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

问题 1： 假设一段代码包含两个有效码字“0000”和“1111”。这两个码字之间的汉明距离为4。以下情况中能否检测到错误？请解释原因。（3分）

a. 一位发生翻转/反转。
b. 两位发生翻转/反转。
c. 四位发生翻转/反转。

答案：

第a和b部分：如果一位或两位发生翻转/反转，则可以检测到错误。因为最小汉明距离为4意味着最多可检测3个错误。

部分 c：如果翻转了四位，则“0000”会变成“1111”，此错误无法被检测到。

问题2： 考虑一个时隙Aloha网络，其中各站点以500 kbps的传输速率在共享信道上传输300比特的帧。假设系统每秒产生1500个帧。请回答以下问题。

a. 计算该网络的易受攻击时间。（1 分）
b. 计算该网络的吞吐量。解释结果。（3 分）
c. 如果 G 改为 1/4，吞吐量将如何受到影响？写出计算过程。（2 分）

答案：

a. 我们知道，在时隙 Aloha 网络中，易受攻击时间等于帧的传输时间。

   T_{fr} = 300 / 500,000 = 0.0006 s = 0.6 ms
   对于时隙ALOHA，易受攻击时间 = T_{fr} = 0.6 毫秒
b. 我们知道 G 是在一个帧传输时间内平均生成的帧数。每 1000 毫秒发送 1500 个帧 → 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 帧有可能存活（或可成功传输）。

c. S = G x e^{-G} = 1/4 x $e^{-1/4}$ = 0.195 → 1500 x 0.195 = 292.5 或 293 帧可能会保留。→ 吞吐量下降

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

问题3： 假设我们有一个拥有450名用户的组织。这些用户来自三个部门，分别是工程部（EN）、人力资源部（HR）和销售部（SA）。其中EN和HR各有128名用户，SA有194名用户。假设某个互联网服务提供商（ISP）拥有一个较大的地址块（192.168.184.0/21），需要使用无类别编址方式为该组织分配一个地址块。

a. 确定ISP分配给该组织的地址块，包括第一个和最后一个地址以及所需的地址数量。（2.5分）

b. 在大的地址块中（即原始地址块），有多少地址未被使用？（1分）

c. 假设将分配给该组织的地址块划分为三个子网络，每个子网络对应一个部门。请指出每个部门的第一个和最后一个地址以及所需的地址数量。（4.5分）

答案：
大的地址块：192.168.184.0/21

a.
分配给该组织的地址有512个（450不是2的幂，因此选择大于450的最接近的2的幂）。
前缀长度 = n = $32 – \log_2 512 = 32 – 9 = 23$第一个地址：192.168.10111000.000000000 → 192.168.184.0/23 最后一个地址：192.168.10111001.11111111→192.168.185.255/23

b.
大块地址= $2^{32-21} = 2^{11} = 2048$ 的数量。因此，未使用的地址数量为：2048 - 512 = 1536

c.
有两个正确答案：

答案1：
给定组织的网络地址（192.168.184.0/23）：

SA：分配了 256 个地址（194 不是 2 的幂，因此我们选择大于 194 的最接近的 2 的幂）。
前缀长度= n = $32 – \log_2 256 = 32 – 8 = 24$第一个地址：192.168.185.0/24 最后一个地址：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

EN：需要128个地址。
前缀长度 = n = 32 – $\log_2 128$ = 32 – 7 = 25
第一个地址：192.168.184.0/25
最后一个地址：192.168.184.127/25

HR：需要 128 个地址。
前缀长度 = n = 32 – $\log_2 128$ = 32 – 7 = 25
第一个地址：192.168.184.128/25
最后地址：192.168. 184.255/25

答案2：
给定组织的网络地址（192.168.184.0/23）：

SA：分配了 256 个地址（194 不是 2 的幂，因此我们选择大于 194 的最接近的 2 的幂）。

前缀长度= n = 32 – $\log_2 256$ = 32 – 8 = 24
第一个地址：192.168.184.0/24
最后地址：192.168.184.255/24

EN：需要 128 个地址。
前缀长度 = n = 32 – $\log_2 128$ = 32 – 7 = 25
第一个地址：192.168.185.0/25
最后一个地址：192.168.185.127/25

HR：需要 128 个地址。
前缀长度 = n = 32 – $\log_2 128$ = 32 – 7 = 25
第一个地址：192.168.185.128/25
最后一个地址：192.168. 185.255/25

问题4： 属于同一消息的三个等尺寸数据报（每个20字节）依次出发前往目的地。然而，它们经过不同的路径，如表中所示。我们假设每个路由器的延迟（包括等待和处理）分别为2、5、15和8毫秒。假设传播速度为 3×10^8 m/s，求每个数据报的延迟以及它们到达目的地的顺序。（5分）

数据报	路径长度	已访问的路由器	每条路径上的链路的数据速率
1	3,000 公里	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

$t_1 = (3000 \times 1000)/(3 \times 10^8) + 3 \times (20 \times 8)/(2 \times 1000) + (2 + 15) \times 10^{-3} = 0.01 + 0.24 + 0.017 = 0.267$ s

$t_2 = (6000 \times 1000)/(3 \times 10^8) + 4 \times (20 \times 8)/(8 \times 10^6) + (8 + 5 + 2) \times 10^{-3} = 0.02 + 8 \times 10^{-5} + 0.015 = 0.035$ s

$t_3 = (9000 \times 1000)/(3 \times 10^8) + 5 \times (20 \times 8)/(5 \times 10^6) + (2 + 5 + 15 + 8) \times 10^{-3} = 0.03 + 160 \times 10^{-6} + 0.03 = 0.060$ 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.

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

数据报1路径上的链路数为3

datagram2 路径上的 4 个链路

datagram3 路径上的 5 个链路

每个数据报的总延迟 = 传播时间 + 传输时间 +等待/处理时间

$t_1 = (3000 \times 1000)/(3 \times 10^8) + 3 \times (20 \times 8)/(2 \times 1000) + (2 + 15) \times 10^{-3} = 0.01 + 0.24 + 0.017 = 0.267$ 秒

$t_2 = (6000 \times 1000)/(3 \times 10^8) + 4 \times (20 \times 8)/(8 \times 10^6) + (8 + 5 + 2) \times 10^{-3} = 0.02 + 8 \times 10^{-5} + 0.015 = 0.035$ 秒

$t_3 = (9000 \times 1000)/(3 \times 10^8) + 5 \times (20 \times 8)/(5 \times 10^6) + (2 + 5 + 15 + 8) \times 10^{-3} = 0.03 + 160 \times 10^{-6} + 0.03 = 0.060$ 秒

到达顺序：D2、D3、D1

问题 5：假设有 17 个支持 k 个 VLAN 组的交换机需要通过中继协议连接。若以链式结构连接这些交换机，需要多少个端口？请解释你的答案。（2 分）

解答：

我们可以将这17个交换机串联在一起。第一个和最后一个交换机会使用一个端口用于中继；中间的15个交换机会使用两个端口。因此，端口总数为 2+2 x (15) = 32 个端口。