Multiple Access

Figure 1.1 *Data link layer divided into two functionality-oriented sublayers*

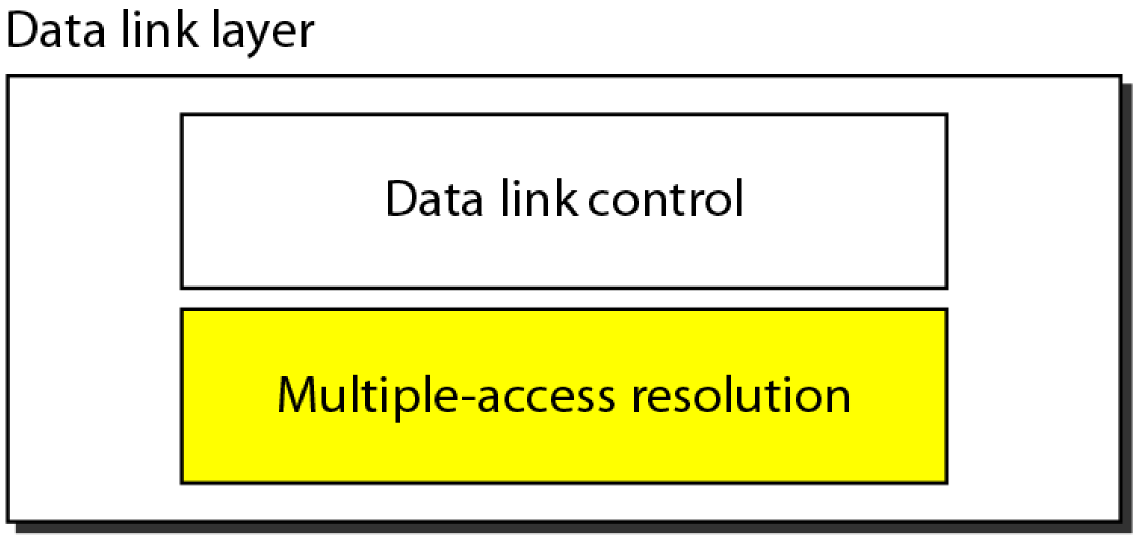
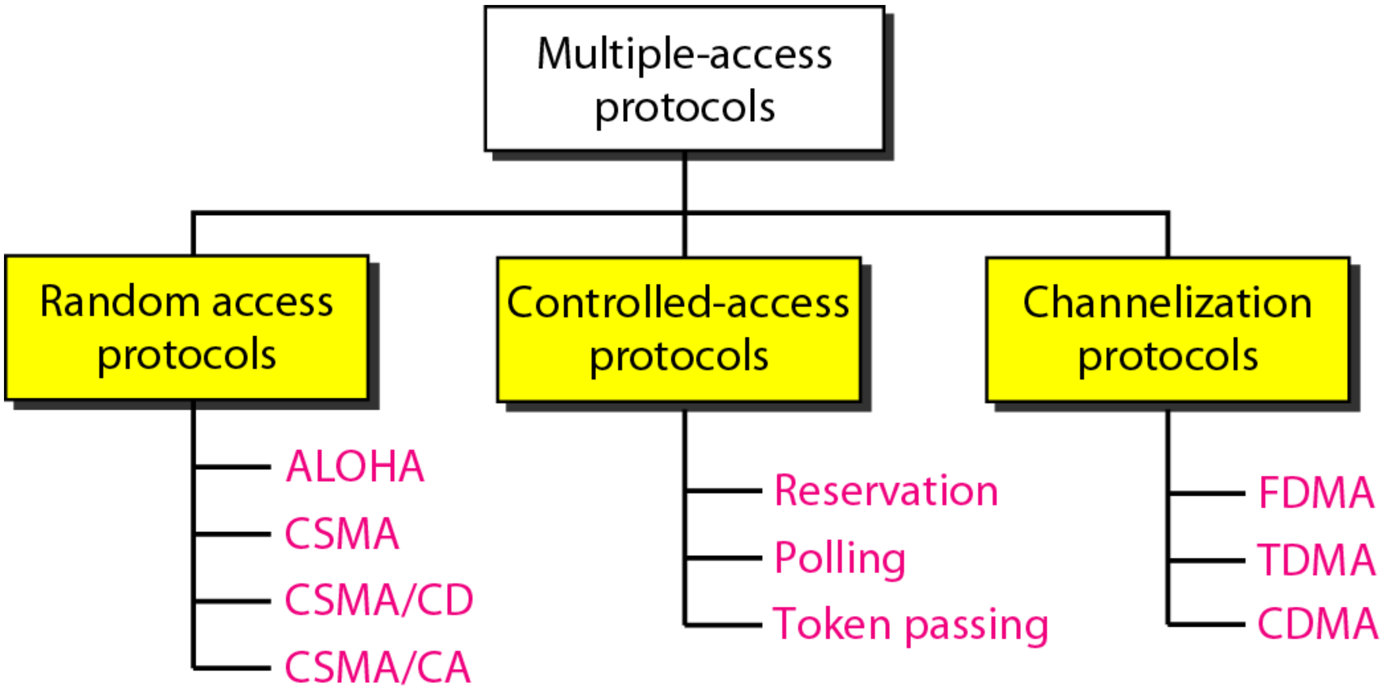


Figure 1.2 *Taxonomy of multiple-access protocols discussed in this chapter*



RANDOM ACCESS

In random access or contention 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. At each instance, a station that has data to send uses a procedure defined by the protocol to make a decision on whether or not to send.

Topics discussed in this section:

ALOHA
Carrier Sense Multiple Access
Carrier Sense Multiple Access with Collision Detection
Carrier Sense Multiple Access with Collision Avoidance

RANDOM ACCESS

- The random access methods have evolved from a very interesting protocol known as ALOHA, which used a very simple procedure called multiple access (MA).
- The method was improved with the addition of a procedure that forces the station to sense the medium before transmitting. This was called carrier sense multiple access.
- This method later evolved into two parallel methods: carrier sense multiple access with collision detection (CSMA/CD) and carrier sense multiple access with collision avoidance *(CSMA/CA)*. *CSMA/CD* tells the station what to do when a collision is detected. *CSMA/CA* tries to avoid the collision.

