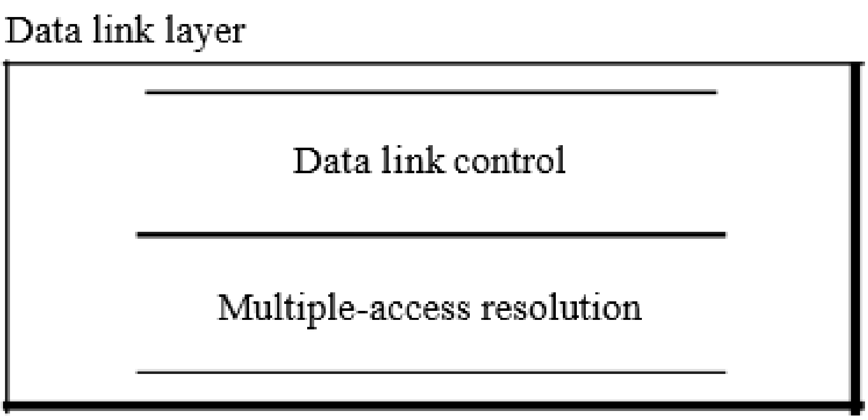
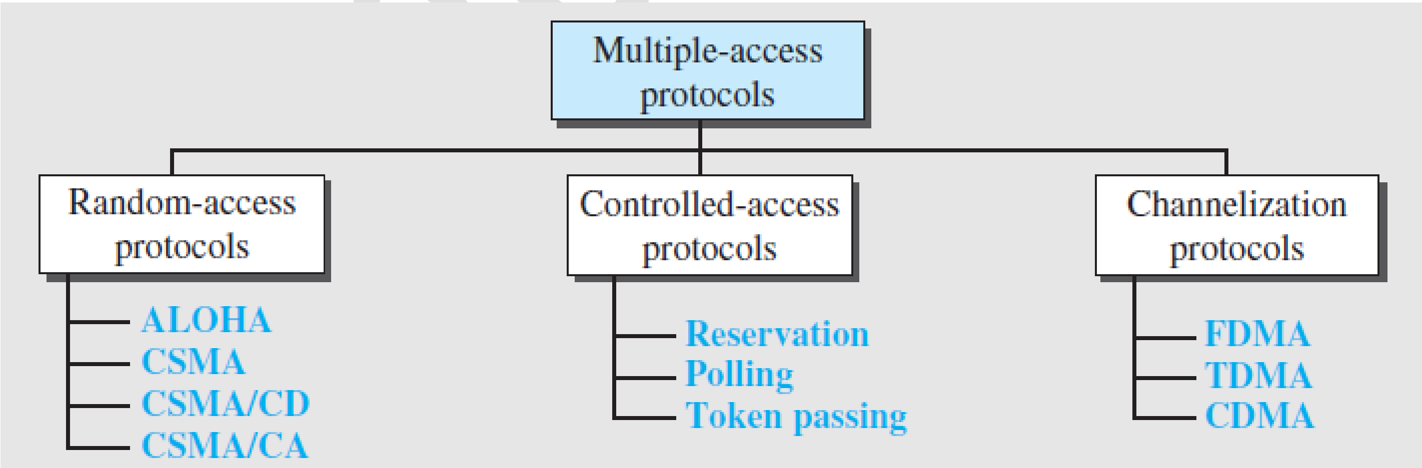
Multiple access control

- IEEE has actually made this division for LANs. The upper sublayer that is responsible for flow and error control is called the logical link control (LLC) layer; the lower sublayer that is mostly responsible for multiple access resolution is called the media access control (MAC) layer.

Data link layer divided into two functionality-oriented sublayers



- 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.
- 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).

