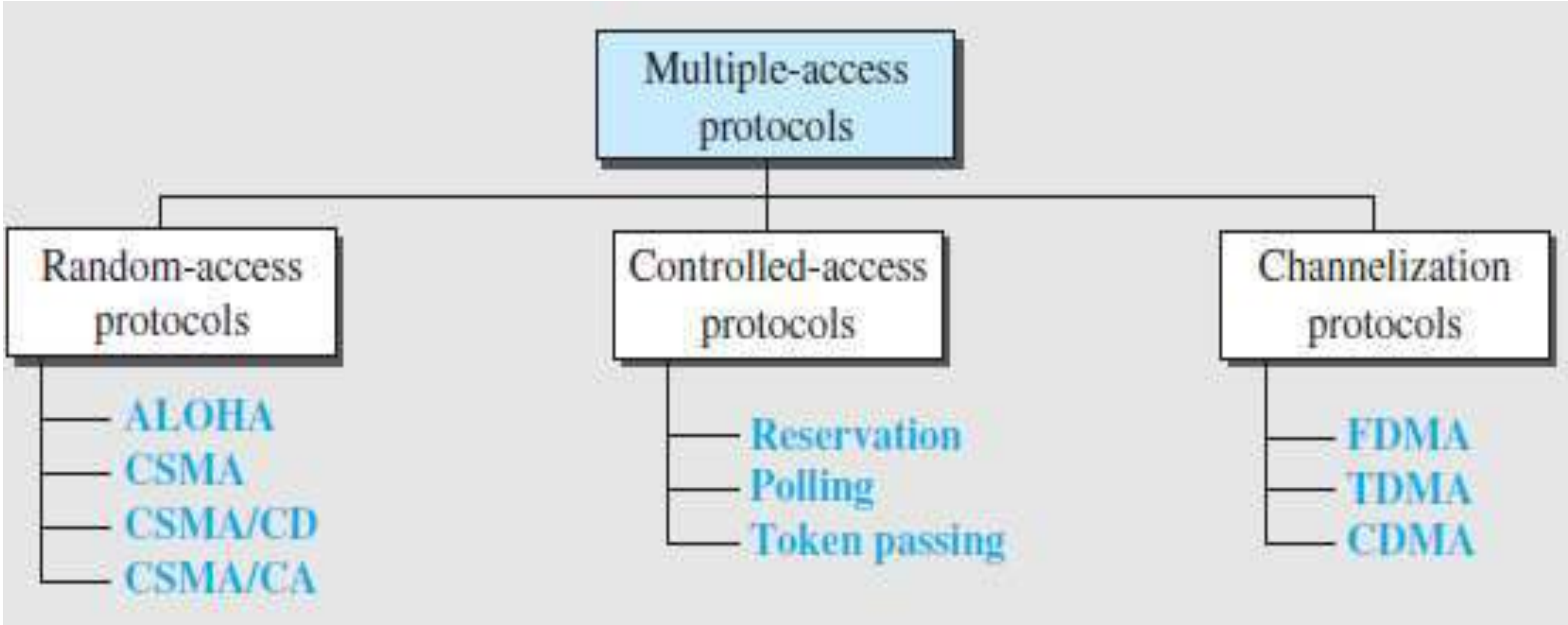
Session 11-MAC Sub Layer

Multiple-Access protocols



Multiple-Access protocols

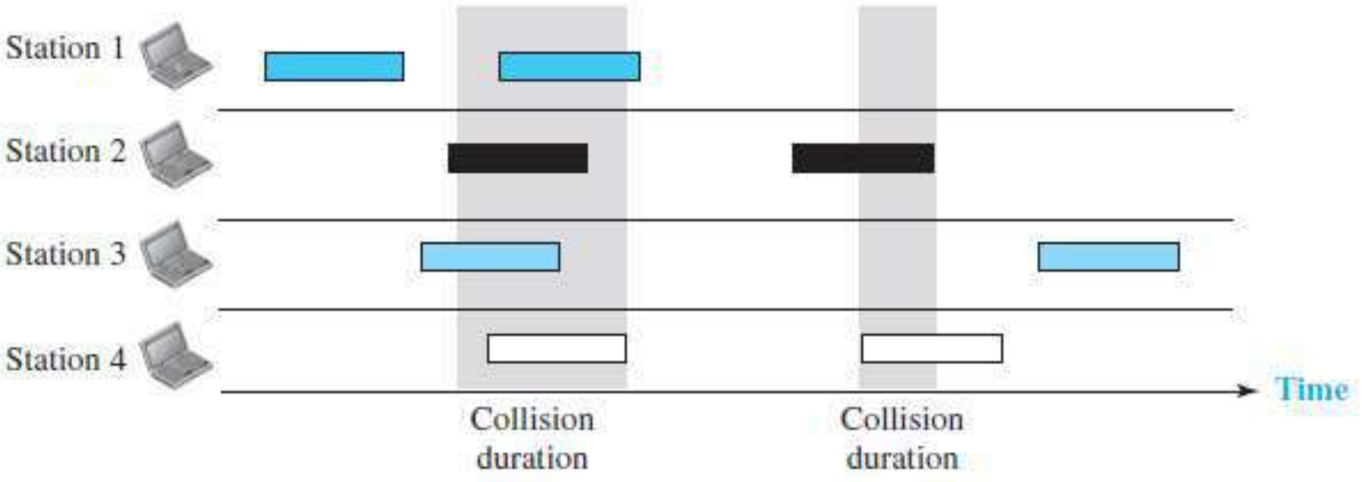
- Four protocols, ALOHA, CSMA, CSMA/CD, and CSMA/CA, are protocols mostly used in LANs and WANs.
- Three protocols, reservation, polling, and token-passing, are used in LANs.
- Three protocols, FDMA, TDMA, and CDMA are used in cellular telephony.

ALOHA

- **ALOHA (Advocates of Linux Open-source Hawaii Association)** the earliest random access method, was developed at the University of Hawaii in early 1970.
- It was designed for a radio (wireless) LAN, but it can be used on any shared medium.
- It is obvious that there are potential collisions in this arrangement. The medium is shared between the stations.
- When a station sends data, another station may attempt to do so at the same time. The data from the two stations collide and become garbled.

Pure ALOHA

- The original ALOHA protocol is called ***pure ALOHA.***
- Each station sends a frame whenever it has a frame to send (multiple access).
- However, since there is only one channel to share, there is the possibility of collision between frames from different stations.