Figure 1.3 *Frames in a pure ALOHA network*

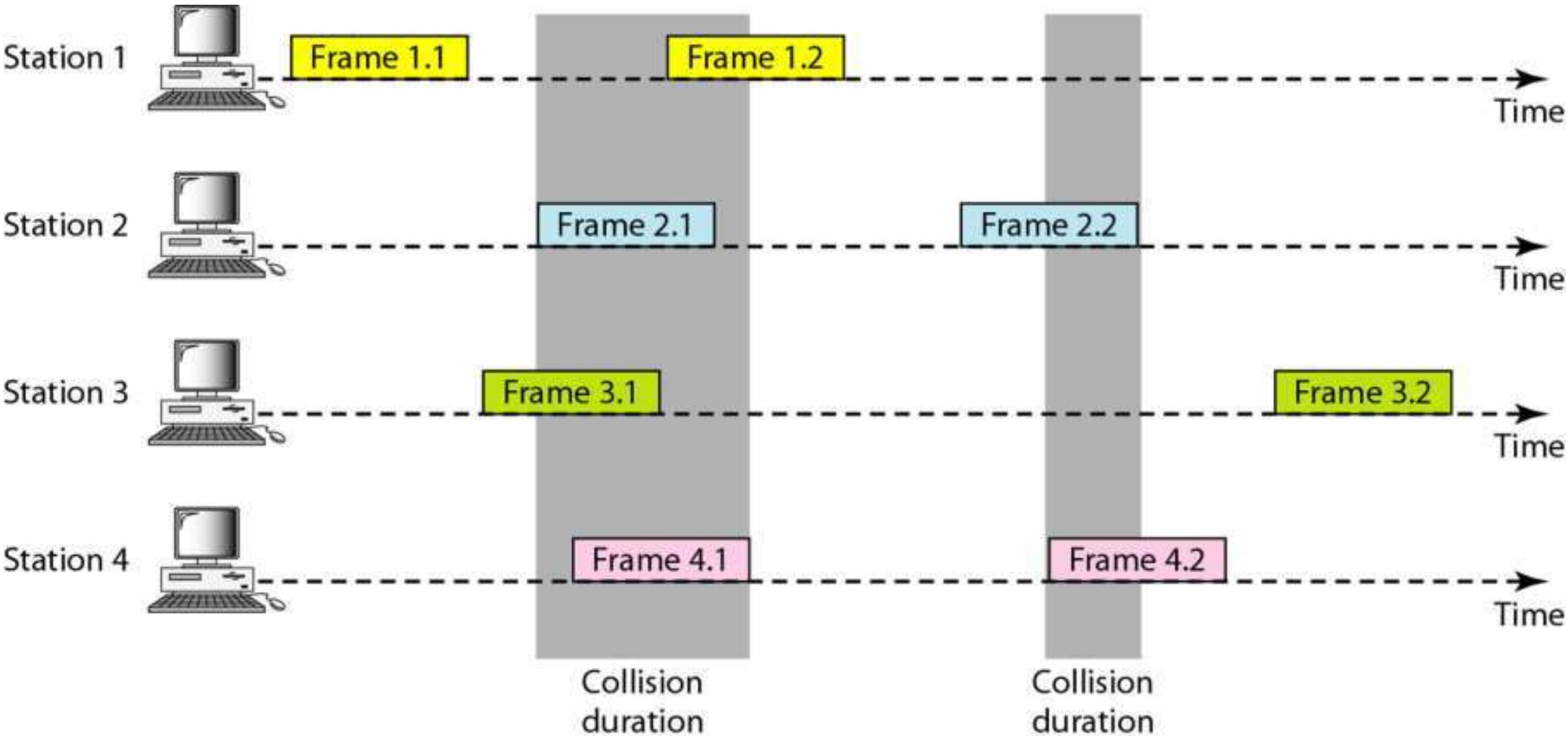
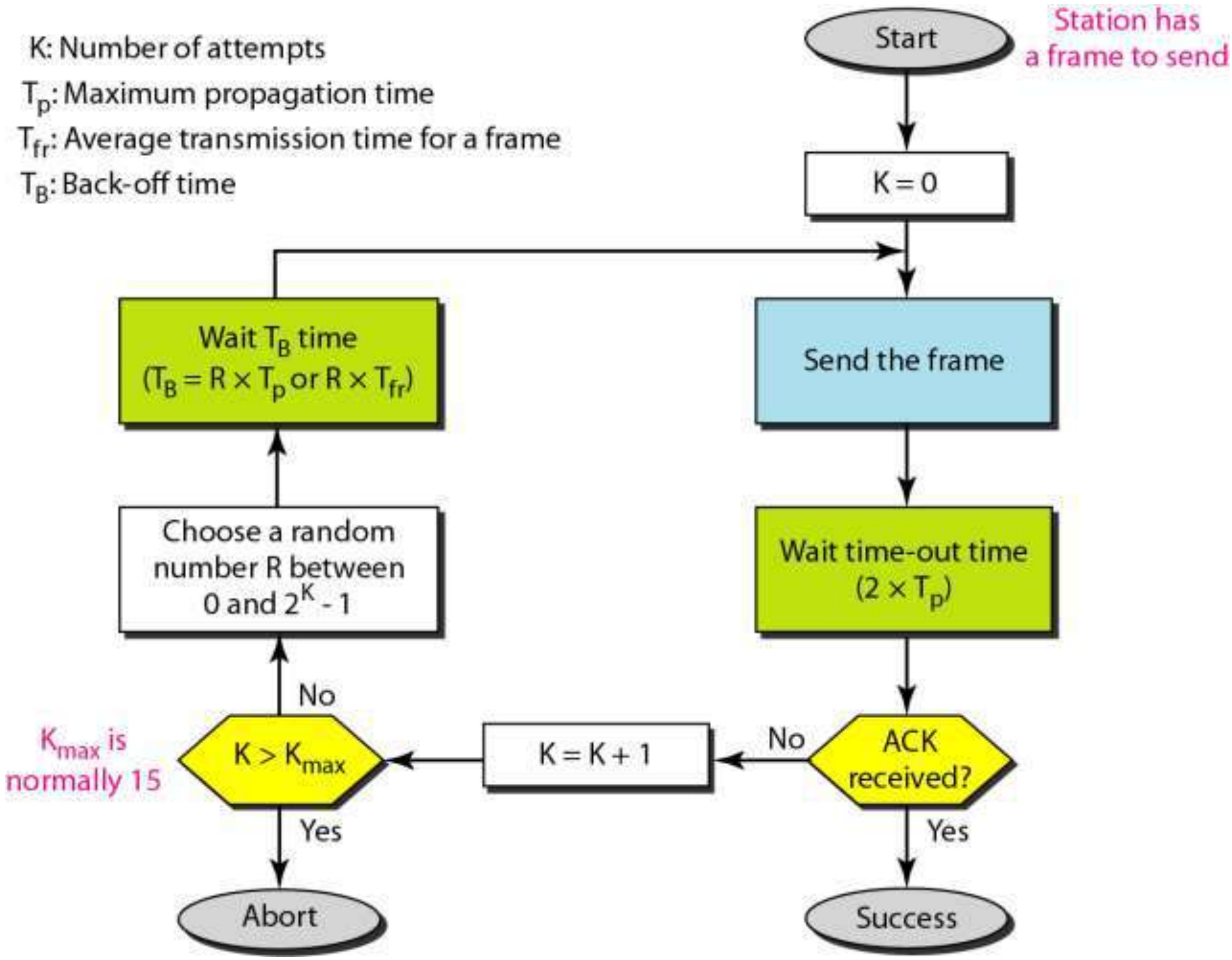