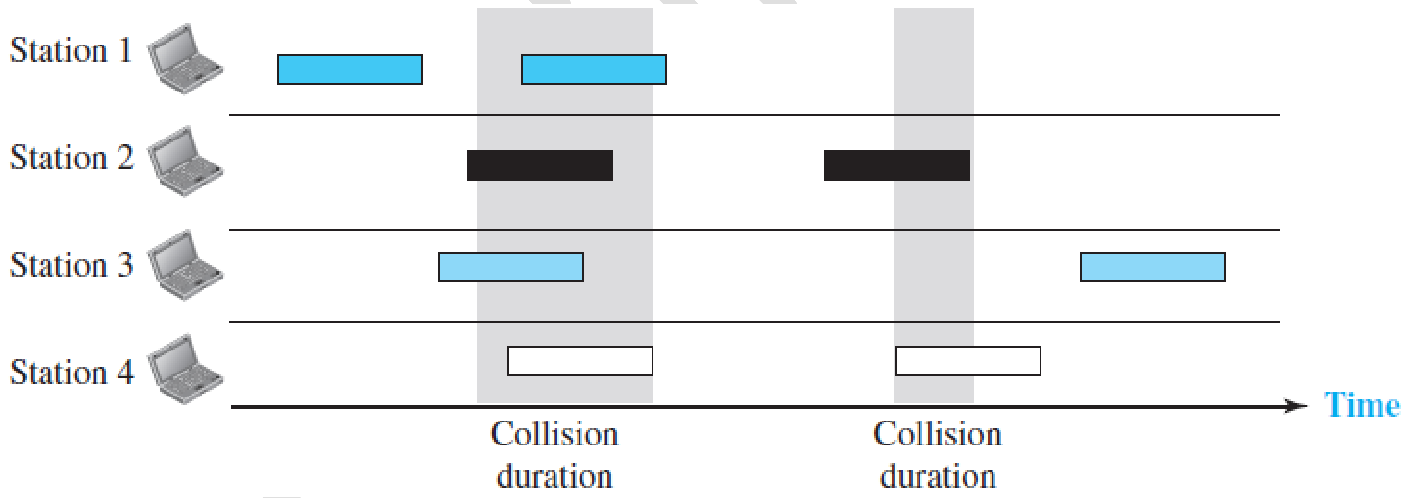


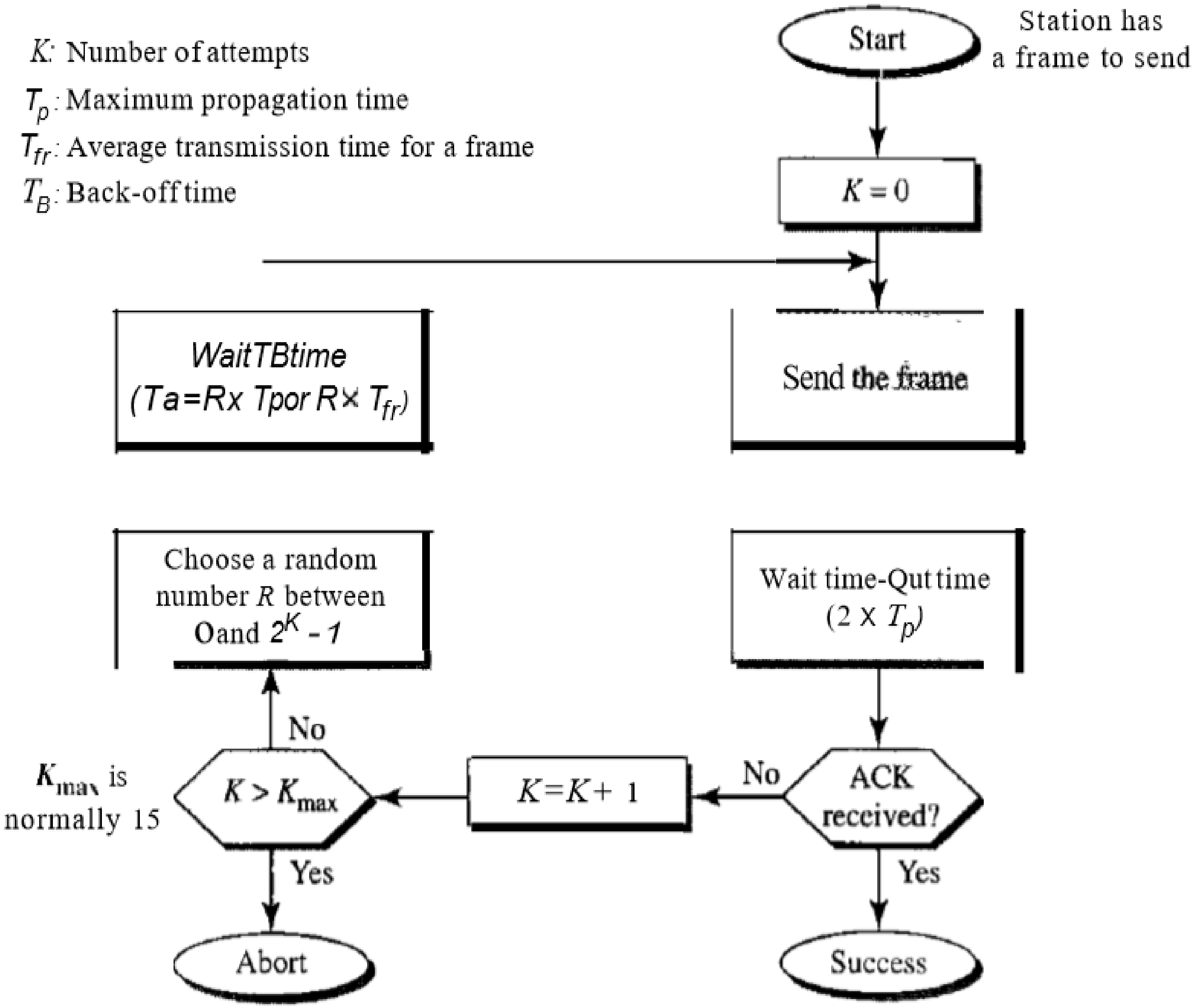
RANDOM ACCESS

- In random access methods, no station is superior to another station and none is assigned the control over another.
- No station permits, or does not permit, another station to send.
- 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.
    - When can the station access the medium?
    - What can the station do if the medium is busy?
    - How can the station determine the success or failure of the transmission?
    - What can the station do if there is an access conflict?

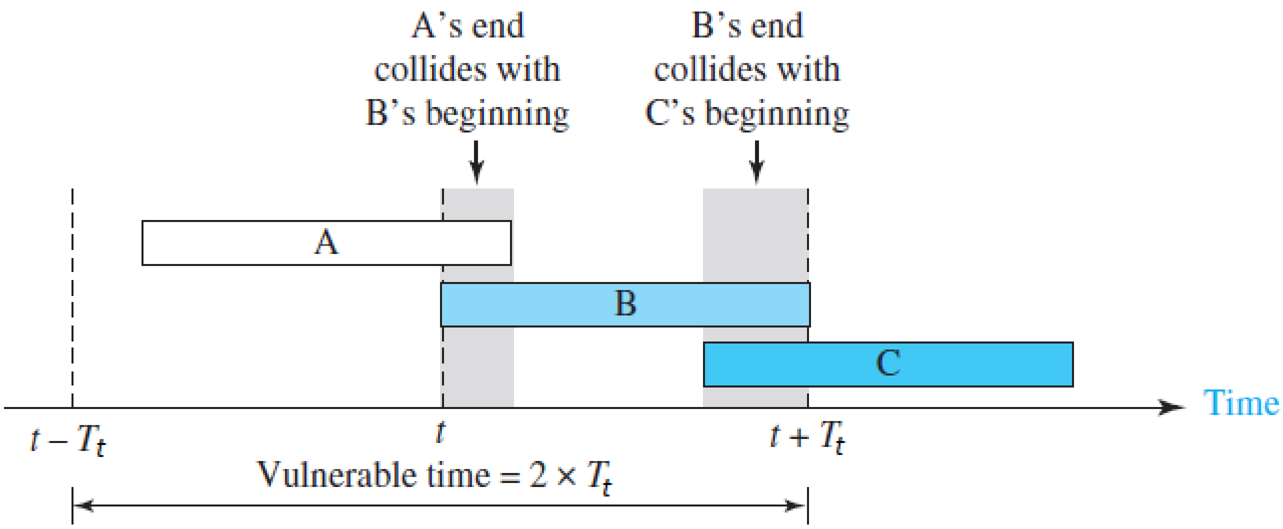
Aloha

- 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.
- 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 after a time-out period, the station assumes that the frame (or the acknowledgment) has been destroyed and resends the frame.
- A collision involves two or more stations. 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.





- 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}



Throughput

- Let, G be the average number of frames generated by the system during one frame transmission time. Then, average number of successfully transmitted frames for pure ALOHA is S.
- The throughput for pure ALOHA is $S = G * e^{-2G}$.
- The maximum throughput $S_{max} = 1/(2e) = 0.184$ when $G = (1/2)$.

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 ?

we find $Tp = (600 \times 10^3) / (3 \times 10^8) = 2$ ms.

after two collision, $K = 2$, the range of R is {0, 1, 2, 3}.

This means that T_B can be 0, 2, 4, or 6 ms, based on the outcome of the random variable R.

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?

Ans: Transmission Time T_t = 200 bits / 200 * 10^3 = 1 ms

So, vulnerable time = 2 * 1 = 2ms

Example: 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 1000 frames per second?

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

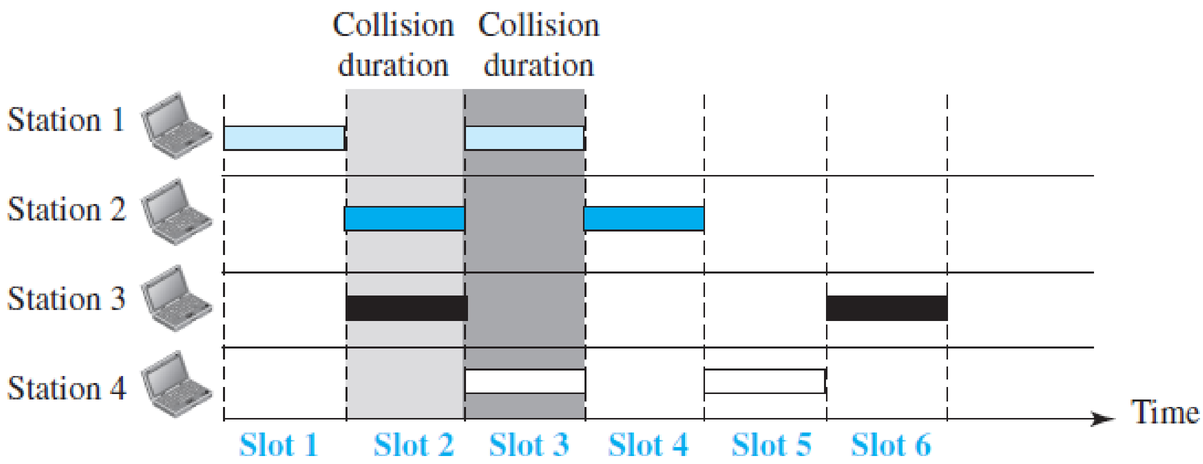
If the system creates 1000 frames per second, or 1 frame per millisecond, then $G = 1$.

$S = G \times e^{-2G} = 0.135$ (13.5 percent).

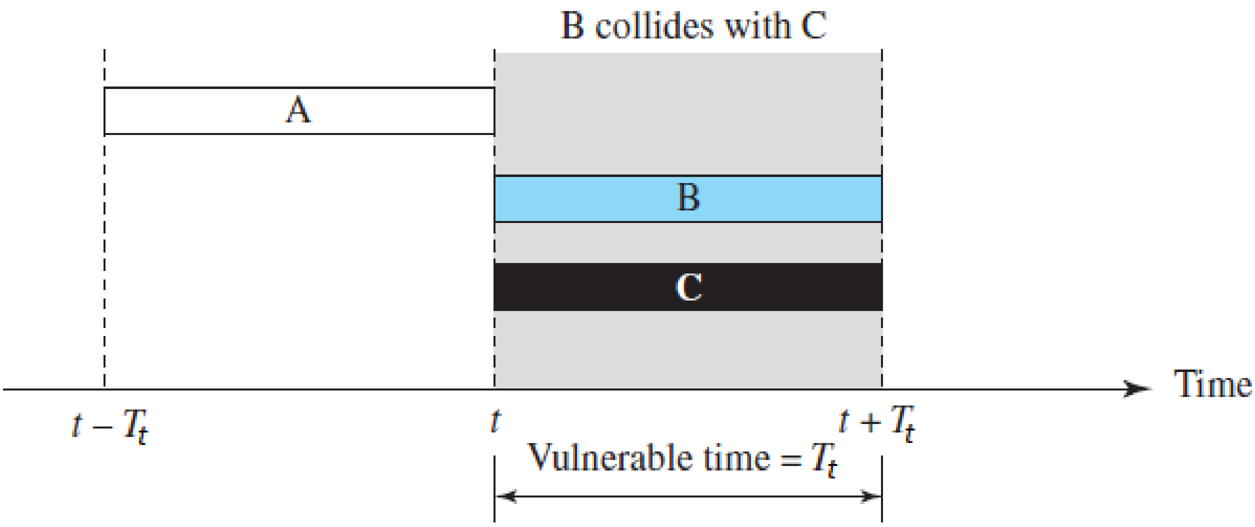
Throughput is 1000 × 0.135 = 135 frames. Only 135 frames out of 1000 will probably survive.