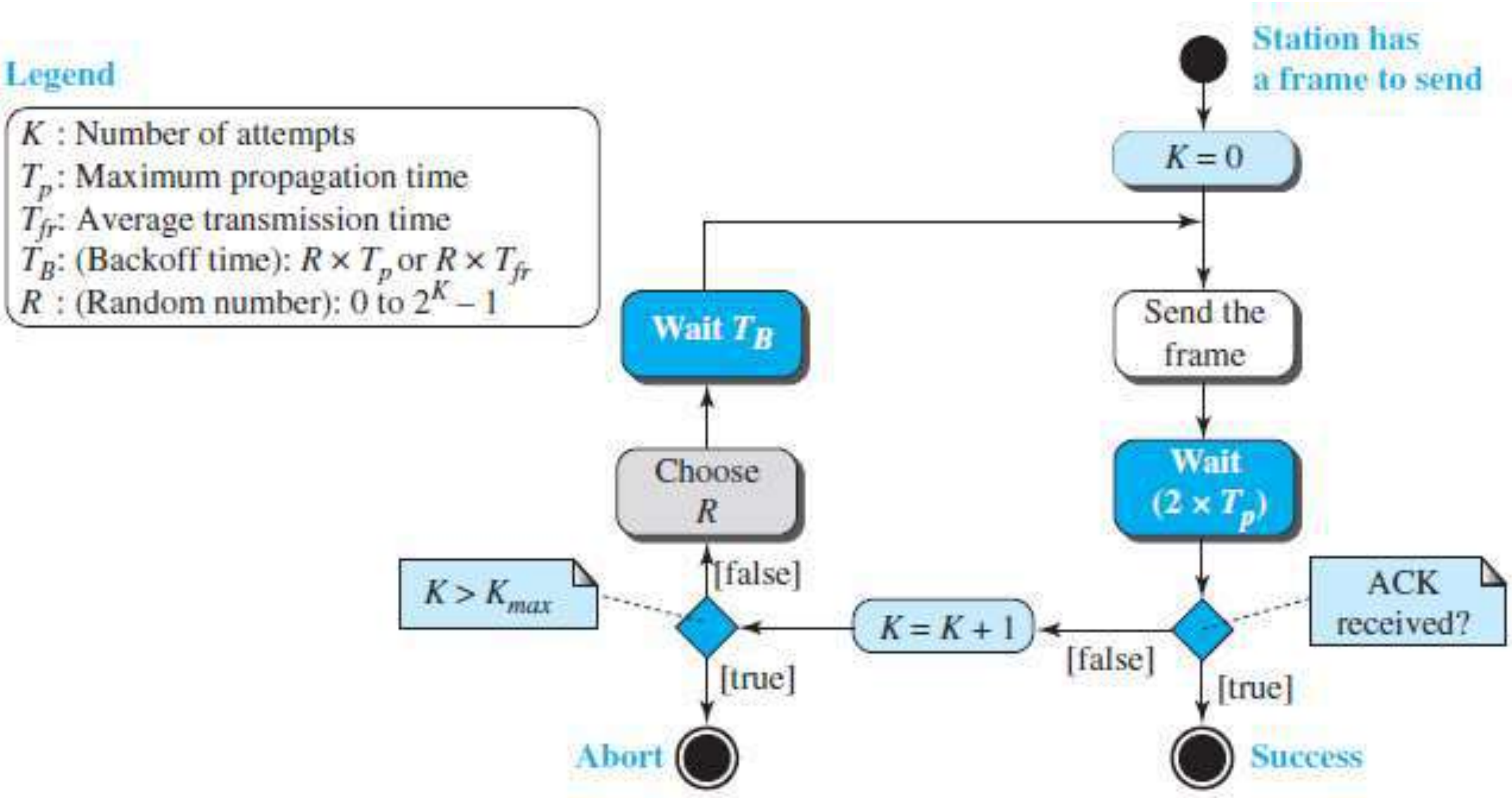
Pure ALOHA

- 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 retransmission attempts , a station must give up and try later.

