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Data Communications

Lab 11

Chapter 12

Multiple Access

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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.

1- Find maximum propagation time (t_p)

Solution:

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

2- Find the value of T_B for different values of K .

$$(T_B = R \times T_p \text{ or } R \times T_{fr})$$

→ When $k=1$ ⇒ range is $\{0,1\}$

the station need to generate a random number with value 0 or 1.

$$\therefore T_B = R \times T_p = 0 \times 2 \text{ ms} = \boxed{0}$$

OR

$$= 1 \times 2 \text{ ms} = \boxed{2 \text{ ms}}$$

→ when $k=2$ ⇒ range = $\{0,1,2,3\}$ ⇒ ~~since~~

$$T_B = 0 \times 2 \text{ ms} = \boxed{0}$$

$$\text{or} = 1 \times 2 \text{ ms} = \boxed{2 \text{ ms}}$$

$$\text{or} = 2 \times 2 \text{ ms} = \boxed{4 \text{ ms}}$$

$$\text{or} = 3 \times 2 \text{ ms} = \boxed{6 \text{ ms}}$$

$$\begin{array}{l} \text{نم انتخاب} \\ \text{کند واتی} \\ \text{به } 0 \\ 2^k - 1 \end{array}$$

→ when $k=3$ ⇒ range = $\{0,1,2,3,4,5,6,7\}$.

∴ T_B can be 0, 2, 4, ..., 14 ms.

⊛ لو کانسٹے $k > 10$ ، فضاة ما سیم ضابطه ب 10 .

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:

الوقت الذي يأخذه الـ frame على إرساله $\Rightarrow$ Average frame transmission time (T_{fr})

$$T_{fr} = \frac{200 \text{ bits}}{200 \text{ kbps}} = \boxed{1 \text{ ms}}$$

المدة الزمنية التي فيها احتمال حدوث Collision $\Rightarrow$ Vulnerable time = $2 \times T_{fr}$

$$= 2 \times 1 \text{ ms} = \boxed{2 \text{ ms}}$$

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.

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:

سؤال: $\Rightarrow$ frame transmission time $T_{fr} = \frac{200}{200k} = \boxed{1 \text{ ms}}$

① 1000 frames per second.

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

هي متوسط الـ frames التي ينجحها النظام أثناء وقت إرسال الـ frame واحد.

$\Rightarrow$ 1000 frames per second $\Rightarrow$ 1 frame per 1 ms

$\therefore G = 1$ متوسط الـ frames في 1000 ms

$S = 1 \times e^{-2} = \boxed{0.135}$ frames per frame-time

$S = 0.135 \times 1000 \text{ ms} = \boxed{135 \text{ frames/sec}}$

(b) 500 frames per second $\Rightarrow \frac{1}{2}$ frame per millisecond.

$$\therefore G = \frac{1}{2}$$

$$S = G \times e^{-2G} = \boxed{0.184 \text{ frames per frame-time}}$$

$$S = 0.184 \times 1000 \text{ ms} = \boxed{184 \text{ frames/sec}}.$$

(c) 250 frames per second $\Rightarrow \frac{1}{4}$ frame per millisecond.

$$\therefore G = \frac{1}{4}$$

$$S = G \times e^{-2G} = 0.152 \text{ frames per frame-time}$$

$$S = 0.152 \times 1000 \text{ ms} = \boxed{152 \text{ frames/sec}}$$

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

$$S = G \times e^{-G} \text{ or } S = \mathbf{0.368 \text{ frames per frame-time}}$$

b. If the system creates 500 frames per second, this is (1/2) frame per millisecond. The load is (1/2). In this case

$$S = G \times e^{-G} \text{ or } S = \mathbf{0.303 \text{ frames per frame-time}}$$

c. If the system creates 250 frames per second, this is (1/4) frame per millisecond. The load is (1/4). In this case

$$S = G \times e^{-G} \text{ or } S = \mathbf{0.195 \text{ frames per frame-time}}$$

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 $25.6 \mu\text{s}$, what is the minimum size of the frame?