Slotted ALOHA

- 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.
- 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}



- **Slotted ALOHA vulnerable time** = T_t
- ***Throughput***: The throughput for slotted ALOHA is $S = G * e^{-G}$.
- The maximum throughput $S_{max} = 0.368$ when $G = 1$.



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

Answer: (A)

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)** $1-(1-p)^{n-1}$

ANSWER A

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

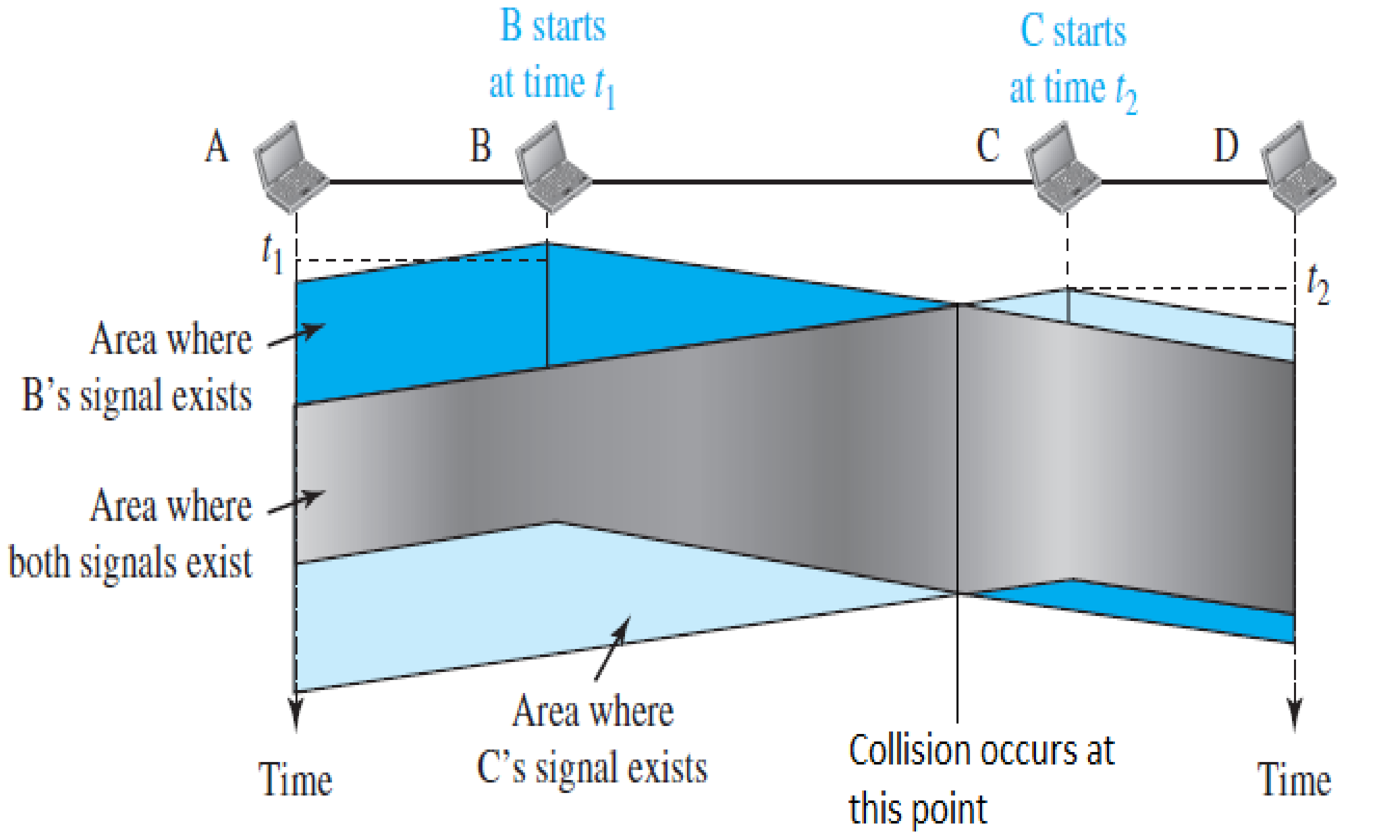
Answer: (B)

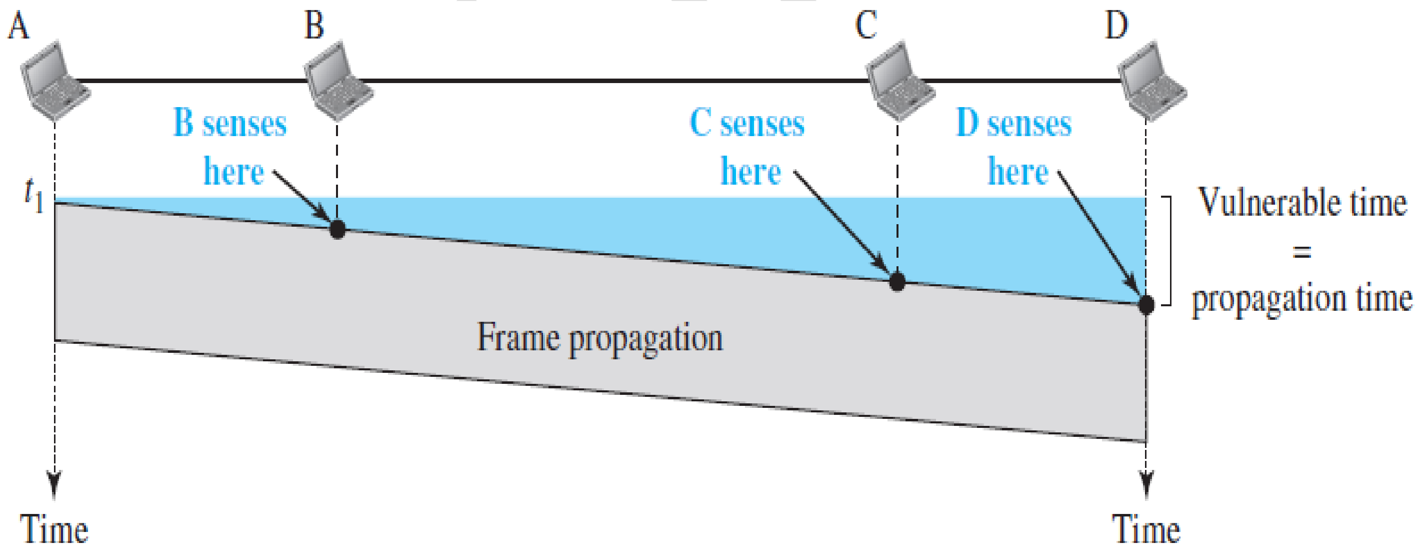
Carrier Sense Multiple Access (CSMA)

- 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. In other words, CSMA is based on the principle "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 tI station B senses the medium and finds it idle, so it sends a frame. At time t2 (t2> tI) 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.