Figure 1.4 *Procedure for pure ALOHA protocol*



Example 1.1

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, we find

$$T_p = (6 \times 10^5) / (3 \times 10^8) = 2 \text{ ms}.$$

Now we can find the value of T_B for different values of K.

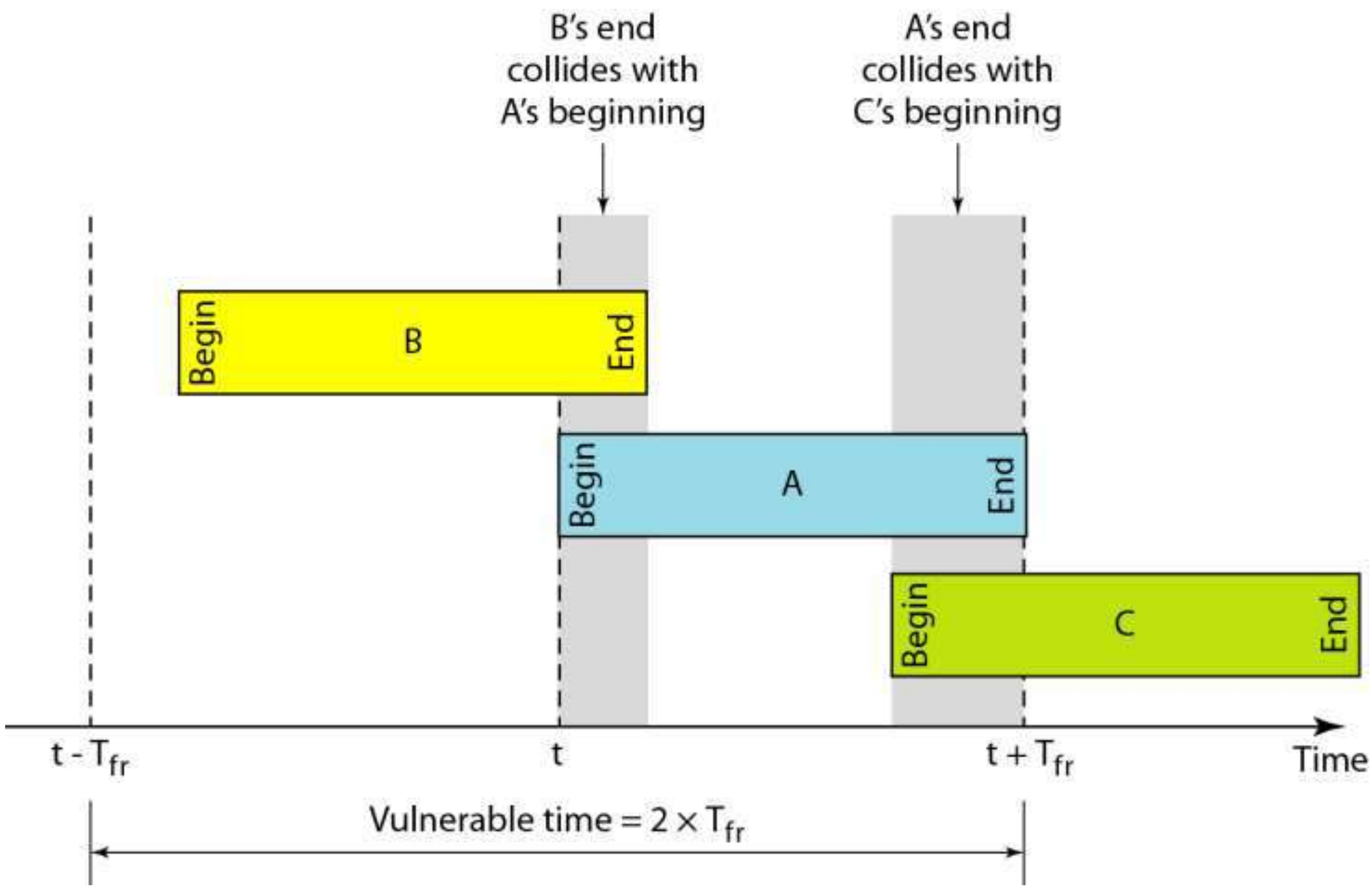
a. ***For $K = 1$, the range is $\{0, 1\}$. The station needs to generate a random number with a value of 0 or 1. This means that T_B is either 0 ms (0×2) or 2 ms (1×2), based on the outcome of the random variable.***

Example 1.1 (continued)

***b.** For K = 2, the range 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.*

***c.** For K = 3, the range is {0, 1, 2, 3, 4, 5, 6, 7}. This means that T_B can be 0, 2, 4, . . . , 14 ms, based on the outcome of the random variable.*

Figure 1. 5 *Vulnerable time for pure ALOHA protocol*



Note

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

Example 1.3

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.

