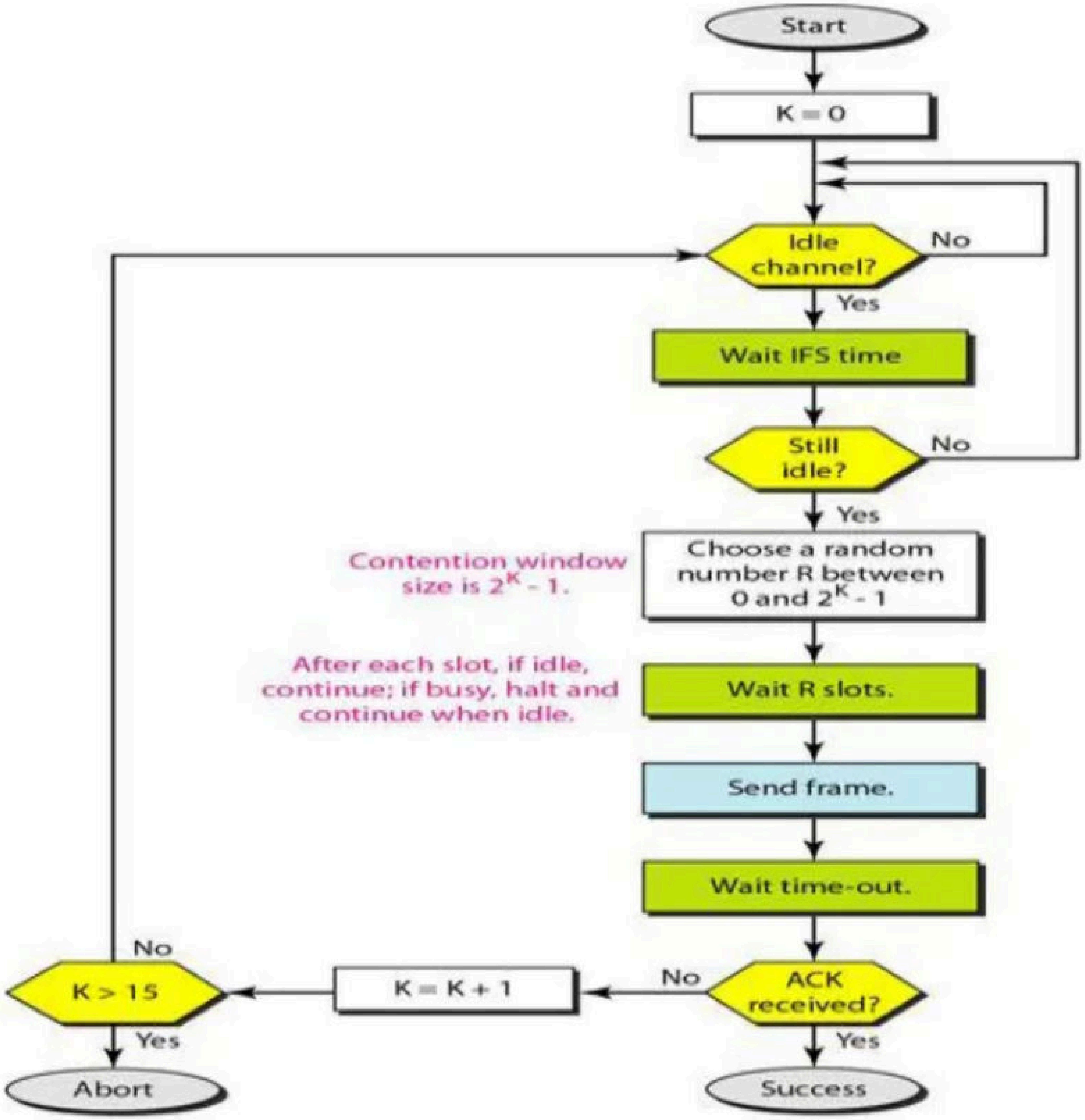
Contention Window

- The contention window is an amount of time divided into slots. A station that is ready to send chooses a random number of slots as its wait time.
- The number of slots in the window changes according to the binary exponential back-off strategy.
- This means that it is set to one slot the first time and then doubles each time.
- One interesting point about the contention window is that the station needs to sense the channel after each time slot.
- However, if the station finds the channel busy, it does not restart the process; it just stops the timer and restarts it when the channel is sensed as idle. This gives priority to the station with the longest waiting time.



- **Acknowledgment**
  - With all these precautions, there still may be a collision resulting in destroyed data. In addition, the data may be corrupted during the transmission. The positive acknowledgment and the time-out timer can help guarantee that the receiver has received the frame.



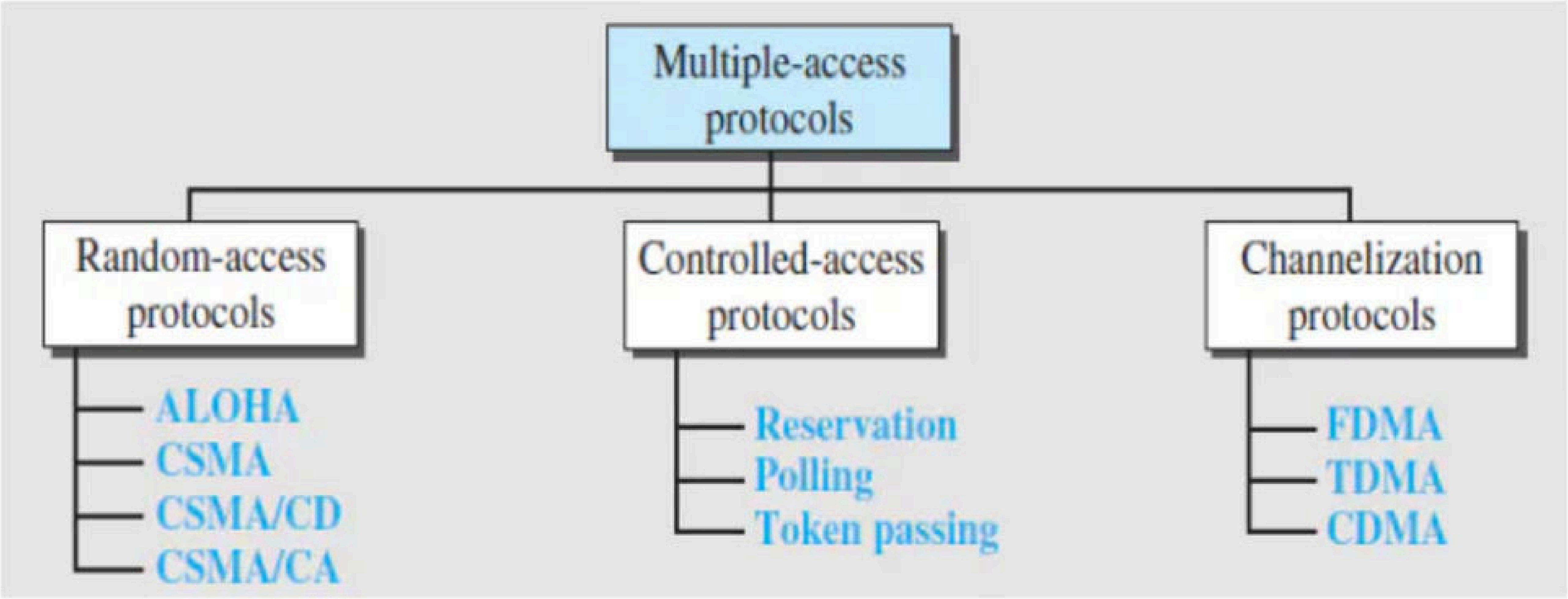


Start
K = 0
Idle channel?
No
Yes
Wait IFS time
Still idle?
No
Yes
Contention window size is 2^K - 1.
Choose a random number R between 0 and 2^K - 1
After each slot, if idle, continue; if busy, halt and continue when idle.
Wait R slots.
Send frame.
Wait time-out.
ACK received?
No
Yes
Success
K = K + 1
K > 15
No
Yes
Abort

