

Data Communications and Networking Fourth Edition

Forouzan

Chapter 12 Multiple Access

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

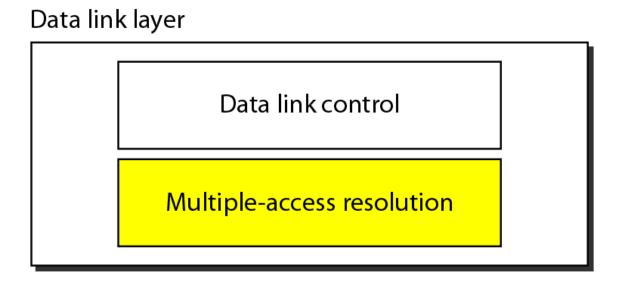
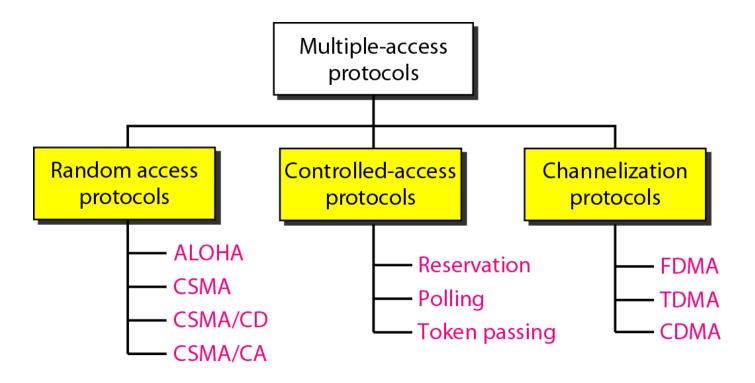