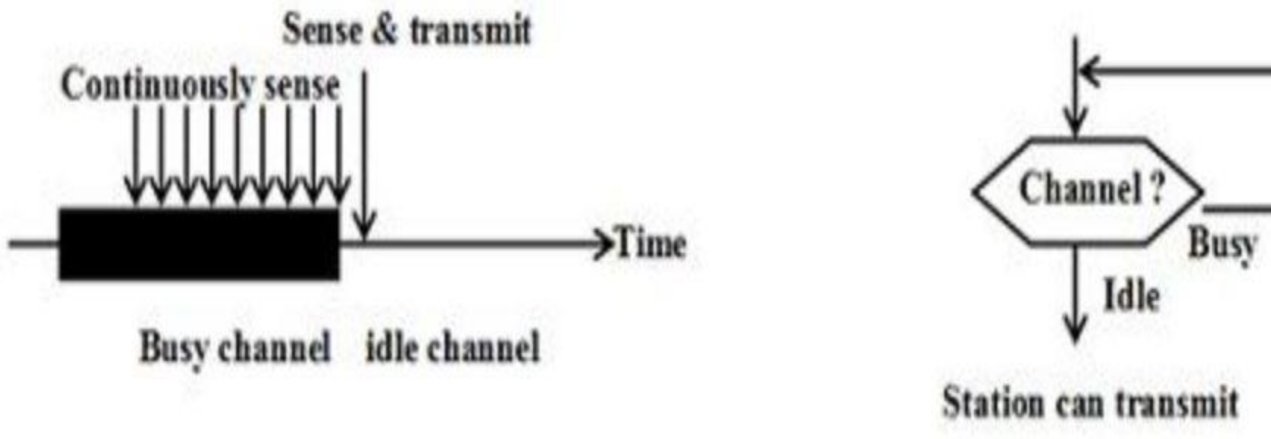
Vulnerable Time

- 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 $t_1 + T_p$.
- The gray area is vulnerable time.


B starts
at time t_1
C starts
at time t_2
A
B
C
D
t_1
t_2
Area where
B's signal exists
Area where
both signals exist
Area where
C's signal exists
Collision occurs at
this point
Time
Time

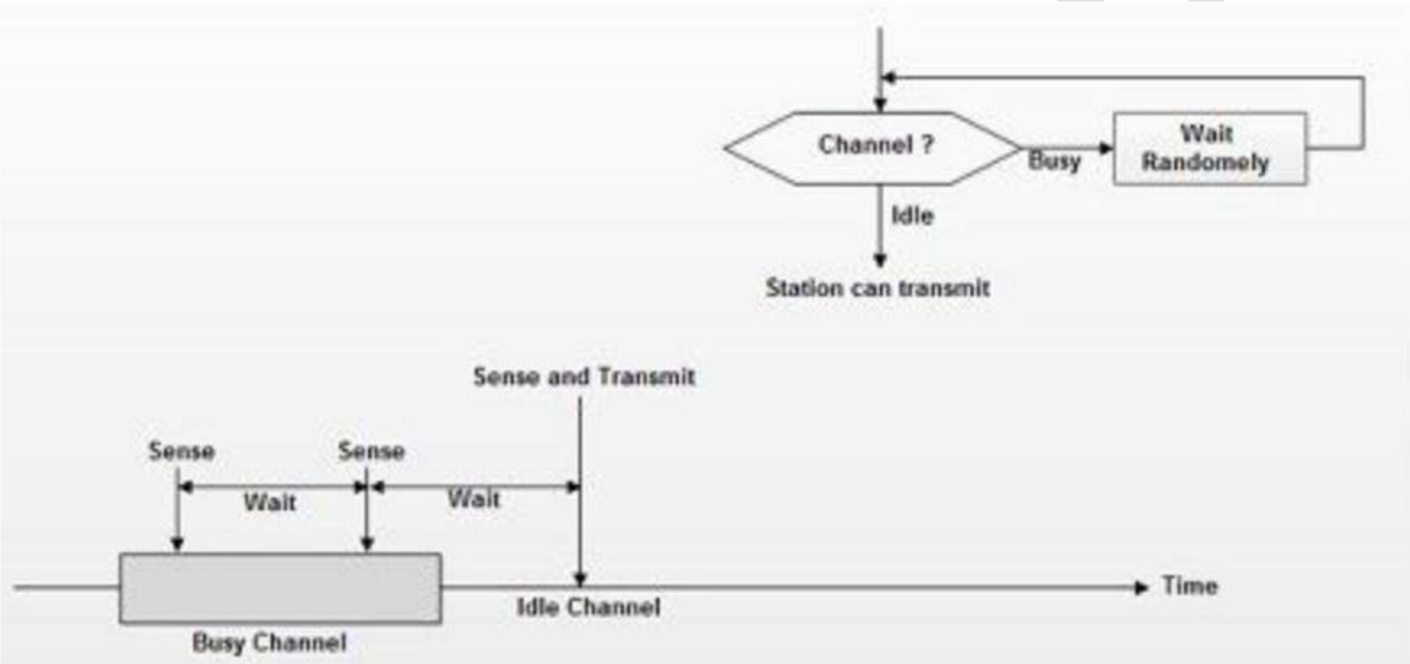

A
B
C
D
t_1
B senses
here
C senses
here
D senses
here
Vulnerable time
=
propagation time
Frame propagation
Time
Time

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

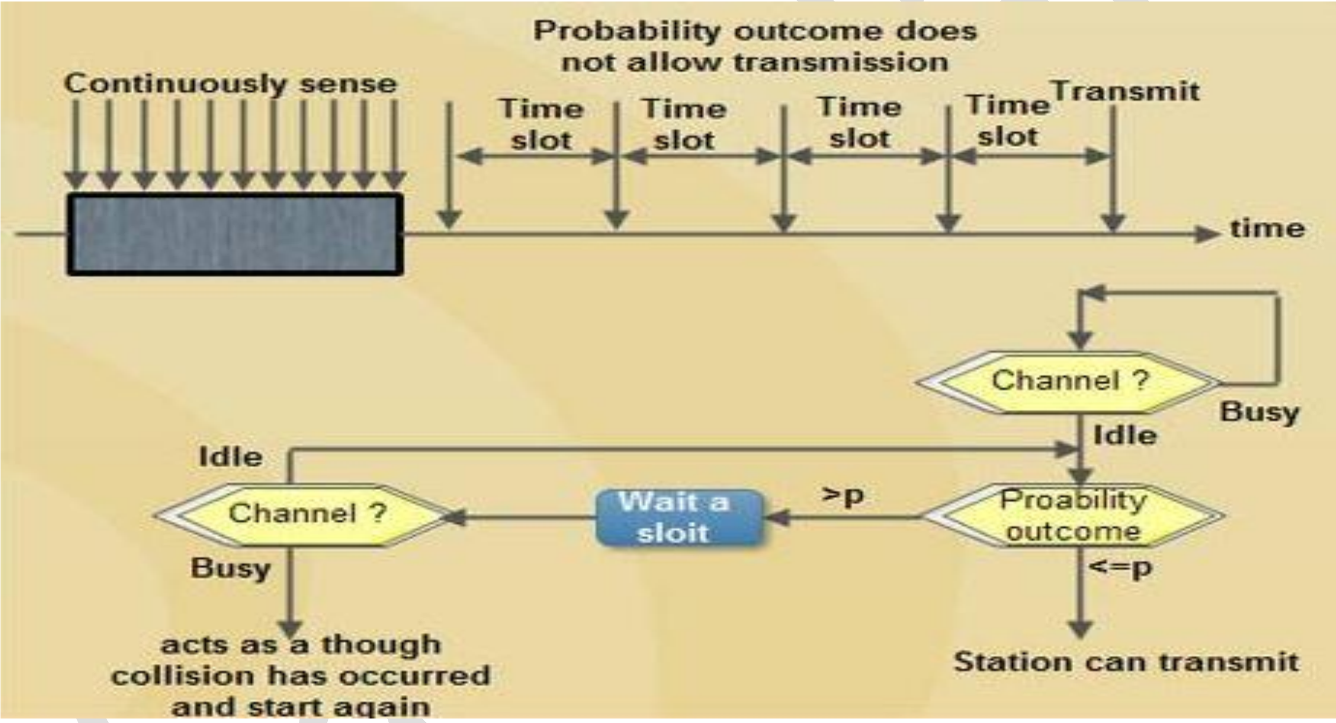


1-persistent CSMA

- **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.

