
CHAPTER 12

Multiple Access

Solutions to Odd-Numbered Review Questions and Exercises

Review Questions

1. The three categories of multiple access protocols discussed in this chapter are *random access*, *controlled access*, and *channelization*.
3. In *controlled access methods*, 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*, *polling*, and *token passing*.
5. In *random access* methods, there is no access control (as there is in controlled access methods) and there is no predefined channels (as in channelization). Each station can transmit when it desires. This liberty may create *collision*.
7. In a *random access* method, the whole available bandwidth belongs to the station that wins the contention; the other stations need to wait. In a *channelization* method, the available bandwidth is divided between the stations. If a station does not have data to send, the allocated channel remains idle.
9. We do not need a multiple access method in this case. The local loop provides a dedicated *point-to-point* connection to the telephone office.

Exercises

11. To achieve the maximum efficiency in pure ALOHA, $G = 1/2$. If we let ns to be the number of stations and nfs to be the number of frames a station can send per second.

$$G = ns \times nfs \times T_{fr} = 100 \times nfs \times 1 \mu s = 1/2 \rightarrow nfs = 5000 \text{ frames/s}$$

The reader may have noticed that the T_{fr} is very small in this problem. This means that either the data rate must be very high or the frames must be very small.

13. We can first calculate T_{fr} and G , and then the throughput.

$$\begin{aligned} T_{fr} &= (1000 \text{ bits}) / 1 \text{ Mbps} = 1 \text{ ms} \\ G &= ns \times nfs \times T_{fr} = 100 \times 10 \times 1 \text{ ms} = 1 \\ \text{For pure ALOHA} &\rightarrow S = G \times e^{-2G} \approx 13.53 \text{ percent} \end{aligned}$$

This means that each station can successfully send only 1.35 frames per second.

15. Let us find the relationship between the minimum frame size and the data rate. We know that

$$T_{fr} = (\text{frame size}) / (\text{data rate}) = 2 \times T_p = 2 \times \text{distance} / (\text{propagation speed})$$

or

$$(\text{frame size}) = [2 \times (\text{distance}) / (\text{propagation speed})] \times (\text{data rate})$$

or

$$\mathbf{(\text{frame size}) = K \times (\text{data rate})}$$

This means that minimum frame size is proportional to the data rate (K is a constant). When the data rate is increased, the frame size must be increased in a network with a fixed length to continue the proper operation of the CSMA/CD. In Example 12.5, we mentioned that the minimum frame size for a data rate of 10 Mbps is 512 bits. We calculate the minimum frame size based on the above proportionality relationship

Data rate = 10 Mbps	→	minimum frame size = 512 bits
Data rate = 100 Mbps	→	minimum frame size = 5120 bits
Data rate = 1 Gbps	→	minimum frame size = 51,200 bits
Data rate = 10 Gbps	→	minimum frame size = 512,000 bits

17. We have $t_1 = 0$ and $t_2 = 3 \mu\text{s}$
- a. $t_3 - t_1 = (2000 \text{ m}) / (2 \times 10^8 \text{ m/s}) = 10 \mu\text{s} \rightarrow t_3 = 10 \mu\text{s} + t_1 = \mathbf{10 \mu\text{s}}$
 - b. $t_4 - t_2 = (2000 \text{ m}) / (2 \times 10^8 \text{ m/s}) = 10 \mu\text{s} \rightarrow t_4 = 10 \mu\text{s} + t_2 = \mathbf{13 \mu\text{s}}$
 - c. $T_{fr(A)} = t_4 - t_1 = 13 - 0 = 13 \mu\text{s} \rightarrow \text{Bits}_A = 10 \text{ Mbps} \times 13 \mu\text{s} = \mathbf{130 \text{ bits}}$
 - d. $T_{fr(C)} = t_3 - t_2 = 10 - 3 = 07 \mu\text{s} \rightarrow \text{Bits}_C = 10 \text{ Mbps} \times 07 \mu\text{s} = \mathbf{70 \text{ bits}}$
19. See Figure 12.1.

Figure 12.1 Solution to Exercise 19

$$W_8 = \begin{bmatrix} \begin{matrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{matrix} & \begin{matrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{matrix} \\ \begin{matrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{matrix} & \begin{matrix} -1 & -1 & -1 & -1 \\ -1 & +1 & -1 & +1 \\ -1 & -1 & +1 & +1 \\ -1 & +1 & +1 & -1 \end{matrix} \end{bmatrix}$$

21.