Figure 12.2 Taxonomy of multiple-access protocols discussed in this chapter



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

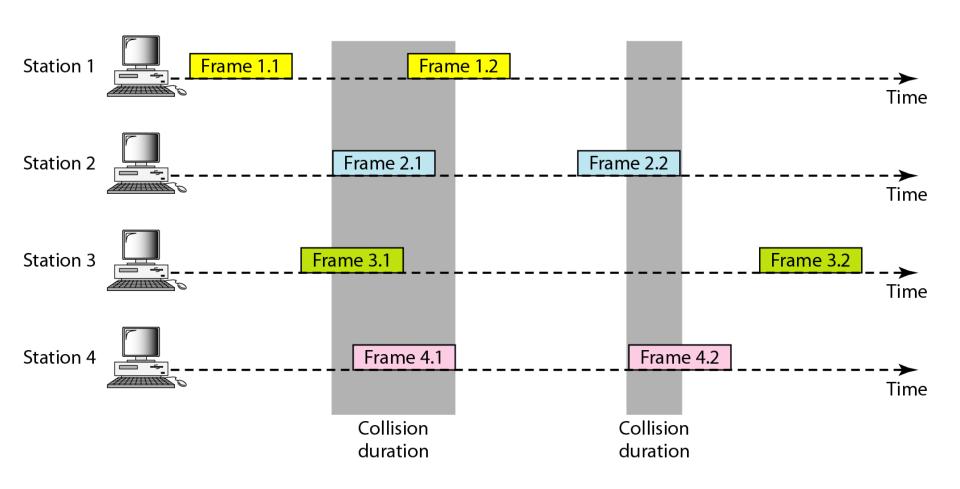


Figure 12.4 Procedure for pure ALOHA protocol

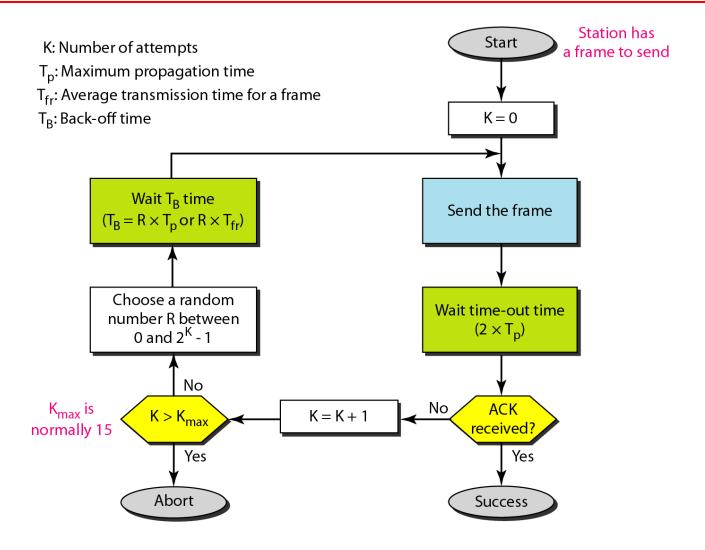


Figure 12.6 Frames in a slotted ALOHA network

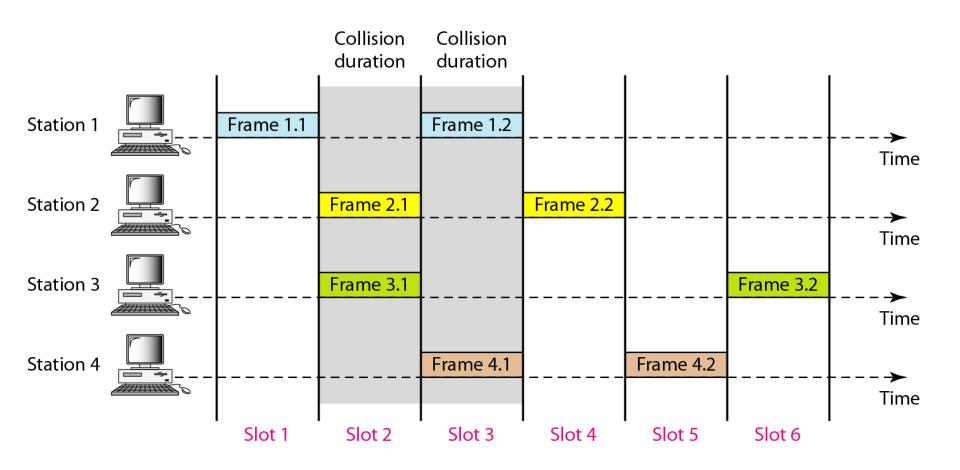


Figure 12.7 Vulnerable time for slotted ALOHA protocol

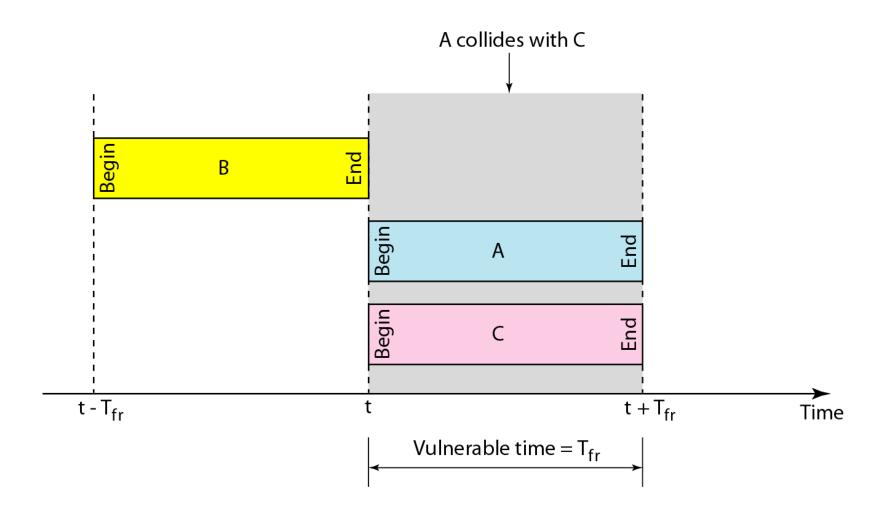


Figure 12.9 Vulnerable time in CSMA

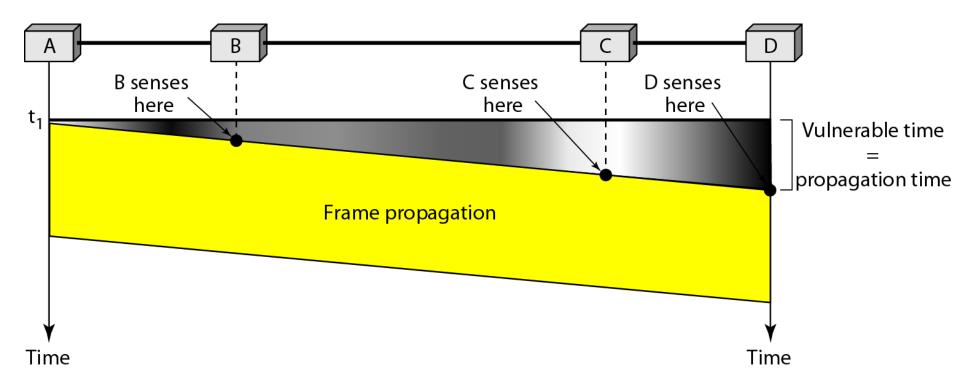
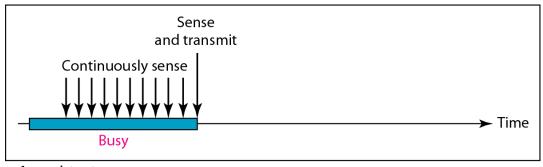
