Chapter 12 Multiple Access

Figure 12.1 Data link layer divided into two functionality-oriented sublayers

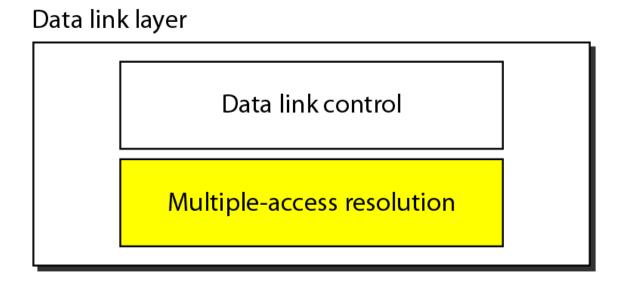
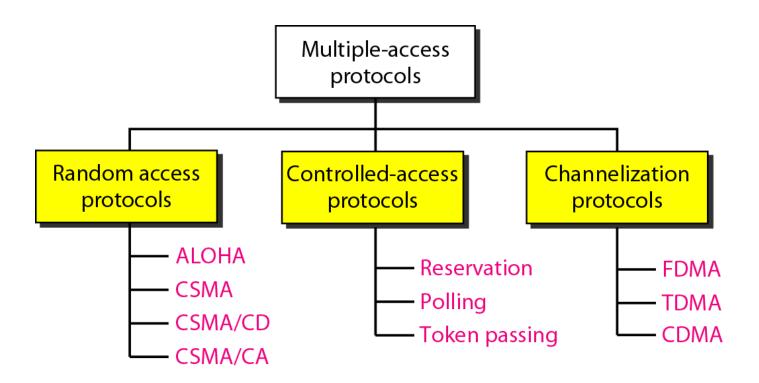


Figure 12.2 Taxonomy of multiple-access protocols discussed in this chapter



12-1 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 with Collision Detection
Carrier Sense Multiple Access with Collision Avoidance

Figure 12.3 Frames in a pure ALOHA network

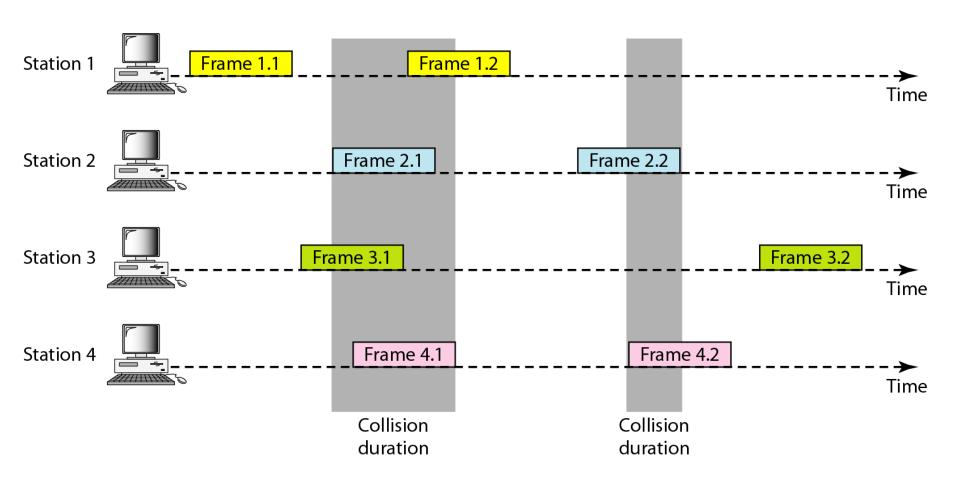
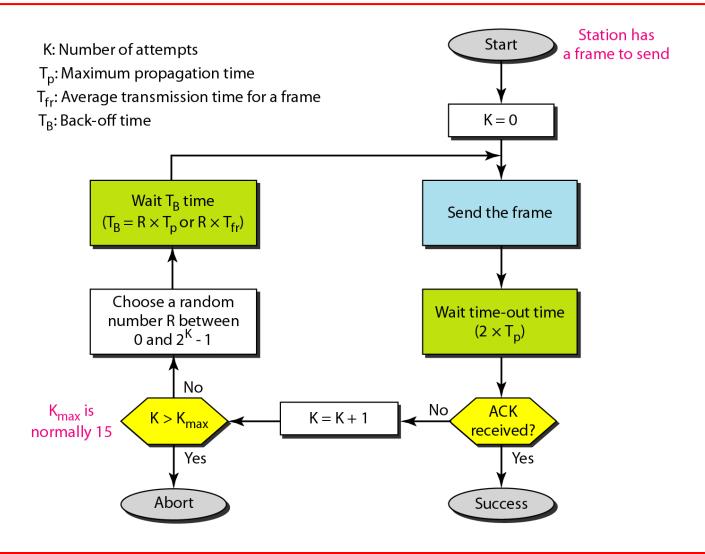