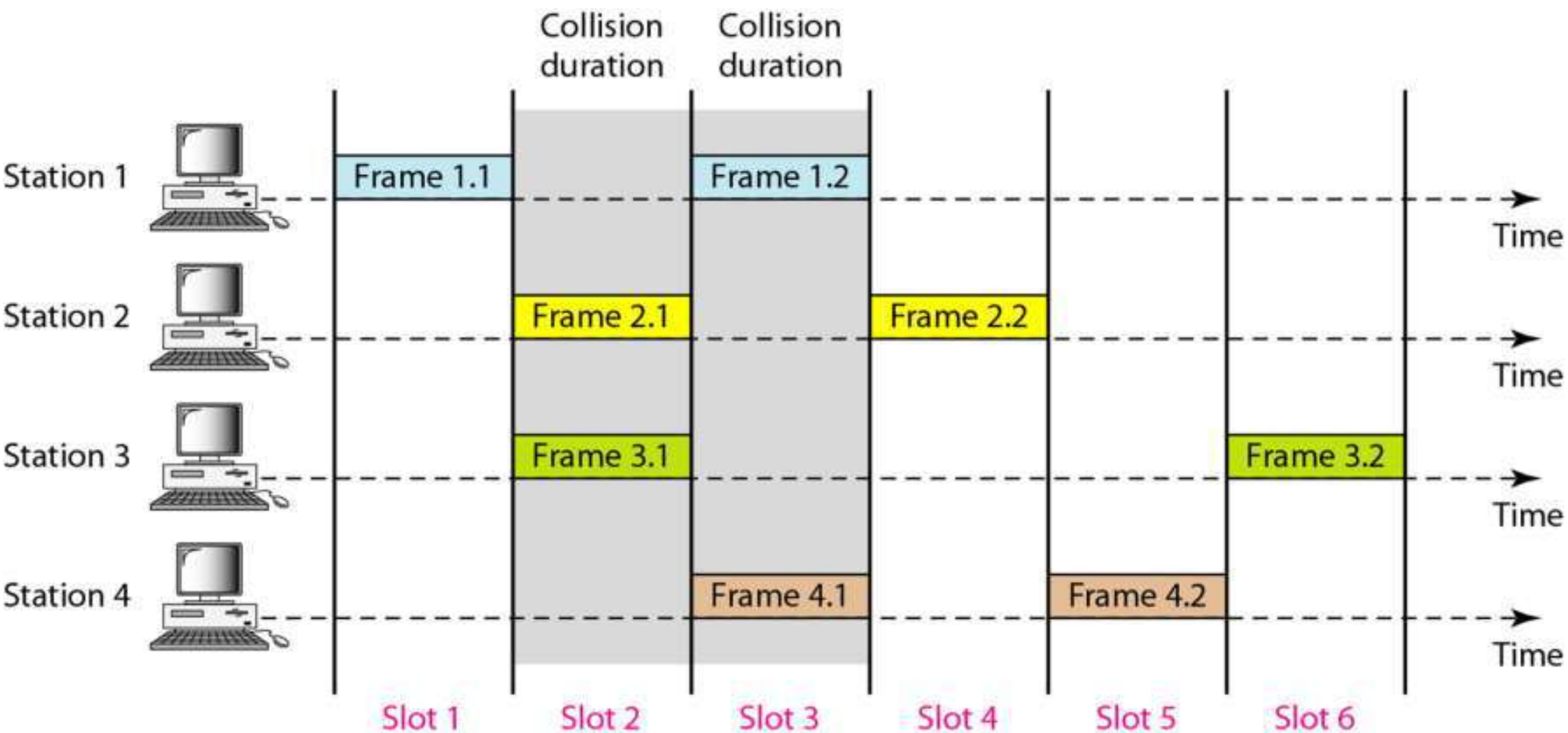
a. If the system creates 1000 frames per second, this is 1 frame per millisecond. The load is 1. In this case $S = G \times e^{-2G}$ ***or*** $S = 0.135$ ***(13.5 percent). This means that the throughput is*** $1000 \times 0.135 = 135$ ***frames. Only 135 frames out of 1000 will probably survive.***

Example 1.3 (continued)

b. *If the system creates 500 frames per second, this is (1/2) frame per millisecond. The load is (1/2). In this case $S = G \times e^{-2G}$ or $S = 0.184$ (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, this is (1/4) frame per millisecond. The load is (1/4). In this case $S = G \times e^{-2G}$ or $S = 0.152$ (15.2 percent). This means that the throughput is $250 \times 0.152 = 38$. Only 38 frames out of 250 will probably survive.*