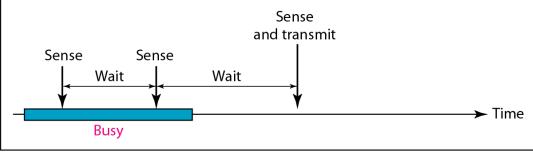


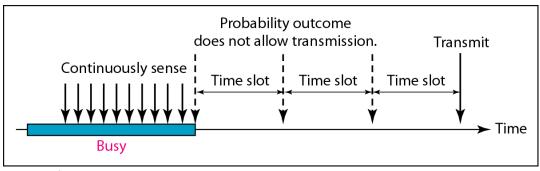
Figure 12.10 Behavior of three persistence methods



a. 1-persistent

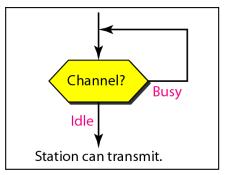


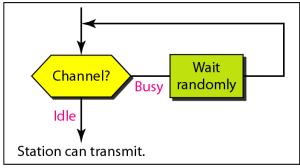
b. Nonpersistent



c. p-persistent

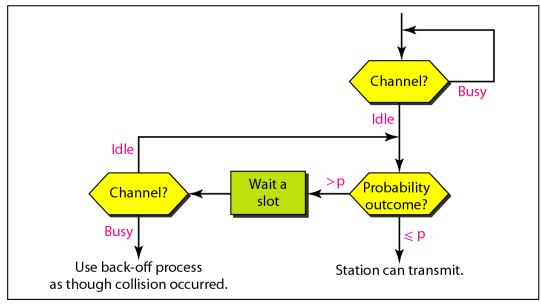
Figure 12.11 Flow diagram for three persistence methods





a. 1-persistent

b. Nonpersistent



c. p-persistent

Figure 12.12 Collision of the first bit in CSMA/CD

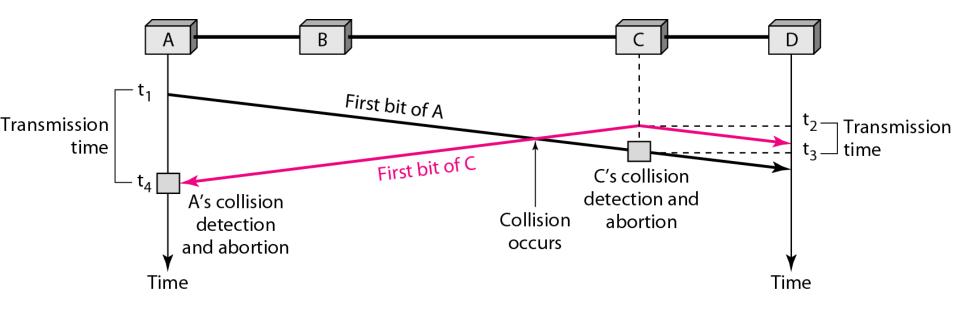
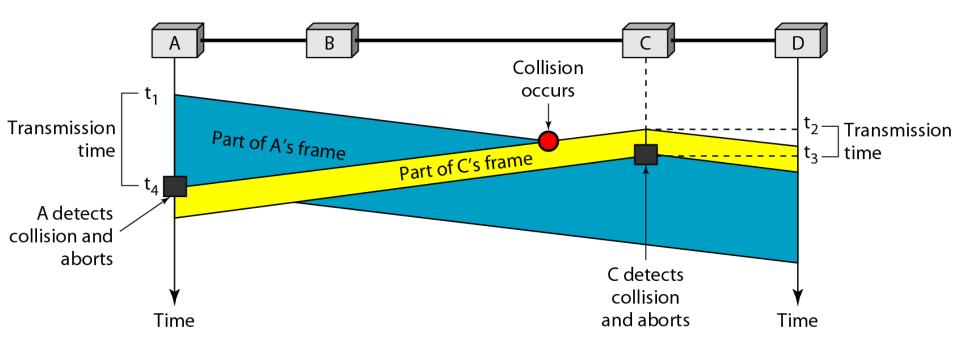