Solution:

The frame transmission time is $T_{\text{fr}} = 2 \times T_p = 51.2 \mu\text{s}$.

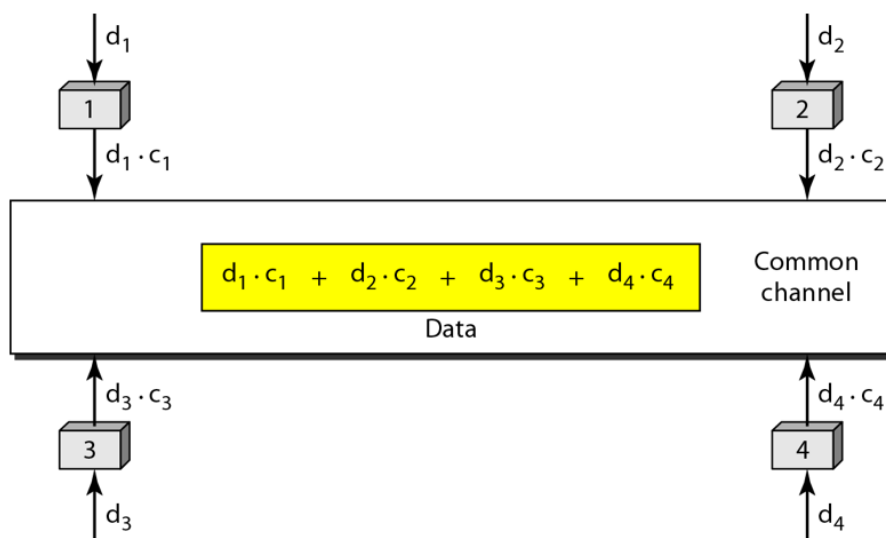
This means, in the worst case, a station needs to transmit for a period of $51.2 \mu\text{s}$ to detect the collision.

The minimum size of the frame is $10 \text{ Mbps} \times 51.2 \mu\text{s} = 512 \text{ bits}$ or 64 bytes . This is actually the minimum size of the frame for Standard Ethernet.

Code-division multiple access (CDMA):

Let us assume we have four stations, 1, 2, 3, and 4, connected to the same channel. The data from station 1 are d_1 , from station 2 are d_2 , and so on. The code assigned to the first station is c_1 , to the second is c_2 , and so on. We assume that the assigned codes have two properties.

1. If we multiply each code by another, we get 0.
2. If we multiply each code by itself, we get 4 (the number of stations).



$$\begin{aligned} \text{data} &= (d_1 \cdot c_1 + d_2 \cdot c_2 + d_3 \cdot c_3 + d_4 \cdot c_4) \cdot c_1 \\ &= d_1 \cdot c_1 \cdot c_1 + d_2 \cdot c_2 \cdot c_1 + d_3 \cdot c_3 \cdot c_1 + d_4 \cdot c_4 \cdot c_1 = 4 \times d_1 \end{aligned}$$