Figure 12.4 Procedure for pure ALOHA protocol



Example 12.1

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

$$T_p = (600 \times 10^3) / (3 \times 10^8) = 2 \text{ ms.}$$

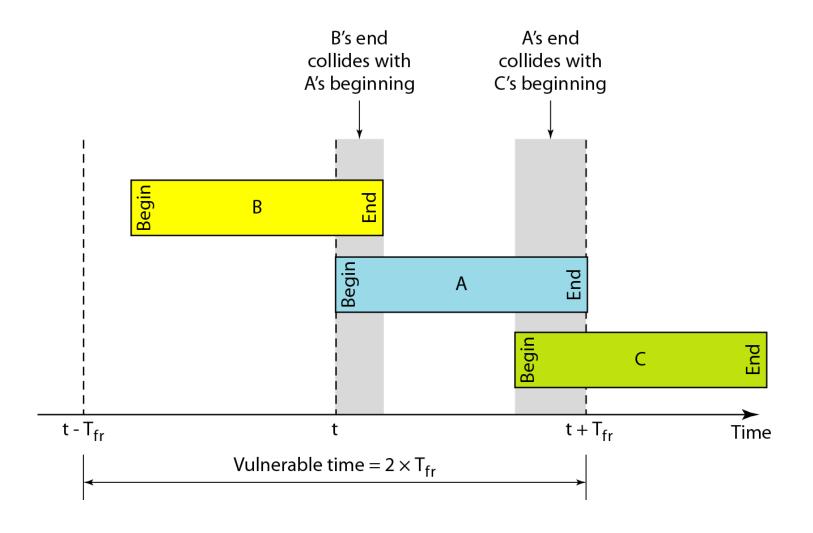
Now we can find the value of T_B for different values of K.

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 12.1 (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 $0, 2, 4, \ldots, 14$ ms, based on the outcome of the random variable.
- d. We need to mention that if K > 10, it is normally set to 10.

Figure 12.5 Vulnerable time for pure ALOHA protocol



Vulnerable:- Length of time in which there is possibility of collision

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 one 1-ms period that this station is sending.

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Note

The throughput for pure ALOHA is

 $S = G \times e^{-2G}$

The maximum throughput

 $S_{\text{max}} = 0.184 \text{ when } G = (1/2).$

Where G = the average number of frames generated during one frame transmission time.

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

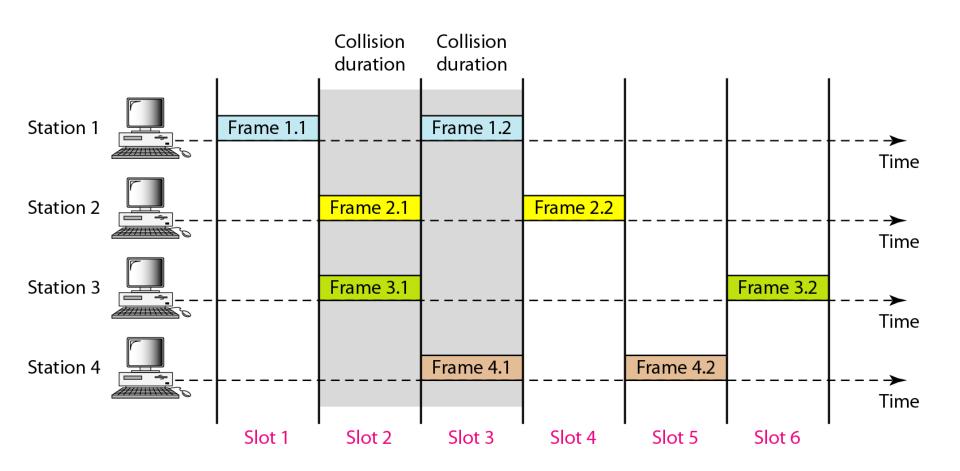
The frame transmission time is 200/200 kbps or 1 ms.

a. If the system creates 1000 frames per second, this is 1 frame per millisecond. The load is 1. In this case $S = G \times e^{-2 G}$ 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 12.3 (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