Figure 12.13 Collision and abortion in CSMA/CD



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 μs = 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

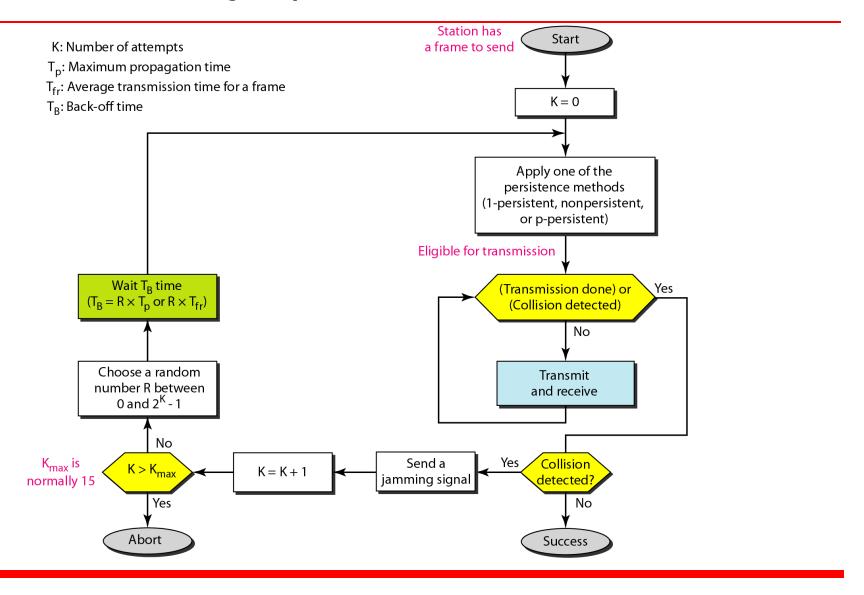
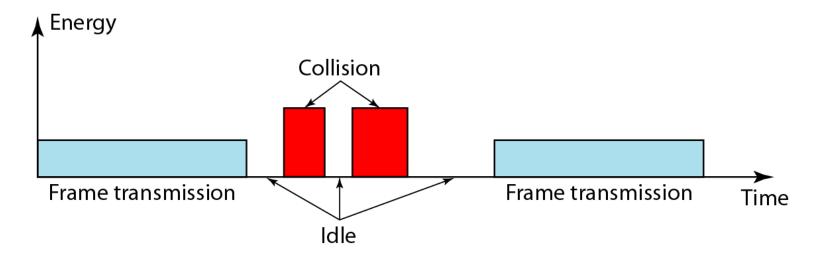


Figure 12.15 Energy level during transmission, idleness, or collision



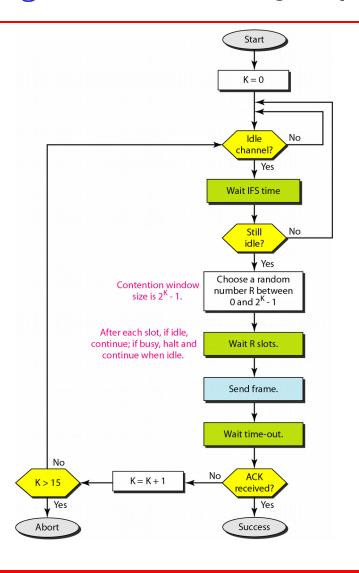
On a wired network, energy level is almost double during a collision.

This is how a receiver tells if there is a collision.

But on a wireless network, energy level is not that high (barely 5-10%

higher). So with wireless, we need to avoid collisions.

Figure 12.17 Flow diagram for CSMA/CA



Channel idle? Don't transmit yet!

Wait IFS time.

Still idle after IFS? Don't transmit yet!

Now in Contention Window.