Break

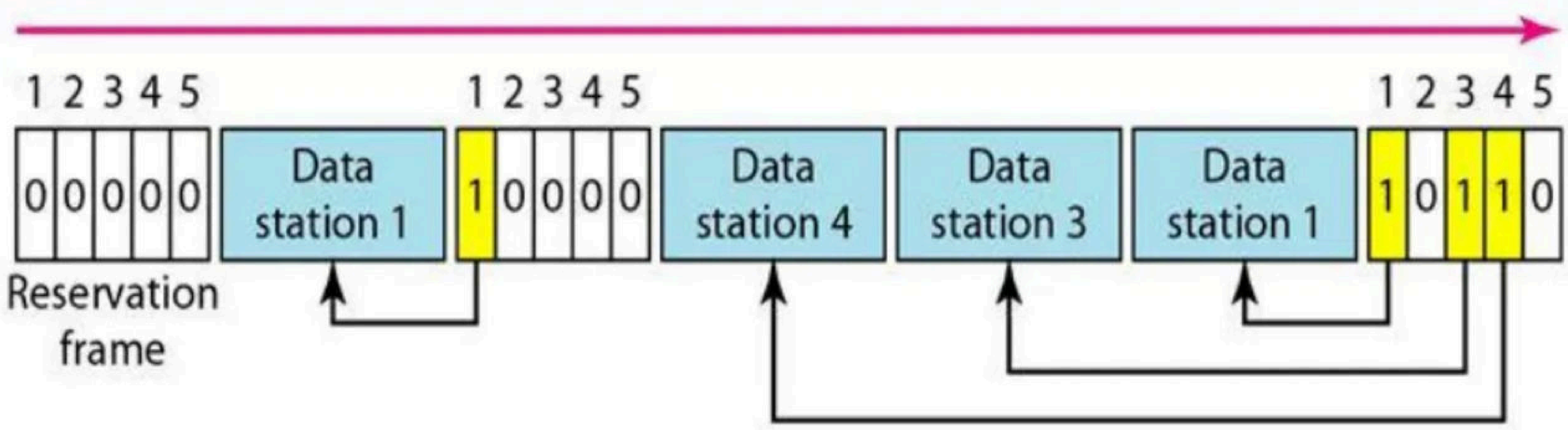
CONTROLLED ACCESS

- In controlled access, the stations consult one another to find which station has the right to send. A station cannot send unless it has been authorized by other stations. We discuss three popular controlled-access methods.