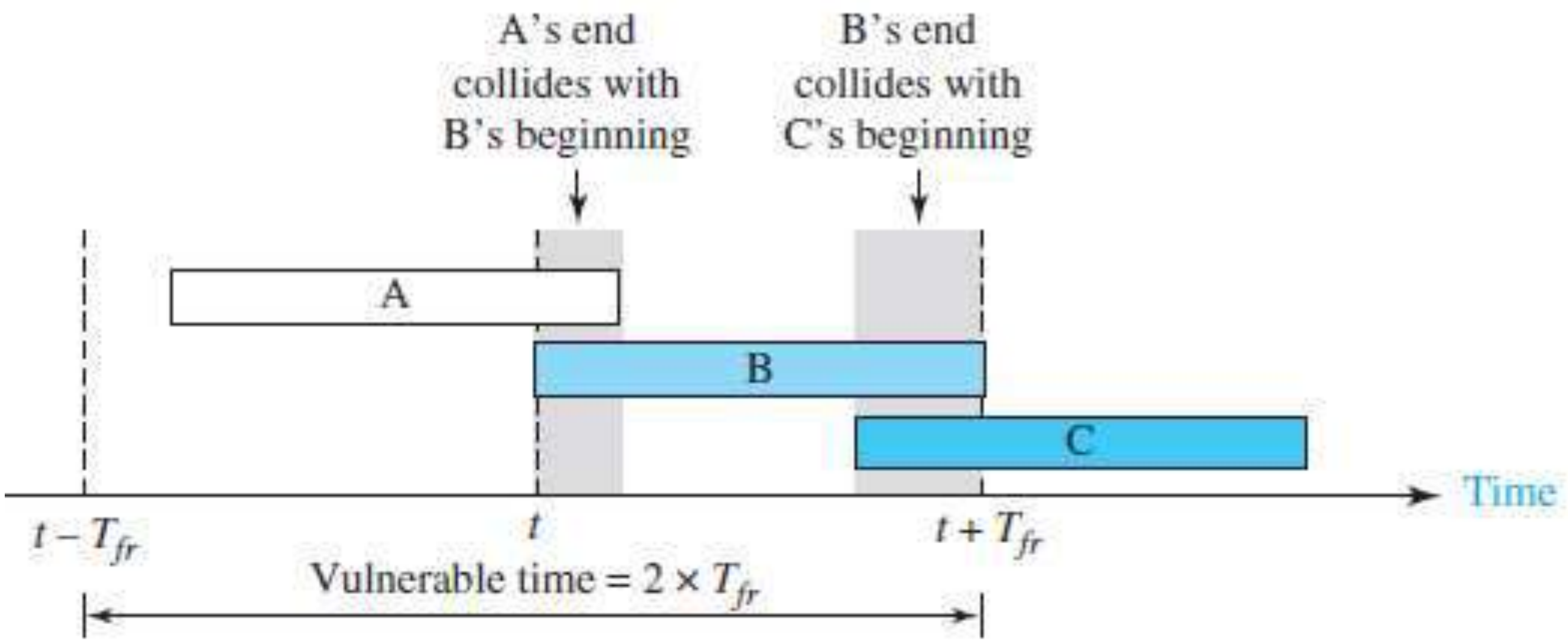
K_{max}

Pure ALOHA



pure ALOHA protocol

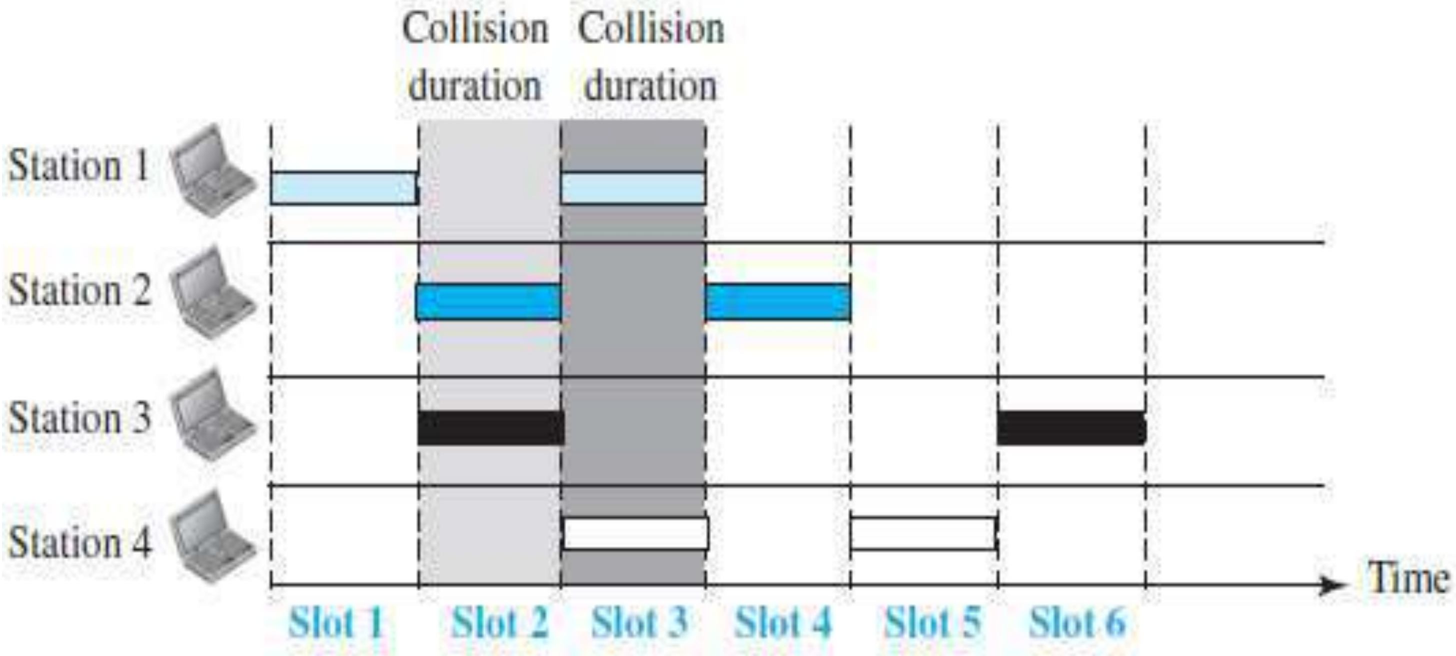
Pure ALOHA



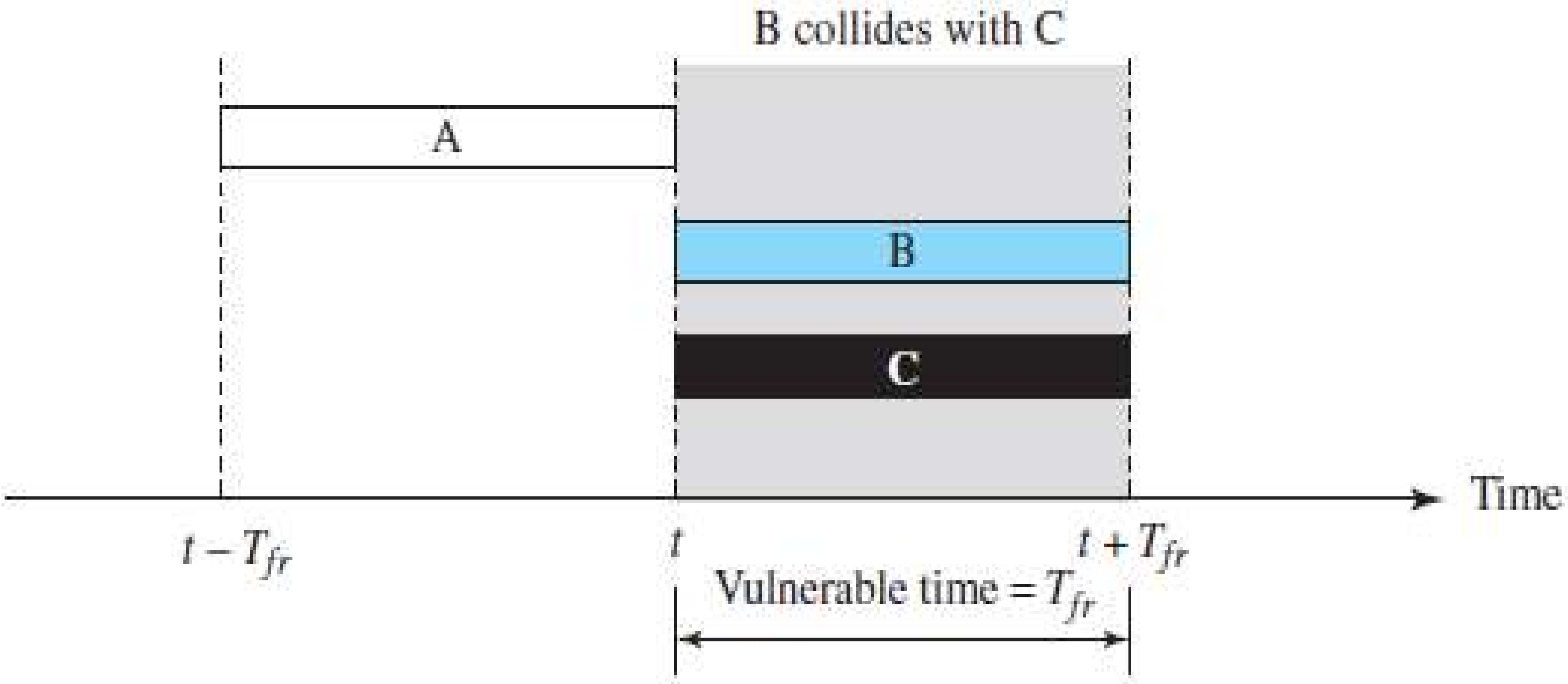
Vulnerable time for pure ALOHA protocol

Slotted ALOHA

- Slotted ALOHA was invented to improve the efficiency of pure ALOHA. Because Pure ALOHA has a vulnerable time of 2 × *Tfr*.
- In **slotted ALOHA** we divide the time into slots of *Tfr* seconds and force the station to send only at the beginning of the time slot.