Choose random number and wait that

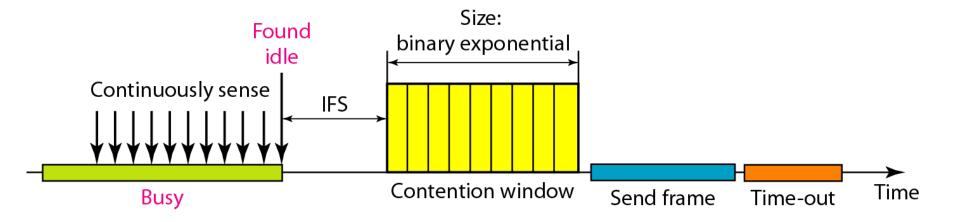
many slots.

Did you wait R slots and all slots were

available? Go ahead, transmit.

Now, wait time-out for a response.

Figure 12.16 Timing in CSMA/CA





Note

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

12-2 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.

Topics discussed in this section:

Reservation
Polling
Token Passing

Figure 12.18 Reservation access method

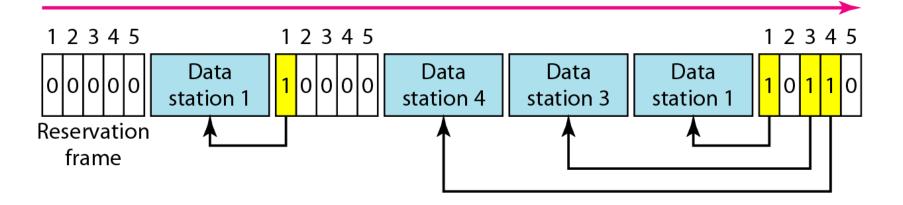


Figure 12.19 Select and poll functions in polling access method

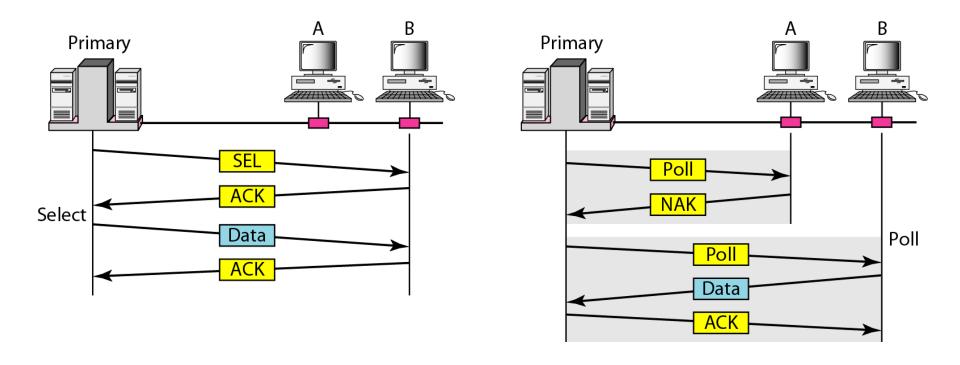
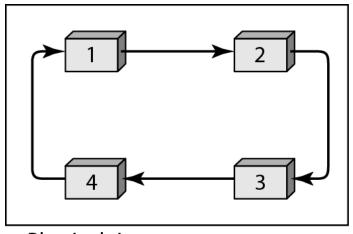
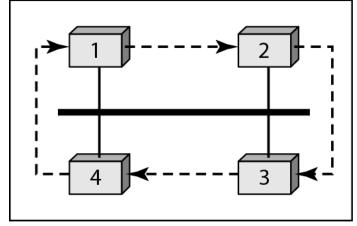


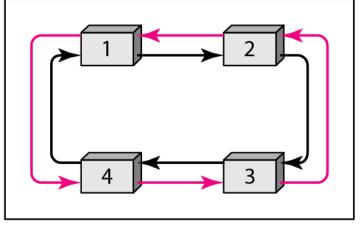
Figure 12.20 Logical ring and physical topology in token-passing access method



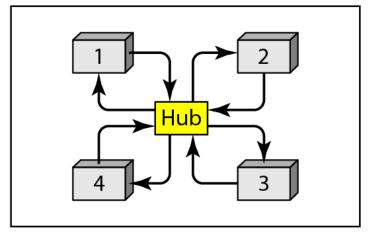
a. Physical ring



c. Bus ring



b. Dual ring



d. Star ring

12-3 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.