Reservation

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

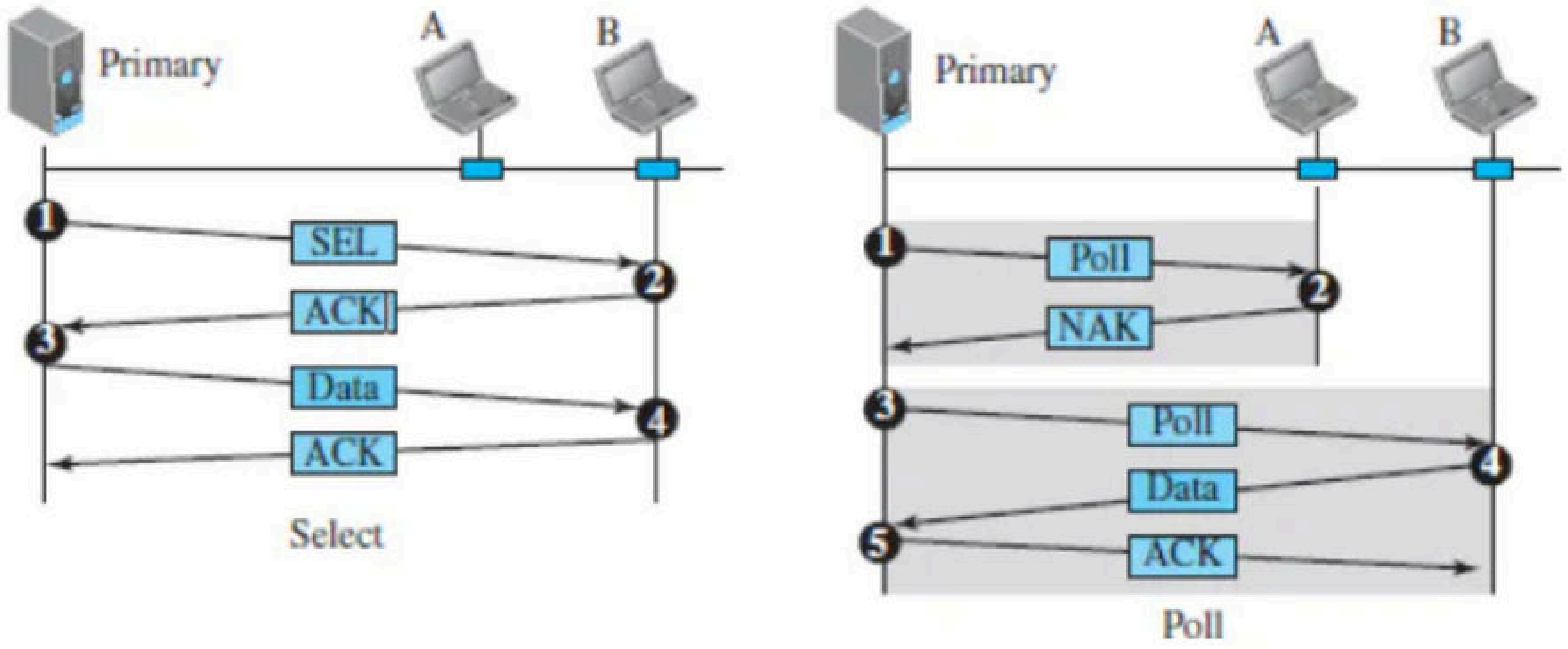


Polling

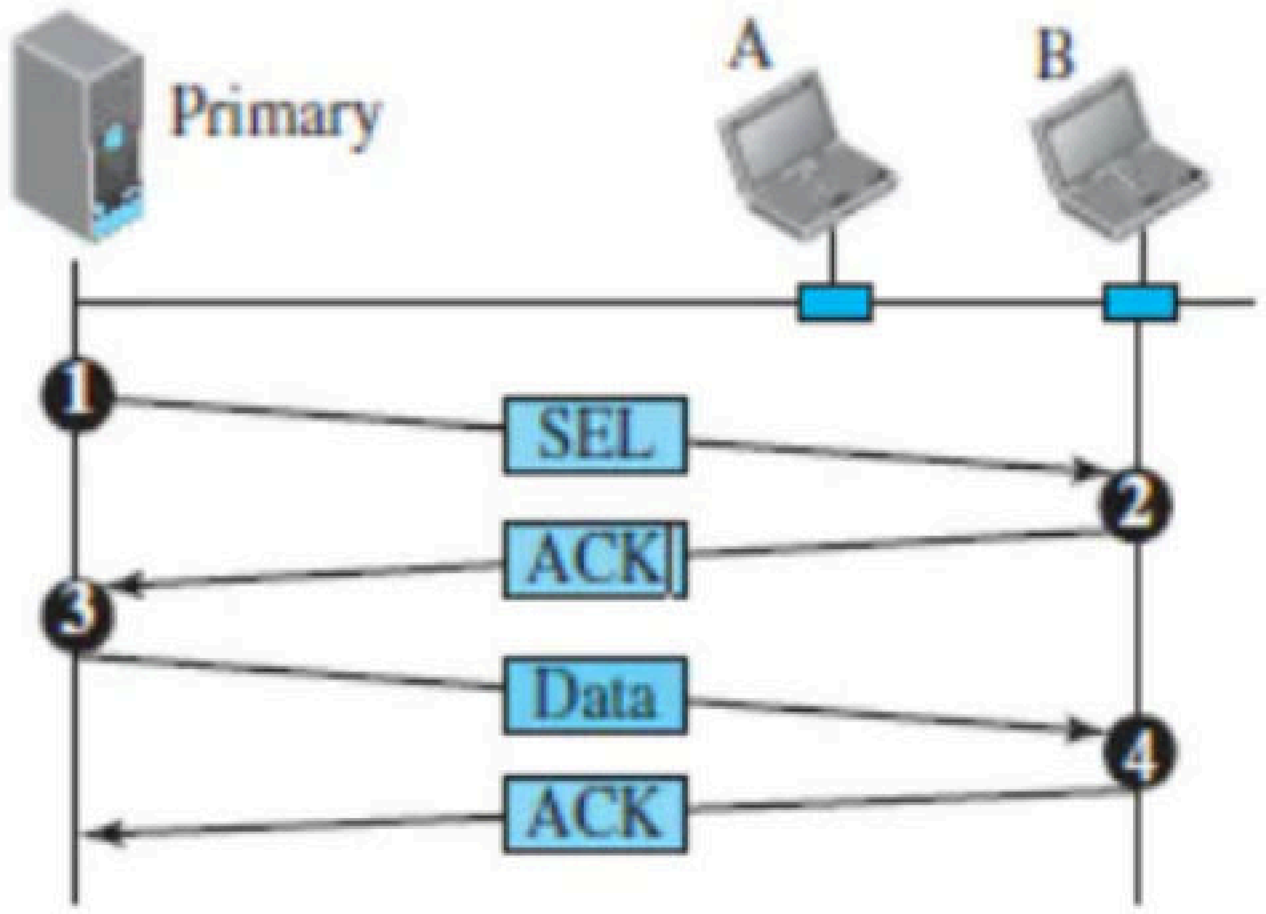
- Polling works with topologies in which one device is designated as a primary station and the other devices are secondary stations.

- All data exchanges must be made through the primary device even when the ultimate destination is a secondary device.

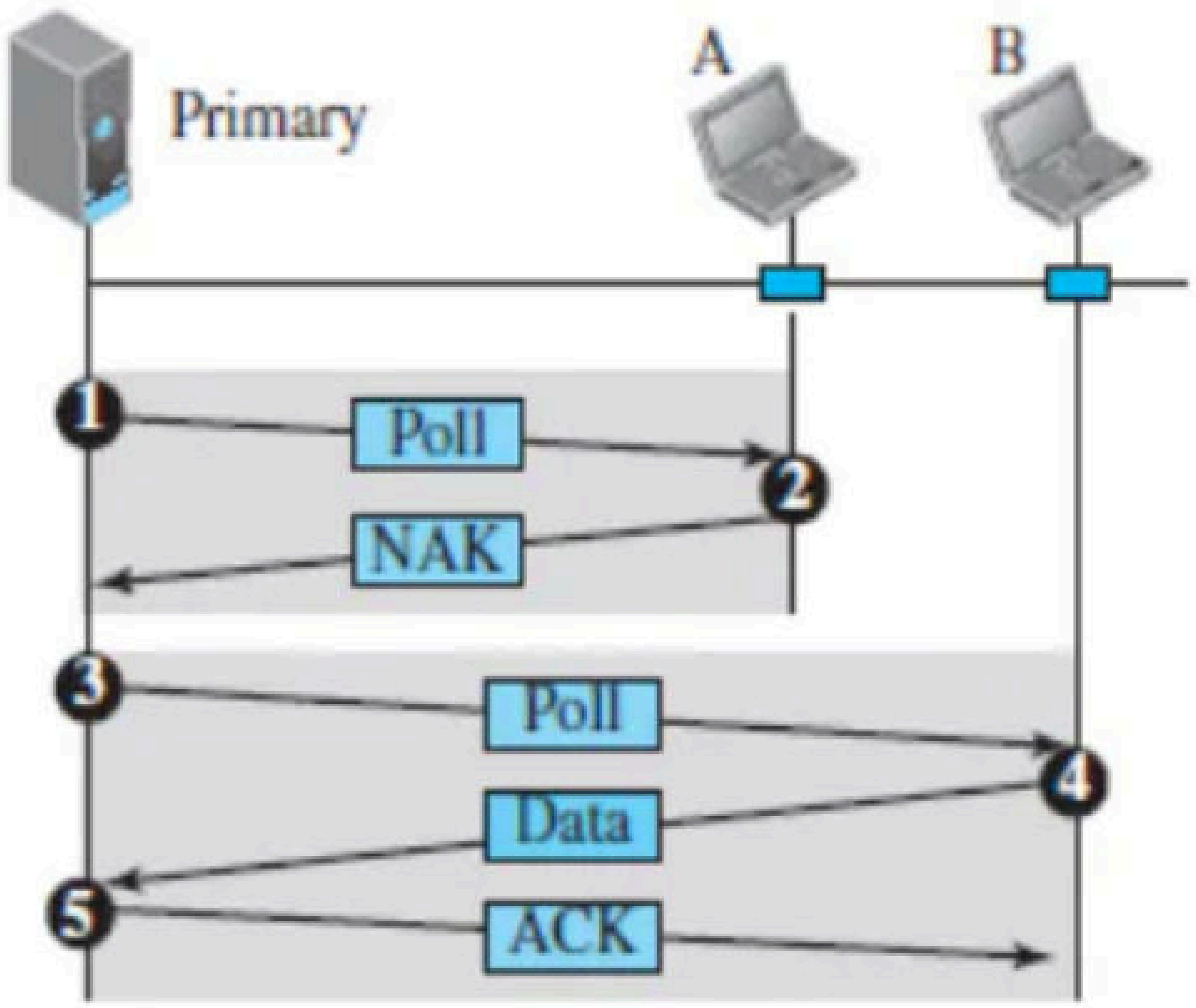
- The primary device controls the link; the secondary devices follow its instructions. It is up to the primary device to determine which device is allowed to use the channel at a given time.



- **Select**
    - The select function is used whenever the primary device has something to send. Remember that the primary controls the link. If the primary is neither sending nor receiving data, it knows the link is available.
    - If it has something to send, the primary device sends it. What it does not know, however, is whether the target device is prepared to receive.
    - So the primary must alert the secondary to the upcoming transmission and wait for an acknowledgment of the secondary's ready status. Before sending data, the primary creates and transmits a select (SEL) frame, one field of which includes the address of the intended secondary.