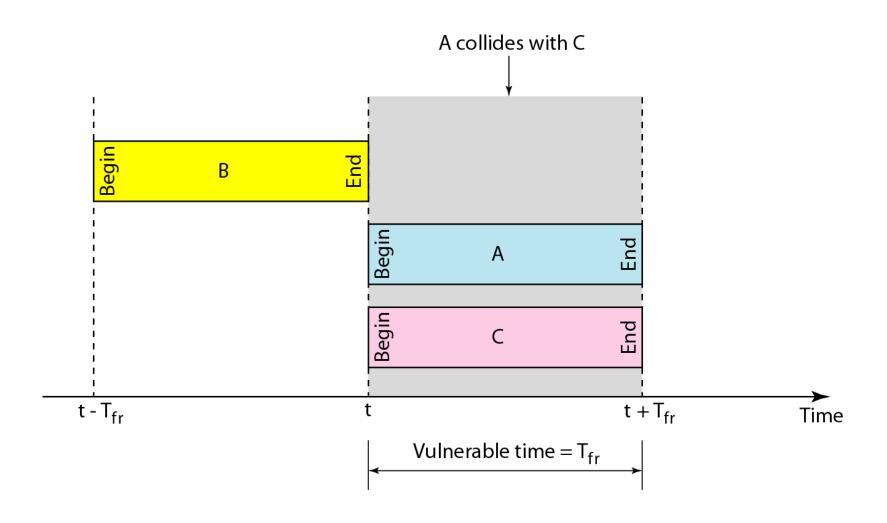
The time divided into slots of T_{fr} secs and force the station to send only at the beginning of the time slot.

Note

The throughput for slotted ALOHA is $S = G \times e^{-G}$. The maximum throughput $S_{max} = 0.368$ when G = 1.

Where G = the average number of frames generated during one frame transmission time.

Figure 12.7 Vulnerable time for slotted ALOHA protocol



Example 12.4

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 12.4 (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.

Carrier Sense Multiple Access (CSMA)

- The CSMA method was developed, to minimize the chance of collision and, increase the performance.
- > CSMA can reduce the possibility of collision, but it cannot eliminate it.
- The possibility of collision still exists because of propagation delay,
- > It still takes time (although very short) for the first bit to reach every station

Figure 12.8 Space/time model of the collision in CSMA

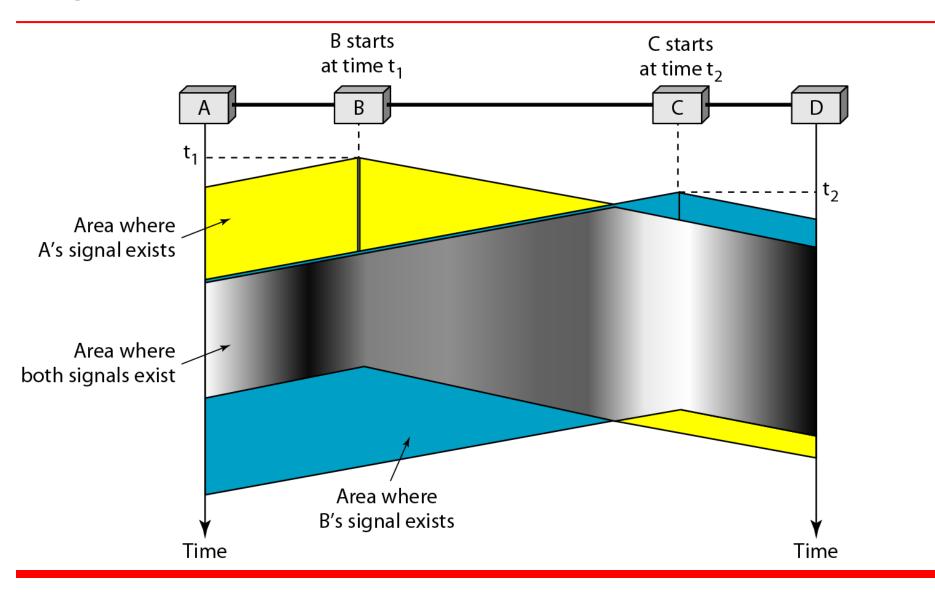
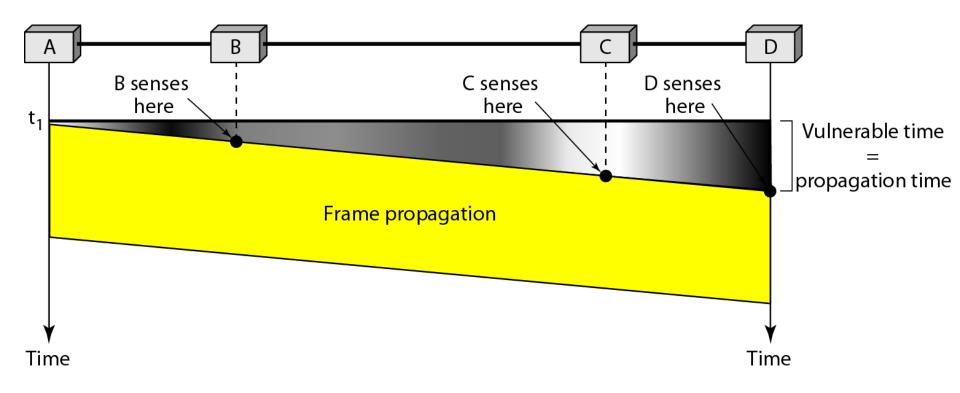