Topics discussed in this section:

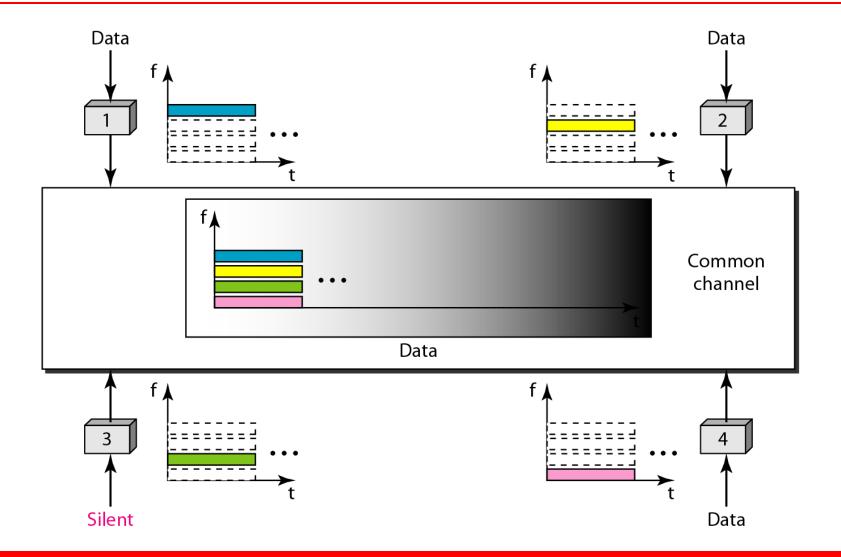
Frequency-Division Multiple Access (FDMA)
Time-Division Multiple Access (TDMA)
Code-Division Multiple Access (CDMA)



Note

We see the application of all these methods in Chapter 16 when we discuss cellular phone systems.

Figure 12.21 Frequency-division multiple access (FDMA)

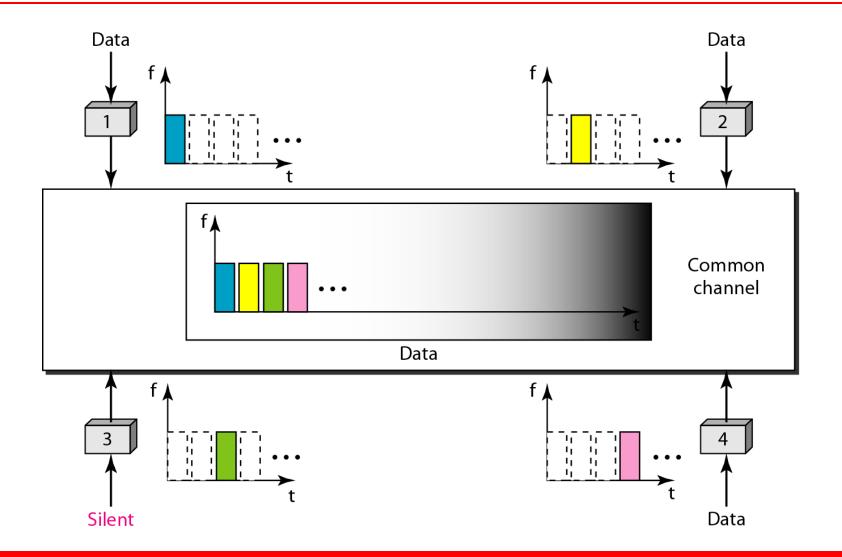


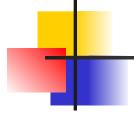


Note

In FDMA, the available bandwidth of the common channel is divided into bands that are separated by guard bands.

Figure 12.22 *Time-division multiple access (TDMA)*





Note

In TDMA, the bandwidth is just one channel that is timeshared between different stations.



Note

In CDMA, one channel carries all transmissions simultaneously.