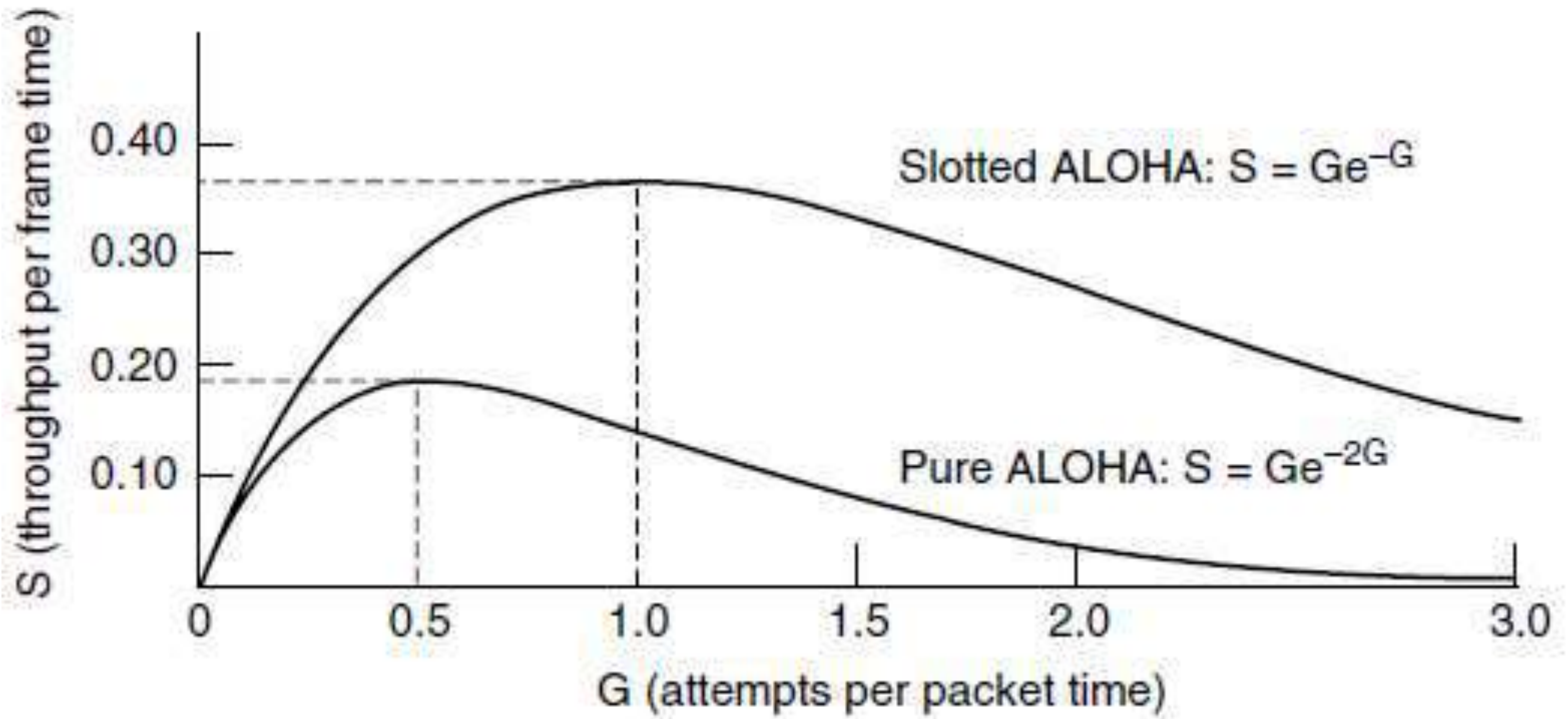


Slotted ALOHA



Vulnerable time for slotted ALOHA protocol

Pure vs Slotted ALOHA



Throughput versus offered traffic for ALOHA systems.

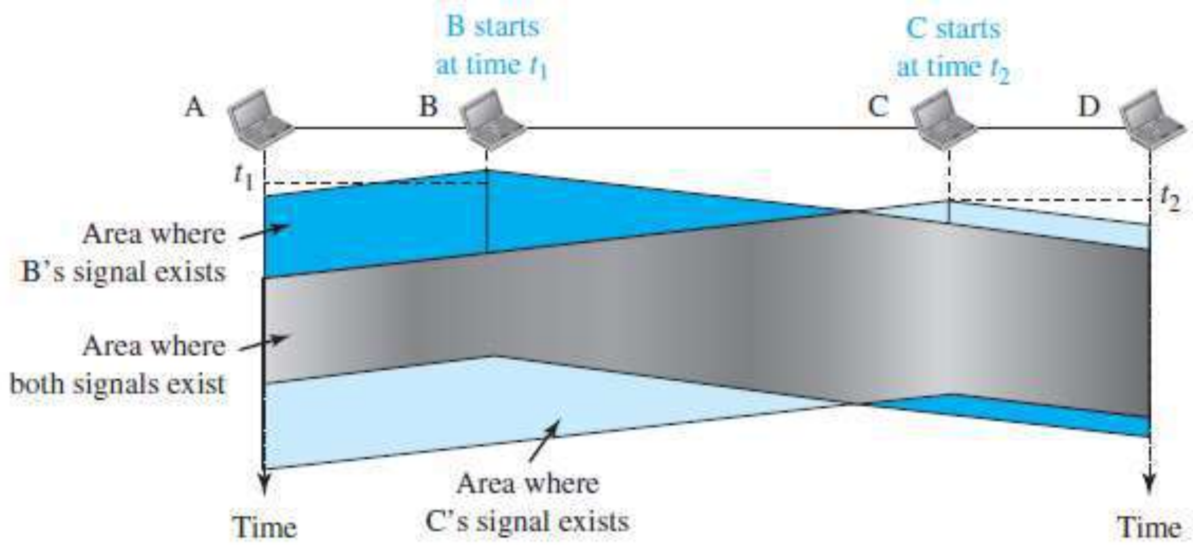
Carrier sense multiple access (CSMA)

- **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.

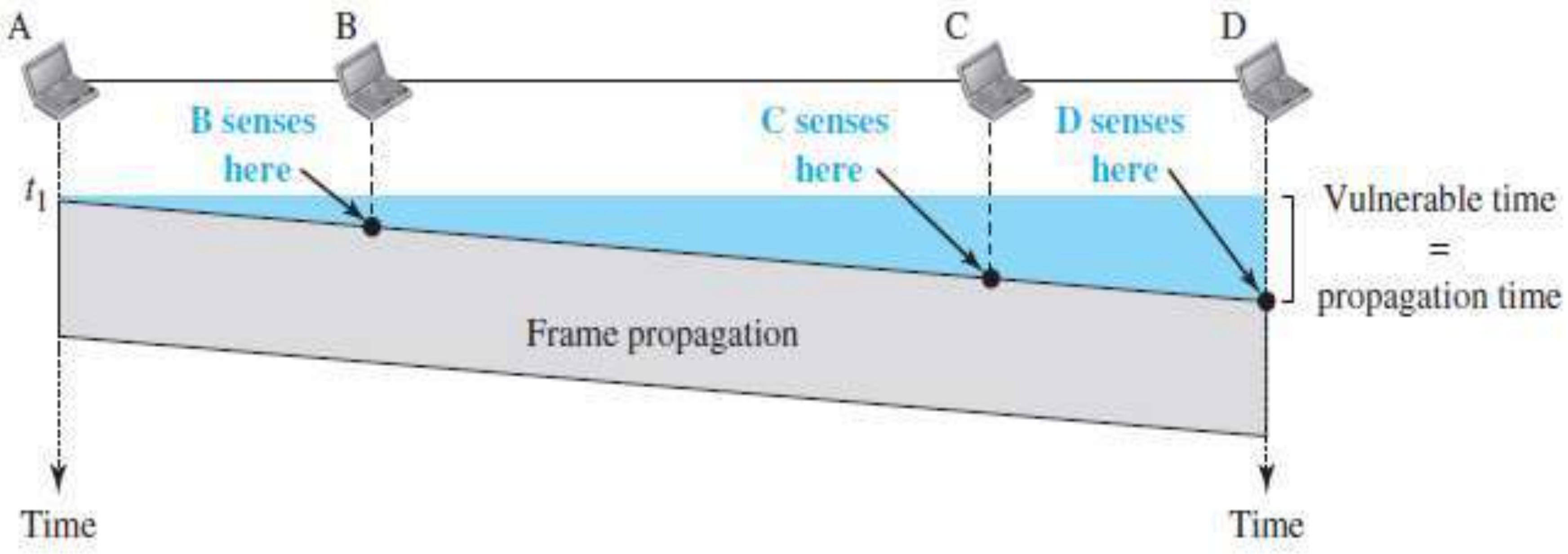
Carrier sense multiple access (CSMA)



At time $t1$, station B senses the medium and finds it idle, so it sends a frame. At time $t2$ ($t2 > t1$), 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.

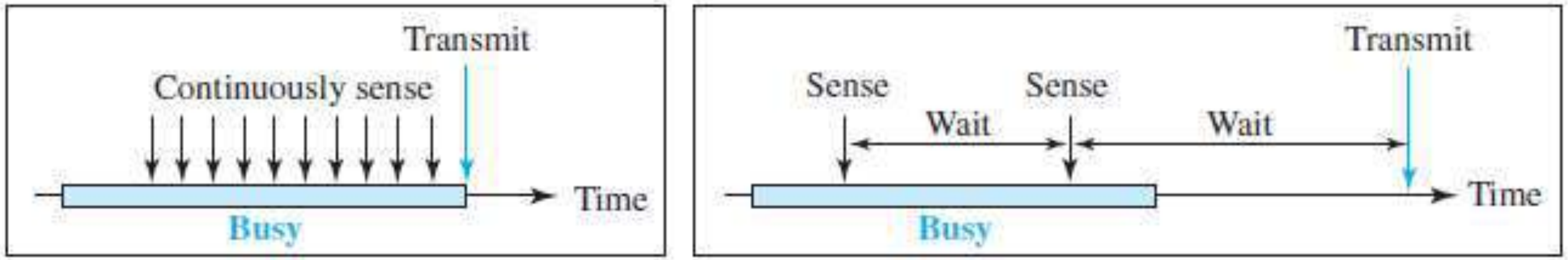
Vulnerable Time in CSMA

- The vulnerable time for CSMA is the ***propagation time*** *Tp.*
- The leftmost station, A, sends a frame at time *t*1, which reaches the rightmost station, D, at time *t*1 + *Tp*.