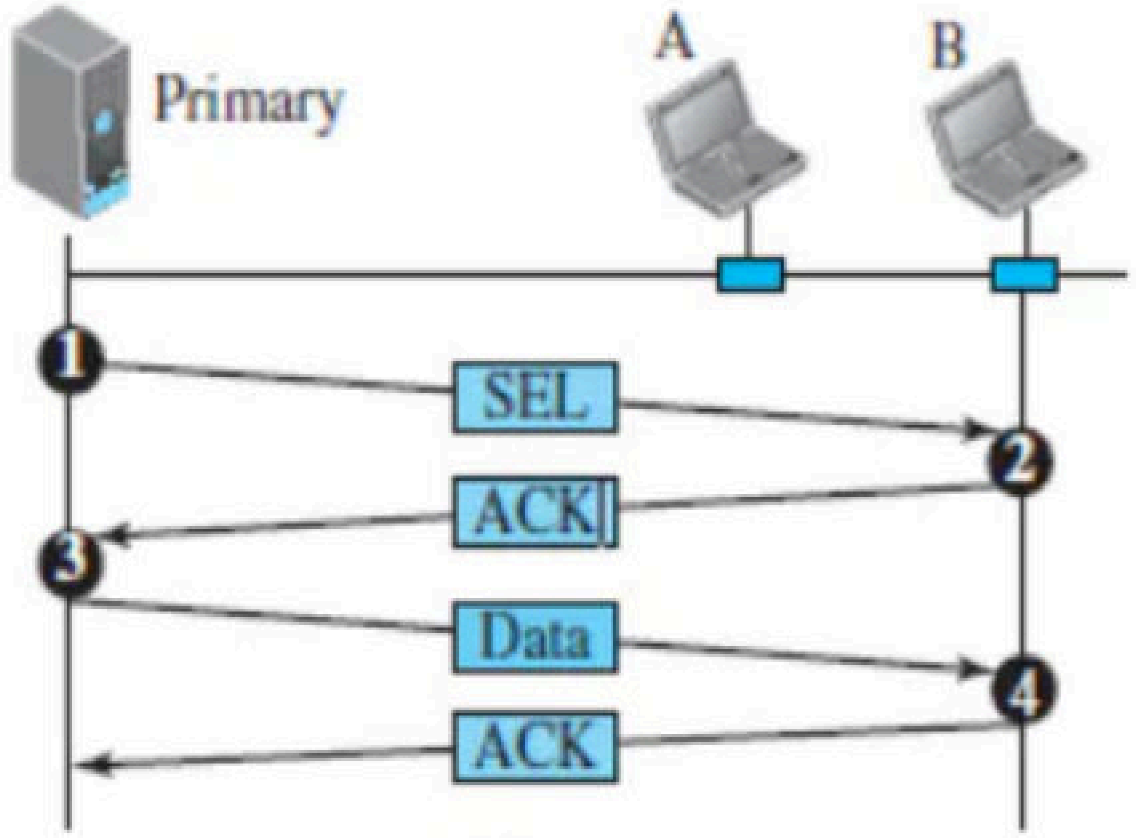


Select

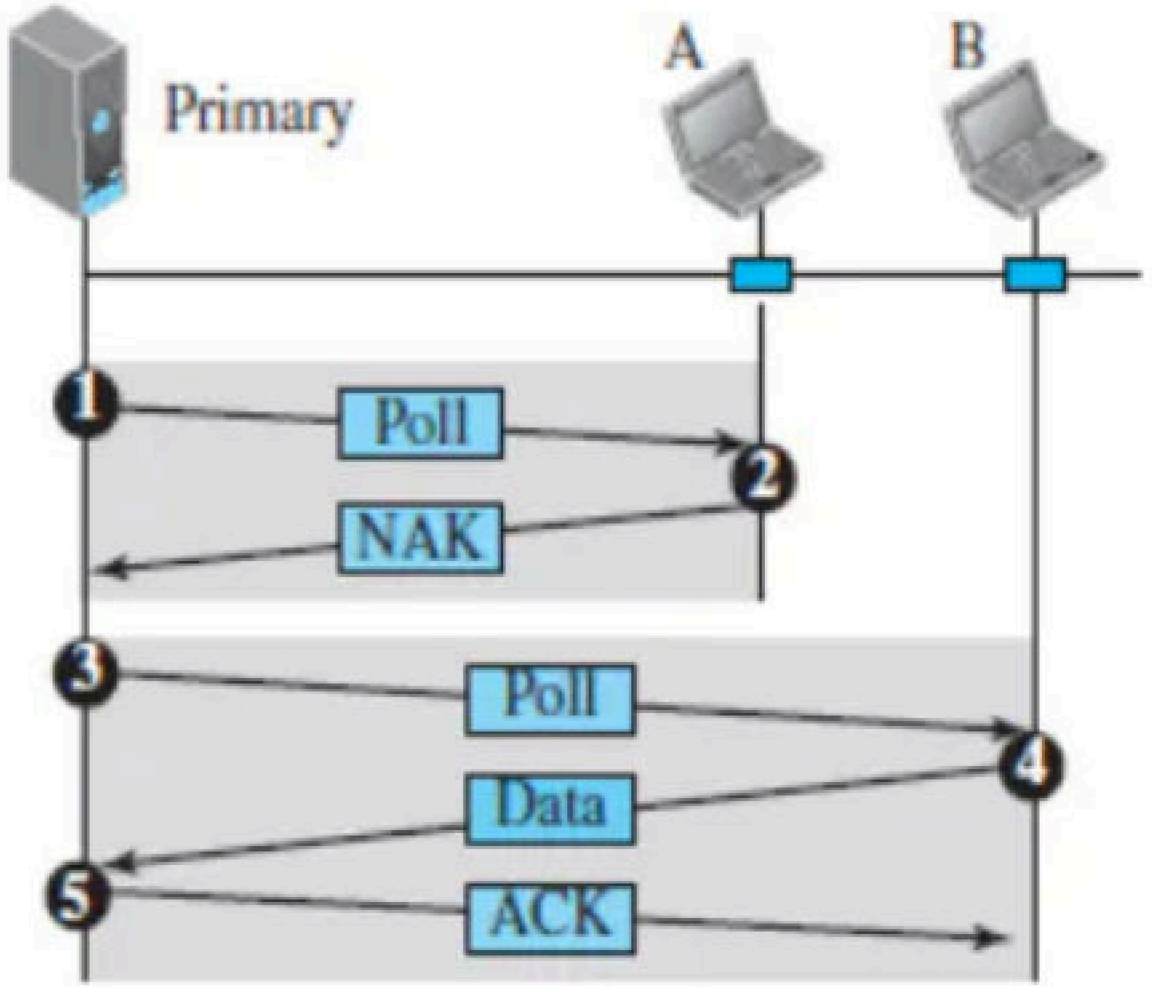


Poll

- **Poll**
  - The poll function is used by the primary device to solicit transmissions from the secondary devices.
  - When the primary is ready to receive data, it must ask (poll) each device in turn if it has anything to send.
  - When the first secondary is approached, it responds either with a NAK frame if it has nothing to send or with data (in the form of a data frame) if it does.
  - If the response is negative (a NAK frame), then the primary polls the next secondary in the same manner until it finds one with data to send.
  - When the response is positive (a data frame), the primary reads the frame and returns an acknowledgment (ACK frame), verifying its receipt.



Select



Poll

Q A broadcast channel has 10 nodes and total capacity of 10 Mbps. It uses polling for medium access. Once a node finishes transmission, there is a polling delay of 80 μs to poll the next node. Whenever a node is polled, it is allowed to transmit a maximum of 1000 bytes. The maximum throughput of the broadcast channel is **(Gate-2007) (2 Marks)**

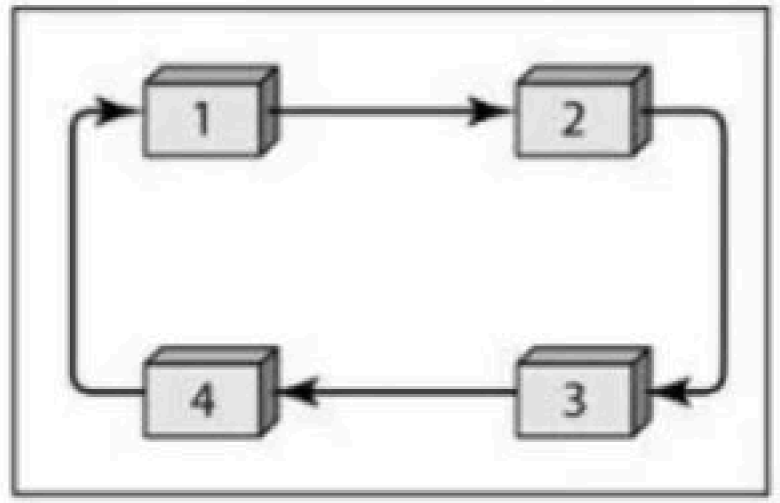
(A) 1 Mbps **(B)** 100/11 Mbps **(C)** 10 Mbps **(D)** 100 Mbps