Figure 12.23 *Simple idea of communication with code*

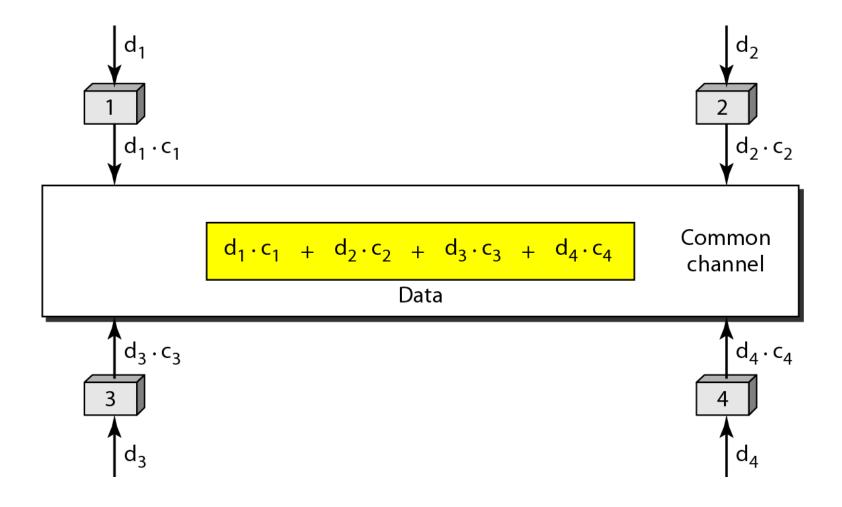


Figure 12.24 Chip sequences

Figure 12.25 Data representation in CDMA



Figure 12.26 Sharing channel in CDMA

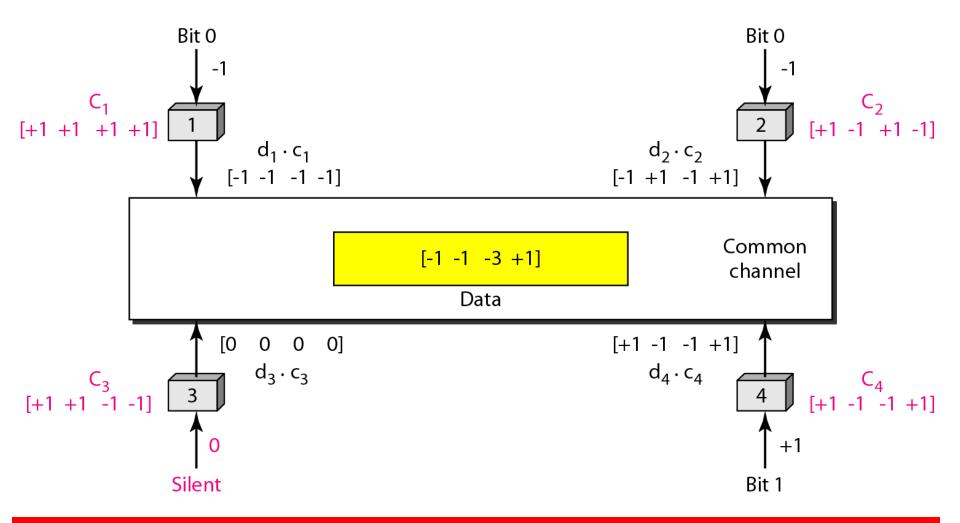


Figure 12.27 Digital signal created by four stations in CDMA

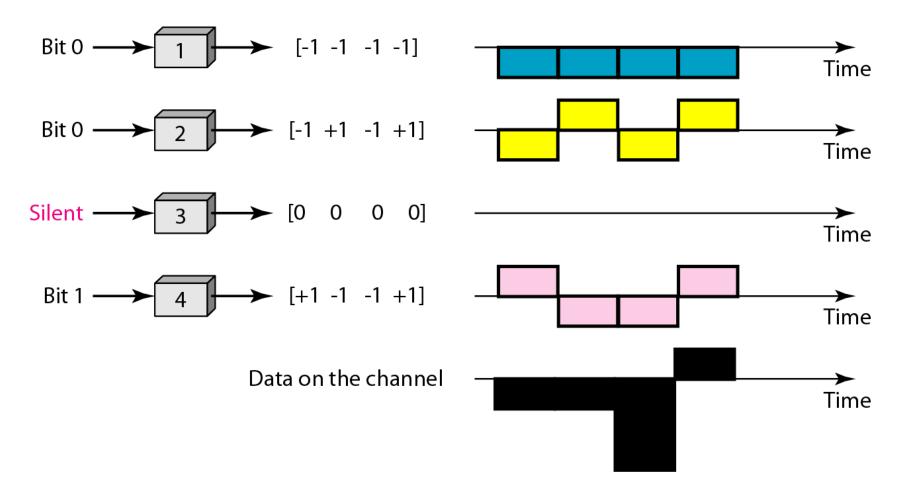


Figure 12.28 Decoding of the composite signal for one in CDMA

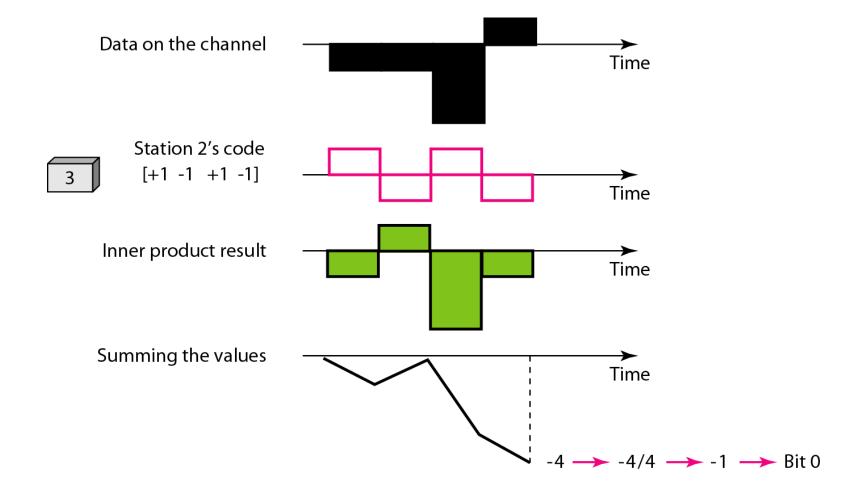


Figure 12.29 General rule and examples of creating Walsh tables

$$W_1 = \begin{bmatrix} +1 \end{bmatrix} \qquad W_{2N} = \begin{bmatrix} W_N & W_N \\ W_N & \overline{W}_N \end{bmatrix}$$

a. Two basic rules

$$W_{1} = \begin{bmatrix} +1 \\ +1 \end{bmatrix}$$

$$W_{2} = \begin{bmatrix} +1 \\ +1 \\ +1 \end{bmatrix}$$

$$W_{4} = \begin{bmatrix} +1 \\ +1 \\ +1 \end{bmatrix}$$

$$W_{4} = \begin{bmatrix} +1 \\ +1 \\ +1 \end{bmatrix}$$

$$W_{4} = \begin{bmatrix} +1 \\ +1 \\ +1 \end{bmatrix}$$

$$W_{4} = \begin{bmatrix} +1 \\ +1 \\ +1 \end{bmatrix}$$

b. Generation of W_1 , W_2 , and W_4



Note

The number of sequences in a Walsh table needs to be N = 2^m.

Find the chips for a network with **a**. Two stations **b**. Four stations

Solution