Figure 12.6 *Frames in a slotted ALOHA network*

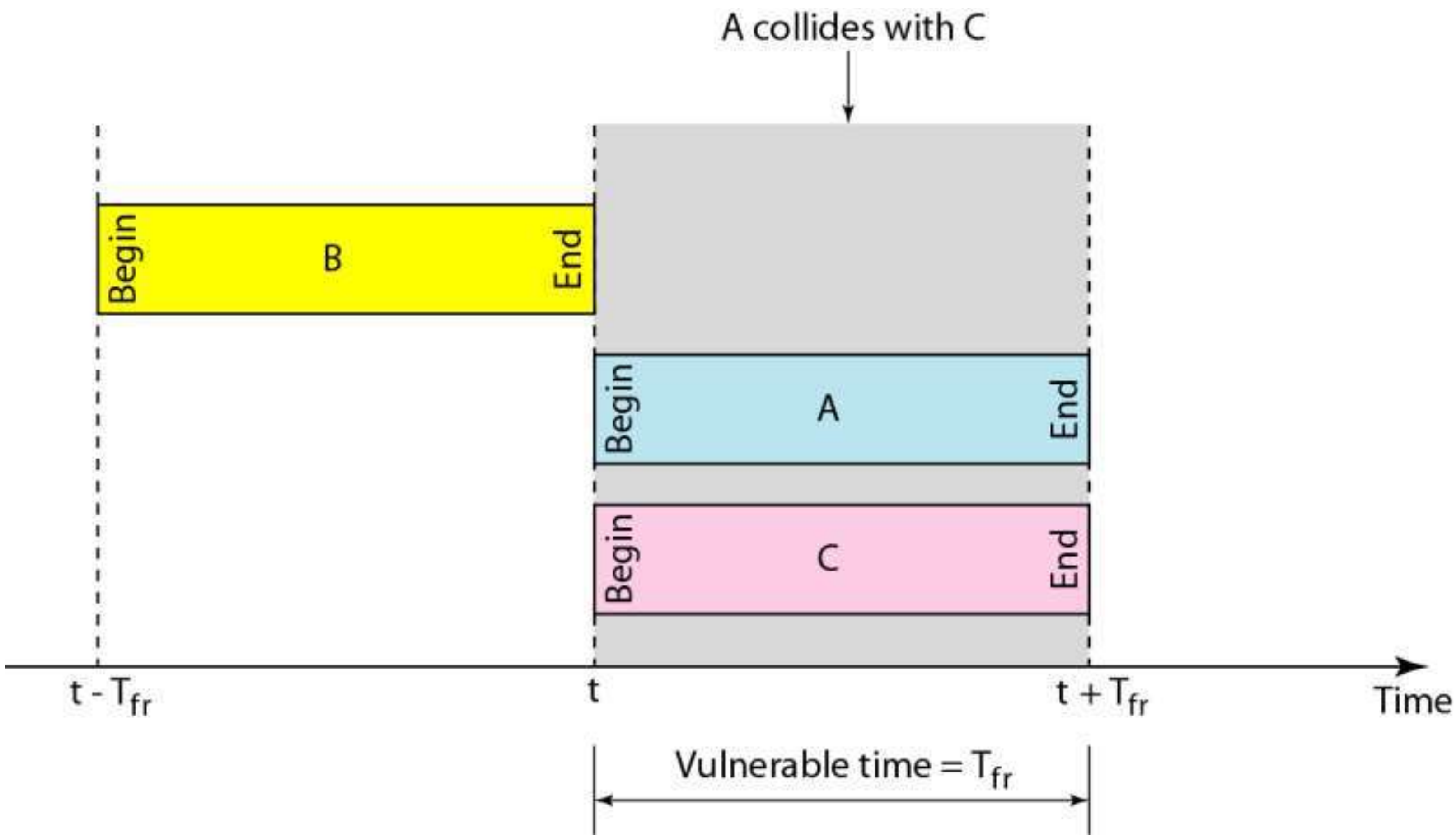


Note

The throughput for slotted ALOHA is $S = G \times e^{-G}$.

The maximum throughput $S_{max} = 0.368$ when G = 1.

Figure 1.7 *Vulnerable time for slotted ALOHA protocol*



Example 1.4

A slotted 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, this is 1 frame per millisecond. The load is 1. In this case $S = G \times e^{-G}$ ***or*** $S = 0.368$ ***(36.8 percent). This means that the throughput is*** $1000 \times 0.0368 = 368$ ***frames. Only 386 frames out of 1000 will probably survive.***

Example 1.4 (continued)

***b.** If the system creates 500 frames per second, this is (1/2) frame per millisecond. The load is (1/2). In this case $S = G \times e^{-G}$ or $S = 0.303$ (30.3 percent). This means that the throughput is $500 \times 0.0303 = 151$. Only 151 frames out of 500 will probably survive.*

***c.** If the system creates 250 frames per second, this is (1/4) frame per millisecond. The load is (1/4). In this case $S = G \times e^{-G}$ or $S = 0.195$ (19.5 percent). This means that the throughput is $250 \times 0.195 = 49$. Only 49 frames out of 250 will probably survive.*