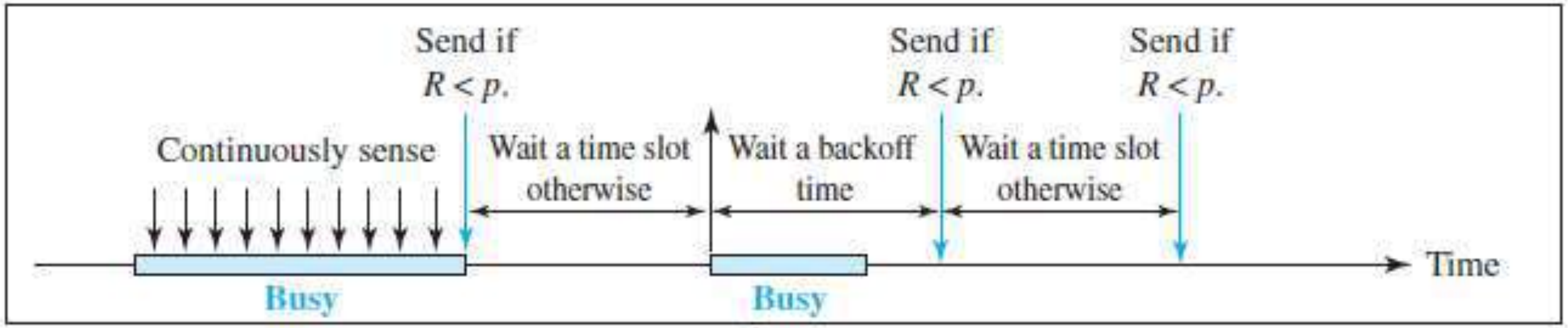


Persistence Methods

1. **1-persistent method,**
2. **non-persistent method**
3. ***p*-persistent method.**

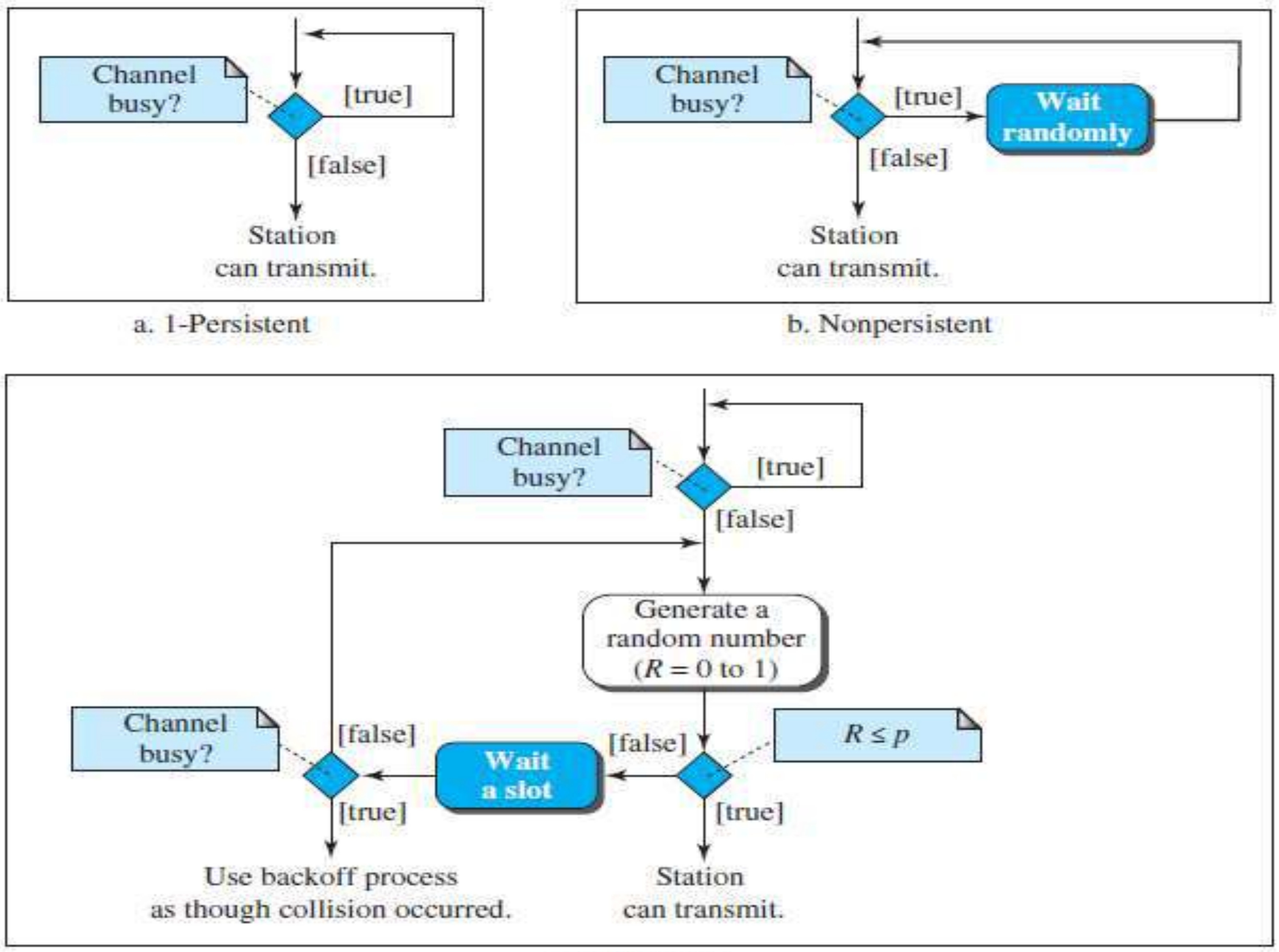


a. 1-Persistent b. Nonpersistent



c. *p*-Persistent

Flow diagram for persistence methods



c. p-Persistent

1-persistent method

- 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.

Non-persistent method

- In the *non-persistent 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 non-persistent 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.