We can use the rows of W_2 and W_4 in Figure 12.29: a. For a two-station network, we have [+1 +1] and [+1 -1].

b. For a four-station network we have [+1 +1 +1 +1], [+1 -1 +1 -1], [+1 +1 -1], and [+1 -1 -1 +1].

What is the number of sequences if we have 90 stations in our network?

Solution

The number of sequences needs to be 2^m . We need to choose m = 7 and $N = 2^7$ or 128. We can then use 90 of the sequences as the chips.

Prove that a receiving station can get the data sent by a specific sender if it multiplies the entire data on the channel by the sender's chip code and then divides it by the number of stations.

Solution

Let us prove this for the first station, using our previous four-station example. We can say that the data on the channel

$$D = (d_1 \cdot c_1 + d_2 \cdot c_2 + d_3 \cdot c_3 + d_4 \cdot c_4).$$

The receiver which wants to get the data sent by station 1 multiplies these data by c_1 .

Example 12.8 (continued)

$$\begin{split} D \cdot c_1 &= (d_1 \cdot c_1 + d_2 \cdot c_2 + d_3 \cdot c_3 + d_4 \cdot c_4) \cdot c_1 \\ &= d_1 \cdot c_1 \cdot c_1 + d_2 \cdot c_2 \cdot c_1 + d_3 \cdot c_3 \cdot c_1 + d_4 \cdot c_4 \cdot c_1 \\ &= d_1 \times N + d_2 \times 0 + d_3 \times 0 + d_4 \times 0 \\ &= d_1 \times N \end{split}$$

When we divide the result by N, we get d_1 .