Token Passing

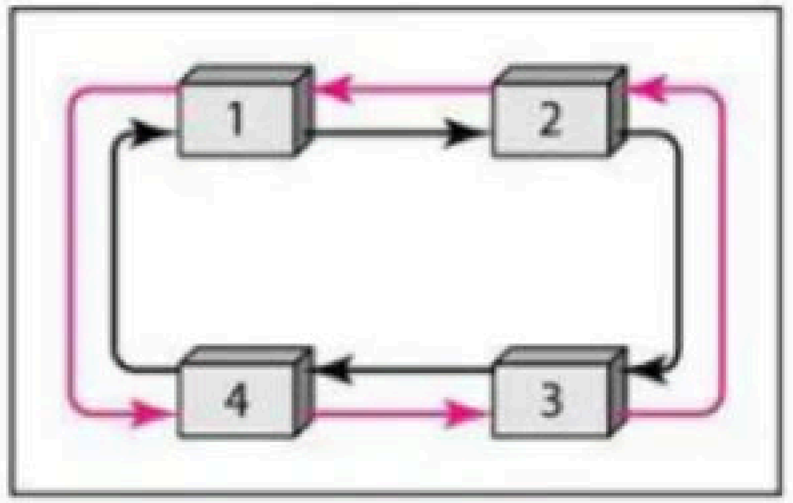
- In the token-passing method, the stations in a network are organized in a logical ring.

- In other words, for each station, there is a predecessor and a successor. The predecessor is the station which is logically before the station in the ring; the successor is the station which is after the station in the ring.

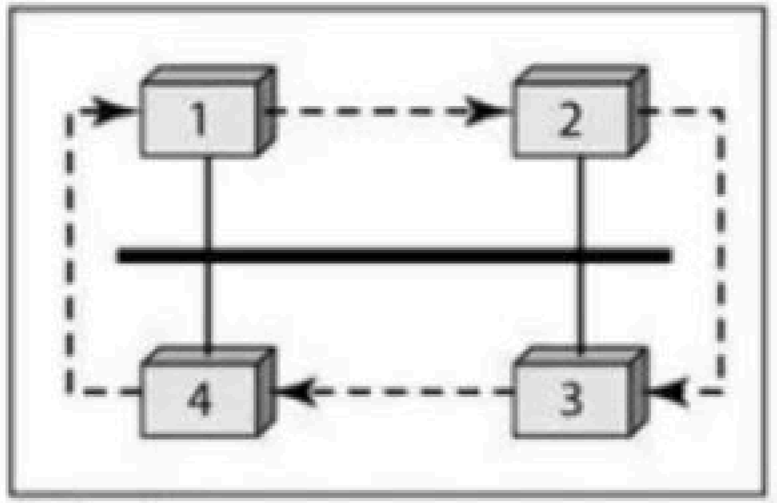
- The current station is the one that is accessing the channel now. The right to this access has been passed from the predecessor to the current station. The right will be passed to the successor when the current station has no more data to send. But how is the right to access the channel passed from one station to another?



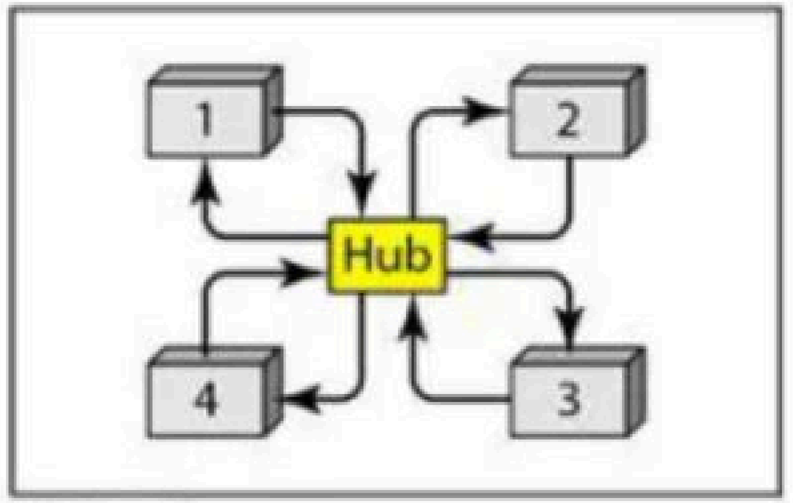
a. Physical ring



b. Dual ring



c. Bus ring

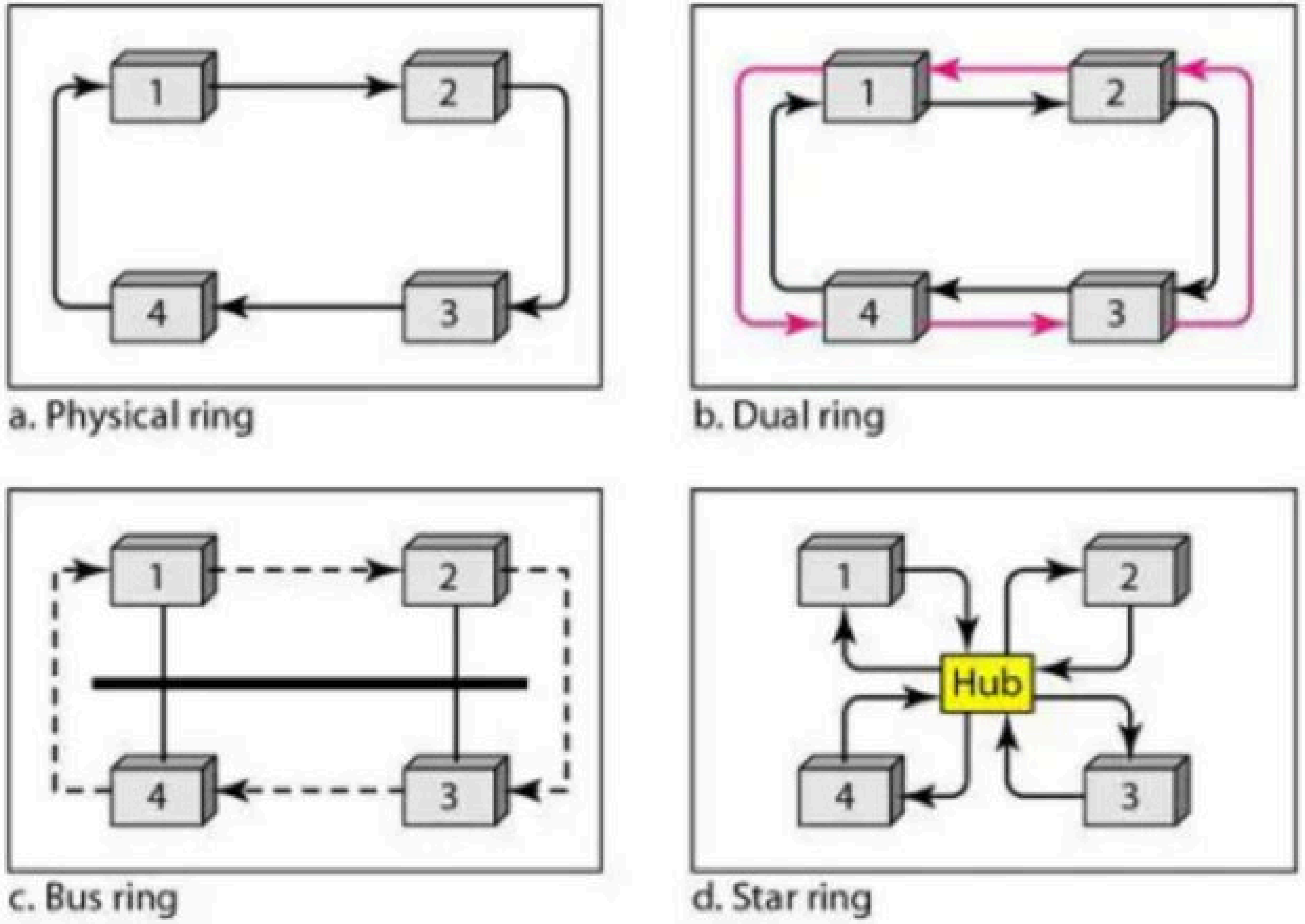


d. Star ring

- In this method, a special packet called a token circulates through the ring. The possession of the token gives the station the right to access the channel and send its data.