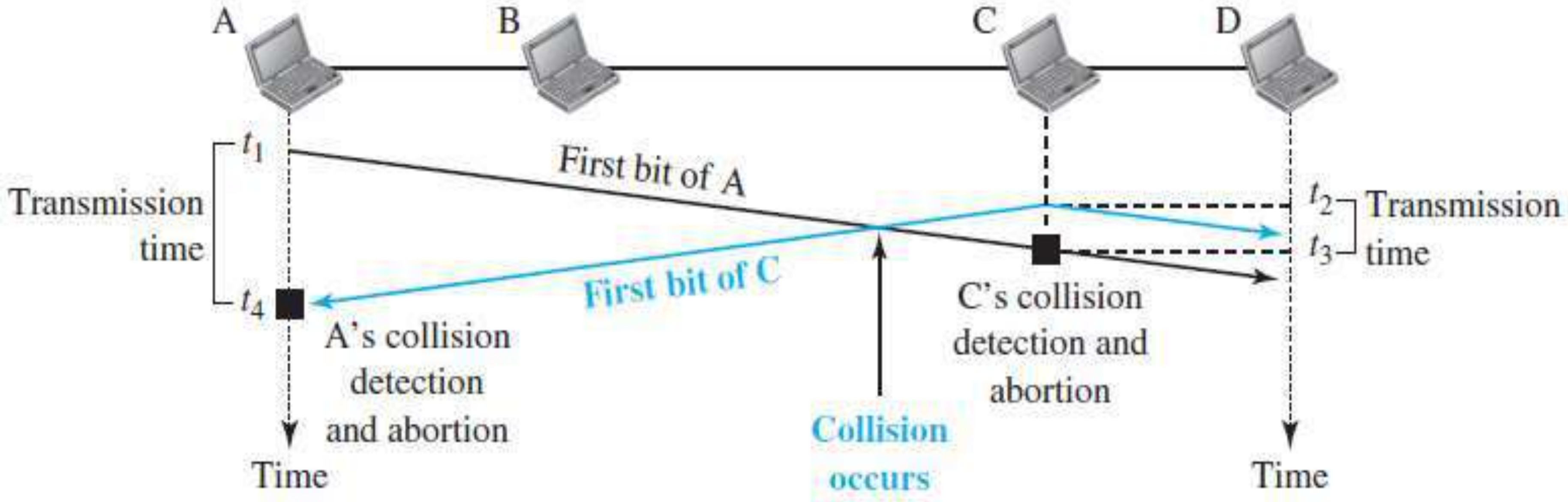
p-persistent method

- The *p*-persistent reduces the chance of collision and improves efficiency. In this method, after the station finds the line idle it follows these steps:

1. With probability p, the station sends its frame.
2. 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 back-off procedure.

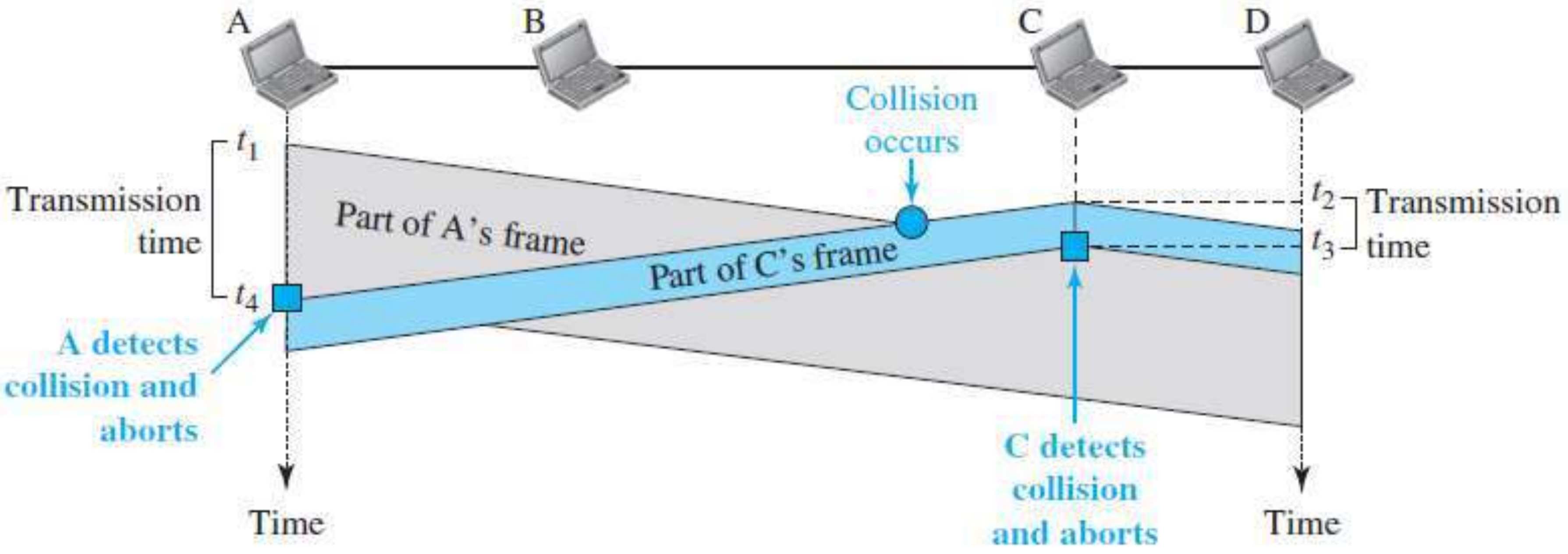
CSMA/CD

- The CSMA method does not specify the procedure following a collision. **Carrier sense multiple access with collision detection (CSMA/CD)** augments the algorithm to handle the collision.



Collision of the first bits in CSMA/CD

CSMA/CD



Collision and abortion in CSMA/CD

CSMA/CD (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*.

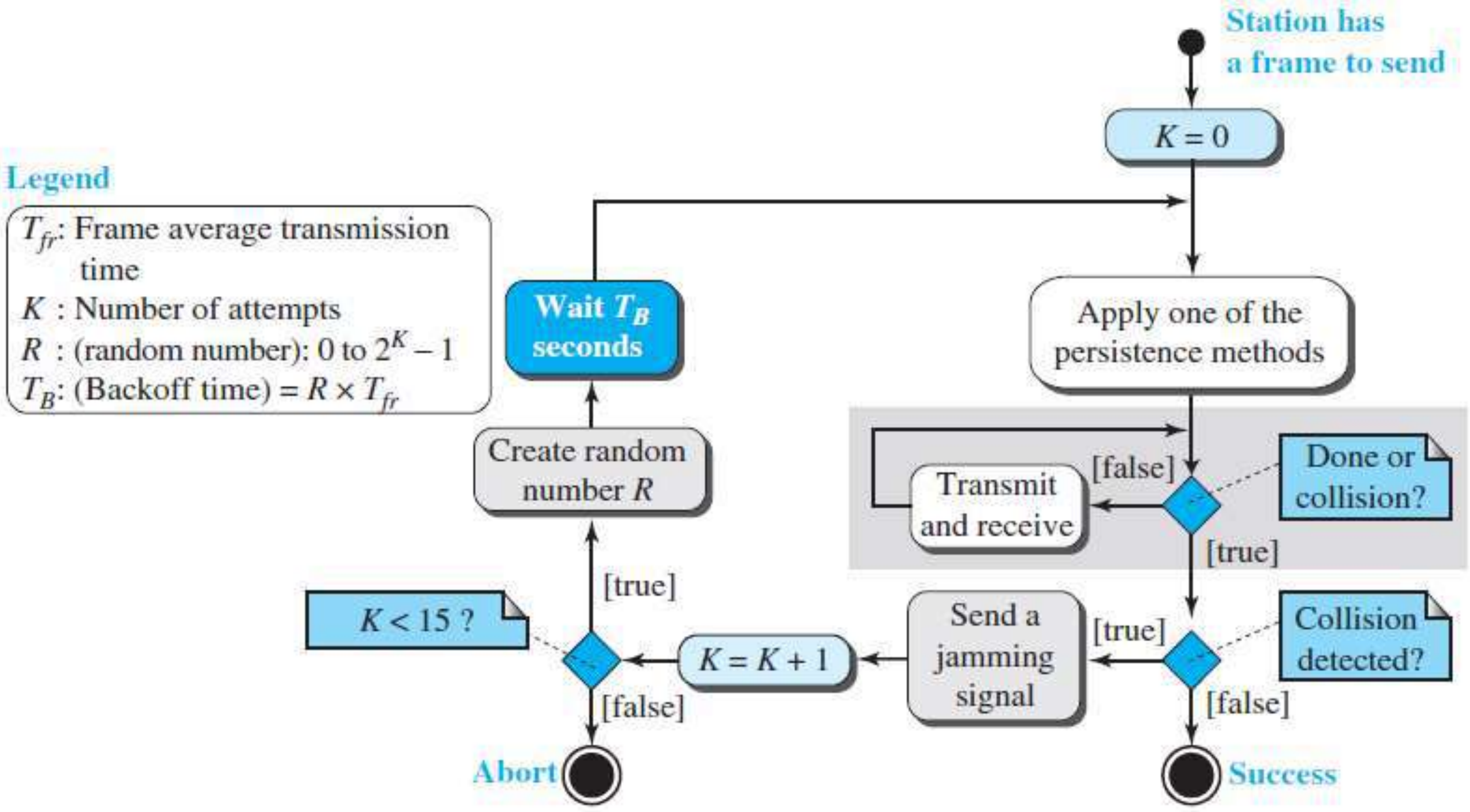
CSMA/CD (Minimum Frame Size)

- 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 2*Tp*.