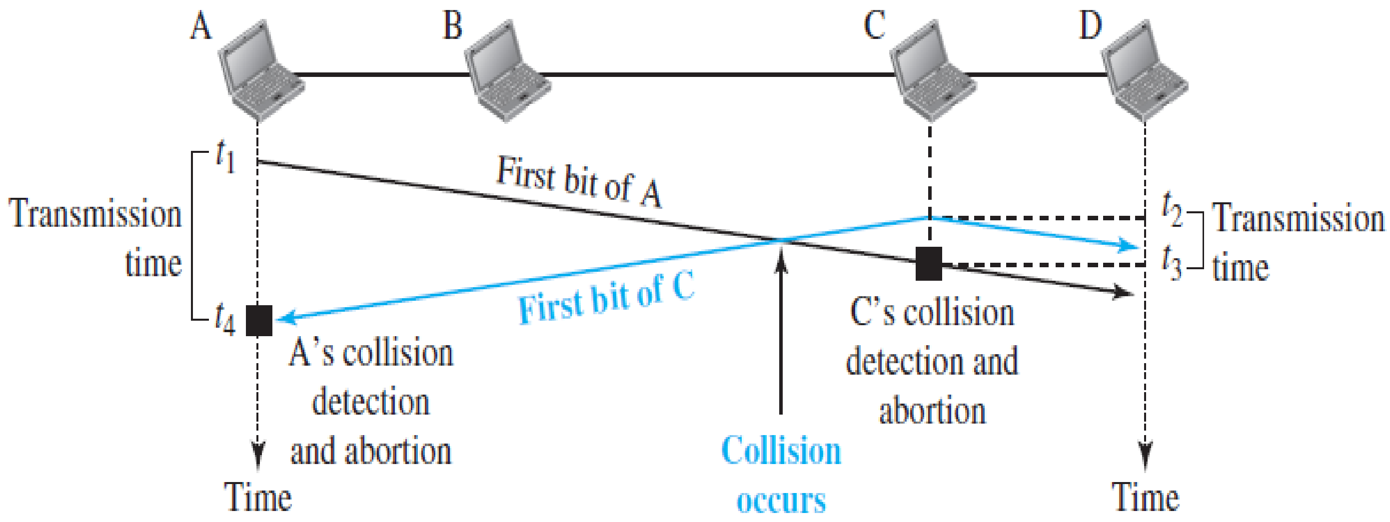


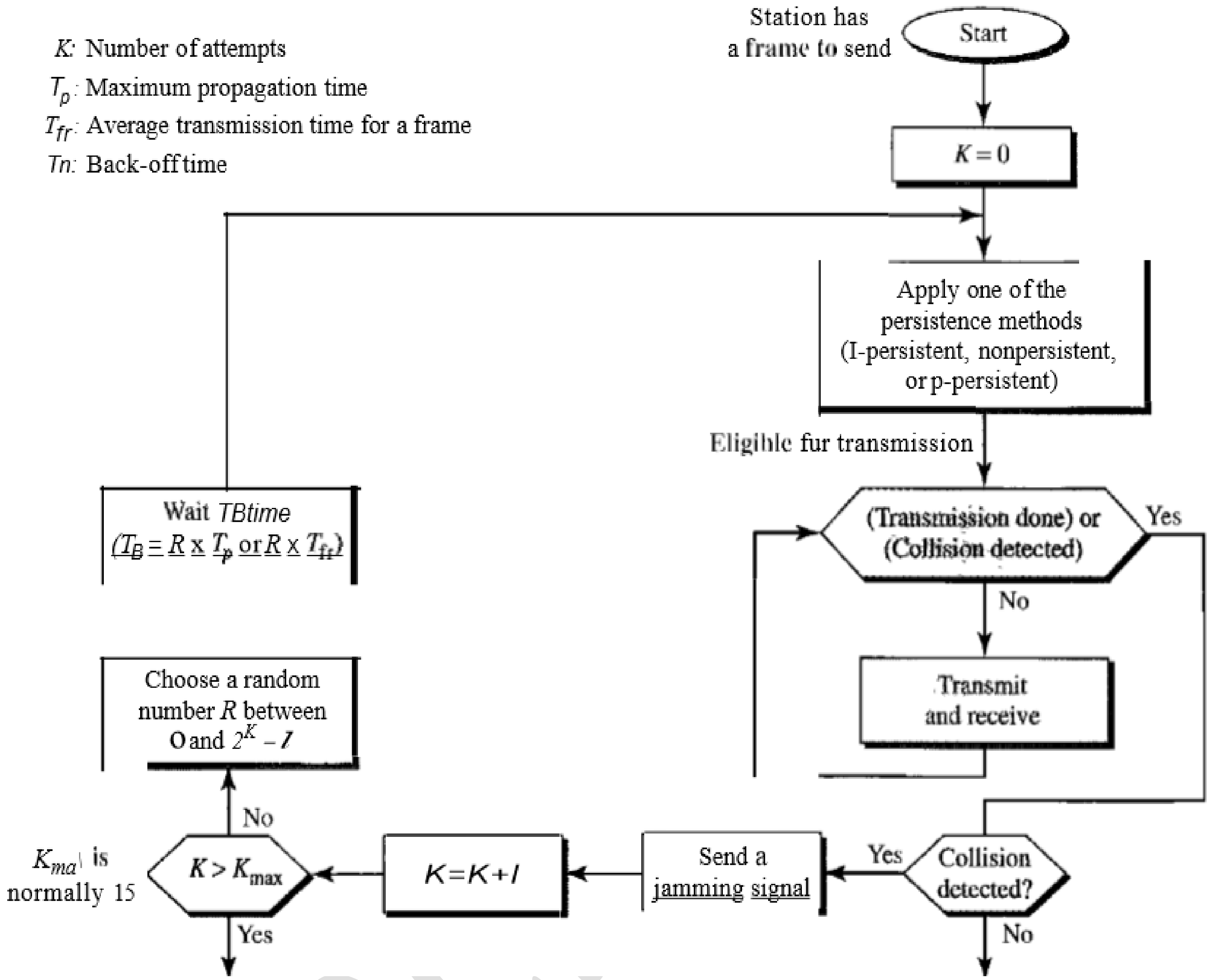
- **p-Persistent**
  - The p-persistent method is used if the channel has time slots with a slot duration equal to or greater than the maximum propagation time.
  - The p-persistent approach combines the advantages of the other two strategies. It reduces the chance of collision and improves efficiency. 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.



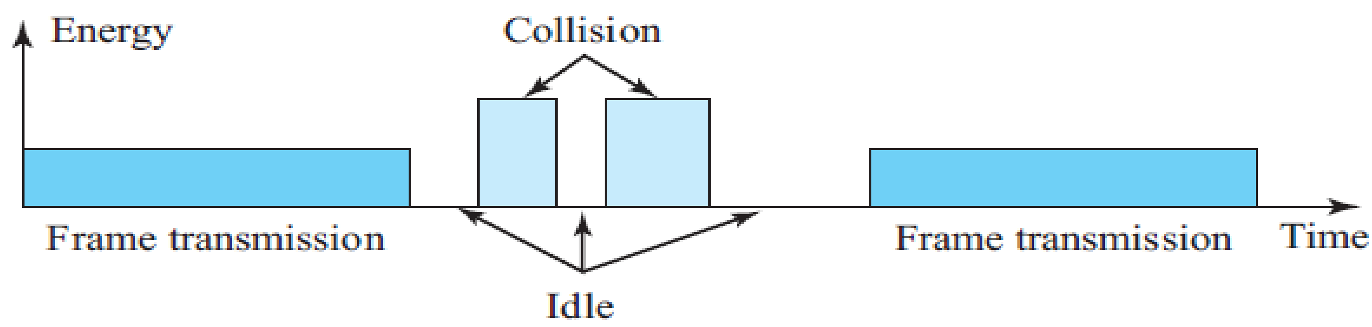
Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

- 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 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 keep a copy of the frame and does not monitor the line for collision detection. Therefore, the frame transmission time Tfr 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 Tp to reach the second, and the effect of the collision takes another time Tp to reach the first. So the requirement is that the first station must still be transmitting after 2Tp.





- **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.



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?

Ans: The minimum frame transmission time is $T_t = 2 \times Tp = 51.2$ μs.

The minimum size of the frame =10 Mbps × 51.2 μs = $10 * 10^6 \times 51.2 * 10^{-6} = 512$ bits or 64 bytes.