Figure 1.8 *Space/time model of the collision in CSMA*

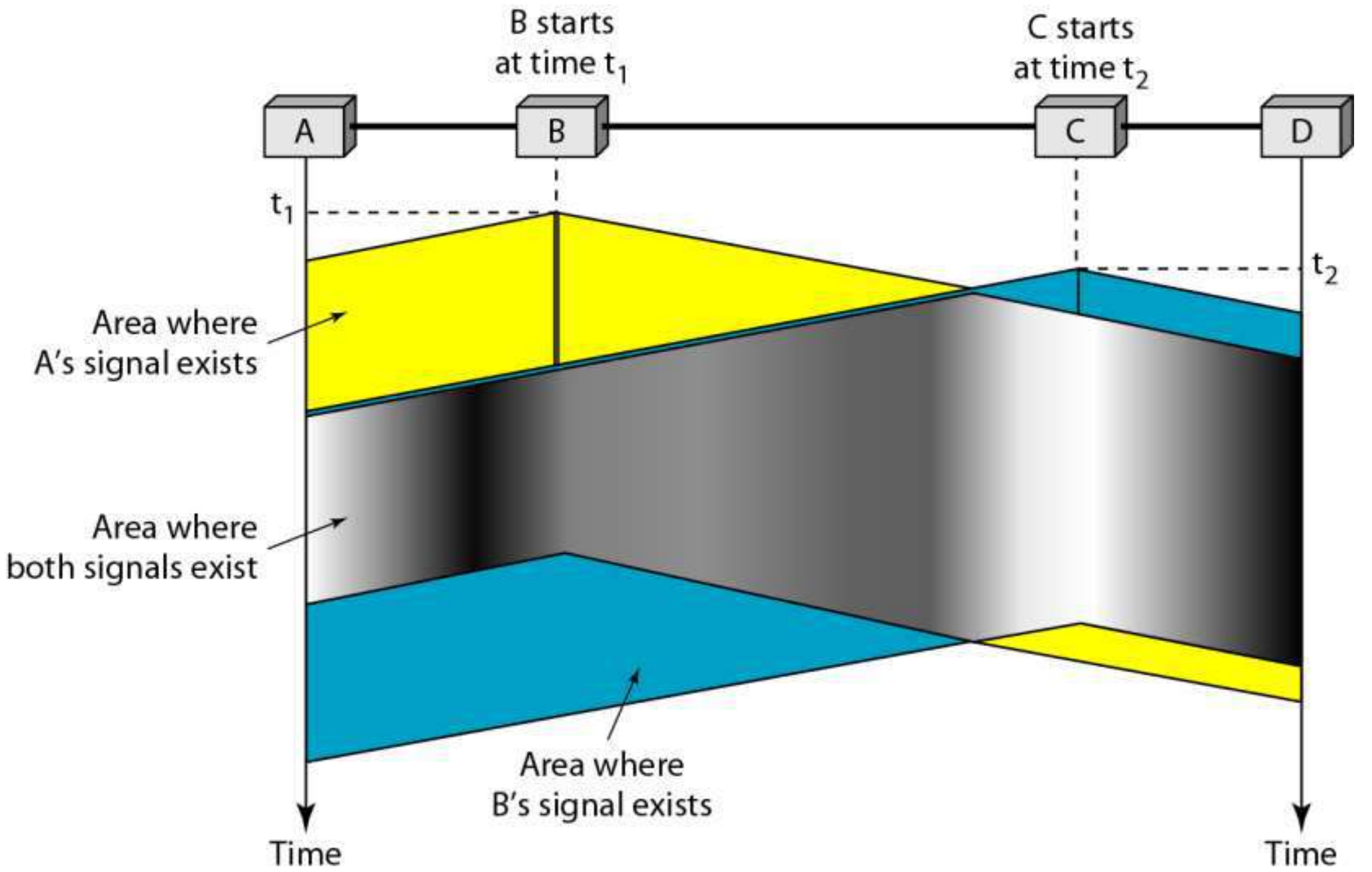


Figure 1.9 *Vulnerable time in CSMA*

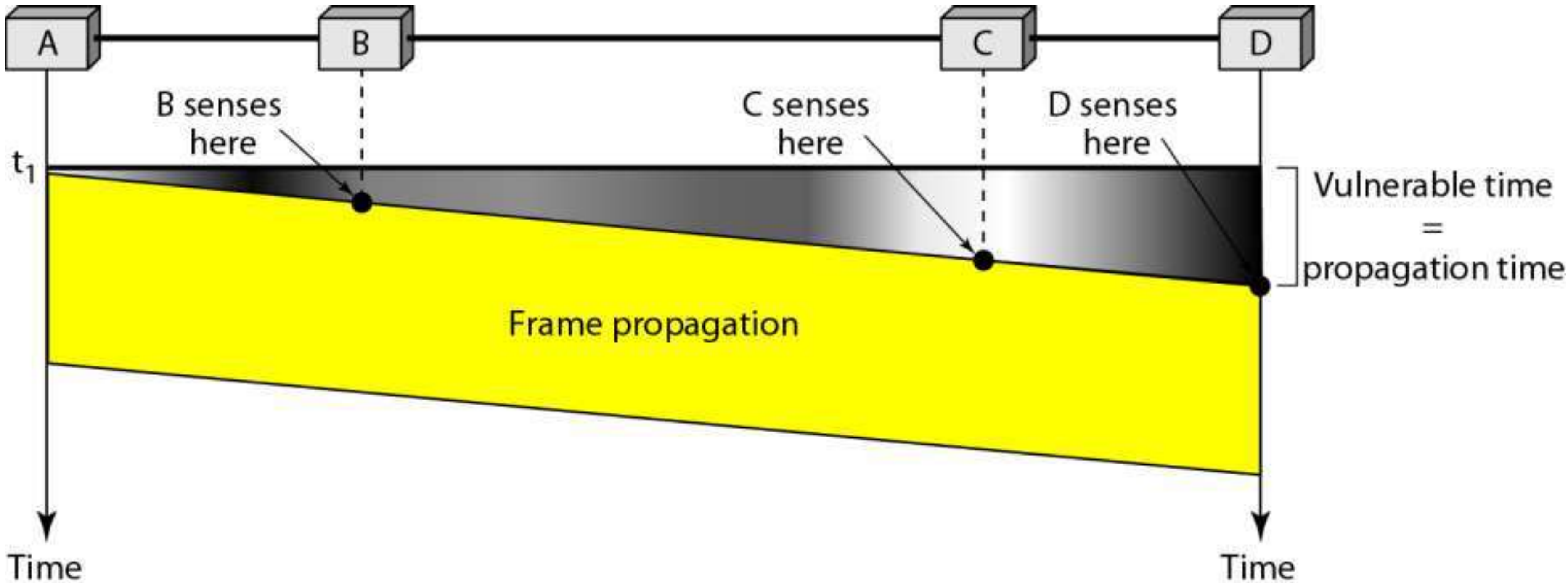
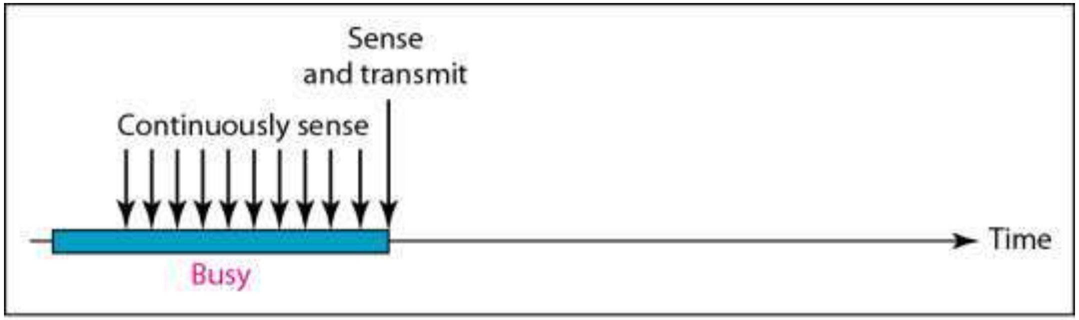
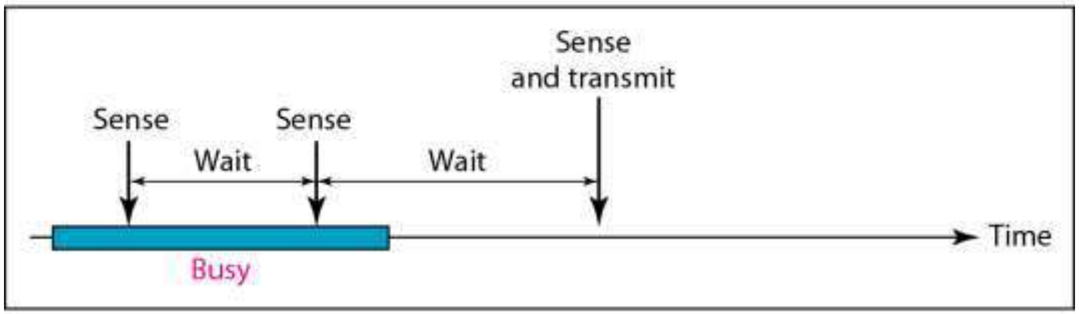


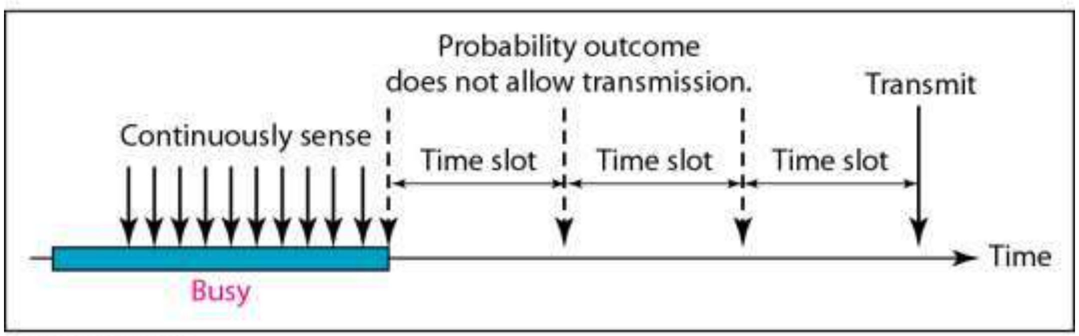
Figure 1.10 *Behavior of three persistence methods*