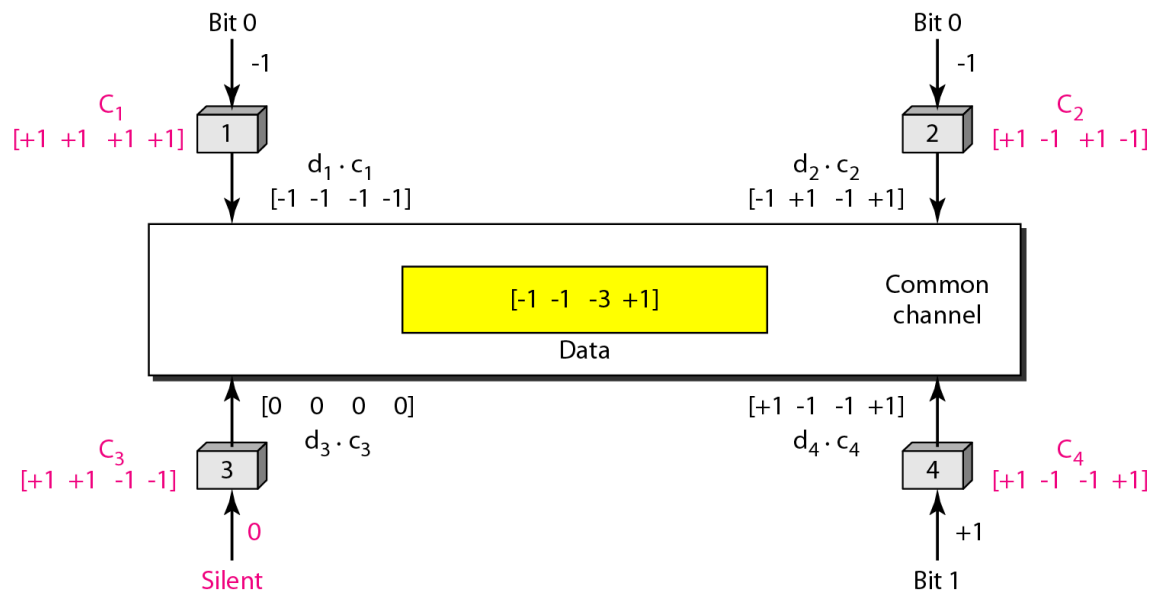
We follow these rules for encoding: If a station needs to send a 0 bit, it encodes it as -1 ; if it needs to send a 1 bit, it encodes it as $+1$. When a station is idle, it sends no signal, which is interpreted as a 0. These are shown in Figure 12.25.

Data bit 0 $\rightarrow$ -1

Data bit 1 $\rightarrow$ +1

Silence $\rightarrow$ 0

Example:



لو جهاز (4) بد يعزف جهاز (1) شوي؟!

الكل:

$$\begin{array}{r}
 \begin{array}{l} \text{جهاز (1)} \\ \text{code} \end{array} \Rightarrow \begin{array}{cccc} +1 & +1 & +1 & +1 \end{array} \\
 \begin{array}{l} \text{جهاز (2)} \\ \text{code} \end{array} \Rightarrow \begin{array}{cccc} -1 & -1 & -3 & +1 \end{array} \\
 \hline
 \begin{array}{cccc} -1 & -1 & -3 & +1 \end{array}
 \end{array}$$

مجموع ههول = -4

$\downarrow$

$$\begin{array}{l}
 \text{جهاز (1)} \Rightarrow \boxed{-1} = \frac{-4}{4} = \frac{-4}{\text{عدد خانة } C_1} \\
 \text{جهاز (2)} \Rightarrow \boxed{-6}
 \end{array}$$

Example 12.6: Find the chips for a network with

- a. Two stations b. Four stations**

Solution:

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

a. Two basic rules

$$W_1 = \begin{bmatrix} +1 \end{bmatrix} \qquad W_2 = \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix} \qquad W_4 = \begin{bmatrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{bmatrix}$$

b. Generation of W_1 , W_2 , and W_4

We can use the rows of W_2 and W_4 in Figure 12.29:

a. For a two-station network, we have

$$[+1 \ +1] \text{ and } [+1 \ -1].$$

b. For a four-station network we have

$$[+1 \ +1 \ +1 \ +1], [+1 \ -1 \ +1 \ -1], \\ [+1 \ +1 \ -1 \ -1], \text{ and } [+1 \ -1 \ -1 \ +1].$$

Example 12.7: What is the number of sequences if we have 90 stations in our network?

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.

Example 12.8: 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

$$\mathbf{D} = (\mathbf{d}_1 \cdot \mathbf{c}_1 + \mathbf{d}_2 \cdot \mathbf{c}_2 + \mathbf{d}_3 \cdot \mathbf{c}_3 + \mathbf{d}_4 \cdot \mathbf{c}_4).$$

The receiver which wants to get the data sent by station 1 multiplies these data by $\mathbf{c}_1$.

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

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