Figure 12.9 Vulnerable time in CSMA



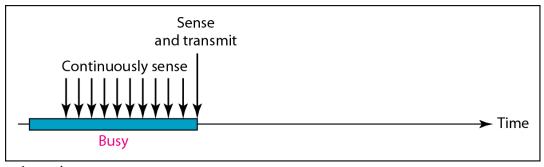
Persistence Methods

- ➤ What should a station do if the channel is busy?
- > What should a station do if the channel is idle?

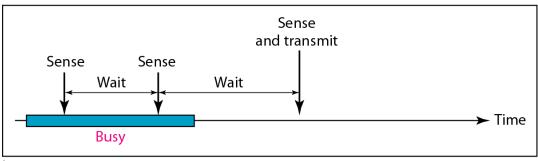
Three methods have been devised to answer these questions:

- the I-persistent method
- the nonpersistent method
- the p-persistent method.

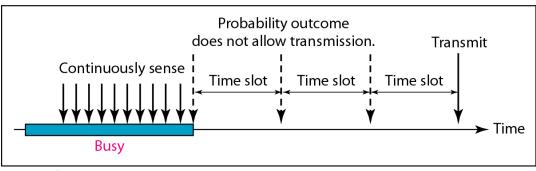
Figure 12.10 Behavior of three persistence methods



a. 1-persistent

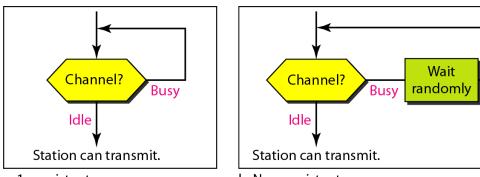


b. Nonpersistent



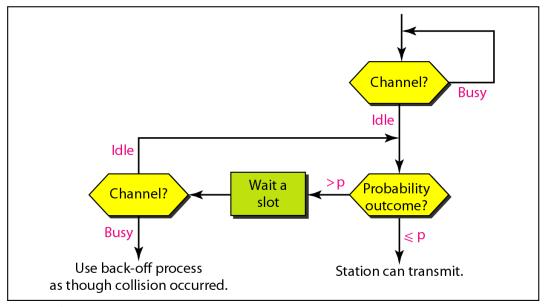
c. p-persistent

Figure 12.11 Flow diagram for three persistence methods



a. 1-persistent

b. Nonpersistent



c. p-persistent

Figure 12.12 Collision of the first bit in CSMA/CD

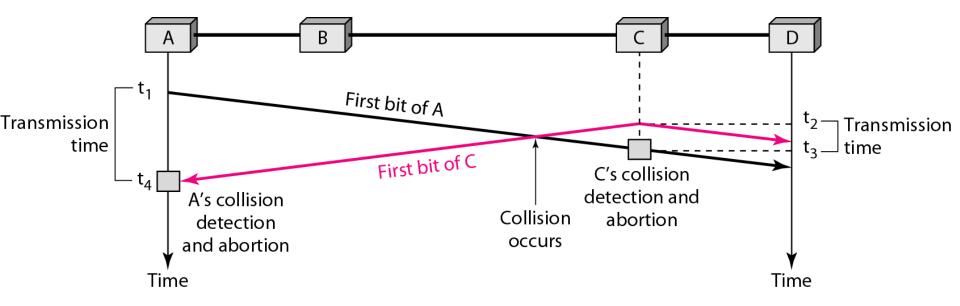
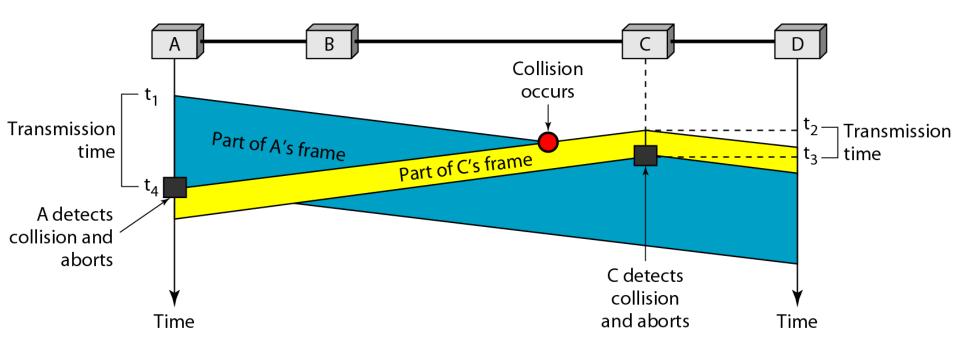