a. 1-persistent



b. Nonpersistent



c. p-persistent

Figure 1.11 *Flow diagram for three persistence methods*

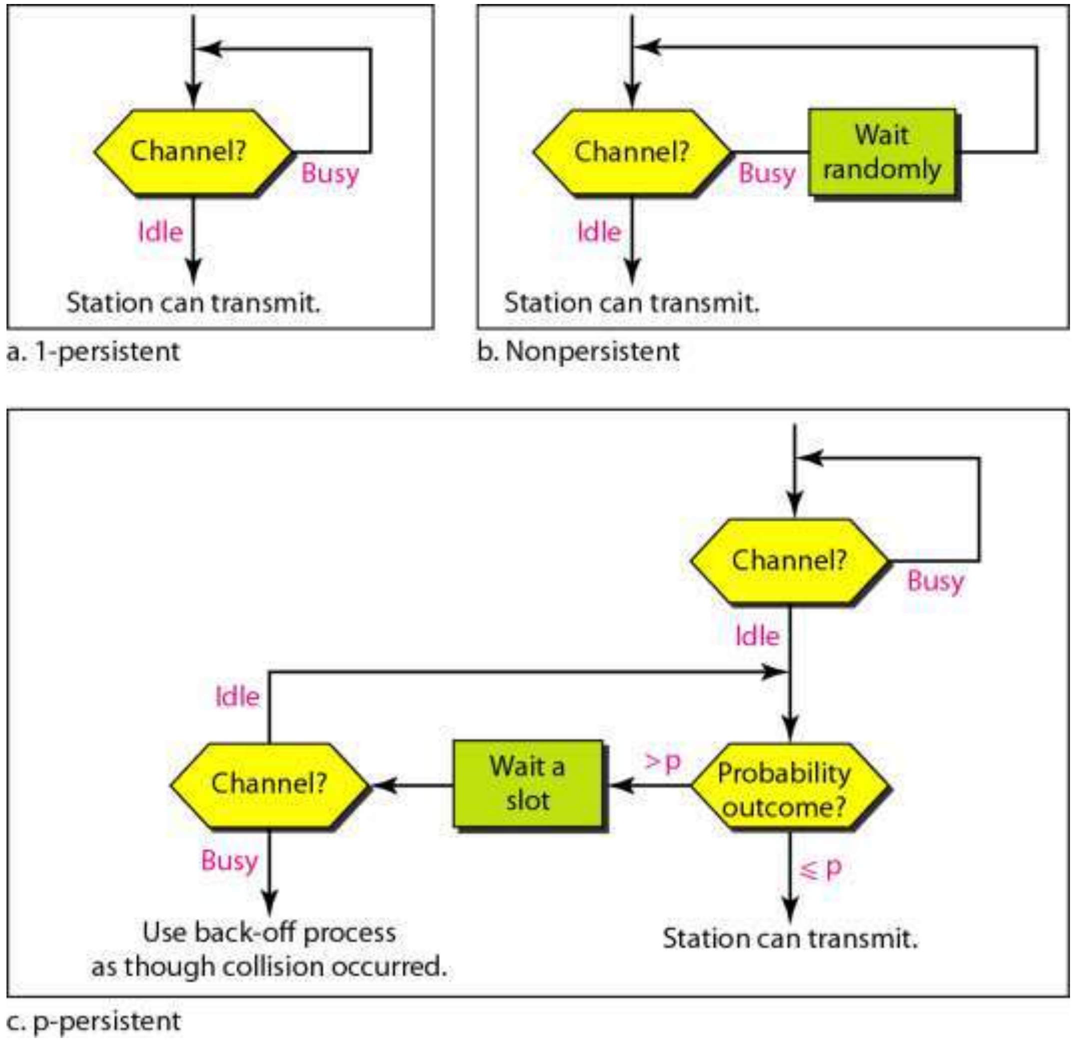


Figure 1.12 *Collision of the first bit in CSMA/CD*

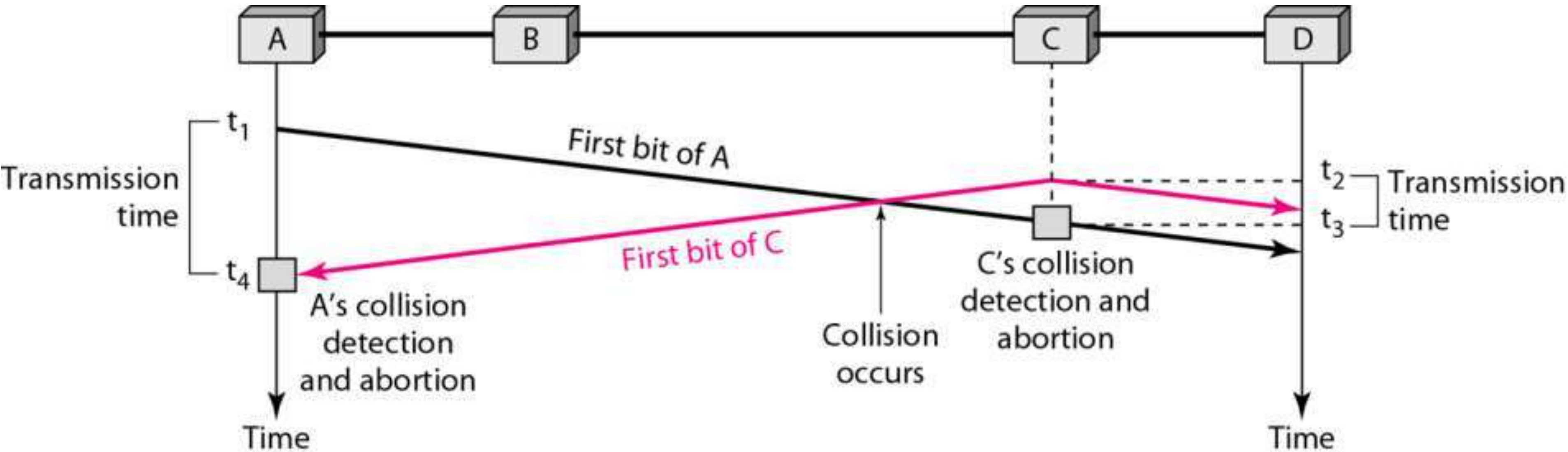
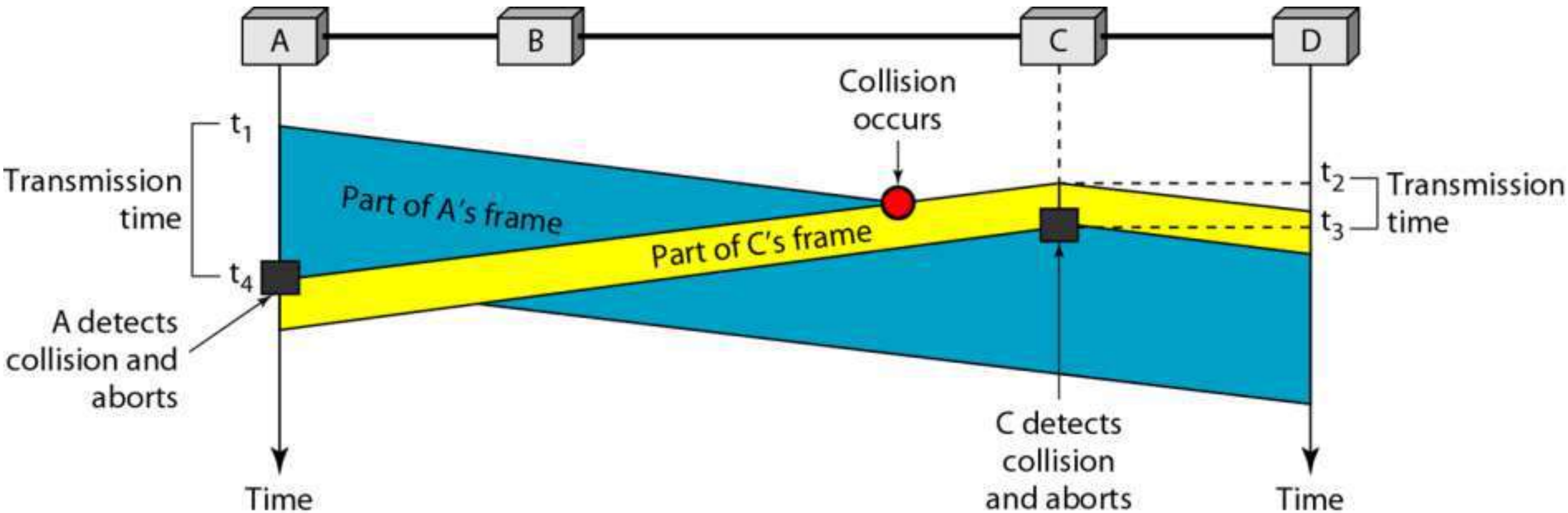