$T_{fr} = L/B$
T_{fr} =is the transmission time or forwarding time
L is the length of the frame in bits
B is the bandwidth of the channel in bits

$T_p = D/S$
T_{fr} is the time taken by frame to travel from one end point to another of access medium
L is the length of the frame in bits
B is the bandwidth of the channel in bits per second

for CSMA/CD
$T_{fr} = 2 * T_p$
$L = 2 * T_p * B$

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)**
ANSWER 200

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

Answer: (D)

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 x 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

Answer: (A)

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

Answer: (D)

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

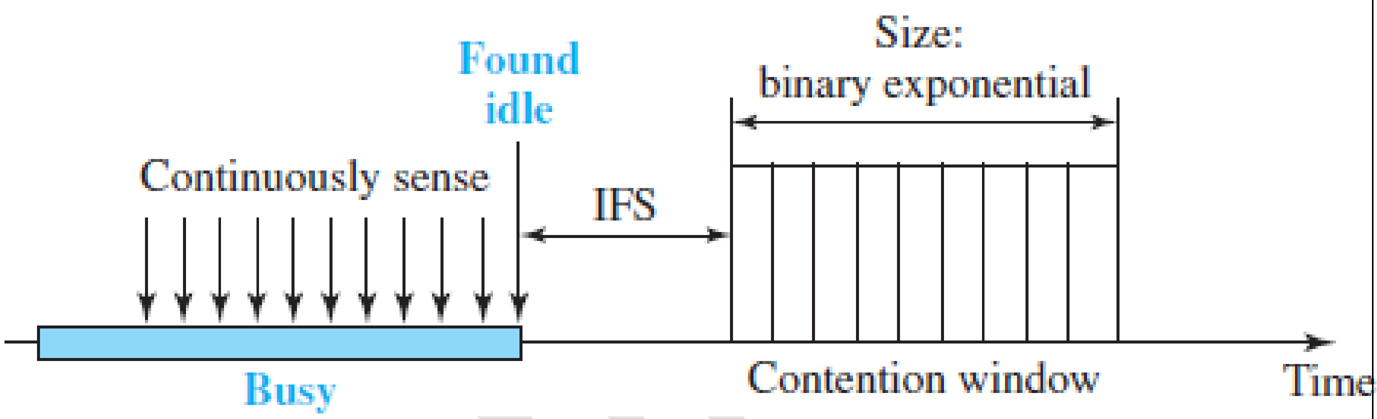
Answer: (B)

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)**

Q Which of the following statements is TRUE about CSMA/CD (Gate-2005) (1 Marks)
(A) IEEE 802.11 wireless LAN runs CSMA/CD protocol
(B) Ethernet is not based on CSMA/CD protocol
(C) CSMA/CD is not suitable for a high propagation delay network like satellite network
(D) There is no contention in a CSMA/CD network
Answer: (C)

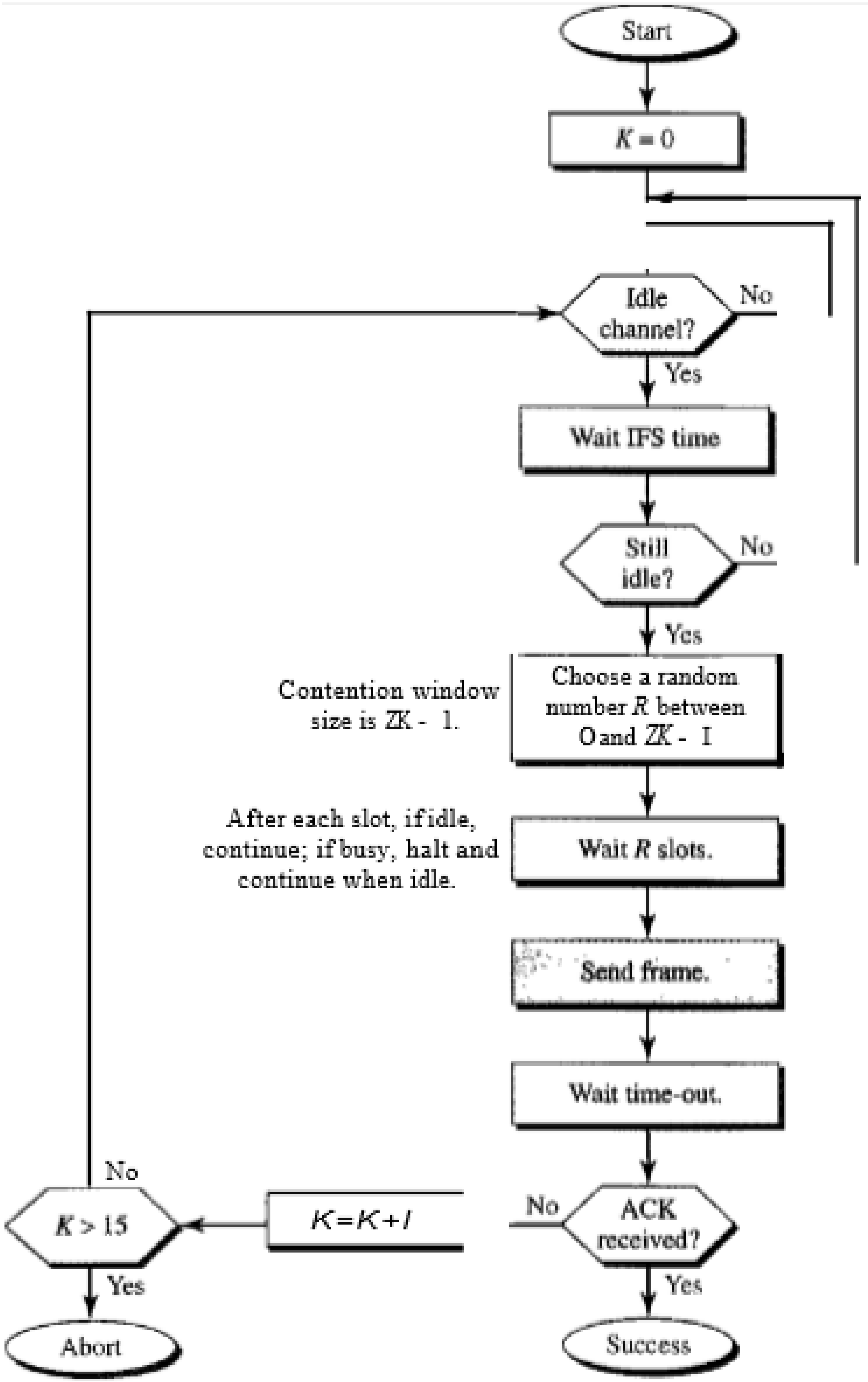
Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)

- 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



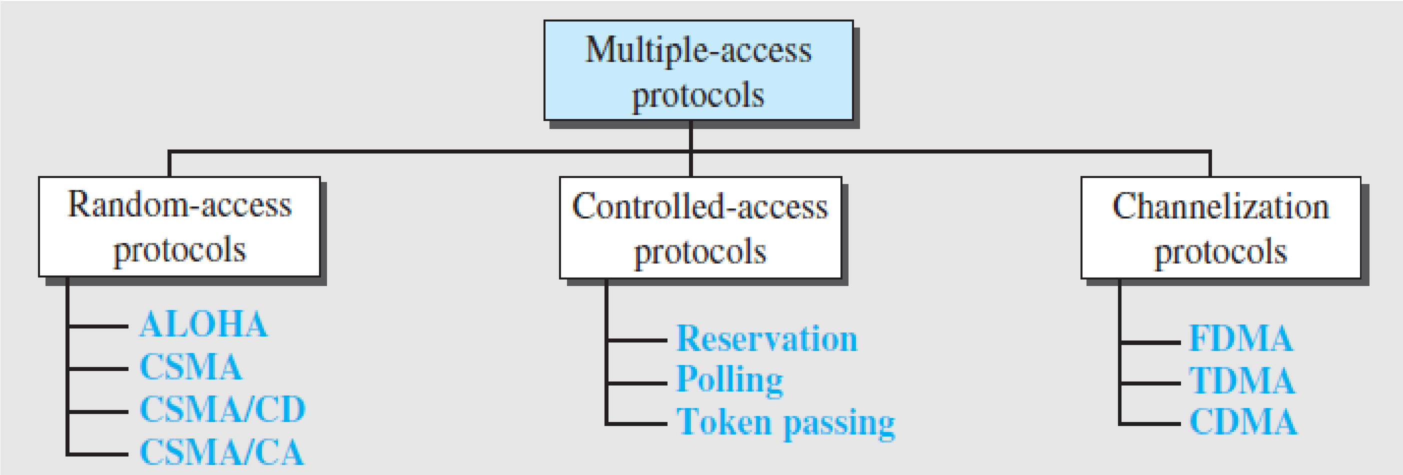
- **Interframe Space (IFS)**
    - First, collisions are avoided by deferring transmission even if the channel is found idle. When an idle channel is found, the station does not send immediately. It waits for a period of time called the interframe space or IFS.
    - Even though the channel may appear idle when it is sensed, a distant station may have already started transmitting. The distant station's signal has not yet reached this station.
    - 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 (described next). 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 the station cannot detect an idle channel after the IFS time. This is very similar to the

p-persistent method except that a random outcome defines the number of slots taken by the waiting station.
    - 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 ZK - 1.
Choose a random number R between O and ZK - I
After each slot, if idle, continue; if busy, halt and continue when idle.
Wait R slots.
Send frame.
Wait time-out.
No
K > 15
K=K+I
No
ACK received?
Yes
Yes
Abort
Success