- When a station has some data to send, it waits until it receives the token from its predecessor. It then holds the token and sends its data. When the station has no more data to send, it releases the token, passing it to the next logical station in the ring.

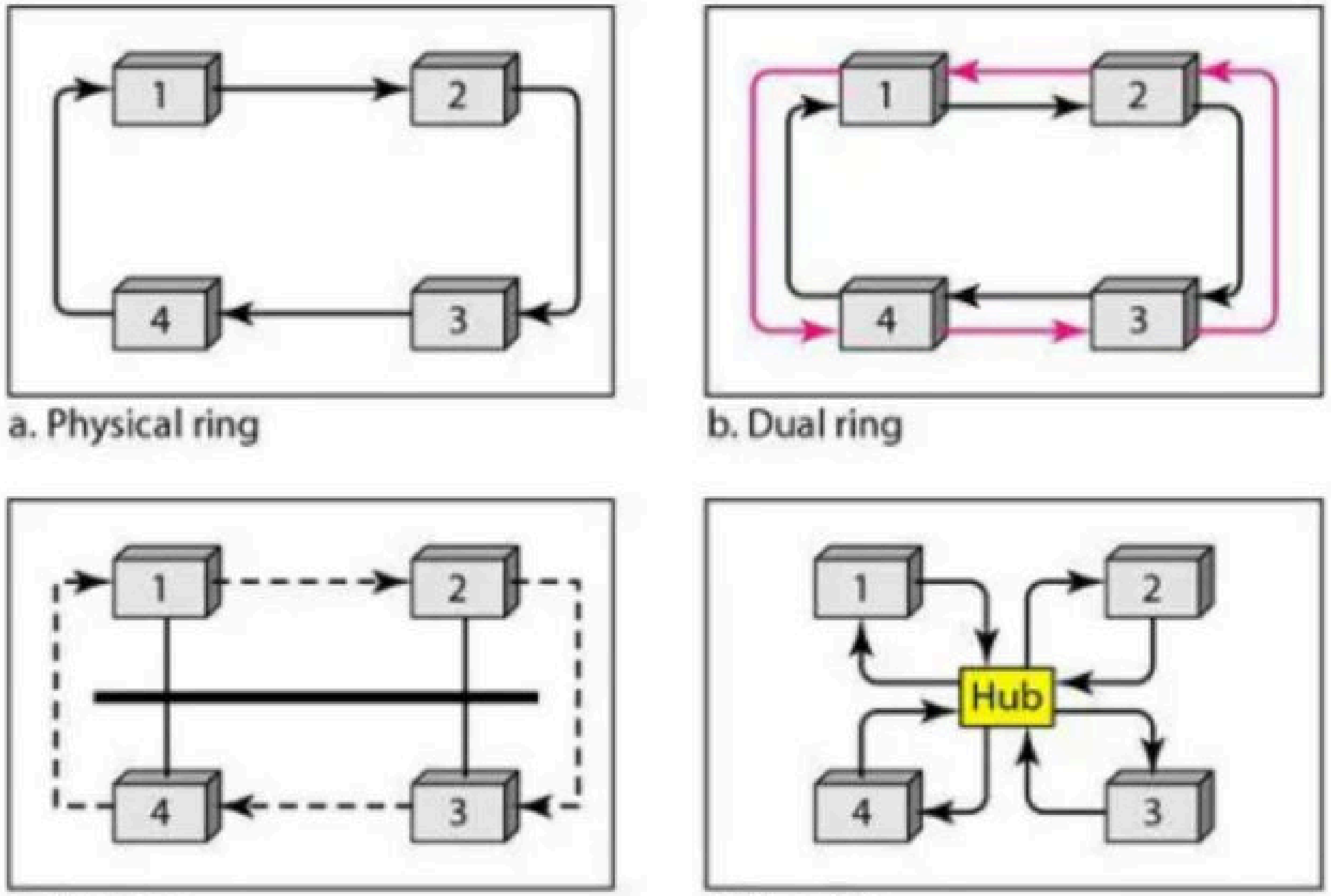
- The station cannot send data until it receives the token again in the next round. In this process, when a station receives the token and has no data to send, it just passes the data to the next station.



a. Physical ring
b. Dual ring
c. Bus ring
d. Star ring

- Token management is needed for this access method. Stations must be limited in the time they can have possession of the token. The token must be monitored to ensure it has not been lost or destroyed.

- For example, if a station that is holding the token fails, the token will disappear from the network. Another function of token management is to assign priorities to the stations and to the types of data being transmitted. And finally, token management is needed to make low-priority stations release the token to high priority stations.