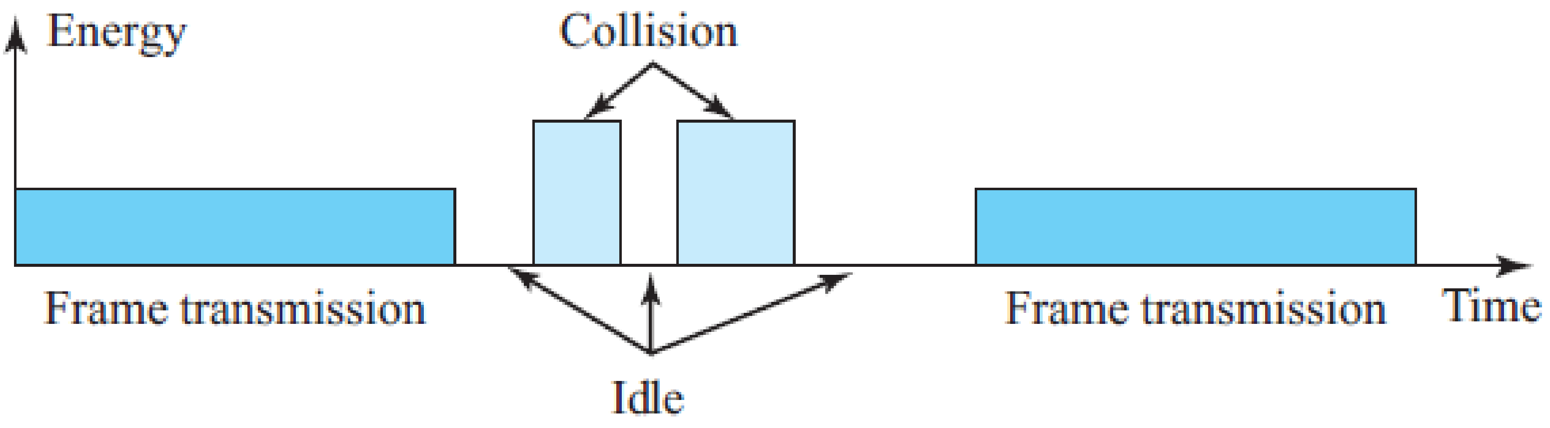
CSMA/CD



Flow diagram for the CSMA/CD

CSMA/CD (Energy Level)

- 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.

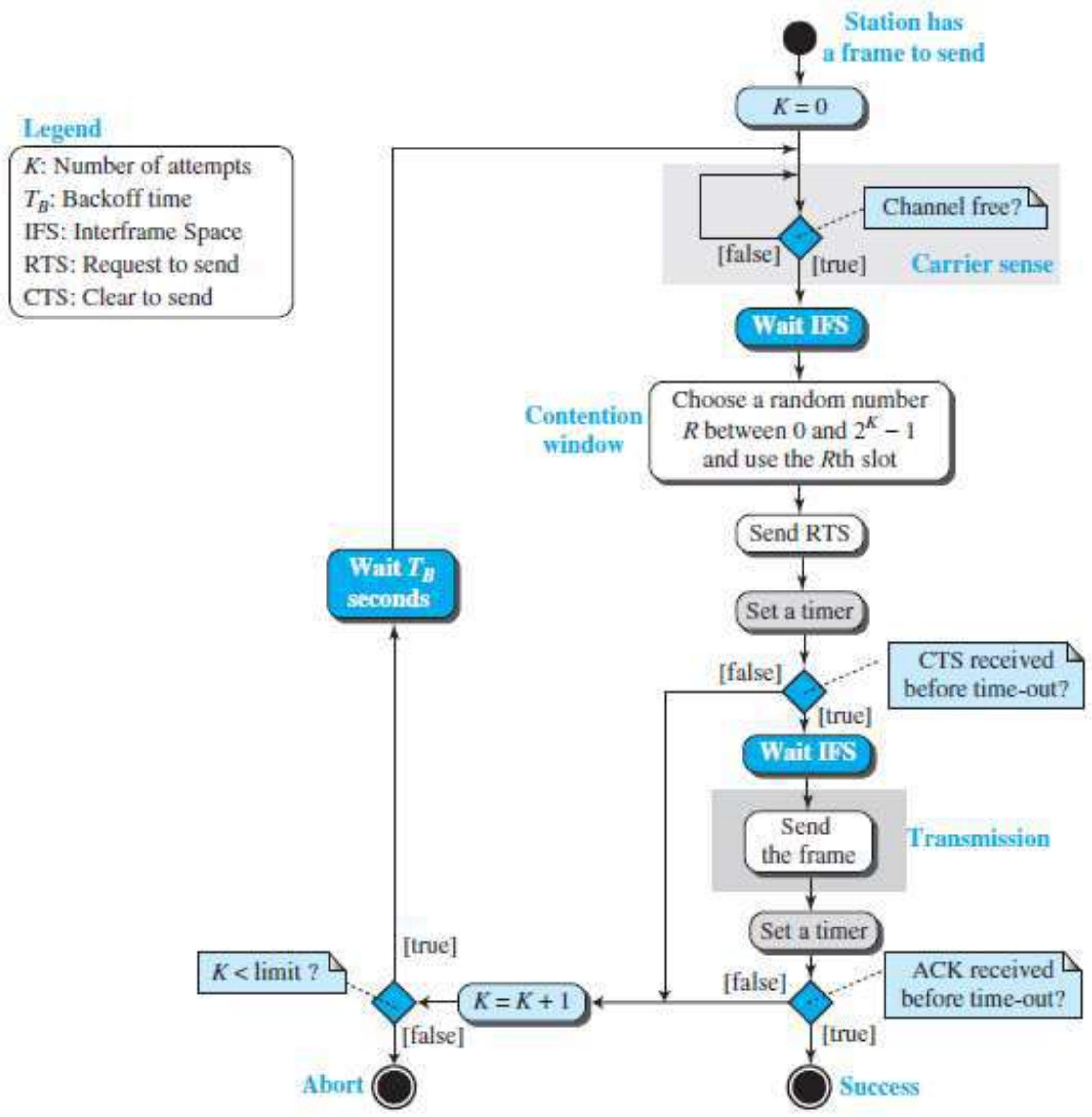


CSMA/CA

- **Carrier sense multiple access with collision avoidance (CSMA/CA)** was invented for wireless networks. Collisions are avoided through the use of CSMA/CA's three strategies:

1. The inter frame space
2. The contention window, and
3. Acknowledgments.

CSMA/CA (Flow Diagram)



