Question 1: Assume a code includes two valid codewords "0000" and "1111". The hamming distance between these two codewords is 4. Can the error(s) be detected in the following? Explain why. (3 points)

a. One bit is flipped/inverted.
b. Two bits are flipped/inverted.
c. Four bits are flipped/inverted.

Answer:

Part a and b:
If one bit is flipped/inverted or if two bits are flipped/inverted, the error can be detected. Because minimum Hamming distance of 4 means that up to 3 errors can be detected.

Part c:
If four bits are flipped, then "0000" becomes "1111" and the error cannot be detected.

Question 2: Consider a slotted Aloha network in which the stations transmit 300-bit fames on a shared channel with transmission rate of 500 kbps. Assume the system produces 1500 frames per second. Answer the following.

a. Calculate the vulnerable time for this network. (1 point)
b. Calculate the throughput of this network. Explain the result. (3 points)
c. How is the throughput is affected if *G* is changed to 1/4. Show your calculation. (2 points)

Answer:

a. We know that the vulnerable time is equal to the frame transmission time in a slotted Aloha network.
   T_{fr} = 300 / 500,000 = 0.0006 s = 0.6 ms
   For slotted Aloha, vulnerable time = T_{fr} = 0.6 ms
b. We know that G is the average number of frames generated in one frame transmission time. 1500 frames are sent per 1000 ms → G = (0.6 x 1500)/1000 = 0.9 → S = G x e^{-G} = 0.9 x $e^{-0.9}$ = 0.364 → 1500 x 0.364 = 546 frames are likely to survive (or can be successfully transmitted).
c. S = G x e^{-G} = 1/4 x $e^{-1/4}$ = 0.195 → 1500 x 0.195 = 292.5 or 293 frames are likely to survive. → throughput decreases

Question 3: Assume we have an organization with 450 users. These users are from three divisions, namely Engineering (EN), Human Resources (HR), and Sales (SA). While each of EN and HR have 128 users, SA has 194 users. Assume that an ISP has a large block of addresses (192.168.184.0/21) and it needs to assign a block of addresses to this organization using classless addressing.

a. Determine the block of addresses which is allocated to this organization by the ISP, including the first and last addresses as well as the number of required addresses. (2.5 points)
b. How many addresses from the large block of addresses (i.e., the original block of addresses) are unused? (1 point)
c. Assume you are splitting the allocated block of addresses to the organization into three subnetworks, each of which corresponds to a division. Indicate the first and last addresses as well as the number of required addresses for each division. (4.5 points)

Answer:
Large block of addresses: 192.168.184.0/21

a.
512 addresses are assigned to the organization (450 is not a power of 2, so, we choose the closest power of 2 that is greater than 450).
Prefix length = n = 32 – $\log_2 512$ = 32 – 9 = 23
First address:192.168.10111000.000000000 → 192.168.184.0/23
Last address:192.168.10111001.11111111→192.168.185.255/23

b.
The number of addresses for the large block = $2^{32-21} = 2^{11}$ = 2048 Therefore, the number of unused addresses is: 2048 - 512 = 1536

c.
There are two correct answers:

Answer1:
Given the network address of the organization (192.168.184.0/23):

SA: 256 addresses are assigned (194 is not a power of 2, so, we choose the closest power of 2 that is greater than 194).
Prefix length= n = 32 – $\log_2 256$ = 32 – 8 = 24
First address: 192.168.185.0/24
Last address:192.168.185.255/24

EN: 128 addresses are required.
Prefix length = n = 32 – $\log_2 128$ = 32 – 7 = 25
First address: 192.168.184.0/25
Last address: 192.168.184.127/25

HR: 128 addresses are required.
Prefix length = n = 32 – $\log_2 128$ = 32 – 7 = 25
First address: 192.168.184.128/25
Last address: 192.168. 184.255/25

Answer2:
Given the network address of the organization (192.168.184.0/23):

SA: 256 addresses are assigned (194 is not a power of 2, so, we choose the closest power of 2 that is greater than 194).
Prefix length= n = 32 – $\log_2 256$ = 32 – 8 = 24
First address: 192.168.184.0/24
Last address:192.168.184.255/24

EN: 128 addresses are required.
Prefix length = n = 32 – $\log_2 128$ = 32 – 7 = 25
First address: 192.168.185.0/25
Last address: 192.168.185.127/25

HR: 128 addresses are required.
Prefix length = n = 32 – $\log_2 128$ = 32 – 7 = 25
First address: 192.168.185.128/25
Last address: 192.168. 185.255/25

Question 4: Three equal-size datagrams (each one is 20 bytes) belonging to the same message leave for the destination one after another. However, they travel through different paths as shown in the table. We assume that the delay for each router (including waiting and processing) is 2, 5, 15, and 8 ms, respectively. Assuming that the propagation speed is 3×10^8 m/s, find the delay of each datagram as well as the order their arrival at the destination. (5 points)

Datagram	Path length	Visited routers	Data rate of each link on the path
1	3,000 km	1, 3	2 Kbps

2	6,000 km	4, 2, 1	8 Mbps
3	9,000 km	1, 2, 3, 4	5 Mbps

3 links on the path for datagram1

4 links on the path for datagram2

5 links on the path for datagram3

Total delay for each datagram = propagation time + transmission time + waiting/procession time

t1 = (3000 x 1000)/(3 x 10^8) + 3x(20 x 8)/(2 x 1000) + (2 + 15) x 10^-3 = 0.01 + 0.24 +0.017 = 0.267 s

t2 = (6000 x 1000)/(3 x 10^8) + 4x(20 x 8)/(8 x 10^6) + (8 + 5 + 2) x 10^-3 = 0.02 + 8 x 10^-5 + 0.015 =0.035 s

t3 = (9000 x 1000)/(3 x 10^8) +5x (20 x 8)/(5 x 10^6) + (2 + 5+ 15 + 8) x 10^-3 = 0.03 + 160 x 10^-6 + 0.03 = 0.060 s

order of arrival: D2, D3, D1

Question 5: Suppose that 17 switches supporting k VLAN groups are to be connected via a trunking protocol. How many ports are needed to connect the switches (in a chain)? Explain your answer. (2 points)

Solution:

We can string the 17 switches together. The first and last switch would use one port for trunking; the middle 15 switches would use two ports. So, the total number of ports is 2+ 2 x (15) = 32 ports.