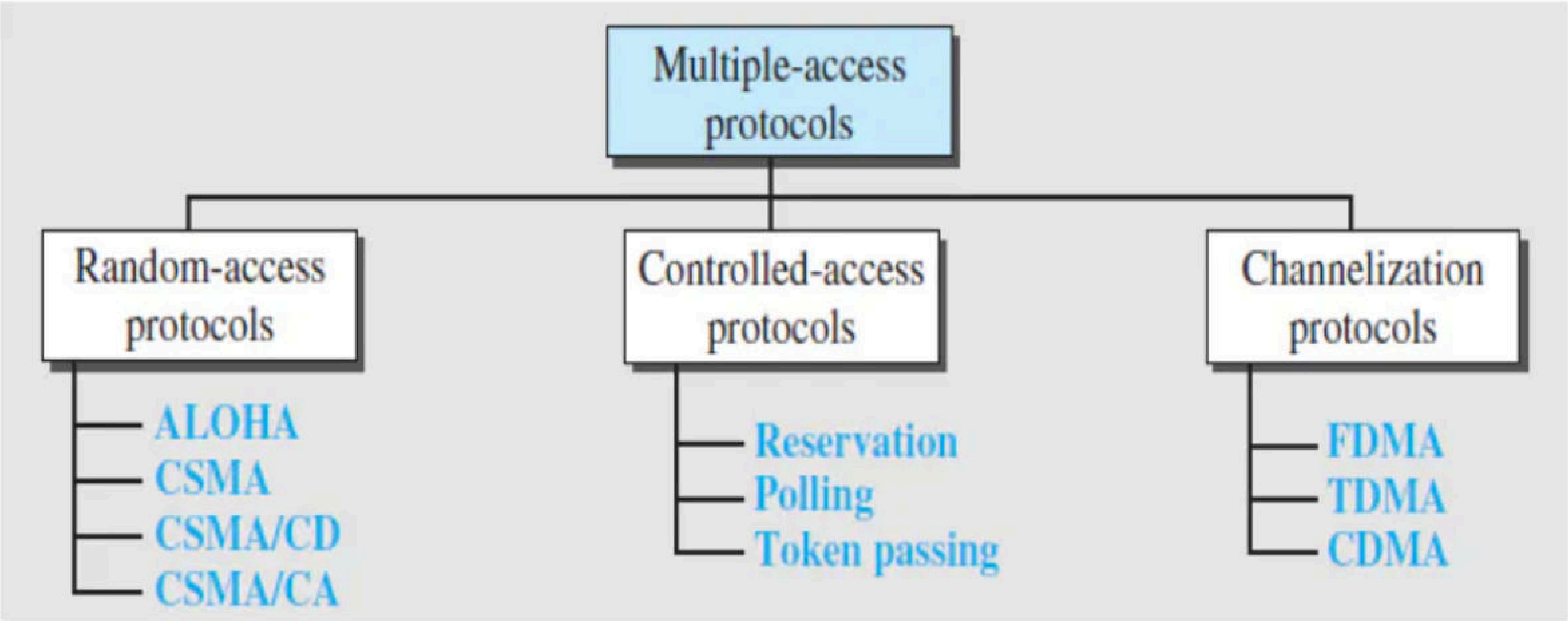


a. Physical ring
b. Dual ring
c. Bus ring
d. Star ring

Break

CHANNELIZATION

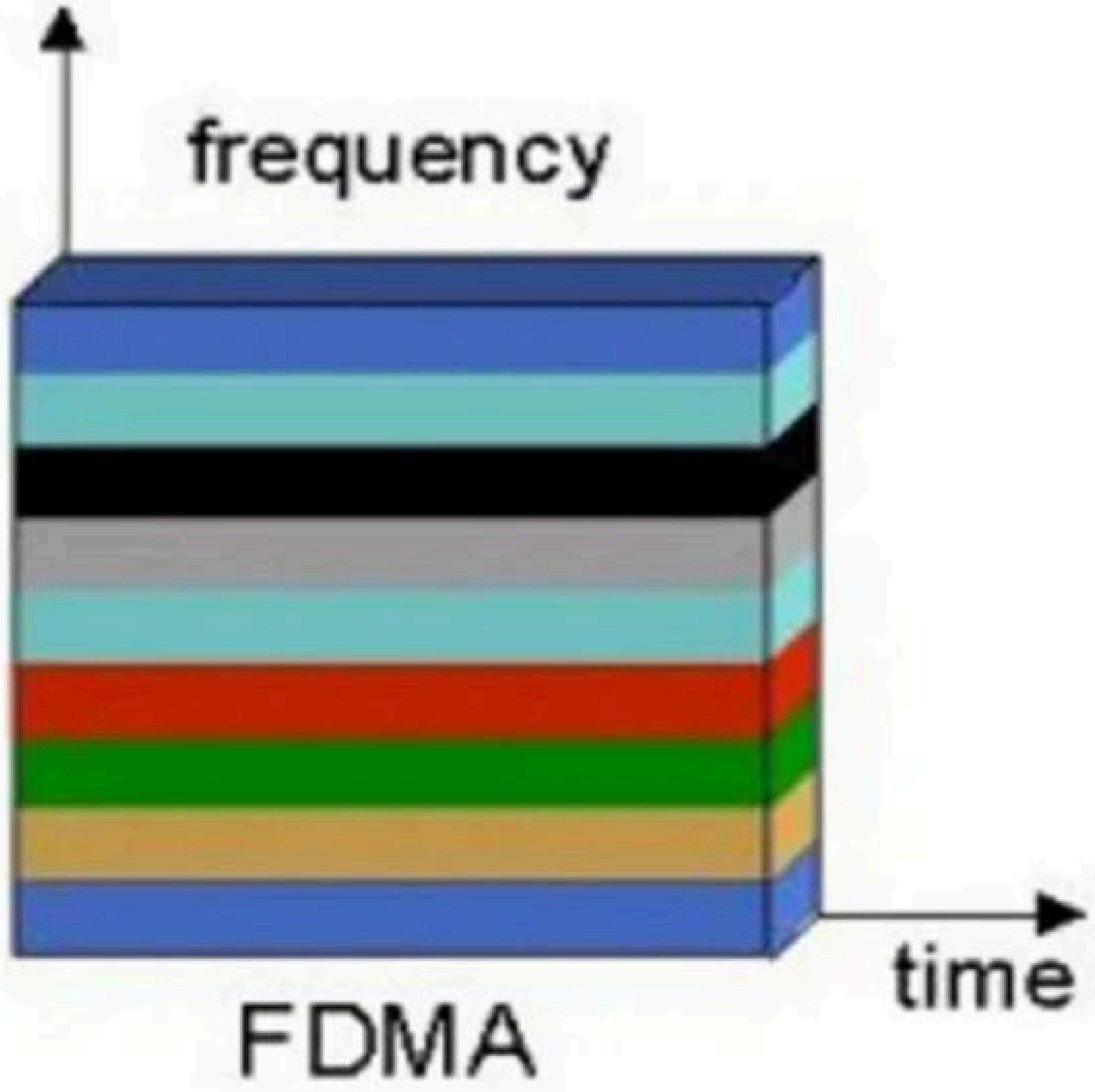
- Channelization is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, between different stations. In this section, we discuss three channelization protocols: FDMA, TDMA, and CDMA.



Frequency-Division Multiple Access (FDMA)

- In frequency-division multiple access (FDMA), the available bandwidth is divided into frequency bands. Each station is allocated a band to send its data.

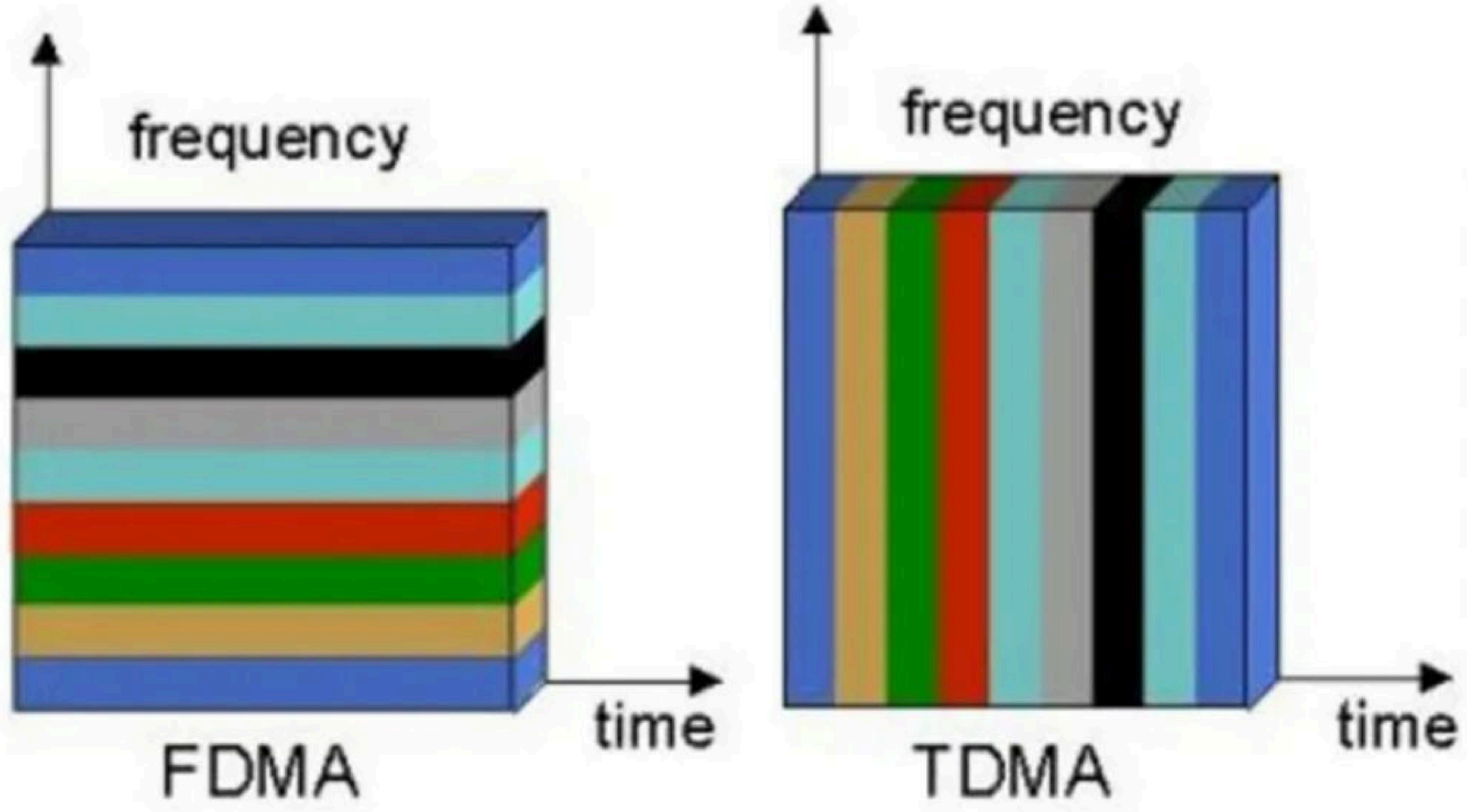
- In other words, each band is reserved for a specific station, and it belongs to the station all the time.