Figure 12.13 Collision and abortion in CSMA/CD



Example 12.5

A network using CSMA/CD has a bandwidth of 10 Mbps. If the maximum propagation time (including the delays in the devices and ignoring the time needed to send a jamming signal, as we see later) 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 \times 51.2 $\mu s = 512$ bits or 64 bytes. This is actually the minimum size of the frame for Standard Ethernet.

Figure 12.14 Flow diagram for the CSMA/CD

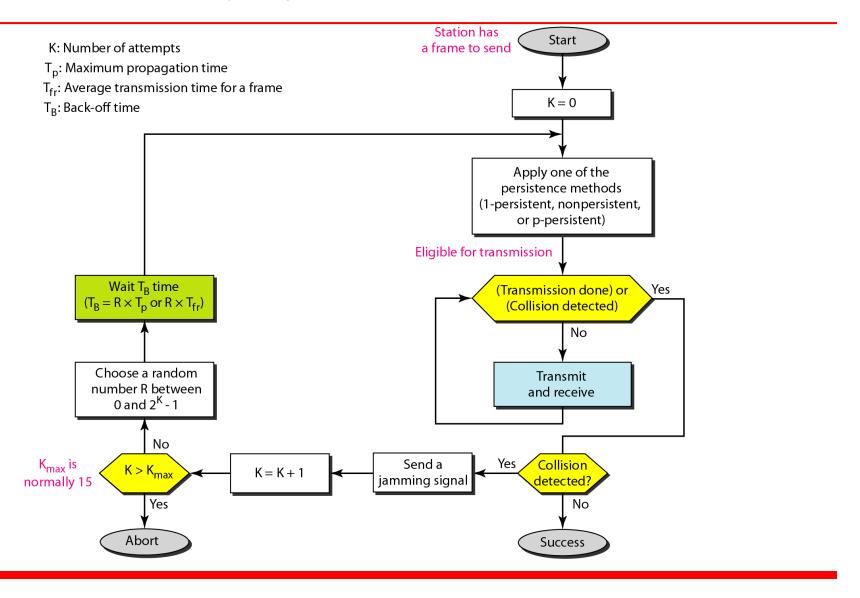


Figure 12.15 Energy level during transmission, idleness, or collision

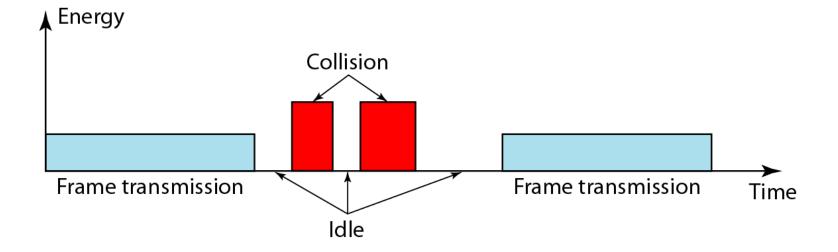
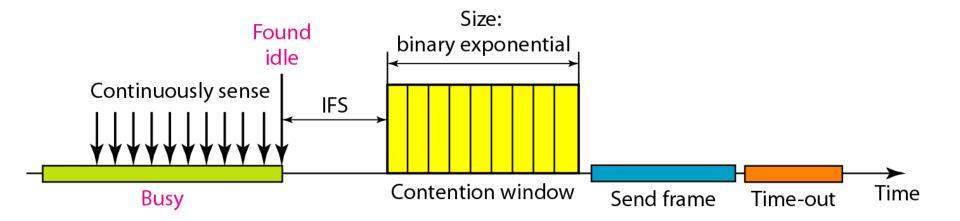


Figure 12.16 Timing in CSMA/CA



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Note

In CSMA/CA, the IFS can also be used to define the priority of a station or a frame.

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Note

In CSMA/CA, if the station finds the channel busy, it does not restart the timer of the contention window; it stops the timer and restarts it when the channel becomes idle.

Figure 12.17 Flow diagram for CSMA/CA