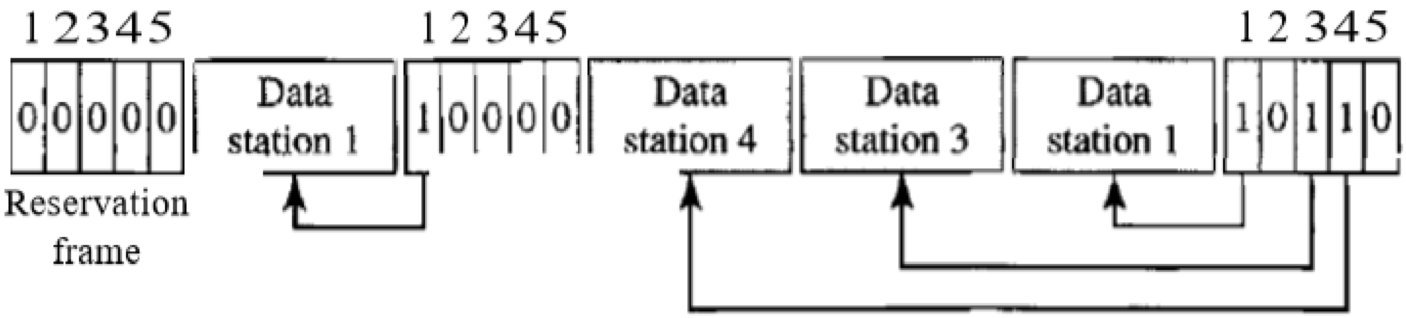
CONTROLLED ACCESS

- 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.



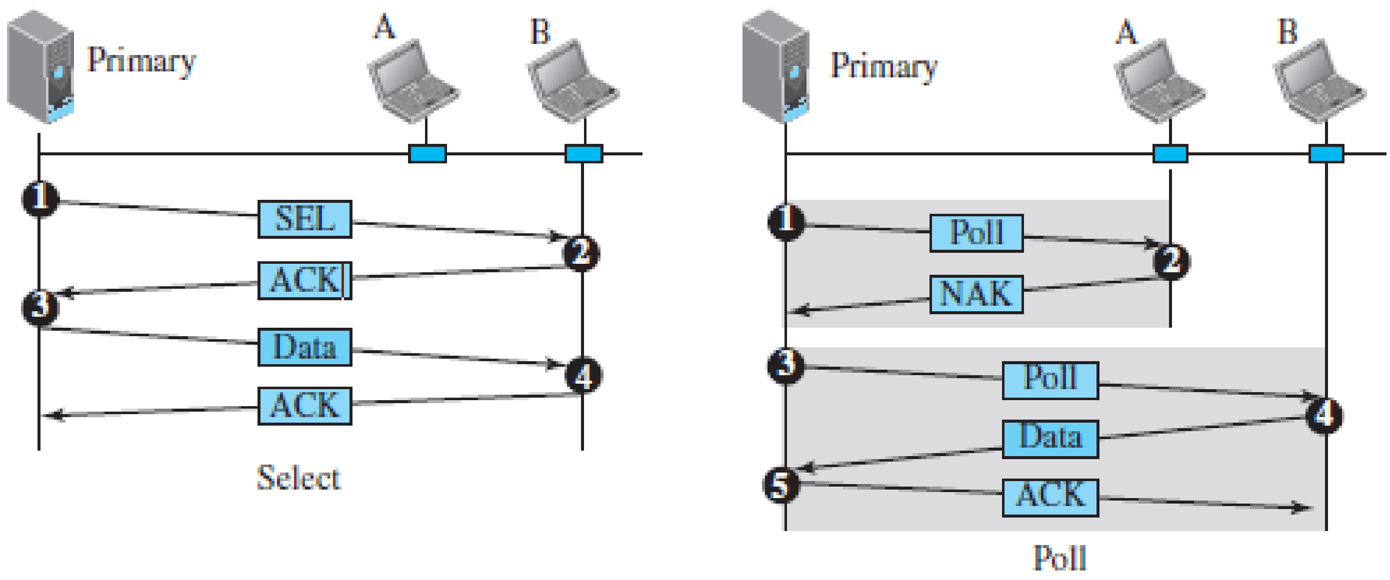
Reservation

- 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.



- If the primary wants to receive data, it asks the secondaries if they have anything to send; this is called poll function. If the primary wants to send data, it tells the secondary to get ready to receive; this is called select function.
- **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.
- 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.

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)

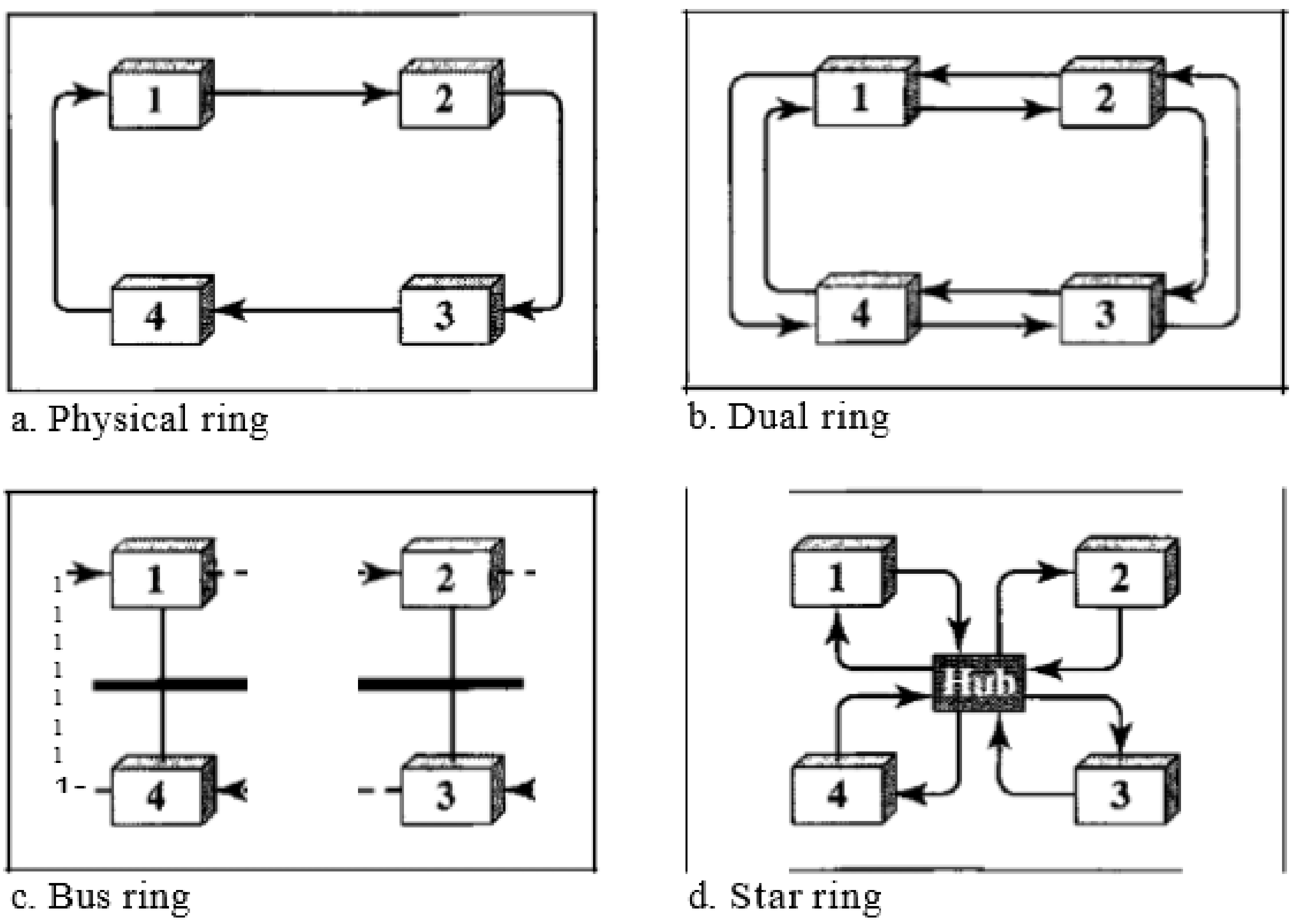
(A) 1 Mbps **(B)** 100/11 Mbps **(C)** 10 Mbps **(D)** 100 Mbps

Answer: (B)

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?
- 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.
- 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.