Figure 1.13 *Collision and abortion in CSMA/CD*



Example 1.5

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?

Solution

The frame transmission time is $T_{fr} = 2 \times T_p = 51.2\ \mu s$. This means, in the worst case, a station needs to transmit for a period of 51.2 μs to detect the collision. The minimum size of the frame is 10 Mbps × 51.2 μs = 512 bits or 64 bytes. This is actually the minimum size of the frame for Standard Ethernet.

Figure 1.14 *Flow diagram for the CSMA/CD*

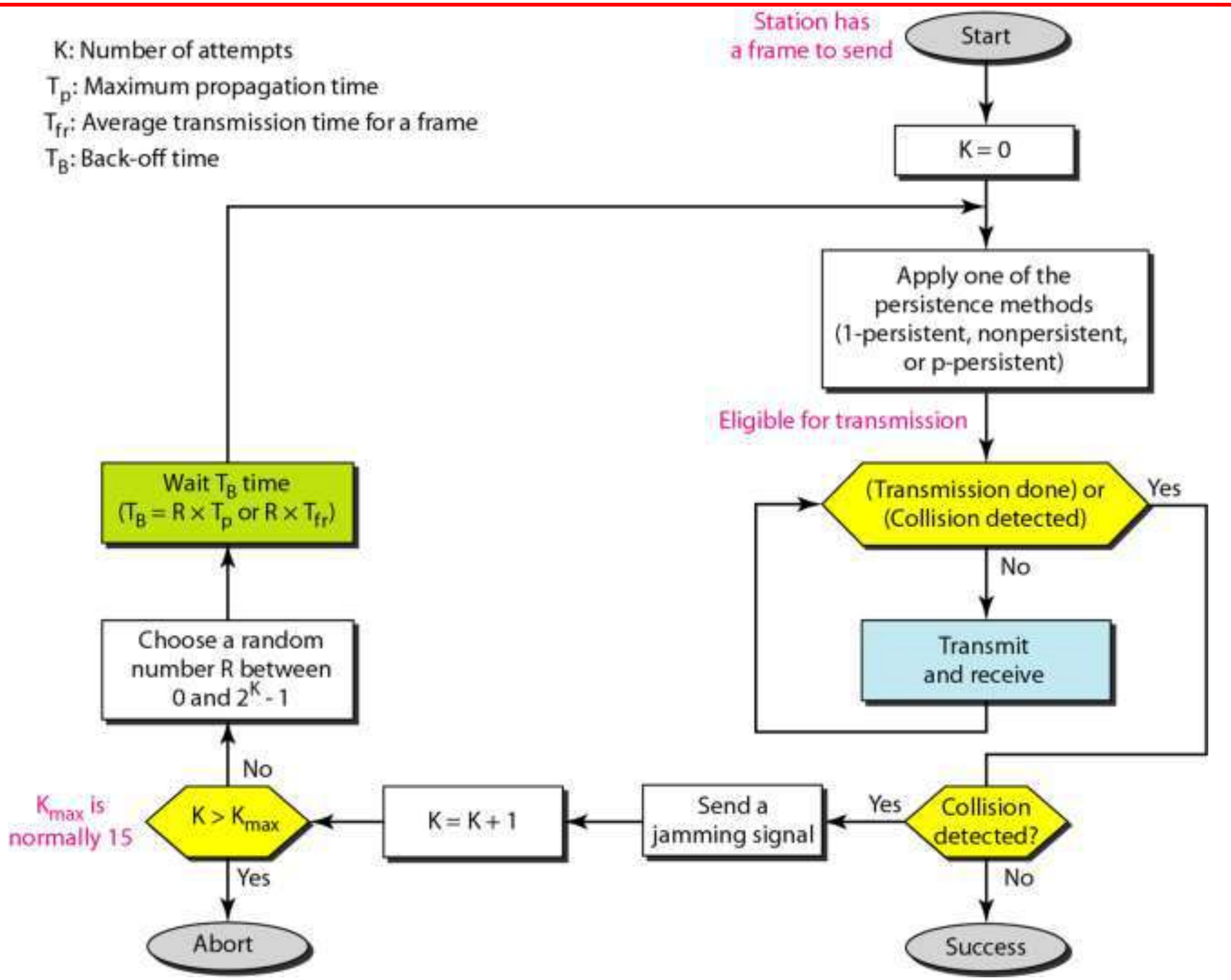


Figure 1.15 *Energy level during transmission, idleness, or collision*