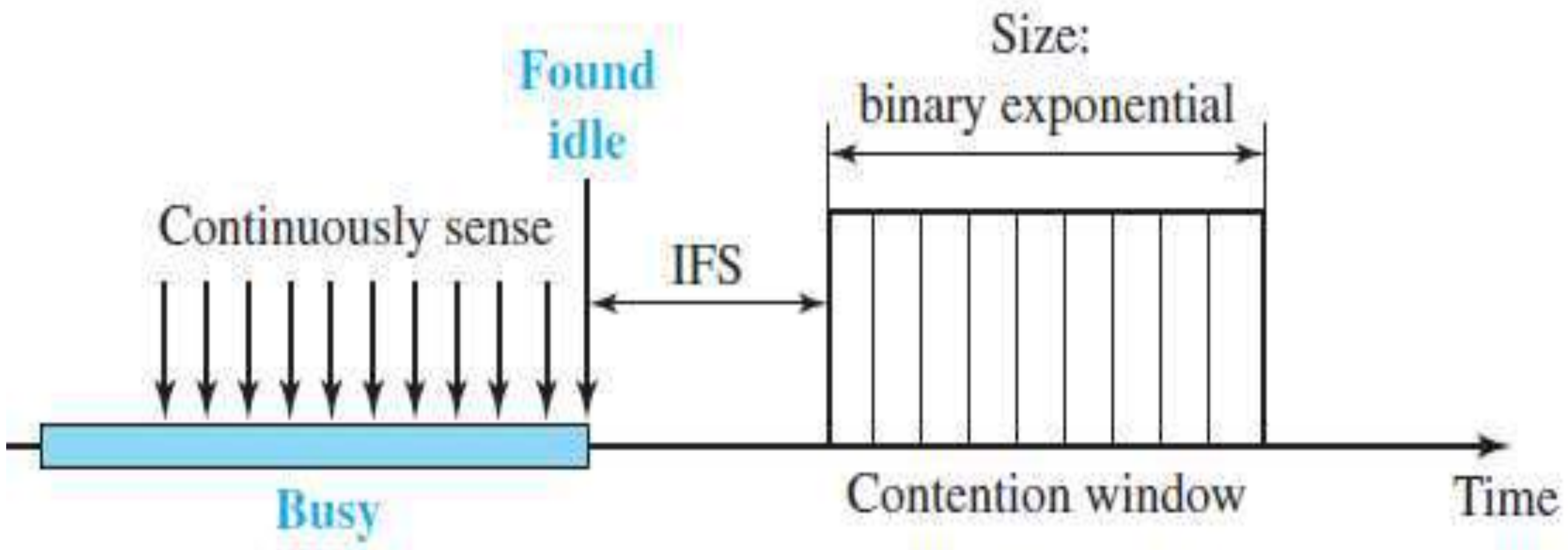
Contention Window

- 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. 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

Inter frame 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 ***inter frame 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. After waiting an IFS time, if the channel is still idle, the station can send, but it still needs to wait a time equal to the contention window.

Contention Window



Contention window

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.

Frame Exchange Time Line

1. Before sending a frame, the source station senses the medium by checking the energy level at the carrier frequency.

a. The channel uses a persistence strategy with back off until the channel is idle.

b. After the station is found to be idle, the station waits for a period of time called the ***DCF interframe space (DIFS);*** then the station sends a control frame called the *request to send (RTS)*.

Frame Exchange Time Line

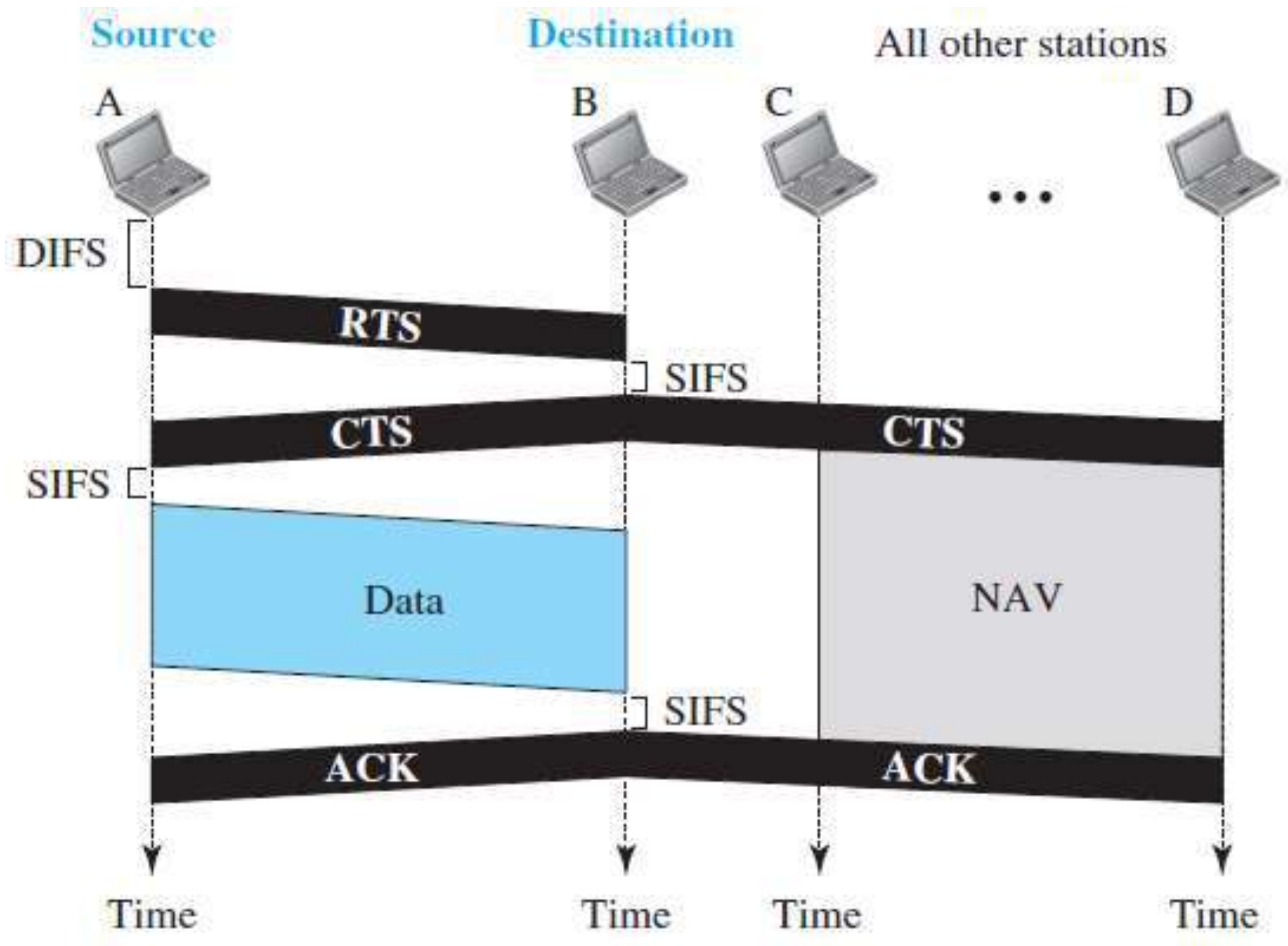
2. After receiving the RTS and waiting a period of time called the ***short inter frame space (SIFS),*** the destination station sends a control frame, called the *clear to send (CTS),* to the source station. This control frame indicates that the destination station is ready to receive data.

3. The source station sends data after waiting an amount of time equal to SIFS.

Frame Exchange Time Line

4. The destination station, after waiting an amount of time equal to SIFS, sends an acknowledgment to show that the frame has been received. Acknowledgment is needed in this protocol because the station does not have any means to check for the successful arrival of its data at the destination. On the other hand, the lack of collision in CSMA/CD is a kind of indication to the source that data have arrived.

Frame Exchange Time Line



CSMA/CA and NAV