Logical ring and physical topology in token-passing access method

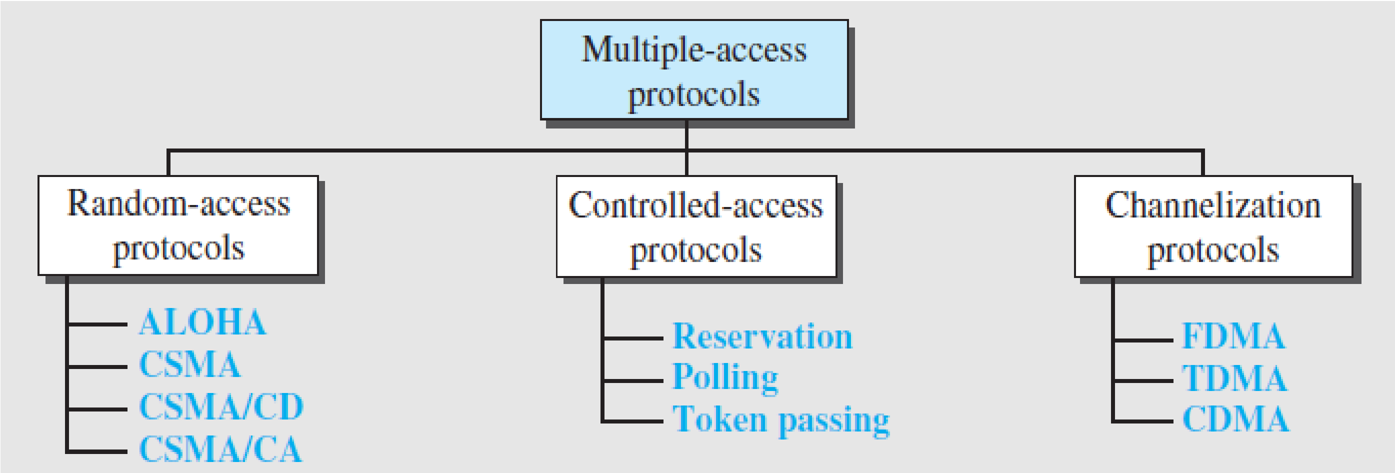


- Logical Ring
- In a token-passing network, stations do not have to be physically connected in a ring; the ring can be a logical one. In the physical ring topology, when a station sends the token to its successor, the token cannot be seen by other stations; the successor is the next one in line.
- This means that the token does not have to have the address of the next successor. The problem with this topology is that if one of the links-the medium between two adjacent stations fails, the whole system fails.
- The dual ring topology uses a second (auxiliary) ring which operates in the reverse direction compared with the main ring. The second ring is for emergencies only (such as a spare tire for a car).
- If one of the links in the main ring fails, the system automatically combines the two rings to form a temporary ring. After the failed link is restored, the auxiliary ring becomes idle again.

- Note that for this topology to work, each station needs to have two transmitter ports and two receiver ports. The high-speed Token Ring networks called FDDI (Fiber Distributed Data Interface) and CDDI (Copper Distributed Data Interface) use this topology.
- In the bus ring topology, also called a token bus, the stations are connected to a single cable called a bus. They, however, make a logical ring, because each station knows the address of its successor (and also predecessor for token management purposes).
- When a station has finished sending its data, it releases the token and inserts the address of its successor in the token. Only the station with the address matching the destination address of the token gets the token to access the shared media.
- The Token Bus LAN, standardized by IEEE, uses this topology. In a star ring topology, the physical topology is a star. There is a hub, however, that acts as the connector. The wiring inside the hub makes the ring; the stations are connected to this ring through the two wire connections.
- This topology makes the network less prone to failure because if a link goes down, it will be bypassed by the hub and the rest of the stations can operate. Also adding and removing stations from the ring is easier. This topology is still used in the Token Ring LAN designed by IBM.

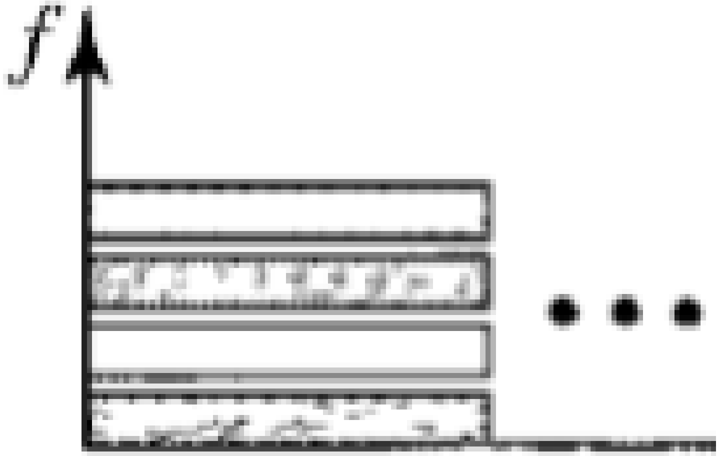
CHANNELIZATION

- 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.



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.

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 x 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

Answer: (C)

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.
- 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).

Differences between CSMA/CD and ALOHA

- The first difference is the addition of the persistence process. We need to sense the channel before we start sending the frame by using one of the persistence processes we discussed previously (nonpersistent, I-persistent, or p-persistent).
- The second difference is the frame transmission. In ALOHA, we first transmit the entire frame and then wait for an acknowledgment. In CSMA/CD, transmission and collision detection is a continuous process. We do not send the entire frame and then look for a collision. The station transmits and receives continuously and simultaneously (using two different ports). We use a loop to show that transmission is a continuous process.
- We constantly monitor in order to detect one of two conditions: either transmission is finished or a collision is detected. Either event stops transmission. When we come out of the loop, if a collision has not been detected, it means that transmission is complete; the entire frame is transmitted. Otherwise, a collision has occurred.
- The third difference is the sending of a short jamming signal that enforces the collision in case other stations have not yet sensed the collision.

CSMA/CD	ALOHA
It has the persistence process, sense before send	There is no persistence in ALOHA
Transmission and collision detection are continuous processes. We do not send the entire frame and then look for a collision.	We first transmit the entire frame and then wait for an acknowledgment.
Sending of a short **jamming signal** to make sure that all other stations become aware of the collision.	No jamming signals are used

Throughput

- The maximum throughput occurs at a different value of G and is based on the persistence method and the value of p in the p-persistent approach.
- For the 1-persistent method, the maximum throughput is around 50 percent when *G* = 1.
- For the nonpersistent method, the maximum throughput can go up to 90 percent when *G* is between 3 and 8.

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)**
Ans: 50

Q Consider a simplified time slotted MAC protocol, where each host always has data to send and transmits with probability p = 0.2 in every slot. There is no backoff and one frame can be transmitted in one slot. If more than one host transmits in the same slot, then the transmissions are unsuccessful due to collision. What is the maximum number of hosts which this protocol can support, if each host has to be provided a minimum through put of 0.16 frames per time slot? (Gate-2004) (2 Marks)

(A) 1 **(B)** 2 **(C)** 3 **(D)** 4

Answer: (B)