Third Property: we calculate the inner product of each row with itself:

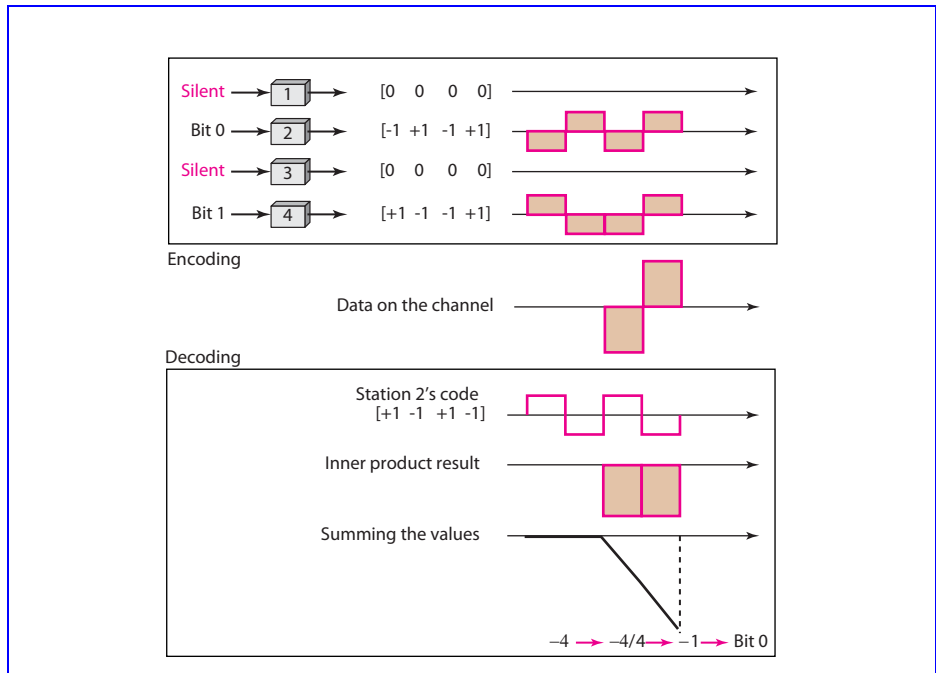
Row 1 • Row 1	$[+1 +1 +1 +1]$	•	$[+1 +1 +1 +1]$	=	$+1 +1 +1 +1 = 4$
Row 2 • Row 2	$[+1 -1 +1 -1]$	•	$[+1 -1 +1 -1]$	=	$+1 +1 +1 +1 = 4$
Row 3 • Row 1	$[+1 +1 -1 -1]$	•	$[+1 +1 -1 -1]$	=	$+1 +1 +1 +1 = 4$
Row 4 • Row 4	$[+1 -1 -1 +1]$	•	$[+1 -1 -1 +1]$	=	$+1 +1 +1 +1 = 4$

Fourth Property: we need to prove 6 relations:

Row 1 • Row 2	$[+1 +1 +1 +1]$	•	$[+1 -1 +1 -1]$	=	$+1 -1 +1 -1 = 0$
Row 1 • Row 3	$[+1 +1 +1 +1]$	•	$[+1 +1 -1 -1]$	=	$+1 +1 -1 -1 = 0$
Row 1 • Row 4	$[+1 +1 +1 +1]$	•	$[+1 -1 -1 +1]$	=	$+1 -1 -1 +1 = 0$
Row 2 • Row 3	$[+1 -1 +1 -1]$	•	$[+1 +1 -1 -1]$	=	$+1 -1 -1 +1 = 0$
Row 2 • Row 4	$[+1 -1 +1 -1]$	•	$[+1 -1 -1 +1]$	=	$+1 +1 -1 -1 = 0$
Row 3 • Row 4	$[+1 +1 -1 -1]$	•	$[+1 -1 -1 +1]$	=	$+1 -1 +1 -1 = 0$

23. Figure 12.2 shows the encoding, the data on the channel, and the decoding.

Figure 12.2 Solution to Exercise 23



25. We can say:

Polling and Data Transfer

Frame 1 for all four stations: $4 \times [\text{poll} + \text{frame} + \text{ACK}]$

Frame 2 for all four stations: $4 \times [\text{poll} + \text{frame} + \text{ACK}]$

Frame 3 for all four stations: $4 \times [\text{poll} + \text{frame} + \text{ACK}]$

Frame 4 for all four stations: $4 \times [\text{poll} + \text{frame} + \text{ACK}]$

Frame 5 for all four stations: $4 \times [\text{poll} + \text{frame} + \text{ACK}]$

Polling and Sending NAKs

Station 1: [poll + NAK]

Station 2: [poll + NAK]

Station 3: [poll + NAK]

Station 4: [poll + NAK]

Total Activity:

24 polls + 20 frames + 20 ACKs + 4 NAKs = **21536 bytes**

We have 1536 bytes of overhead which is 512 bytes more than the case in Exercise 23. The reason is that we need to send 16 extra polls.