Frequency	Station Name
90.4	Bol Radio
91.1	**Radio City**
92.7	BIG FM 92.7
93.5	**RED FM**
94.3	Fever
95	**Mirchi95**
98.3	Radio Mirchi
101.9	**AIR Rainbow**
102.8	AIR Vividh Bharati
104	**KOOL FM**
105.6	IGNOU Gyan Vani
106.4	**Magic FM**
107.8	Deccan Radio
107.8	**Radio Charminar**

Time-Division Multiple Access (TDMA)

- In time-division multiple access (TDMA), the stations share the bandwidth of the channel in time. Each station is allocated a time slot during which it can send data. Each station transmits its data in is assigned time slot.



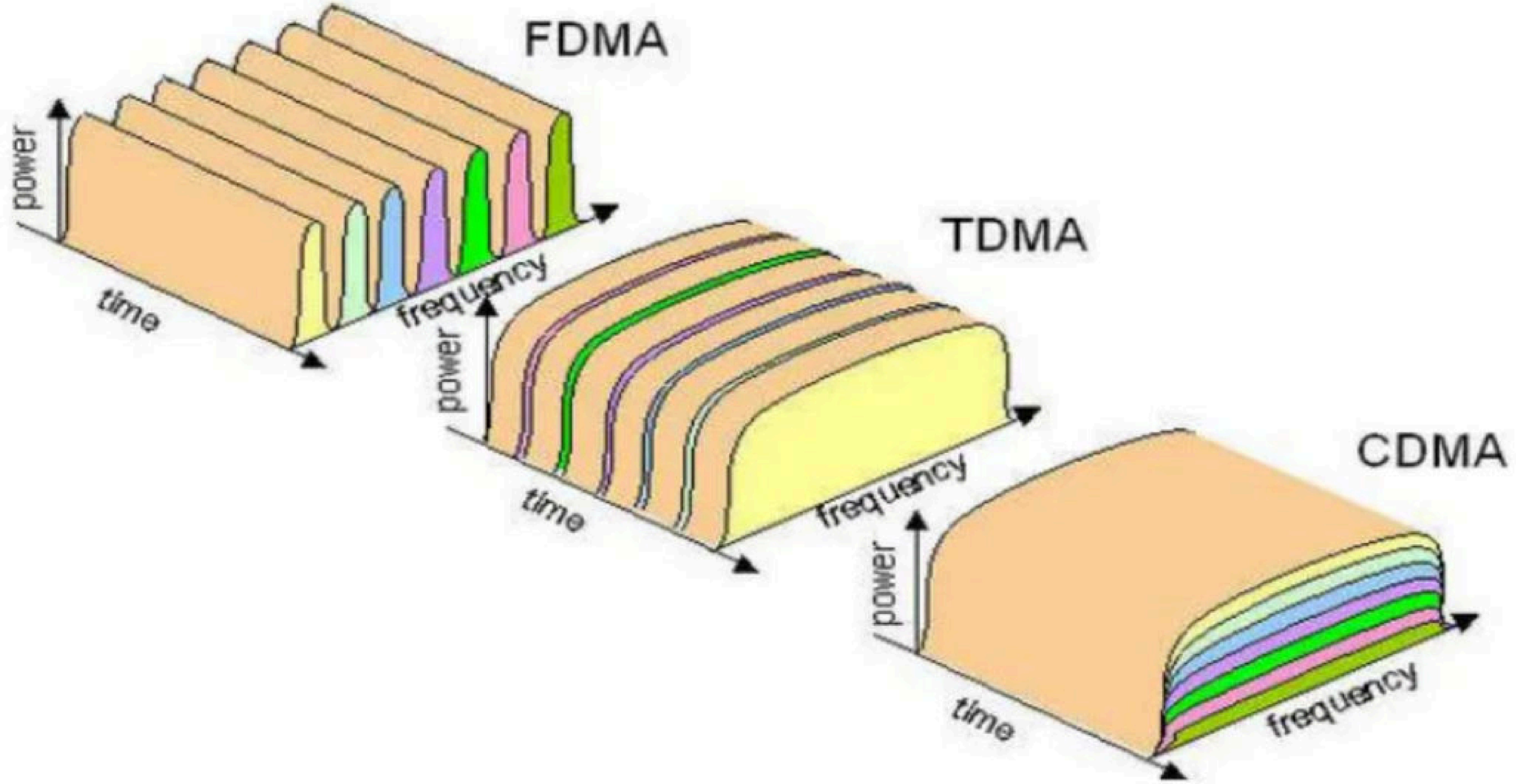
	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	
MON	Sooryodayam Soorya		Morning No 1 Soumya				Mid Day Masala RJ MIKE			YUVA rj VIvek			Red on Demand Nitha		
TUE	Sooryodayam Soorya		Morning No 1 Soumya				Mid Day Masala RJ MIKE			YUVA rj VIvek			Red on Demand Nitha		
WED	Sooryodayam Soorya		Morning No 1 Soumya				Mid Day Masala RJ MIKE			YUVA rj VIvek			Red on Demand Nitha		
THU	Sooryodayam Soorya		Morning No 1 Soumya				Mid Day Masala RJ MIKE			YUVA rj VIvek			Red on Demand Nitha		
FRI	Sooryodayam Soorya		Morning No 1 Soumya				Mid Day Masala RJ MIKE			YUVA rj VIvek			Red on Demand Nitha		
SAT	Sooryodayam Soorya		Morning No 1 Soumya						Immini Balya Ruchi Albee			Red Carpet RJ MIKE			R
SUN	Sooryodayam Soorya								Immini Balya Ruchi Albee			Red Carpet RJ MIKE			

Q In a TDM medium access control bus LAN, each station is assigned one time slot per cycle for transmission. Assume that the length of each time slot is the time to transmit 100 bits plus the end-to-end propagation delay. Assume a propagation speed of 2×10^8 m/sec. The length of the LAN is 1 km with a bandwidth of 10 Mbps. The maximum number of stations that can be allowed in the LAN so that the throughput of each station can be 2/3 Mbps is **(Gate-2005) (2 Marks)**

(A) 3 **(B)** 5 **(C)** 10 **(D)** 20

Code-Division Multiple Access (CDMA)

- Code-division multiple access (CDMA) was conceived several decades ago. Recent advances in electronic technology have finally made its implementation possible. CDMA differs from FDMA because only one channel occupies the entire bandwidth of the link. It differs from TDMA because all stations can send data simultaneously; there is no timesharing.

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- Let us first give an analogy. CDMA simply means communication with different codes. For example, in a large room with many people, two people can talk in English if nobody else understands English.

- Another two people can talk in Chinese if they are the only ones who understand Chinese, and so on. In other words, the common channel, the space of the room in this case, can easily allow communication between several couples, but in different languages (codes).